DEMOGRAPHY AND DISEASE OF THE NAESTVED HELLIGÅNDSHUS COLLECTION; AN A.D. 15TH TO 19TH CENTURY CEMETERY POPULATION OF THE 'HOUSE OF THE HOLY SPIRIT' IN SOUTH-WEST DENMARK

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Demography and Disease of the Næstved Helligåndshus Collection; an A.D. 15th to 19th Century Cemetery Population of the 'House of the Holy Spirit' in South-West Denmark

by

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A thesis submitted to the School of Graduate Studies
in partial fulfilment of the
requirements for the degree of
Master of Arts

Department of Anthropology

Memorial University of Newfoundland

May 1996

St. John's Newfoundland

ISBN 0-612-13924-7

ABSTRACT

Together with archaeological and historical information, demographic and palaeopathological investigations can provide valuable insights into aspects of the health and social background of the otherwise silent members of a past population. The Helligåndshus cemetery collection from Næstved is the only burial population of its kind which has been excavated in Denmark. Functioning as a charitable religious hospital during the late mediaeval and post-reformation periods, the Helligåndshus provided charity, healthcare and burials for poverty stricken and unfortunate members of society. The burial collection, consisting of 328 defined interments, provides a rare glimpse of the age and gender structure of the facility's clientele as well as the diseases which posed threats to their health and well-being.

Although representing just a sector of society, the Helligåndhus burial population is comprised of individuals of all ages, from infancy to old age. Childhood mortality appears to have been high and life expectancy for adults was just 32.5 years on average. A slight gender bias may indicate a greater need for charity among females.

Disease was not an uncommon phenomenon and over half of the burial population had suffered from one or more pathological condition. In accordance with the social background of the population, diseases of an occupational, nutritional and infectious nature were the most common while trauma, congenital disorders and neoplastic diseases were few. While poverty and disease placed their demands on the individual, the need for charity and heathcare made its demands on the greater charitable society of Næstved.

ACKNOWLEDGEMENTS

This research began as an opportunity to take part in an exchange program between Memorial University of Newfoundland, Canada and the University of Copenhagen, Denmark. There are thus many people who deserve thanks on both sides of the Atlantic.

Firstly, on this side of the Altantic, I would like to thank Dr. Priscilla Renouf and Dr. Sonja Jerkic for offering me the opportunity to participate in the exchange and for assisting me in the planning. Dr. Renouf has also lent her support in countless ways throughout and Dr. Jerkic deserves many thanks for directing the writing of this thesis and for providing suggestions and guidance. Dr. Erik Brinch Petersen, Institut for Arkæologi og Etnologi, and Dr. Hart Hansen, Universitets Antropologiske Laboratorium, Panum Instituttet, were my contacts on the other side of the Atlantic and I owe them both many thanks for their assistance in making the exchange a reality.

For providing the financial assistance which made this research possible, my appreciation is extended to the Institute of Social and Economic Research at Memorial University of Newfoundland.

Whatever merit this research attains, it is very much owing to the kindness, inspiration and enthusiasm of Dr. Pia Bennike. I should not have learned so much from the collection nor of the relevant history had it not been for Dr. Bennike's help; for all of this I am extremely grateful. Pia's interest was also invaluable, in that, through her involvement, this research was supplemented with x-rays, suggestions and many insights. I am thankful to the Radiology Staff at Frederiksborg Amt. Sygehus for taking the bone x-rays and to Birgitte Sørensen for providing dental x-rays for two interesting cases.

I owe many thanks to Palle Birk Hansen, director of the Næstved Museum who was in charge of the 1982 excavation of the Helligåndshus cemetery. Palle did a great deal of charting and mapping of the archaeological information from the excavation. All of this information as well as some very valuable historical background information was generously made available to me. For this and the hospitality of Palle and his famlily, I am very thankful. For the funding and development of photographs, the assistance of the Næstved Museum was invaluable and I express my appreciation for that as well as time and the expert photographic development work of Jens Peter Olsen.

Copenhagen would not have been nearly as "wonderful" without the friendship of those at the Panum Antropologiske Laboratorium and at Regensen. Thanks to "Tilia" and "Kyst Defensions" for trying to teach me some Danish whether I liked it or not and for lots of fun on the side. To Margie/Matthew, Ken, Jim, Jarrett, Cindy and Grant... thanks for dropping over to Copenhagen to remind me that, no matter how far away you may go, the Cape Breton crowd are never far behind. I am also grateful to Ken for the generous loan of photographic equipment which was an invaluable aid to this research.

Sincere thanks to are extended to Christian Adamsen who went out of his way to search for obscure articles on my behalf, to put me in touch with people working on related topics and for continuing to send me information overseas. Also to Aage Andersen, Grete Jacobsen, Liz Trabjerg, Dr. Peter Bartlett and Dr. Paul Walsh, to mention a few, I am grateful for historical and pathological information.

To Peter Bruce for his mapping and digitizing skills and Michael El-Gohary and John Wicks for their great help with alot of tedious tasks, I express my appreciation. A warm and special thanks to Ron and Ethel, who are without a doubt the world's finest neighbours, the embodiment of kindness and caring ...ensuring daily that I would not develop any of the nutritional deficiencies of which I am to speak. Finally, thanks to my family and friends for their support and understanding and for not mentioning the dreaded "T" word at the end of a long day!

List of Figures and Tables

List of Plates

Plates: **Page**

Plates: **Page**

TABLE OF CONTENTS

Page

CHAPTER 1: INTRODUCTION

A skeletal population provides a "window" to the past and thereby an opportunity to view some of the range of variation occurring in a particular group of individuals: their ages, their gender, and aspects of their morbidity and mortality. The absolute range or extent of possible variation in the living counterpart of the collection may only be a subject for speculation. Nonetheless, the data provided by burial populations is valid and it can contribute much information on past populations.

This research is an interpretation of osteological and palaeopathological data collected from an investigation of 328 skeletons. The skeletal material was excavated from a cemetery of the *Helligåndshus* (House of the Holy Spirit) in Næstved, southwest Sjælland, Denmark. As the first systematic study of these skeletal remains since their excavation in 1982, the intent of the study was two fold: 1) to gain an understanding of the basic demography of the research population and 2) to focus the data collection on indicators of health and/or disease in the population, in light of the fact that the Helligåndshus was a charitable chapel hospital which catered almost exclusively to the poor. Therefore, aside from establishing a demographic profile for the population, the study was aimed at describing and quantifying the occurrence of pathology in the skeletal material.

There is no written history for Næstved's Helligåndshus nor is there any information from other Helligåndshus populations in Denmark. To this end, the Helligåndshus collection can be viewed as unique and therefore able to provide information where little is known of the history and society within the hospitals of such establishments in Denmark. Although there is a distinct shortage of information on the activities and policies of the Helligåndshus, the little knowledge that is available has provided a basis for making some assumptions to facilitate the interpretation of the present data. In turn, the interpretation of the data has shed some light onto the Helligåndshus and its residents.

Data compiled for each skeleton included age, gender and pathological diagnoses according to established disease categories. At the interpretative stage, pathological indications, namely skeletal lesions and anomalies, were considered in terms of their representation of different disease processes. The disease processes were then assigned to diagnostic categories. Finally, all information was entered into a database (dBASE IV) catalog and then sorted on the basis of disease categories. Each category of disease is discussed separately in relation to the manifestation of the disease process and its demographic associations within the research population. Case descriptions are provided for each category of disease to illustrate the manifestation of the disease process in the individual as well as to demonstrate the range of variation occurring within the population.

The final interpretation stage, after preliminary correspondences of disease occurrence were considered and discussed in relation to age, gender and

associated disease processes, entailed a consideration of the significance of the findings. In particular, the presence of pathological lesions was considered in terms of its significance as an indicator of the level of health in the individual and within the research population as a whole. At this stage of interpretation a number of problem areas had to be considered.

Several problem areas, apparent at the outset, certainly shaped the focus and scope of the ensuing investigation. Thus limits were set as to the type of study and the relative degree of reliability attainable for any conclusions made. Two of the most significant problem areas in this respect were the considerable time span, i.e. approximately 400 years of interments, and the incomplete and possibly biased nature of the rescue excavation. Some of the many factors which required consideration in this study included the differential preservation of individual skeletons within the research collection, the variability in age and gender determinations, the ambiguity and limits of diagnostic success on skeletal material especially when incomplete, and the representivity of the burial population to a living counterpart.

The representivity of the research sample was an important factor to be considered, both in terms of its relationship to the "entire" cemetery and in terms of its relationship to the "living" society and the time span from which it was derived. In the case of the cemetery, it is known that the research sample is only a portion of the cemetery which was excavated from a trench going through the graveyard. It is difficult to say what percentage of the total cemetery is present in

the excavated sample since the entire extent of the cemetery is not known. Yet, it was important to consider to what degree the research sample was either representative or biased toward the greater cemetery population. In order to investigate possible biasing within the excavation trench, all palaeodemographic and palaeopathological information was plotted on a burial plan to determine if there was any possible patterning on the basis of age, gender or disease presence. If clustering of graves was observed, in relation to any of the aforementioned factors, it would suggest that burials were patterned in relation to a given factor within the graveyard. From the burial plot (Fig. 1.1), it appears that clustering of age groups, gender groups or pathological skeletons does not occur. Hence, it is suggested that burial patterning was not practised in relation to these factors and thus, for all intents and purposes, the excavated sample has been considered as a representative sample of the entire cemetery.

With respect to the relationship of the Helligåndshus research population to other populations of the time, the issue of representability becomes that much more complex. This aspect of the investigation is difficult to resolve. Initially, the problems of dealing with a time period of approximately 400 years of cemetery use needed to be accommodated in order to facilitate population-based interpretations. In terms of societal representation it is said that, at least during the Middle Ages, village burial populations can be considered representative of their living populations; Iregren (1992) notes that it was the norm for individuals to be buried in their home parishes along with their ancestors and family members

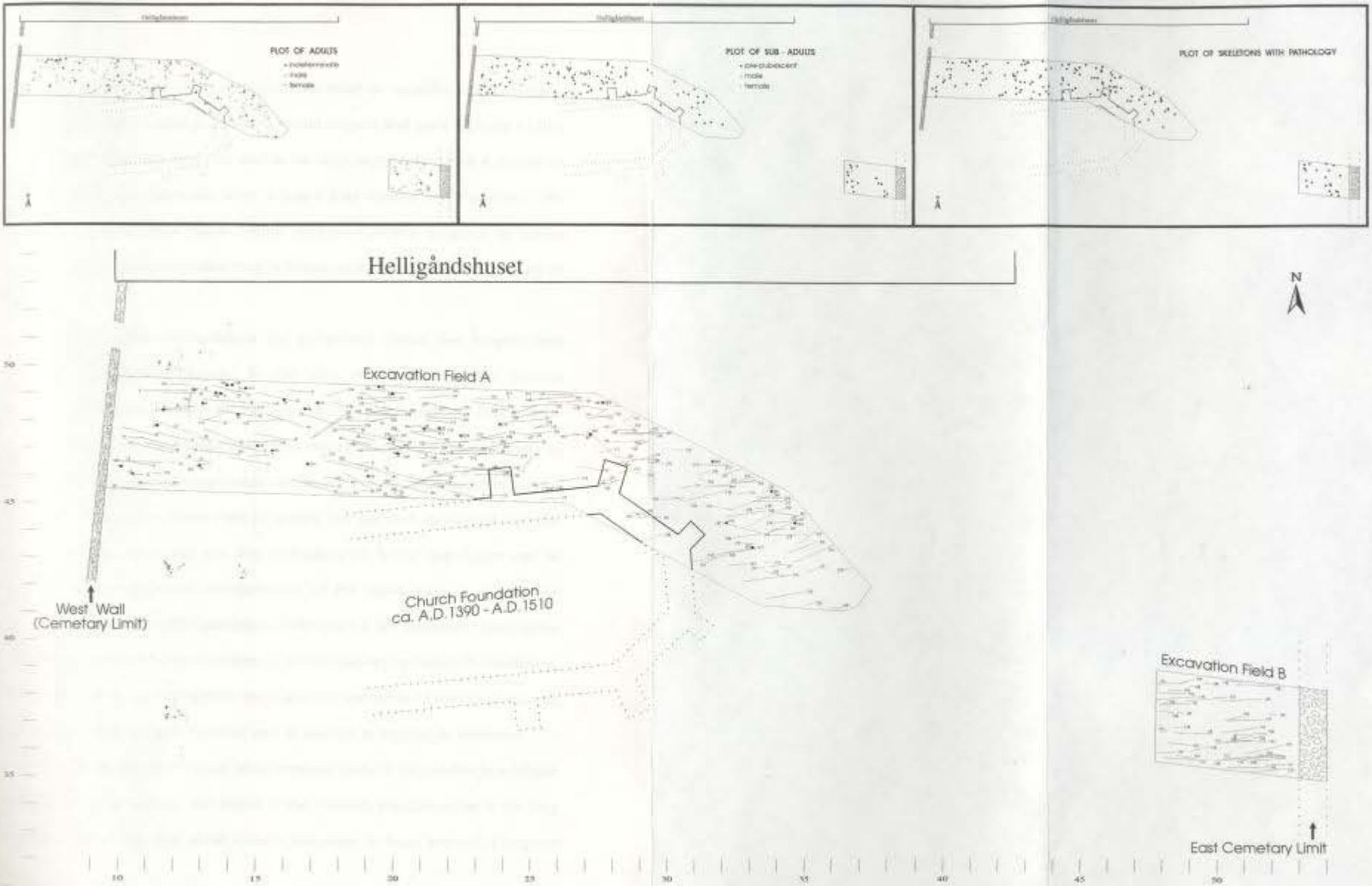

Figure 1.1: Helligåndshuset Excavation and Burial Plot; Plan View of Helligåndshus Land Registry Block (#246) showing the present location of the Helligåndshus/ Næstved Museum, the outline of the 1982 excavation trench and the archaeological findings related to the ecclesiastical occupation of the land (A.D. 15th - 18th century burial placements and ca. A.D. 15th century church foundation).

Nevertheless, this view of burial populations must be considered with caution. Current opinions on burial populations would suggest, and quite logically so, that burial populations can never be said to be truly representative of a society as there is almost unequivocally some inherent bias (Ortner and Putschar, 1985; Wood et.al., 1992). Such biases would obviously include religious or parish affiliation bias, but also included may be biases on the basis of wealth, poverty or disease.

Iregren (1992) acknowledges the exceptional biases that hospital and monastery populations present to the idea of cemetery versus societal representation. In this respect, the Helligåndshus population clearly falls into the category of exceptional populations. However, rather than mirroring society in general, the Helligåndshus population can be seen as reflecting a sector of society, i.e. namely the poor or lower class of society that has been associated with the facility. This is not to say that the Helligåndshus burial population can be considered an unequivocal representation of the lower class or of the true residents and life in the Helligåndshus. There are too few skeletons covering too long a time span for it to be considered a representative population. Nevertheless, instead of comparing this "special" population to the norms of society in general, it has been illuminating to consider and to attempt to explain its contrasts.

All of the aforementioned considerations make it impossible to establish complete control over any one aspect of the research population, be it the time period or the lifestyle and social stratum associated to those interred. Complete

certainty is not, however, something that history, archaeology or physical anthropology has ever claimed. Therefore, like many studies before this and perhaps like many of those to follow, this study is a test of considerations, assumptions and problems. Keeping all these obstacles between the bare facts and the derived conclusions in mind, the goal of this investigation is to provide some new ideas on the past residents of the Helligåndshus.

In short, the main focus of this research is to describe the population characteristics of the Helligåndshus collection and to attempt to place these characteristics in a social context. Considering the hospital function of the Helligåndshus, the occurrence of pathology in the collection was an interesting and important area on which to focus. Therefore, aside from age and gender determinations, pathological investigation became a significant focus due to the prevalence of gross morphological bone changes occurring in the collection. More than one third of the skeletal research population had been affected by one or more pathological condition. During the collection of data, much time was spent examining each of the 328 skeletons for any observable signs of pathology. All pathological conditions were noted and, where appropriate, detailed descriptions were made. Thus, this research focuses on the description of the types of pathology present in the population. At the interpretive stage, these findings are placed into the contextual setting in order to establish a better understanding of the vital statistics, level of health and possible indications of lifestyle for the Helligåndshus population in Næstved.

CHAPTER 2: HISTORICAL AND ARCHAEOLOGICAL DATA

2.1 Project Location: Development and Growth of the Town

The town of Næstved is located in the south-western part of Sjælland, Denmark (Fig. 2.1). It is the present day capital of South Sjælland and has a population of approximately 45,000 inhabitants. The town is situated on a moraine plateau along the Sus River approximately 5 km from the mouth of the Karrebæk Fjord. During Viking times there were two villages, Lesser Næstved on the more exposed west bank of the River Sus and Greater Næstved on the east bank. Owing to its preferred sheltered location for harbour development and its ready access to fresh water supply, Greater Næstved became the area of concentrated development throughout the Middle Ages and beyond (Andersen, 1987). Given its navigable river access, its protected harbour and its close proximity to trading towns in Northern Germany, in particular the town of Lübeck, Næstved quickly developed into an influential trading centre during its early history (*ibid.*).

With the establishment of a trading centre and consequent urban development came the opportunity for ecclesiastical activities. The early Middle Ages (mid-12th century) witnessed the establishment of a Benedictine monastery and its parish church in the centre of the mediaeval street net (Andersen, 1987). While the monastery, *Sankt Peders Kloster* (Saint Peter's Monastery), eventually moved just outside of town, becoming known as the '*Skovkloster*'- forest monastery or monastery in the forest, the parish church of Sankt Peder remained in the

centre of the town. The growth of the town, from a pre-existing village community, is largely attributed to the establishment and influence of the Benedictine monastery community (Andersen, 1987), with the parish church and an adjacent market place providing the nucleus for its development (Fig 2.2).

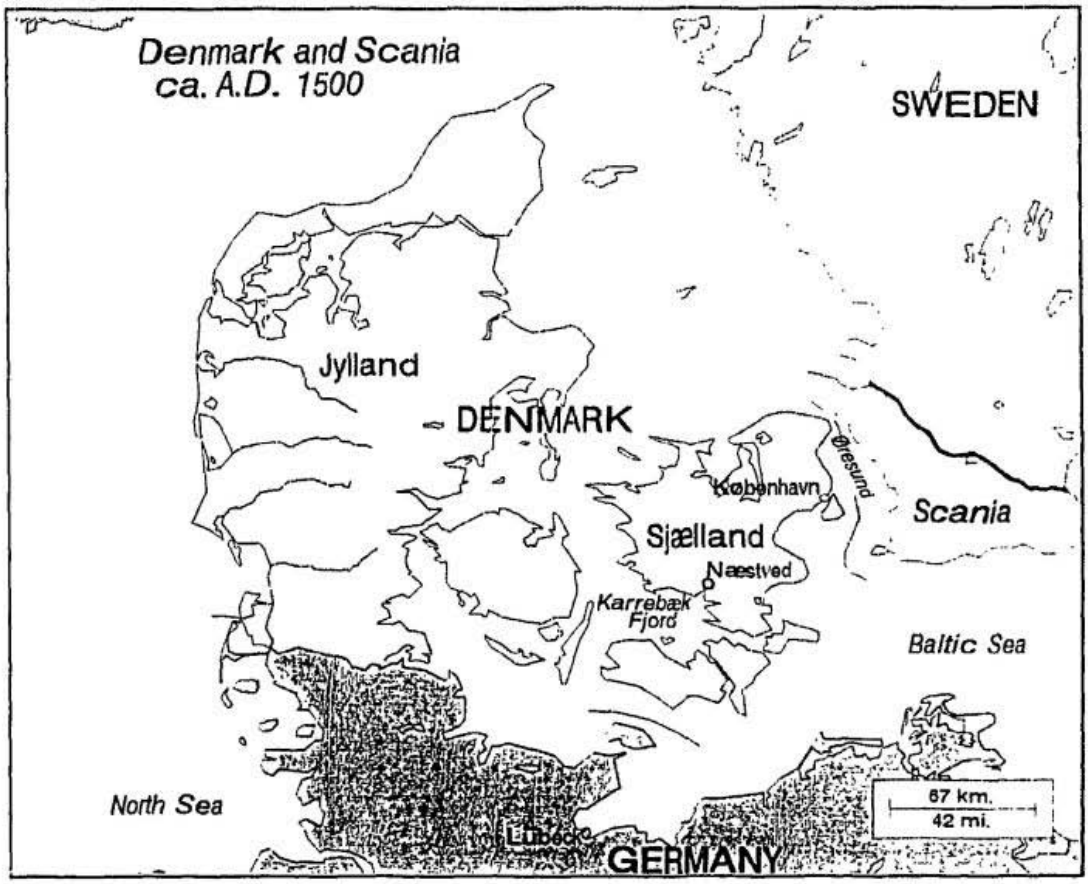

Figure 2.1: Location Map; Denmark and Scania ca. AD 1500

In time, as the town continued to grow, friaries of the two Mendicant Orders were established. Around A.D. 1270 the Franciscans settled to the north

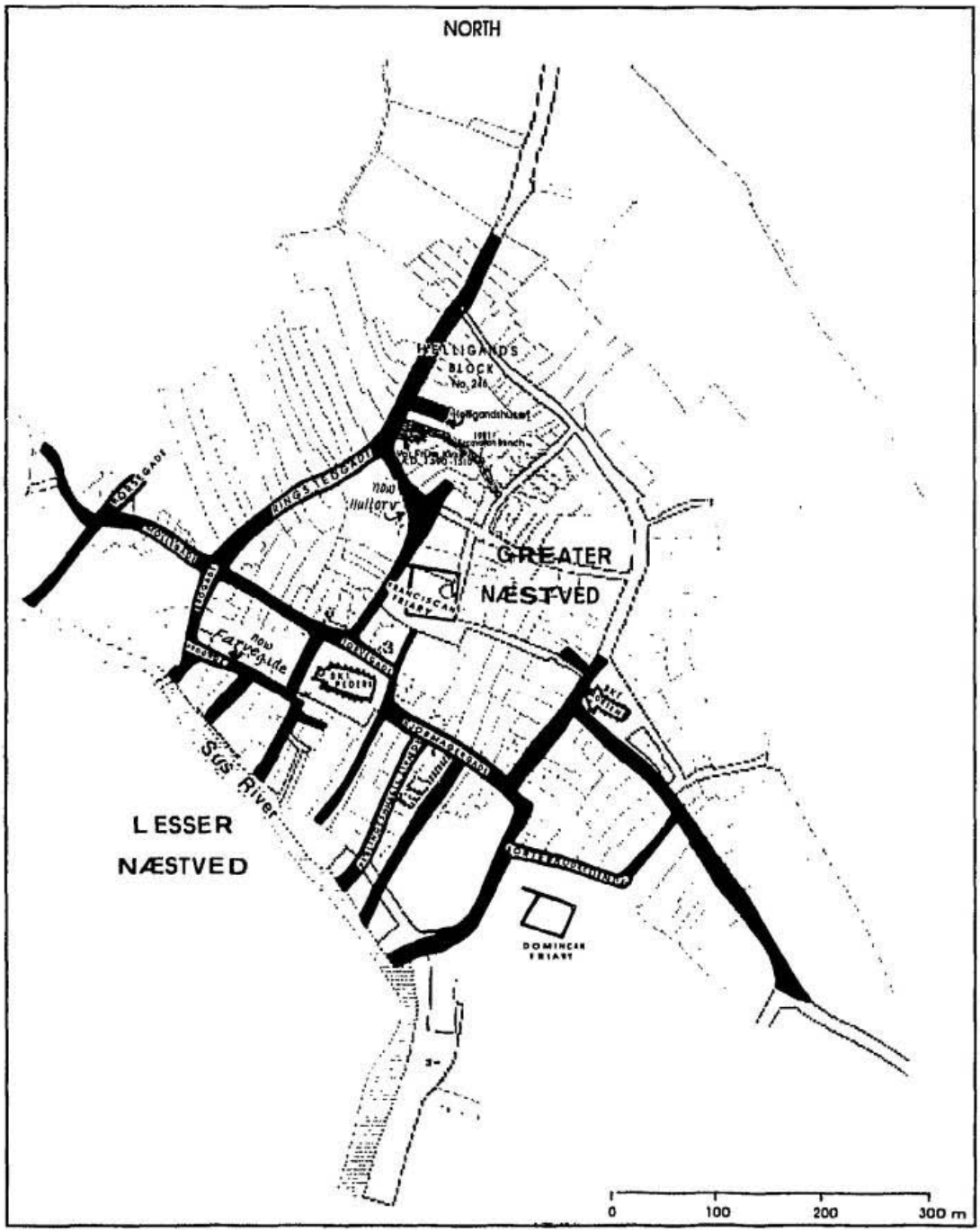

Figure 2.2: Location Map; Town of Næstved. Modified after Andersen (1987:49). The late mediaeval streets are emphasized in black. Known streets names are labelled; others are either unnamed or they cannot be linked to existing street names. The Helligåndshus land registry block 246 is shown with the existing Helligåndshus in black and the excavation trench and features shaded.

of Sankt Peders Church and the Dominicans settled on the southeastern edge of the town. Both friaries were located near busy thoroughfares.

In addition to the establishment of monasteries and parish churches, the religious community established two chapel hospitals. The first, Sankt Jørgensgaard, was mentioned as early as A.D. 1261, around the same time as the mendicant friars came to Næstved (Andersen, 1987). This hospital and chapel complex was located just outside of the town in Åderup. It was an exclusive hospital facility dedicated to *Sankt Jørgen* (St. George), the patron saint of leprosy sufferers and used solely for the isolation and treatment of leprosy patients.

The second chapel hospital was established by the Order of the Holy Spirit. The chapel was named *Vor Frue Kirke* (the Church of Our Lady) but together with its infirmary it became known as *Helligåndshus(et)*, (the) House of the Holy Spirit. The hospital was a charitable facility located on Ringstedgade, one of the busy thoroughfares in the centre of the mediaeval town. The first mention of the Helligåndshus, in A.D. 1398, was just 50 years after the outbreak of the Black Death in Europe. The establishment of the Helligåndshus in the late 14th century as well as other renovation and rebuilding projects which were were carried out in the late 14th and early 15th century, indicate that Næstved recovered quickly and continued to prosper even after the devastation of the Black Death in Denmark (Andersen, 1987).

2.2 Historical and Archaeological Background of Næstved

The name *Næstved*, meaning 'clearing' or 'felled forest', is one of the oldest town names in Denmark (Andersen, 1987). Town names with the suffix, "tved", are thought to have originated at the beginning of the Middle Ages. However, urban settlement may have preceded the establishment of the town's name (Jeppesen, 1978).

Recent archaeological work places the antiquity of settlement continuity in Næstved well before the beginning of the Middle Ages. Næstved Museum's 1991 excavations in the southwest section of the town, along Brogade, have uncovered layers that date back to the Germanic Iron Age ca. A.D. 400. With this evidence, Næstved can now claim over 1500 years of settlement continuity up to the present (Orduna, 1991). This is perhaps the longest continuous settlement span of any town in Sjælland (Schiørring, 1982). Although this new information does not push back the date for the beginning of an urban settlement in the town, it would seem to confirm the existence of a very stable habitation base prior to the establishment of an urban centre. It is believed that the town developed from the Viking age village, centred west of where Sankt Peders Church now stands (Andersen, 1987).

The historical background of Næstved has been greatly expanded in recent years, primarily due to a government project initiated for the promotion of work on mediaeval archaeology in Danish towns. Næstved was one of ten towns selected for study under the project, *Projekt Middelalderbyen* (the Mediaeval Town Project), launched by the Danish State Research Council for the Humanities in

1977. The project followed four phases: 1) registration of archaeological, geological, cartographic and literary source materials; 2) collation of source materials and formation of research questions; 3) archaeological excavation aimed at answering significant research questions; and 4) compilation and interpretation of all information for the purpose of publication. The fourth phase was completed for Næstved in the publication: *Middelalderbyen: Næstved* (Andersen, 1987).

Prior to the discovery of cultural layers dating back to ca. A.D. 400, The Mediaeval Town Project in Næstved placed settlement continuity back to the 10th century (Andersen, 1987). Excavations in the region of the river crossing between Greater and Lesser Næstved, south of Farvergade exposed a 10th century layer with traces of blacksmith activity and an overlying 11th century layer containing Baltic ceramics (Schiørring, 1982). Like the Germanic Iron Age cultural layers, these 10th century layers secure settlement continuity very early on in the history of Næstved. However, no archaeological indication of an urban settlement can be derived from any of the early cultural layers.

The layers from the 10th and 11th centuries are said to represent settlement based on agrarian production rather than the urban activities of trade and craft (Nielsen, 1982). However, the next cultural layer, dating to the 12th century exhibits signs of both trade and craftsmanship and is taken as the first evidence of an urban community in Næstved (Schiørring, 1982; Andersen, 1987). Historical sources support this finding and Næstved is first considered as a market town in A.D. 1140 (Olsen, 1981; Andersen, 1987).

Among the elements responsible for the growth of Næstved are: its long-standing and stable population base; its sheltered but navigable harbour; its strategic location as a connection point between Northern Europe and the Baltic trade network and the establishment of a very powerful monastery. As early as the 12th century there is evidence of economic and occupational specialization, in the form of metal forging, pottery manufacture and comb manufacture. At the same time, the Catholic church must have seen great potential in this population base, and therefore established the monastery of Sankt Peders during the mid-12th century. The subsequent growth and prosperity of the town is greatly attributed to the establishment of the monastery (Andersen, 1987, Johansen and Nielsen, 1988). Market privileges were granted to the town and production and trade made it a very prosperous urban centre.

During the 13th and 14th centuries Næstved was the leading trade centre of Sjælland (Johansen and Nielsen, 1988). The significance of its role in Baltic trade is not questioned; it is often cited that Næstved's own separate column in Lübeck's pound-duty books attests to its past importance as a trading centre. Næstved's early trade status was put on par with Copenhagen, Scania and the whole of Denmark (Andersen, 1987). By the end of the 14th century Næstved had established a high level of economic prosperity, but this was not to continue. Perhaps as early as the first half of the 15th century, while the monarchy was being firmly established in Copenhagen, the Øresund region (Fig. 2.1) became differentially favoured and Næstved lost much of its significance as a trading

centre. The North German towns, which had been chief international trading partners with Næstved, began to pass it by. Although Næstved probably continued to be an important centre for local trade, the economic growth of the 13th and 14th centuries were not to continue into the 15th century or beyond (Andersen, 1987).

The Catholic Church was a very important force, during the town's early history (Michelsen, n.d., Andersen, 1987). In fact, the abbot of Sankt Peders Monastery essentially ruled Næstved during the Middle Ages (Andersen, 1987). There is more evidence of Næstved's importance as early as the 13th century (Michelsen, n.d.). Michelsen (n.d.:2) observes that, "as a rule only one of the two mendicant friars [friaries] were represented in a provincial Danish town. But in Næstved we find both [the Franciscans or Greyfriars and the Dominicans or the Blackfriars]...". Andersen (1987) asserts that, in addition to the Benedictines of Sankt Peders Monastery, the presence of the two mendicant orders by ca. A.D. 1270 in Næstved, indicates both the expectations for growth and prosperity and the possibilities of the town and its future. In addition, he adds, the presence of all three orders and their pursuant activities must have added greatly to the development and prosperity of the town.

In addition to the establishment of the monasteries, two parish churches and two hospital chapels were set up in Næstved during the Middle Ages. The earliest known church is that of Sankt Peders, which was already present as early as A.D. 1135 (Trap, 1955). Records also indicate that Sankt Peders Abbey had

planned to build a monastery church, namely *Vor Frue Kirke* (The Church of Our Lady), where the Monks could hold services. However, Michelsen (n.d.:1) notes that instead of following through on the monastery church, the Abbey decided to erect a new parish church, dedicated to St. Martin (Sankt Mortens Kirke). It is thought that this church existed as far back as A.D. 1200 but it is not mentioned by name until A.D. 1292 (Trap, 1955; Michelsen, n.d., Andersen, 1987). Lastly, two hospital chapels, Sankt Jørgensgaard and Helligåndshuset, were built in the 13th and 14th centuries (Andersen, 1987). These institutions were associated with charity and the care of the sick and they may be viewed as part of a common trend which occurred in the established towns of Mediaeval Europe.

2.3 Helligåndshuset Excavation

In 1982, two field trenches having a total area of approximately 48 metres by 4 metres wide were dug through the cemetery of the Helligåndshus as part of a rescue excavation. The excavation was pre-planned but quickly carried out so that municipal works could complete drainage operations on a long standing and problematic wet area behind the grounds of the Helligåndshus.

The skeletal material for this investigation was excavated from the two field trenches and within the east and west limits of the cemetery walls (Fig. 2.3). Throughout the period during which the cemetery was used, the Helligåndshus functioned as a charitable facility for the care of orphans, the elderly and others who were infirm and/or needy. The present building housed both a chapel and

a hospital and replaced an earlier 15th century church after it likely burned ca. A.D. 1510 (*ibid.*). The site of Helligåndshuset on Ringstedgade is in a retail district in the centre of the town. The Helligåndshus still stands and now functions as the town's museum. The cemetery lies to the south and to the east of the building (Fig. 2.2 and Fig. 2.3).

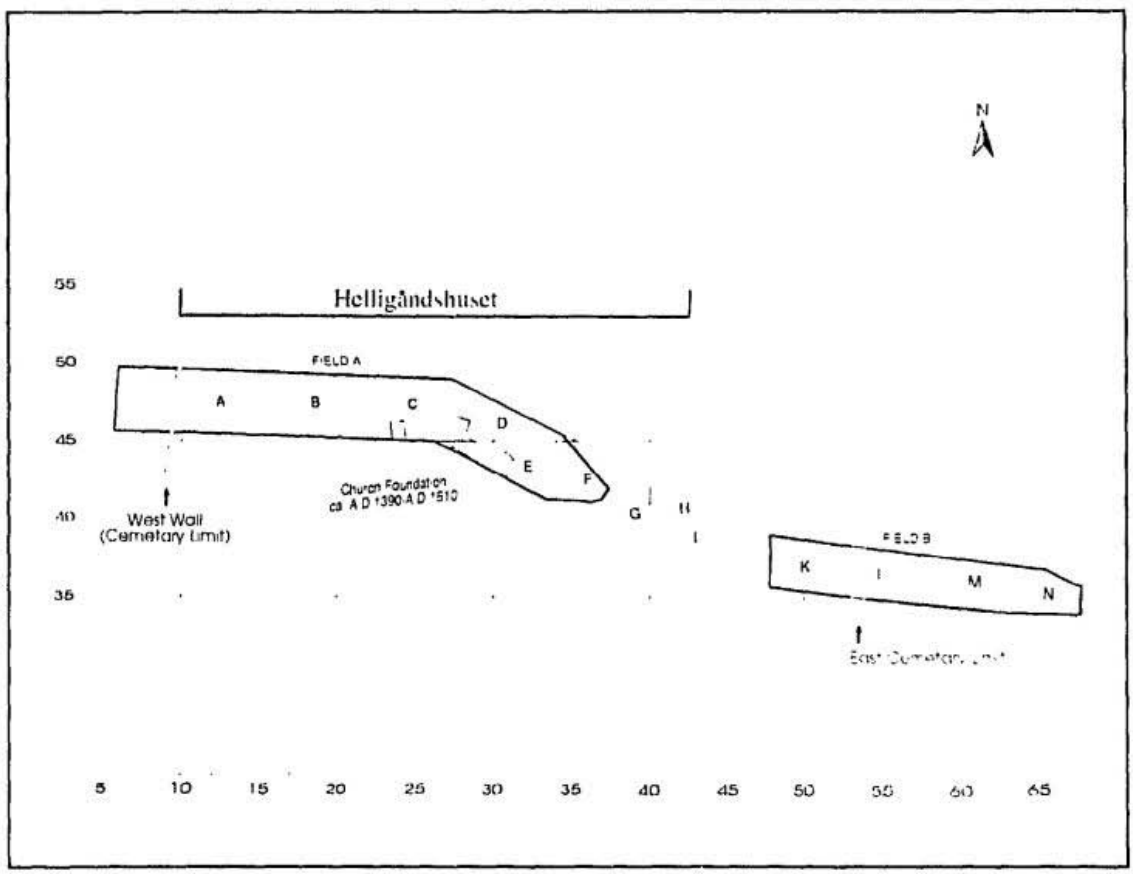

Figure 2.3: Helligåndshuset Site Map; Plan View of the 1982 Excavation Fields. Schematic illustration of the outline and extent of the excavation fields and sub-divisions within the Helligåndshus grounds/cemetery. Numerous closely spaced and/or overlapping burials were excavated from the darker shaded sub-divisions (A-F and K) within the east ans west limits of the cemetery in excavation Fields A and B.

Although little is known of the detailed history and function of the Helligåndshus in Næstved, archaeological and historical evidence supports that the cemetery was used between ca. A.D. 1400 and A.D. 1804 in conjunction with either the early 15th century church or the later Helligåndshus chapel hospital. The first mention of the Helligåndshus appears in a will dated A.D. 1398 while the last burial is recorded as January 12th, 1804 (Trap,1955; Helligåndshusets Burial Records A.D. 1796-1804, n.d.).

The 15th century church, discovered for the first time during the 1982 excavation, was believed to have been erected on a previously used residential plot which had been gutted by fire at the end of the 14th century (Hansen, pers. comm. 1992; Hansen, 1984; Andersen, 1987). The period of use for this church is thought to extend from ca. A.D. 1390 until ca. A.D. 1510. A coin dated to A.D. 1380, which was found on level with the church foundation, supports the earliest date and a fire dated to ca. A.D. 1510, which left only the stone foundation of the church, supports the latest date for the use of the church (Hansen, 1984 and pers.comm. 1992). Construction of the more recent church and hospital facility began soon after the fire in the new and present location just to the north of the 15th century ruins (Hansen, pers. comm., 1992). Since the skeletal collection directly relates to the ecclesiastical occupation of this plot, the time period of concern is ca. A.D. 1390 to A.D. 1804. This occupation period will be the temporal focus of the following discussion.

Findings from the 1982 Helligåndshus block excavation outline a long period of use for the property and a number of different occupations. The entire excavation was planned along a 63 metre line extending from the street, Nygade, to the middle of the Helligåndshus land registry block, #246 (Fig. 2.2). Two fields, A and B, were opened; Field A, in the Helligåndshus yard and Field B, southeast of the yard (Fig. 2.3).

Approximately 48 metres by 4 metres of ground was opened by the A and B field excavations. These two field trenches were further subdivided into a total of 14 sub-fields, designated by letters A through N. Well over 150 different layers were identified, including variously coloured and textured soils, post holes, ditches, building foundations and other structures (Hansen, 1984).

Between March and July, 1982, cultural layers and feature constructions were uncovered and later incorporated into a nine phase explanatory scheme, as follows (Hansen, 1984: p.17):

Phase	Events/Features	Time Frame (A.D)
Phase 1;	agricultural period	1000-1100
Phase 2;	drainage ditch	1100-1150
Phase 3;	ash pits and hearths (residential lots)	1150-1250
Phase 4;	wells and residential lot?	1250-1350
Phase 5;	ash pits, two room dwelling and house lots?	1350-1400
Phase 6;	church with graves,drainage canal, and house lots?	1400-1450
Phase 7;	wall near church and house lots?	1450-1500
Phase 8;	churchyard and pavings.	1500-1600
Phase 9;	churchyard, lane and pavement.	1600-1700

As discussed in Section 2.2, in relation to archaeological research in Næstved, excavations in other areas of the town have uncovered cultural layers which are equally as old and/or older than those on the site of the present Helligåndshus, block #246 (Fig. 2.2). All of this information provides a framework for the history of the town and together enables an understanding of the occupational history and the sequence of urban developments that were to govern the social and economic basis of the town and its workings.

The sequence of cultural layers uncovered at the site demonstrates the changing uses of the land from its agricultural use in the 11th century (Fig. 2.4), the beginnings of its residential and craftsmen's occupation in the later part of the 12th century, and its ecclesiastical occupation by the late 14th century. Residential and craftwork occupation continued on the site until the early 16th century, while ecclesiastical occupation began as early as the late 14th century on the southern part of the land block. Finally, in the first decade of the 16th century, ecclesiastical occupation expanded as the Helligåndshus bought out the residential buildings to the north and thus maintained the entire block for the provision of charity and sick care in its hospital. The 16th century hospital and chapel were converted from the residential/ mercantile housing to the north, and burials continued to be added in the adjacent cemetery to the south.

Thus, following the agricultural occupation, land use on block #246 may be summarised in terms of three main occupational periods as follows: (also see Fig. 2.4, modified after Hansen, 1982).

A) A.D. 1200-1400; Phases 2-5: Occupation by Craftsmen; house plots, hearths, work pits. Residential housing and workshop lots occupied the land where Helligåndshuset now stands to the north of the excavation trench.

B) A.D. 1400-1500; Phases 6-7: Residential and Ecclesiastical Occupation; Bothies (Boderne) employed for residential or retail workshop use in the north of the Helligåndshus block. Section I was standing from the previous century while section II was a sequence of flats built on to this structure during the 15th century. Ecclesiastical use was confined to the south of the block where the first church of the Helligåndshus was built ca. A.D. 1390 and burials were placed in its surrounding cemetery (Hansen, 1984; Hansen, 1989).

C) A.D. 1500-1800; Phase 8-9: Ecclesiastical Occupation; by ca.A.D. 1510 the first church had burnt. The Helligåndshus then bought the Boderne complex, rebuilding and converting it into a Church of Our Lady on the west end and a two story building which became the infirmary on the east end (Trap, 1955; Hansen, 1981; Hansen, 1989).

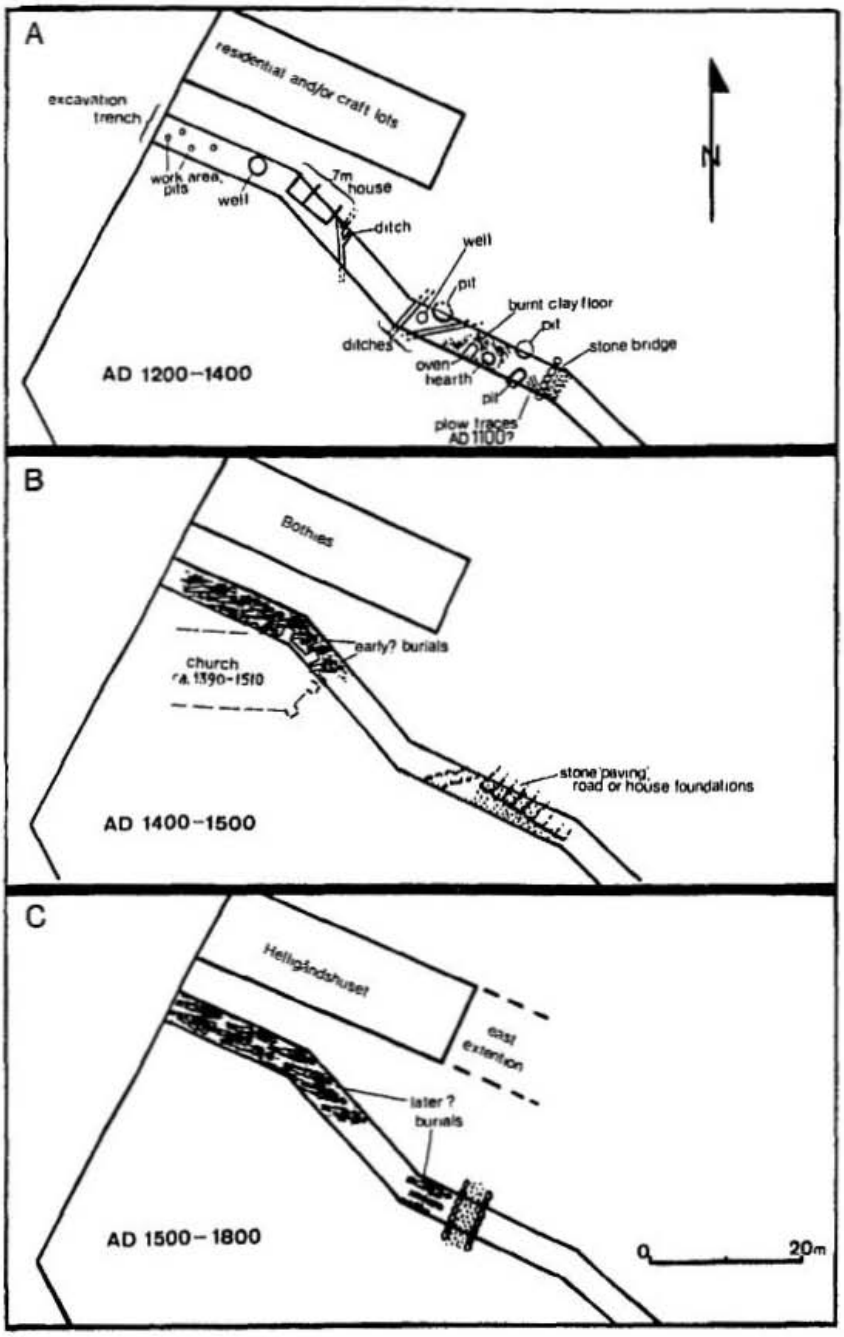

Figure 2.4: Archaeological Composite: Land Use, Helligåndshuset Block; A.D. 1200 - A.D. 1800. Modified after Hansen (1982). Phases 2 - 5 (a), 6 - 7 (b) and 8 - 10 (c) are represented by the archaeological features shown in the plan view for the period. The changing use of "Helligåndshuset Block" (land registry block #246) is illustrated. Following agricultural use of the land up to A.D. 1100, land use shifted to combined residential and craft or trades use (a: Phases 2 - 5; A.D. 1200 - 1400). By A.D. 1400, occupation of the land by craftsmen had all but ceased and ecclesiastical occupation had begun with the construction and use of the first Church of Our Lady - *Vor Frue Kirke*. Residential occupation continued to the north of this church (b: Phases 6 - 7; A.D. 1400 - 1500). The last significant occupational shift prior to the present public (Museum) use of the land (c: Phases 8 - 10; A.D. 1500 - 1800) saw the end of residential use and the sole ecclesiastical use. These latter two periods of ecclesiastical use included the occupation of the land for the church, hospital and cemetery of the House of the Holy Spirit - *Helligåndshuset*.

It is the latter two periods with which this investigation is concerned. The burials in the cemetery of the Helligåndshus block are all believed to have been dug during these occupational periods. The majority of the burials were excavated from a soil layer designated as AC, *kirkegårdsjord* (cemetery soil). One exception included grave G-135 which was excavated from layer AY, described as a grey-brown sandy soil grave fill. This grave was different than the others in that the few bones present from the lower vertebrae down were oriented roughly north-south while in all other cases the grave orientation was more or less east-west, or northwest-southeast and parallel to the church orientations. There is no indication of an earlier or later than average date for this grave. The only deviation from the norm is in the orientation of the grave and there is no clear explanation for this grave orientation.

Dating the individual graves is problematic at best. Although, several considerations have been made to this end, none of the dating possibilities has been successful in providing a reliable comprehensive dating scheme for different periods of the cemetery's use. The initial hope was that graves could be dated or at least correlated to either the early 15th century church or to the more recent, and presently standing, building of the Helligåndshus. The premise for this possibility is the belief that churches were commonly built on an east-west trend and burials were oriented accordingly, parallel to the church. This premise was indeed an apparent and widespread practice during the period covered by both churches (Hansen, 1984; Hansen pers.comm., 1992). The interesting finding is that

the first church was oriented strictly east-west, but since the second church was a renovation of the previous Boderne complex, it is oriented perpendicular to the street, Ringstedgade, and thus slightly off the east-west axis, to the northwest-southeast. It was proposed that the difference in the orientation of the two churches may provide a basis for relative dating by correlating burial orientation to one or the other church orientation and its known period of use (Hansen, 1984).

The second method, used in concert with the above, as supportive evidence, concerns grave depth. As logic would dictate, the deepest graves should be the oldest graves. This logic follows that as the oldest graves settled down through time, as soil accumulated and as the cemetery became filled, later burials would be placed above older interments and the most recent interments would be the most shallow. Thus, a deep grave with a strict east-west orientation would be expected to correlate to the older, 15th century church and likewise more shallow graves which are oriented northwest-southeast would be expected to correlate to the present Helligåndshus which has the same axis of orientation. However, the problem is that, although there are differences in the orientation and depth of the graves, there is no unequivocal correlation between depth and orientation. In fact, for a period of 400 years, there is a total depth difference of just 60 cm between the deepest grave and the most shallow. Taking into account such factors as the natural topography of the cemetery and the difficulty of establishing a standard grave depth for a given time period considering seasonal, soil and individual variations in digging, the difference in grave depth has little

meaning. Similarly, there is no strict dichotomy of grave orientations, but instead a range of grave orientations that vary from slightly southwest-northeast, through east-west to northwest-southeast, with one falling almost north-south.

Studies completed on a number of Scandinavian graveyards have led to the conclusion that common layer stratigraphy cannot normally be used on the majority of graveyards (Kieffer-Olsen, 1990 and 1992[1]). Alternatively, stratigraphical interrelationships, i.e. cross-cutting relationships, between the graves have been the basic dating tool. This has not been satisfactorily completed for the Helligåndhus collection and it may not be possible due to the disturbed status of many graves, the possible lack of a continuous stratigraphic sequence for throughout the cemetery and/or any other ambiguity with respect to stratigraphic interrelationships. In any event, this is a possible area for investigation but since it was beyond the scope of the present research endeavour, it was not fully investigated at the time of the study.

There are a few cases where dating has been secured for individual graves. A number of coins were recovered during the excavation. Four of these coins were found in the AC, cemetery soil, layer and these provide a date range of A.D.

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[1] An unpublished transcript of Jakob Kieffer-Olsen's (1992) paper which was presented at the Conference on Medieval Archaeology in Europe: September 21-24, 1992 at the University of York, England provided a discussion of cemetery stratigraphy and burial customs in Medieval Denmark. Articles from this conference are to be found in several volumes published by: Medieval Europe 1992, 1 Pavement, York Y01 2NA, England. Kieffer-Olsen has presented evidence for the dating of graves on the basis of arm placement typology; however, as his findings are concerned only with the Medieval period, he has expressed to the author during personal communication in October, 1992 that this method has not been proven for the post-Medieval period. Hence, the method is not applicable to the Næstved collection since no clear separation of Medieval and post-Medieval graves can be made.

1699 - 1766, which falls into the historically known period of use (Hansen, 1984). In addition, an A.D. 1524 coin with textile attached to both surfaces, was found in direct relation to individual G-53 and an A.D. 1563 shilling was sifted from the grave fill of G-240. The one anomalous date from a coin relates to the similarly anomalous north-south oriented grave, G-135. This coin was also sifted from the grave fill and it dates to A.D. 1259-1286, which is before the time of known cemetery use (Hansen, 1984). How directly this coin relates to the individual, i.e. whether it may be erratic, is not known. Since all other historical and archaeological evidence indicate that A.D. 1390 is the earliest date for cemetery use, this coin may be little more than an isolated and aberrant find. Therefore, aside from a very few graves where a date is indicated, absolute dating of singular graves is almost certainly impossible from stratigraphic data alone and relative dating of single graves or grave groups is not reliable for the purpose of the following palaeoepidemiological consideration of disease in the collection. Therefore, the cemetery and its individual remains will be considered as a whole in this report.

A final discussion on the subject of the excavation is necessary to consider how cemetery conditions and burial practices may have affected the quality of the skeletal data which was collected and interpreted. The fact that the entire cemetery was not excavated and the full extent of its size is not known may have resulted in a biased skeletal sample. Since the excavation was a rescue operation the intent was not to excavate all graves but to clear an area for municipal works.

A number of graves were cut by the profile walls and it was clear that the cemetery continued into these undisturbed walls. It is believed, by excavator and museum director, Palle Birk Hansen, that the north west and east limits of the cemetery were defined by the south wall of the Helligåndshus, the east side of Ringstedgade and the west side of the 17th century cobble street respectively (Hansen pers.comm., 1992). It is the southern extent of the cemetery that is not known for certain (*ibid.*). In any event, it must be understood that the skeletal collection is but a sample of the total cemetery.

There are several ways in which this 'sampling' of the cemetery may have affected the representivity of the data collected. These affects could conceivably include the following biases: age group, gender, disease affiliation, status or socio-economic group, and temporal association, among others. The main reason for bias due to sampling of the cemetery is historic cultural patterning of interments. Areas of early mediaeval and to a lesser extent later mediaeval cemeteries often have specific use patterning such as female areas, children's areas or status areas. Although, Kieffer-Olsen (1992) notes that gender segregation was common practice in early mediaeval Denmark, it was abandoned by the mid to end of the 14th century. However, since the earliest use of the Helligåndshus in Næstved post-dates this practice, it is not surprising that a correlation of all physical anthropological data to the burial locations for each individual does not indicate any patterning on the basis of gender, age group or the presence of infectious or other disease states (Fig. 1.1). The determination of whether patterning occurs in

relation to other factors such as socio-economic group or time period is not possible from the physical evidence, yet since Helligåndshus is well known as a pauper's cemetery we may essentially rule out all but the lower socio-economic class in this cemetery and, thus, any status biases in burial patterning.

The remaining possibility for burial patterning to be considered here is that of temporal patterning. There is a possibility that a temporal bias may exist in the sample; Kieffer-Olsen (1992) notes that the oldest graves were often placed around the church and the cemetery then grew in a centrifugal manner. Hansen (1984 and pers. comm., 1992) has expressed his thoughts concerning a rough patterning differential in relation to the two churches. This problem has been discussed in detail above in relation to E-W burial orientations. The only conclusion for dealing with this unresolved problem is to consider that all graves belong to a four hundred year period. Hence, it has been important throughout this investigation not to place too much emphasis on isolated, time-specific details but, rather, to consider the similar aspects of the socio-economic situation of the population in relation to the physical remains. Although not ideal, similar circumstances involving prehistoric remains that span even greater periods of time have been studied as a single population. Therefore, some meaningful interpretation of demography and health issues can be made from this standpoint in this case.

2.4 Osteological Material Recovered by the Excavation

The condition of the collection reflects the burial situation; during the excavation it was found that existing graves had been disturbed or destroyed so

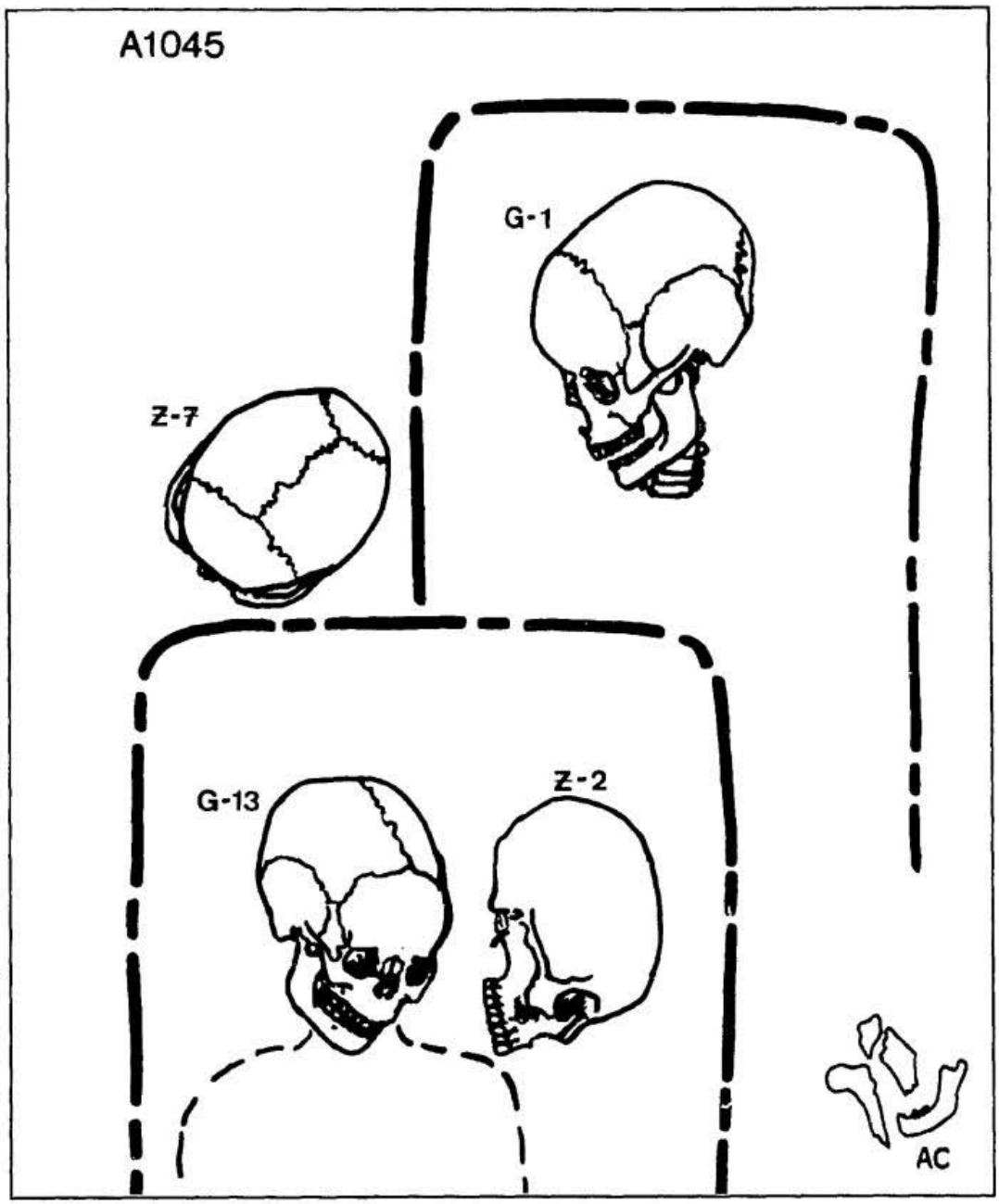

Figure 2.5: Schematic Plan View of Burials; Modified from Palle Birk Hansen's "Skematisk Plan" (Hansen, 1982). G-1 and G-13 illustrate remains designated as graves (G-series) on the basis of context. These are the minimum requirements for grave designation; a skull in association with *in situ* cervical vertebrae or with post-cranial remains and a grave outline. Remains given "Z" designation indicate remains out of a grave context and AC remains are mixed and broken bones and refuse.

that new interments could be made. All skeletal material that was believed to be *in situ*, i.e. in its original grave context, was designated as a grave and given a G-series number from 1 to 332 (Fig 2.5). Three of the G-series numbers, G-63, G-64 and G-122, were omitted during the excavation and one, G-88, was later found to be part of another grave, G-86. Therefore, the total number of individual graves excavated was 328. This was one of three categories of excavated remains.

The second category of remains was of those isolated but not *in situ*. In many cases loose skeletal elements were found completely out of their original context and included in a later grave as "grave fill". Much of this 'out of context' material consisted of loose isolated skulls or individual bones occurring in such a fashion as to indicate they were no longer part of their original grave; this material was designated as non-grave material and given a Z-series number from 1 to 163.

A third category of material has much to say about the condition of the cemetery and perhaps the attitude of the people toward it. Fifty-one boxes measuring approximately 50 x 30 x 20 centimetres were filled from areas of co-mingled human remains found as refuse-like deposits mixed with animal bones, ceramic, glass and the like. As this material was found scattered throughout the cemetery and related soil layers, it was given only a layer designation, e.g. "AC", cemetery soil. This material is probably a result of the long period of use and reuse described above. However, it says something more; the admixture of animal bones and cultural debris indicates that some garbage dumping was also

occurring on the cemetery land. This, one might add, portrays the ambience of the pauper's cemetery and, indeed, this phenomenon of garbage dumping was not observed at the more highly regarded Sankt Peders cemetery (Hansen, pers. comm., 1992). Of course, it must be remembered that people were residing on essentially the same grounds where burials were interred at Helligåndshuset. Therefore there was a direct source of refuse created on the grounds. Nevertheless, what was observed at Helligåndshuset cemetery was a large number of closely placed interments, almost exclusively without evidence of grave markers, burial with and without coffins, interrupted graves, graves disturbed by rodent activity, and garbage dumping. This makes it decidedly difficult and inaccurate to date the graves by relative means, resulting in a heterogenous assemblage of skeletal material for the represented individuals.

The character of the burials effectively reduced the size of the sample which would be suitable for this study. Because of the many problems inherent in statistical analysis of the latter two categories of material, they were excluded from the preliminary investigation of the Helligåndshus skeletal population. The G-series was thus selected for osteological investigation because, unlike the other material collected, each number of the G-series could be said to represent a single individual. The "G" thus designates a single grave (Fig. 2.5) where the bones were found in a context suggesting their affiliation to a single individual. Even though defined as graves, much of G-series was represented by incomplete individuals. In some cases, there were very few bones indeed. The definition used to establish

the minimum requirement for grave status during the excavation was a skull with at least the first cervical vertebrae in place or alternatively a complete hand or foot in place (Fig. 2.5). The heterogeneity of the G-series would obviously complicate the comparability of the collection elements and thus a further sampling of the collection was necessary for interpretation of population characteristics. This sampling and the resultant "research population" will be discussed in the section on data treatment. In any event, the preliminary procedure was to examine the entire population of the G-series and to record all possible data for aging, sexing, pathological diagnoses and suitability for detailed and comparative interpretation.

CHAPTER 3: SOCIO-ECONOMIC SETTING

3.1. The Charitable Society

While the town of Næstved was developing as a prosperous urban centre, ideas concerning charity and piety were circulating and becoming prevalent throughout Europe. The dominating religious principle that led to this widespread practice of charity advocated that the poor man was somehow closer to God; this is abundantly clear in chalk paintings and wood cuts from the period (Pentz, 1989). It is now generally acknowledged that Mediaeval society, and especially the latter part of the period, was characterised by a clear distinction between rich and poor which can be easily detected throughout Mediaeval literature (Graus, 1988). This great difference in the distribution of wealth was a definite problem with which the Church was obliged to deal. To this end, poverty was glorified by the church and considered next to Godliness.

Thus since the poor were, by nature, holy and pure and, by extrapolation, the rich were inherently sinful, it was the rich who were compelled to redeem their sins by abundant alms-giving and other forms of charitable assistance (New Cath. Encl., 1980; Graus, 1988; Horden, 1988; Pentz, 1989; Hansen, pers. comm., 1992). Horden (1988: 367-368) states that prayers and monetary or other support did as much for religious absolution for the benefactors as they did to alleviate the physical suffering of the poor. However, these 'gifts' should not be seen, in Horden's words, "...as originating in self-regard rather than genuine compassion

for the poor... Welfare provision was not something separable from its religious expression." Such, it seems, was the birth of institutionalized charity.

In the early Middle Ages in Næstved, it was Sankt Peders Kloster (Skovkloster) that provided charity to the poor by way of institutionalising alms-giving and serving the community in many ways including the following monastic roles: herbarium, hospital, asylum, poorhouse, pensioners/seniors home, school and medical residency (Helms, 1940). One of the major functions was the monastery's operation as an annuity institution; i.e, the wealthy, who for years made donations to the monastery, would be granted a "pay back" in old age security for themselves and their families and sometimes this included their servants as well. This pay back included food and residence either within the monastery or in some of the monastic holdings within the environs of Greater and Lesser Næstved (*ibid.*). Care extended to the poor, the injured and the orphaned would follow the same general principle of food, shelter and 'healthcare'. (Helms, 1940; Kulturhist. Leks., 1959:202-208).

3.2. The Establishment and Function of Helligåndshuset in Næstved:

Quite possibly, with a sustained demand for the care of the poor and infirm, the Helligåndshus was established to specialise in this sector of Sankt Peders charity service. It is noted that the Helligåndshus was originally under the suzerainty of the Skovkloster (Nielsen, 1925:39). In fact, McGuire (1988) notes that the 'Hospital Brothers of the Holy Ghost' (the Order of the Holy Spirit) did not come to Denmark until A.D. 1451. Furthermore, it wasn't until A.D. 1514 that

Næstved's Helligåndshus was officially admitted to the Order of the Holy Spirit (Trap, 1955; Hansen, 1989). Yet, it is known that Næstved's *Helligåndshus* (House of the Holy Spirit) was present as early as A.D. 1398, as it is mentioned in a will pledging money to the institution (Trap, 1955). Why the small chapel/ infirmary was named after The Holy Spirit Hospitallers and yet not under its direct control is not known. However, it is suspected that the answer to this question relates to the projected mandate of the institution, i.e. the desired regulations which would direct the operation of the facility and govern its practices and policies in the administration of charity. Rubin (1987:156) submits that hospital rules regulated the lives of both 'staff' (including servants, lay groups and priestly groups) and inmates.

Naming or devoting a hospital to a specific order or saint, such as the "House of the Holy Spirit", served to define the institution and the facilities it offered[2]. For example, hospitals named after Sankt Jørgen, the patron Saint of Leprosy sufferers, were widespread in Denmark and these were exclusively associated with the treatment of leprosy. The Houses of the Holy Spirit would seemingly follow the mandate of the Order of the Holy Spirit, as was the case throughout Europe. This order, established as an order of hospitallers ca. A.D. 1180 in Montpellier, France, is described in Hug (1980:103): "Medically progressive

[2] For a detailed discussion of this idea, see Clay (1986). Her book, **The Mediæval Hospitals of England,** provides a detailed account of the many hospitals of England and discusses their corresponding diversity of policies for the admission and care of patients. A cursory overview of hospital patron-saints is also presented and reference is made to a detailed treatment of the subject in a book by Arnold-Forester (1899); **Studies in Church Dedications.**

in its care of the sick, it expanded Christian hospitality to embrace the works of Mercy in general." Similarly, Rubin (1987:156) observes the order's attitude towards the poor as apparent in the following excerpt which she cites from its rule; "...they are to be received willingly and treated charitably...". Indeed, the Kulturhistorisk Leksikon for Nordisk Middelalder VI (1961:407) cites the motto of the Danish Helligåndshus as being: "*de fattige, syge og sårede mennesker, som inde er*", i.e., the poor, sick and injured are those within.

In the case of Helligåndshuset in Denmark, the rules followed were essentially the same as those that governed the *Heliegengiest* (The Holy Ghost) Hospital in Lübeck, Germany (Trabjerg, 1993a; 1993b). These were, namely, the Augustinian rule and the rule of St.John of Jerusalem (Trabjerg, 1993b). Trabjerg (*ibid.*) adds that an understanding of the governing principles of these rules can provide us with an indication of the organizational basis of the Helligåndshus operation. According to Horden (1988:367), the historiography of the pre-modern hospital must be considered as much in light of its religious history as its social history, as any hospital with a chapel was "...above all a religious house". By considering not only the rules of the Augustinians and of St.John of Jerusalem but also of the Order of the Holy Spirit, it may be possible to suggest what the goals and policies of the established Helligåndshus were aspired to be. Furthermore, it may be these principles of religious guidance that give us some idea of the charitable functions of the Helligåndshus in Næstved and the people who were thus served.

The Augustinian rule was a popular rule for hospitals as it provided guidelines for the interaction of religious communities and laypersons. In fact, the rule of the order of St.John of Jerusalem was a branch of the Augustinian theme which was specifically tailored to the treatment of the poor and the sick (Rubin, 1987:155). The main principles of these rules were an insistence upon communal living, the lack of private property, kindness to inmates, chastity and obedience (Rubin, 1987:156). These rules were thus an inspiration to orders and institutions devoted to charity and hospital care.

The policy of the Order of the Holy Spirit was to employ both brothers and sisters to follow the same rule and "...to care equally for the sick, the indigent, orphans, foundlings, unmarried mothers, the aged, the insane, and the homeless." (Hug, 1980:103). Again it must be emphasized that there were a great number of hospitals, and all did not follow the same rules nor did they have the same policies. For example, the early mediaeval Hospital of St. John, which later became St.John's College at Cambridge University, had a strict rule which prohibited the admission of pregnant women, lepers, the wounded, cripples and the insane (Rubin, 1987; Horden, 1988). Many hospitals did not accept women, foundlings, and serious infectious cases; i.e. cases that could place too great a strain on the resources of the hospital (Horden, 1988; Kult.Hist.Leks, 1959:206).

The motto of the Helligåndshus would suggest a much more open and non-discriminatory policy on admissions than the vast majority of small hospitals. For example, Rubin (1987) notes that the rule of the Hospital of the Holy Spirit

went so far as to direct the community to seek out the insane and take them to the house for care. The all encompassing charity of the order is reflected in the resources of the hospital as well. In contrast to many hospital institutions, those designated as the House of the Holy Spirit employed men as well as women caregivers, in the form of religious Brothers and Sisters, and laypersons who provided volunteer help as 'religious favours' (Hug, 1980; Dahl, 1984). Furthermore, Trabjerg (1993b) notes that, not only does the word Helligåndshus, refer to the institution but it, as translated from the Latin *'Domus Sancti Spiritus'*, refers to the work of the Holy Spirit among people in general. These temporal as well as ecclesiastical policies enabled the institution to admit and/or otherwise care for both male and female patients which would include many of the those 'undesired' by other institutions. In addition to this, being under the control of the large and more powerful Sankt Peders Monastery, the Helligåndshus probably had many extended resources such as financial assistance and community aid as well as perhaps some supplementary property and lodging space. Supporting this contention, Trabjerg (1993b) affirms that the institution's economic maintenance included donations of property, inheritance and charity. In short, she observes that these institutions can be thought of as a part of the mediaeval social service.

A final yet important consideration in relation to the role which the Helligåndshus may have played, is the time depth of its service and the possibility of policy changes during the period of its operation. Although there is evidence for the existence of Helligåndshuset as early as A.D. 1398, neither the full extent

of its service nor of the comparability of the original building and institution to the later 16th-19th century counterpart is certain. One reason for the uncertainty is that no hospital building or infirmary proper was found in association with the ca. 15th century chapel. Amongst the possible explanations, Trabjerg (1993a:67) contends that the flats on the east part of the Boderne complex were the oldest and that these were used by the ca. 15th century Helligåndshus as an infirmary.

A second possibility, suggested by the present author, is that the chapel itself functioned as a charitable facility and administered alms and care directly from the small chapel. Butler (1980:158) emphasizes that most mediaeval hospitals had fewer than 30 beds and that the early style of hospital was, in fact, a church. Similarly, Horden (1988) remarks that, although large hospitals for certain restricted clientele did exist, those catering to the poor and sick were commonly very small facilities. Furthermore, extended care within these small hospitals was not common; care varied from overnight shelter for travellers to short term sick care. It is noted that healthcare was most often facilitated in the home (Getz, 1992). Only in the case of foundlings, orphans and needy seniors would the hospital necessarily require beds for chronic care. The early hospital should not be equated with its present namesake. Kealey (1981:82) summarises this idea:

> "The term hospital itself was vital and flexible; encompassing hostels for travellers and indigent students, dispensaries for poor relief, clinics and surgeries for the injured, homes for the blind, the lame, the elderly, the orphaned, and the mentally ill, and leprosaria for people of all ages and classes. A single unit frequently combined many of these functions. Most facilities probably resembled modern nursing homes, for custodial care and rehabilitation were particularly emphasized...".

Two additional factors may support the idea that the ca.15th century church could have served the infirmary and chapel function of the Helligåndshus. One is that the "hospital" institution essentially evolved from a hospice both in Scandinavia and throughout Europe (Butler, 1980; Horden, 1988; Gustafsson, 1989) and thus the original facility need not have been a separate infirmary proper. The second supporting evidence is that infirmaries with internal altars were common organizational schemes (Trabjerg, 1993a; 1993b). According to Butler (1980:156), early hospital facilities were in the form of a church "...with the aisled hall opening at the east end into a chapel." This plan is said to have developed into a plan resembling that of a monastery or a college. It is thus interesting that in A.D. 1514, four years after the Helligåndshus was accepted into the Order of the Holy Spirit, there were plans to develop the Boderne complex into the south wing of a "monastery or friary". Presumably, the early church had burnt by this time and the Boderne complex was bought by the Helligåndshus.

Although the planned "friary" never came to fruition, it is still possible to view the history of the Helligåndshus in Næstved as beginning with a small chapel hospital that gave alms to the poor; provided limited lodging and care for a few sick and/or orphaned and maintained a pauper's cemetery. In fact, Sankt Peders Monastery would also have provided charity and care of the elderly under its annuity and charity policies. Hence, the early Helligåndshus may have served a supplemental role to Sankt Peders' charity-giving. Later, when Helligåndshuset came under the auspices of the Order of the Holy Spirit, it would have expanded

its infirmary, orphanage, senior's and pauper's home facility in the Boderne complex. Had it not been for the Reformation, the planned "friary" may have been built and the Helligåndshus may have followed the expansion plan of so many other mediaeval hospitals. Most reports speak of the plans for a four winged facility arranged around a central quadrangle as the plans for a friary (Trap, 1955; Hansen, pers.comm., 1992); yet, again, it may be significant that the plan for late style hospitals was one which resembled that of a monastery or college (Butler, 1980:156). Thus, it is possible that the A.D. 1514 plan was actually slated for an expansion of the 'hospital' and not for a friary proper. Whatever the case may have been, the plans for expansion suggest that there was an appreciable demand for the services of the Helligåndshus, i.e for charity and 'healthcare' in Næstved.

In all probability, it is likely that some combination of Trabjerg's and this author's suggestions may best describe the original and changing set up the Helligåndshus. A utilization of available resources to best meet the demands of charity and 'healthcare' would most assuredly describe any such institution. Hence, it is quite probable that the Helligåndshuset began as a small chapel-like hostel/infirmary and utilised 'satellite' lodging space as resources and demand increased accordingly. Although the sick and needy may have always been in high number, it does not follow to assume that the original Helligåndshus therefore provided a great number of beds. In the first place, it is recognised that the mediaeval community already provided a number of sickcare and charitable resources, including home healthcare, neighbourly relief, confraternities, alms-

giving at funerals and obits (anniversaries), monastic distributions, and the redistribution of tithes and bequests (Horden, 1988). Secondly, a demand for institutionalised healthcare (as would be presently perceived), does not mean that mediaeval society had the notions, the mechanisms or the resources to supply it.

Gustafsson's (1989:126) outline of Swedish 'healthcare' in the Middle Ages concluded that: "...basic threats to public health seldom lead to a restructuring of "the healthcare system"."; i.e, changes in social beliefs, ideals and structuring were as much, if not more, of an impetus for changes in the 'healthcare system' as were health risks and the needs of the poor and infirm. This argument lends itself to answering the, perhaps rhetorical, question as to whether there were changes in the set up and functioning of the Helligåndshus through time. Certainly there would have been changes, yet this is where, to cite Horden (1988:359), 'a discipline of relevance' is called for; i.e. "...knowing what to include, what connections to make" in the historiography of mediaeval hospitals or the supply side of the institutions of charity and 'healthcare'.

For studies on the demand side of healthcare, for example "...the links between poverty and disease...", Horden (*ibid.*) calls for a similarly tailored 'discipline of relevance'. Thus the aim here is to consider only the elements of significant and pivotal effect and/or change during the history of the Helligåndshus.

In order to establish some semblance of what Helligåndshuset was - its residents, social contemporaries, the ultimate users of the cemetery and its

consistency through time - it is important to remember the main function of the facility and the premise under which it was established and operated. That function was above all religious. The early hospital institution was as much concerned with the care of the soul as the care of the body and, indeed, it was deemed essential that the former be saved before the latter could be 'cured' (Clay, 1966; Rubin, 1987; Horden, 1988). In terms of the significance of institutional changes, Horden (1988:367) asserts that, whatever changes were witnessed, they were minor in comparison with the enduring religious mandate. On this count, it seems that Helligåndshuset remained constant and the rules and ideals of the Order of the Holy Spirit did not fall into decline or deviation from it original mandate as did so many others (Clay, 1966; Hug, 1980; Horden, 1987; Trabjerg, 1993a and 1993b). It seems that, even with the obvious restructuring brought about by the Reformation, the original function of the Helligåndshus was maintained (Andersen, 1987).

3.3. Poverty and its Victims:

Taber's Cylcopedic Medical Dictionary (1989) defines poverty as; "The condition of having an inadequate supply of money, resources or means of subsistence...". However, the equation is not really this easy to define. There is, in fact, much variability in the group defined as 'poor' and there are many facets to the condition referred to as poverty. It is not just a condition to be defined in material terms but one that has physical and psychological connotations as well

(WHO, 1963; Iliffe, 1987). Iliffe (1987) calls for an understanding of the nature of poverty and the means by which it is survived to complete the equation of any contemporary situation of poverty[3]. A more functional definition of poverty is called for in spite of the fact that, by virtue of poverty's dynamic and multi-faceted nature, "...a precise and consistent definition is not feasible." (Iliffe, 1987:2). What Iliffe presents instead is a definition on several levels which will describe the "inescapable connotation of want" in relation to its chronicity. He then qualifies this condition in relation to its underlying cause. On the first matter of chronicity, Iliffe makes the distinction between the 'poor' and the 'very poor'. The former term designates those who know hunger and are in constant struggle to keep themselves from physical want, while the latter term designates those who have failed in this struggle and have fallen into temporary or protracted periods of physical want. The definition of 'poor' or 'very poor' can then be qualified as to whether the cause is structural in nature, i.e. a long term poverty due to adverse personal or social circumstances, or conjunctural in nature, in contrast to a short term condition affecting normally self-sufficient persons experiencing a time of crisis. On another level, structural and conjunctural poverty is viewed in its socio-economic context; this concerns the population versus resource stress of the society. In land/resource-rich societies, the 'very poor' are primarily those who cannot access resources due to physical or social hindrances such as physical disability, senility, youth or lack of kindred assistance. However, in land/

[3] See Iliffe (1987), Chapter 1, pp.1-8, "The Comparative History of the Poor", for a discussion of the meaning of poverty and its historical evolution in Europe and elsewhere.

resource-scarce societies, the 'very poor' group expands to include those able-bodied persons who lack access to land and cannot meet their minimum subsistence needs at the price offered for their labour power (Iliffe, 1987:4).

Europe had witnessed a transition from land/resource-rich society to land/resource-poor society during its mediaeval and early modern history and thus poverty had evolved in turn. When the individual and social background of 'the poor' are considered, it is important to remember that variability may well exist on any of the aforementioned levels, i.e., 'the poor' may include: both those able bodied and disabled; those very young or very old; those of chronic, 'very poor' background as well as those of short duration physical need.

For this study, the final definition of the poor must include an understanding of the means by which the poor survived and here too it is seen that a definition of the social background of the group called 'poor' is further warranted. Graus (1988) groups the late mediaeval 'poor' into five main headings which subsume the following identities: 1. those "outside society"- thieves, cripples, prostitutes, and vagrants (this group may have also included orphans, unwed mothers and impoverished seniors unable to provide for themselves); 2. wage workers- servants of the rich bourgeoisie to day labourers and journeymen whom guild rules had kept from being masters; 3. guild masters who had fallen into economic dependence on well-to-do artisans or merchants; 4. students and wandering clerks; and 5. peasants having insufficient land for subsistence. In addition, a sixth group may be proposed as Andersen (pers. comm., 1993) submits

the case of those nobility who lost their place during or after the agrarian crisis of the late Middle Ages in Denmark. Groups one through four (and group six) are the highly heterogenous lot which comprise the urban poor, while group five plus miscellaneous wage workers including farm girls would have made up a more homogeneous rural poor lot (Graus, 1988). Not all of these 'poor' would have been cared for in the same manner and perhaps not all types would have been served by the Helligåndshus in Næstved. Iliffe (1987:7) lists four means by which people and communities have dealt with poverty. These include: 1. community establishment of institutions that cared, confined, or helped the poor escape their lot; 2. individual neighbourly relief; 3. the organisation of the poor themselves, in underworld groupings; and 4. the individual's reliance on his or her own efforts instead of institutions and organisations at all costs, i.e. including begging and stealing. The fourth method is thought to have been the most preferred action taken by the poor and it should be realised that the poor, being a variable group of individuals, did not band together. In effect, Graus (1988:317) asserts:"...the sole link between these groups of men [and women] was poverty."

In this investigation, the most important element at the Helligåndshus is, obviously, the human element. This raises the question of: exactly who were the people buried at Helligåndshuset? It may not be that the cemetery was used solely by the residents of the Helligåndshus. One might even suggest that the plots in the pauper's cemetery at Helligåndshus were originally, or even ultimately, in greater demand than the beds that the facility could provide. This was likely the

case at St. John's Hospital in Cambridge as well; Rubin (1987:181) contends that this cemetery was viewed as a suitable place to bury the poor even if they were not former inmates. In any event, it seems that all who were buried in Helligåndshuset cemetery had lived in poverty for a time before their deaths and could not afford to be buried elsewhere. Hansen (pers.comm., 1992) maintains that there was always an aura of poverty associated with Helligåndshuset and it is very doubtful that anyone other than the lowest of classes, the poor, would have been buried in its cemetery.

The next step on the way to profiling the residents and/or burial population at Helligåndshuset is to consider the connotation of poverty and/or the low social class. Given the case of charitable hospitals in England, and in particular St. John's hospital in Cambridge, Horden (1988) demonstrates that the relationship is not at all clear. The few poor and sick who were originally accepted by St. John's were presumably chosen from a much larger 'pool'. Indeed, she continues, "If, as theology urged, they were Christ's truest representatives, they were presumably respectable, and perhaps not of the very poorest (*ibid.*:368)." Hence, without historical records, the true and full identity of the 'patients' of Helligåndshuset, or perhaps differentially, the identity of those buried in its cemetery cannot be established. Yet there is still the possibility that a wide variation in personal backgrounds existed: occupations, families, geographical roots etc. The one seemingly reliable conclusion as to the similarity amongst those buried is that they experienced a life of poverty for a period prior to their deaths.

Whether they were all residents of the hospital facility or not may not be as significant as considering the commonality of their social status. Thus assuming, as is most likely, all of the buried were of low social status and having some degree of subsistence resource stress, the incidence of disease may be viewed in this context.

Horden (1988) also makes reference to poor scholars and corrodians (pensioners) who, during the later Middle Ages, came to take the place of the original poor at St. John's hospital, the idea being that there should be little 'real' difference in the residents of the facility. However, since the residents were still poor, there was simply a change to accepting the more socially acceptable poor; i.e." those who could hardly be expected to beg and were a model of obedience (*ibid.*,:368)." Whether this was true or not is difficult to say. Yet, there is a potential for differences existing between those who have grown up in spite of poverty and finally landed destitute or ill at the doors of the charitable hospitals and those who may have led a previously well provided life, only to be faced with a period of charitable need later on in life. These are differences that may indeed make a difference in the long term epidemiology of disease. However, it is clear that, without detailed records for individual burials, the full implications of these life history details will remain a shortcoming of interpretation. This is certainly the case for the Helligåndshus residents and yet it is important that these shortcomings be recognised for a better understanding of the potential diversity within the group defined as "poor".

At one extreme there was the selective advantage of the impoverished land holders, who after a life of wealth and surplus, were compelled to rely on the services of charity after the agrarian crisis of the late Middle Ages left them destitute. They, being those of presumably noble upbringing, were (in accordance with Horden's conclusions) more eligible and attractive candidates for the services of charity. At the other extreme, there were those who were born and raised poor. The policies of the Order of the Holy Spirit maintained that all, including the "undesirables" such as pregnant women, cripples and the insane, be accepted and cared for equally with others in need of charity.

The possibility for some diversity as well as for selective admission bias in the ultimate population of the hospital may exist. However, given the mandate of the Helligåndshus and its strict policy for administering charity to the poor and 'undesirable' coupled with the fact that Næstved would have had many other resources (homecare, St.Peders charities, etc.) to serve those infirm and needy from other "more desirable" social backgrounds, it is quite possible that those cared for and/or buried by the Helligåndshuset really were the 'truest poor'; i.e. those of the lowest class.

It is important, when considering the community of the Helligåndshus and its association with the poor, that the idea of a select population be well understood. Reconstruction of the relationship of the hospital residents to the surrounding population may indeed be a difficult task. On the one hand, there are the selection processes of preservation and excavation at work and on the other

there may have been selection in terms of the selected type of 'poor' who would be forced to seek this type of assistance. The cemetery population is now but a segment of the total population; the question is what kind of segment is it? How large, how representative or how significant its indications are to understanding the past history and society of Næstved may never be fully known, yet there is much to be gleaned from the data at hand. In this study the data will be investigated to the end that they may inform us of the range and variation in disease in this social milieu and in this specific context in the town of Næstved.

CHAPTER 4: RESEARCH METHODOLOGY

4.1.Data Collection

The Helligåndshus collection, property of the Næstved Museum, is presently stored at the University of Copenhagen's Laboratory of Medical Anatomy, Panum Institute, Copenhagen, Denmark. Skeletal material from the G-Series was studied by the author at this location over a period of approximately 7 months in 1992 and 1993.

The main goal of this preliminary investigation of the Helligåndshus collection was to gain an overview of the collection in terms of its preservation and its demographic characteristics, in order to determine its potential as a research collection. Early in the investigation it was observed that pathology was a significant attribute of the population. Hence, the focus of this research was expanded to include a description and contextual discussion of pathology in the population. To this end, the various lines of investigation to be covered by this thesis are: demographic statistics of the population including age and gender; epidemiological relationships of the various pathology types observed and contextual (socio-economic and/or environmental) associations of disease in the collection.

4.1.1 Age Determination

A number of different methods were utilised in order to determine the age of any given individual. No one method of age determination is thought to be conclusive. Therefore, it is generally agreed that the more criteria that can be gathered to give indications of the age at death the closer and more reliable the final estimate will be. All aging methods employed were based on grossly observable characteristics. In the case of subadults, tooth eruption sequence, epiphyseal fusion sequence, and long bone length charts were evaluated to arrive at a relatively objective age conclusion. However, in the case of adults, most grossly observable aging characteristics are based on evaluating the progression or degree of post-maturity degenerative changes. Thus, there is an inherent subjectivity in these latter types of age determination methods.

Subjectivity was dealt with in two ways. The first approach was to employ several age determination methods to establish independent age ratings based on several individual methods. These ratings were then compared and considered for the final calculated age. The calculated age is a simple average, yielding both a range in years and a "median age" for the individual. Given the great variability in skeletal preservation among individuals, the statistically weighted average suggested by the multifactoral method of Lovejoy et.al. (1985a) was neither applicable nor deemed necessary when the final assessments were made. In a test of several different methods of skeletal age estimation, including the multifactoral method of Lovejoy, et.al. (1985a), Saunders et.al. (1992) concluded that a simple

average of as many of the commonly employed age indicators as are available, is no less accurate than the multifactoral method. Furthermore, these authors advocate the evaluation of each suite of age estimates separately and without the application of statistical methods.

A second method which was employed, to try to reduce the subjectivity inherent in the age determination process, was simply the use of objectivity wherever possible. Although most, if not all, macroscopic aging methods employ a certain amount of subjectivity, by following a checklist of age related criteria some level of objectivity was maintained. This checklist method was employed throughout the data collection process in order to maximize objectivity for the various methods utilised. The particular methods employed in the scheme of age determination are outlined on the checklist, i.e. the data collection sheet entitled "Age Determination Record" which was the guideline followed for each determination in the sample population (see Appendix I - A). The methods employed and references to their respective originators are as follows:

Age Determination in Subadults:

i. Age Corresponding to Dental Development: Ubelaker (1989); ages may be estimated from 5 months *in utero* to 21 years on the basis of the eruption of primary and secondary dentition and to 35 years on the basis of alveolar bone regression. Tooth eruption is most reliable from infancy up to 15 years of age, after which the method becomes

less reliable since the only teeth which erupt after age 15 are the third molars and this does not occur in all individuals. Estimating age from regression of the alveolar bone is also less reliable since it is a variable process which may be influenced by factors other than age, such as periodontal disease. Therefore, the tooth eruption method was considered desirable for aging children from infancy up until 15 years after which other methods were preferred.

ii. Age Corresponding to Long Bone Length: Shoukai and Hanáková (1978) in Knußmann (1988); age may be estimated from 6 months to 14 years on the basis of age/long bone length categories for any one of the humerus, radius, femur or tibia. Where possible, correspondences were sought for all of these bone range categories for a given individual. This method was found to be useful throughout the applicable age range and was used in concert with dental eruption information whenever possible. For the Helligåndshus collection, correspondence was found to be agreeable between long bone length age and dental age.

iii. Age Corresponding to Epiphyseal Development and Fusion Rates: Pelvic and rib centres after Bass (1987); long bones and other secondary centres after W.E.A. (1980) and Knußmann, (1988). Age

is estimated on the basis of development, maturation and fusion of skeletal epiphyses. This method was used for estimation of subadult age from approximately 7 to 24 years and was often used along with the two above methods. Again this method was found to be generally agreeable with other aging information.

Age Determination in Adults:

i. Age related changes in the sternal clavicular face: After Szilvássy (1980). Ages can be estimated for young adults between 18 and 30 years of age. This method was sometimes used along with epiphyseal fusion rate charts for aging the younger adults.

ii. Age Related Metamorphosis of the Pubic Symphyseal Face: The Suchey-Brooks six category method after Katz and Suchey (1985), following the original Todd (1920) methodology, was practised. Casts supplied by France casting were utilised for comparison. Ages were estimated between approximately 18 and 62 years using this method. Although used whenever possible, this method could not be used in many cases due to incomplete preservation of the pubic symphyses.

iii. Age Related Metamorphosis of the Auricular Surface: Lovejoy et.al. (1985b). This method was used to estimate the age of individuals between 20 and 60 years. For its ease of application as well as for objectivity, this was a preferred method and since auricular surfaces were often present, it could be applied in many cases. This method was used along with the pubic symphyseal method and any other applicable methods whenever possible.

iv. Age Related Metamorphosis of the Sternal Rib Ends: Krogman and Işcan (1986). This method was useful for age determination individuals between approximately 15 and 65 years of age. This method was used along with all of the above whenever possible.

v. Cranial Suture Obliteration: The technique of Meindl and Lovejoy (1985) was preferred for the assessment of vault and lateral-anterior ectocranial suture closure. In a consideration of the different suture-age determination methods, the Meindl-Lovejoy method was regarded as the simplest and most objective method to carry out. Furthermore, its reliability is reportedly as good as or better than other suture-age methods (ibid.). The Meindl-Lovejoy method was used whenever possible and results were generally in agreement with other methods of age determination which were used in this study.

4.1.2. Gender Determination

Gender determination was accomplished using the same type of approach as was used for age determination; i.e., as many indicators as could be considered for a given individual were used to reach a final conclusion. The criteria used are those which have been introduced by a number of researchers examining different areas of the body. Gender determination was primarily carried out on adult skeletons where skeletal maturity had been reached. In a very few cases, late sub-adult skeletons were sexed because sexually dimorphic traits were observed, such as a precursor ventral arc noted on the pubis of a late teen aged skeleton. For the final determination of gender from all evidence available, individuals were given a gender designation from the following scheme:

Male: These individuals were assessed as being definitely male. Most of the trait evaluations were rated as male and apart from a few questionable trait assessments no major ambiguities were observed.

Male ?: These individuals were assessed as probably male. Those individuals placed in this category exhibited many male morphological traits and/or definite male metric traits (see Bass, 1987, for gender specific metric traits). However, there may have been some ambiguity with certain traits or key areas for gender determination may have been missing, e.g. part or all of the pelvic bones missing or damaged.

Male??: These individuals were assessed as possibly male. Individuals in this category were often represented by very few areas of the skeleton or very few bones at all. In other cases the skeleton may have been fairly complete, but the gender features were highly ambiguous. However, any areas that could be assessed appeared to indicate male gender for these cases. This designation was also given in cases where the few bones present were extremely robust.

Indeterminate: This designation was given in cases where the net indication from all gender evidence was deemed ambiguous, giving no reliable indications for either gender. Poorly preserved and very incomplete skeletons make up most of this category. A few nearly complete skeletons having no clear sexual dimorphism are also in this category, but all indeterminate material is of adult, sexually-mature material. In general, gender determination was not attempted on subadults and all were designated as "p" gender, meaning they were prepubescent or of no defined gender.

Female: These individuals were assessed as being definitely female on the basis of numerous morphological traits. In some cases metric indices used for gender estimation (Bass, 1987) were also considered in support of morphological observations. No significant gender ambiguities were observed in these individuals.

Female?: These individuals were assessed as probably female using the same guidelines as for 'Male?'. Gender indicators may have been somewhat subjective but no significant ambiguities were observed for these individuals.

Female??: These individuals were assessed as possibly female according to the same conventions outlined in the 'Male??' category. The few gender traits that were observed, suggested female as opposed to male gender in these cases. This determination was often the result for poorly preserved or very incomplete individuals where all bones that were present were relatively small and gracile.

The criteria chosen for establishing gender were selected, largely, due to recommendations from a recent study by Rogers (1991). All criteria employed are well known and commonly used gender assessment criteria; the methods and their founders are listed below. The complete list of criteria considered for each individual are outlined on the data collection sheet entitled "Gender Determination Record" (see Appendix I - B).

Gender Determination from Pelvic Observations:

i. Gender Determination of the Os Pubis: Phenice (1969). These criteria were used as part of a multiple criteria assessment of gender affiliation. This approach is a common practice advocated by many osteologists today (Buikstra and Mielke, 1985; Knußmann 1988; Rogers, 1991).

ii. Gender Dimorphic Traits of the Whole Pelvis and its Components: W.E.A. (1980); Buikstra and Mielke (1985); Bass (1987); Rogers (1991). Each of these authors describes traits which are of use in estimating gender. Rogers (1991) conclusions indicate that not all gender traits are of equal value for gender determination and, in fact, some are often ambiguous. For this reason, it was decided that for the present study traits would be evaluated as male, possibly male, indeterminate, female or possibly female. The most reliable traits according to Rogers' system were most heavily considered. Thus the final determination of gender is a reflection of whatever certainty or ambiguity existed when all these determinations were considered together.

The recommendations of the W.E.A.(1980) study were also incorporated into the gender determination scheme of the present study but the rating scheme was not employed. The W.E.A. (1980) study was used along with the methods Bass (1987) primarily for the purpose of comparison and description of gender based traits.

Gender Determination Based on Cranial Observations:

i. Gender Dimorphic Traits of the Cranium: Rogers (1991); Bass (1987); Buikstra and Mielke (1985); W.E.A. (1980). A checklist (Appendix I-B) of the commonly evaluated cranial criteria was employed

following the recommendations of Rogers (1991). Greatest weight was given to the most reliable criteria, as reported by the various aforementioned authors, but all criteria were examined and considered when present.

Gender Determination Based on Post-Cranial Metric Evaluations:

In cases where pelvic and cranial morphology could not be examined for a given case, due to either breakage or lack of material, sexually dimorphic metric indices for the femur and tibia were evaluated. These indices were also evaluated when trait evaluations were deemed ambiguous or insufficient. All individuals where gender was determined on the basis of metrics only, were given a questionable gender. Metric indices were derived from the following methods and sources:

i. Univariate Discriminant Function Sectioning Points on the Tibia: Bass (1987:237-238) after Symes and Jantz (1983). Metric values were compared to caucasian male and female means and sectioning point values to estimate gender in the Helligåndshus collection when pelvic and cranial observations could not be made (see Bass 1987:238 after Symes and Jantz, 1983).

ii. Rules for Sexing the Femur: Bass (1987) after Pearson (1917-1919:56). Four measurements, which Bass (1987:219) derived from the work

of Pearson (1917-1919), were used for gender estimation in the Helligåndshus collection when pelvic and cranial observations could not be made.

4.1.3. Pathological Diagnoses

Pathological diagnoses were established following the examination of all skeletal material available for a given individual. Age and gender were determined and anomalies were noted. The primary procedure employed for eventual differential diagnosis was to describe anomalous conditions and their skeletal distributions. Based on the descriptive characteristics of lesions and their skeletal distribution, broad aetiological categories were considered. Aside from a few problematic cases, it was generally not difficult to recognise lesions and lesion distributions as being characteristic of one of the following categories of disease processes: metabolic disorders; vascular or circulatory disorders; infection; trauma; acquired growth disorders; congenital and developmental disorders; arthritis and neuromechanical disorders; or dental conditions. However, specific diagnoses were more problematic to establish and in some cases the determination was uncertain, as is often the case when only skeletal indications of disease processes are available for consideration.

Following the initial categorization of disease processes, relationships between pathological conditions were considered. In many cases, more than one pathological condition was present. Connections between disorders were

considered in order to understand aetiological relationships. For example, if both trauma and infection were noted in a single individual, it was necessary to attempt to establish whether both conditions were possibly the result of a single cause or of separate causes. Even within a disease category, such as infection, there may be more than one type of condition that may or may not be related. For example the connection between localised osteomyelitis and systemic periostitis must initially be understood in order for the causative factor to be established. The descriptive stage of pathological analyses was, therefore, of utmost importance. Lesion types, lesion characteristics, distributions and related anomalies were all recorded before an attempt at differential diagnosis was made. The method of narrowing down disease categories and establishing causative agents followed a course of description, leading to an understanding of disease process, progression and patterns. This basis of information was the framework for literature review and eventual establishment of differential diagnoses.

4.2. Data Treatment

4.2.1 The Research Sample

Age, gender and pathological investigations were carried out for all of the 328 skeletons in the G-series. In terms of skeletal completeness, the G-series individuals varied from only a few bones recovered to all or most bones recovered from the skeleton. All skeletons were given an initial cursory

examination to make note of skeletal preservation and completeness, to determine age, gender, and to describe skeletal anomalies and pathologies.

All individuals showing any signs of pathology were examined, described in detail and a diagnosis made where possible. However, due to incomplete skeletal representation, poor preservation or ambiguous pathological indications, some diagnoses remain uncertain. The full range of pathology(ies) or the full extent of lesion distribution occurring on an incomplete individual may not be preserved for observation. Thus poor skeletal preservation and incomplete recovery remains a source of error, both for the interpretation of disease patterns and for the evaluation of relative disease prevalence in the population.

Due to time and financial limitations, only a macroscopic investigation of disease was carried out. In many instances, pathology was clearly observed on one bone or one area of the skeleton. However, in each case, all skeletal elements were examined for grossly observable signs of nutritional and/or disease stress as well as for mechanical stress. Stress indicators such as dental hypoplasia and cribra orbitalia, which may often have ambiguous manifestations, were noted as being either obvious and unequivocal or as possible traces of the disease.

Chronic systemic diseases were observed and described in terms of their affects on the whole body and disease interactions or complications due to other co-existing conditions were considered. In this way, the aetiology of disease processes could be explored. Pathology was thus first considered in terms of broad categories such as infection, trauma and nutrition or metabolic disorder.

Secondly, detailed description of lesion types and bodily distribution were utilized to try to differentially diagnose, as specifically as possible, the aetiology of disease.

4.2.2. Database Analysis

A database file (dBASE IV) with 15 variable fields and two text (descriptive) fields was created to record all the data which has been gathered for each of the 328 skeletons in the Næstved Collection G-series. The master file structure was set up to record archaeological provenience and burial position data as well as detailed osteological (demographic and palaeopathological) data. Each skeletal record lists the provenience of the skeleton in the graveyard; the age and gender, if known; details on skeletal preservation; the presence of any pathological conditions and notes and comments of either an archaeological or osteological nature in relation to the excavated skeleton.

In order to facilitate the demographic and palaeopathological interpretation of the data, the database records were sorted (via dBASE commands) with respect to certain variables or fields of information. Sorting of the database on the basis of age and gender, respectively, generated the demographic breakdown of the collection and enabled a quick check for any patterning, such as provenience patterning, in relation to age or gender. Other sorting runs, such as by arm placement, by presence of pathology and by location within the cemetery (gravefield) were carried out to check for patterning within the excavation trench on the basis of one or more of these variables.

Sorting by arm placement was run in order to investigate whether certain arm placements were associated with areas of the cemetery. While different arm placements are known to have a temporal significance during certain time periods (Kieffer-Olsen, 1990 and 1992), no such correlation or temporal significance was indicated for the Helligåndshus cemetery sample.

Sorting by location in the cemetery trench, "gravefield location", was carried out as a check for any possible variable patterning that might show up in relation to a skeleton's burial location within the cemetery. By looking at the database in relation to coordinates within the cemetery trench, patterning on the basis of age, gender, arm placement, and pathology or combinations thereof, could be double checked. This sorting operation revealed no obvious patterning on the basis of any of the aforementioned variables, thus suggesting that the burials were placed at random and not according to any locational conventions or burial plan within the cemetery. The random placement of burials is an important consideration, since only a portion of the entire cemetery was excavated. Thus if burials were placed at random, as it seems, the collection which was excavated from the trench has a good probability of being a representative "sample" of the entire cemetery population.

Lastly, the database was modified in order to relate pathological information to demographic information. A separate field was created to record the presence of disease under each of the eight disease classification categories separately. Sorting of this osteological and palaeopathological database was then

carried out in order to reveal the total number of individuals affected by each pathology type and the age and gender associations observed within.

The tables generated from the sorting of pathological categories are to be found at the beginning of each respective section in Chapter 5: Palaeopathology. The codes used in these tables are explained in Appendix II.

4.2.3. Demographic Composition: Age and Gender Breakdown

Age determination resulted in the estimation of an age range in years for each individual. The premise of the age range supposes that the individual was most likely alive to the minimum age of the range and most likely dead after the maximum age of the range (Bolsen, 1984). Individual age ranges were then manipulated in two ways in order to explore age patterns and relationships within the population; firstly, age ranges were translated to age categories and secondly, age ranges were translated to mean ages.

The translation of individual age ranges into age categories was carried out in order to group individuals of the G-series into descriptive units based on age. The age categories were modified from the age breakdown used in the study of a similar burial population in Sweden, i.e. *Heglegeandsholmen*, 'The House of the Holy Spirit', outside of Stockholm, Sweden (Jacobzon and Sjögren, 1983:126). Minor modifications were made in order to eliminate overlaps in the age categories and to make the scheme more comparable to categories used in other mediaeval skeletal series from Scandinavia (See that of Löddeköpinge, Sweden

(Persson and Persson, 1984); Västerhus, Sweden (Gejvall, 1960), Ærbelholt, Denmark (Møller-Christensen, 1982) and Svendborg, Denmark (Tkocz, 1985). The age categories used in this investigation are explained below in Table 4.2.3a and listed in Table 4.2.3b along with the corresponding age in years that each category represents and the total number and percentage of G-series individuals allocated to each category.

Table 4.2.3a

Explanation of Age Categories

Nbn- foetal or newborn infants; 0 +/- 2 months.

Inf- infant; 2 months to 1 year of age.

Ch1- young child; 1 year to 6 years of age.

Ch2- older child; 6 years to 12 years of age.

Jv- late juvenile; adolescent youth 12 years to 21 years of age.

FG- full grown individual; applied to very incomplete skeletons, for which a specific age could not be estimated. All remains indicate that skeletal (epiphyseal fusion) maturation is either complete or near complete. Generally these individuals are considered to be equal to or older than 15 to 21 years of age.

Ad?- mature individual; applied to very incomplete skeletons, for which a specific age could not be estimated. All remains indicate that skeletal maturation is complete and some degenerative changes are present. The individual is considered to be over 21 years but no specific or maximum age can be determined.

Ad1- young adult; 21 years to 39.5 years of age.

AdM- mature adult; 39.5 years to 57 years of age.

AdS- senior adult; 57 years of age and over. No individuals in the G-series were estimated to be older than 79 years.

Table 4.2.3b

Categorical Age Composition of the G-Series

Age Category (Abbreviation)	Range in months/yrs	Total	Percentage
Newborn (Nbn)	0 +/- 2 months	12	3.7
Infant (Inf)	2mn - 1 year	2	0.6
Young child (Ch1)	1 - 6 years	35	10.7
Older child (Ch2)	6-12 years	44	13.4
Juvenile (Jv)	12-21 years	31	9.5
Full Grown (FG)	≥ 15-21	35	10.6
Adult; (Ad?)	≥ 21-...?	17	5.2
Young Adult (Ad1)	21-39.5 years	103	31.4
Mature Adult (AdM)	39.5-57 years	46	14.0
Senior Adult (AdS)	57-79 years	3	0.9
Total all ages	**0-79 years**	**328**	**100.0**

The second translation of individual age ranges, into a mean age for each individual, was carried out in order to calculate life expectancy and to otherwise deal with age as a finite variable. The method used for establishing mean age was

simply to take the mid-point of each individual age range. The mid-range age is considered to be the mean or finite age for a given individual.

In dealing with gender categories, the probable and possible individuals were grouped with the positive determinations for the given gender and all were considered female or male, as the case may be, for the purpose of interpretations and associations on the basis of gender. Again, in this way gender could be dealt with as a finite variable. In any case, possible and probable categories have better than a 50% chance of belonging to the assigned gender. Individuals in the indeterminate gender group can be considered to have a 50/50 chance of being female and or male and thus, for the purpose of calculating life expectancy for each gender, the indeterminate group was allocated as half female and half male. Otherwise, gender categories were kept as positive (male or female), probable (male? or female?) and possible (male ?? or female??), in order to maintain the actual "gender quality" of the individual.

Age and gender composition of the G-series is presented in Tables 4.2.3b (above) and 4.2.3c (below). The total number of skeletons with visible signs of pathology is summarised at the end of Table 4.2.3c. All of the data in these two tables form the basis of demographic and palaeopathological interpretations which are presented in the following two chapters.

Table 4.2.3c

COMPOSITION OF THE SKELETAL POPULATION:

Total number of individuals: 328

AGE:

Adults:	(Ad?+Ad1+AdM+AdS)	169 (51.5%)
Full Grown:	(FG);	35 (10.7%)
Subadult:	(Nbn+Inf+Ch1+Ch2+Jv);	124 (37.8)
All Ages:	Nbn to AdS	328 (100%)

GENDER:

	Gender Composition Total G-Series Population (328)		Gender Composition Mature Skeletons Only (216)	
Male:	50; (15.2%)		(23.1%)	
Male?:	22; (6.7%)	78 (23.8%) ♂	(10.2%)	36.5% ♂
Male??:	7; (2.1%)		(3.2%)	
Indeterminate:	35; (10.8%)	35 (10.7%) I	(15.7%)	15.7% I
female??:	4; (1.2%)		(1.9%)	
female?:	28; (8.5%)	103 (31.4%) ♀	(13.0%)	47.8% ♀
female:	71; (21.6%)		(32.9%)	
Total Mature:	**216 (65.9%)**		(100%)	
Prepubescent:	112; (34.1%)			

PATHOLOGY:

Pathological indications: 154 individuals (47.0%) of the G-series collection show signs of one or more pathological conditions.

CHAPTER 5. PALAEOPATHOLOGY

5.1 Pathological Categories, Descriptions and Relationships

A total of 328 individuals were visually examined for macroscopic signs of pathology. However, since skeletal preservation is less than complete for many individuals, skeletal evidence for a given pathology which an individual may have suffered during life may not be present for palaeopathological observation. Consequently, it is possible that the actual number of traceable pathological conditions may have been much higher, in reality, than that which may be detected on the variously preserved remains for this number of individuals. Therefore, in the following categorical descriptions of the different disease processes, it is the minimum number of individuals exhibiting indications for traceable conditions that is presented. Of the 328 individuals in the total research population the minimum number of individuals exhibiting indications of one or more observed pathological condition is 154 or 47% of the total skeletal population.

Skeletal lesions which were recognised and diagnosed as specific disease processes were classified under seven categories established, with modifications, after the basic principles of disease classification (Underwood, 1992a). Although pathology affecting the dentition may be separated into several categories of disease processes, in this investigation all dental conditions, except for dental hypoplasia which is a result of systemic disease, have been grouped together to

be treated as a single category. The eighth category of disease description is thus titled dental pathology[4]. The seven disease categories plus the combined category of dental conditions, as listed below, may subsume the following pathological conditions as observed in the Helligåndshus collection:

1. Metabolic Disorders: vitamin D deficiency: rickets and osteomalacia, osteoporosis, dental hypoplasia, vitamin C deficiency.

2. Vascular (Circulatory) Disturbances and Haematopoietic Disorders: anaemia, necrosis of the femoral head and other circulatory disturbances of the epiphyses.

3. Inflammation and Infection : Specific and non-specific infections including: tuberculosis, syphilis, osteomyelitis, periostitis, dental and periodontal lesions and a variety of aetiologically problematic infectious and inflammatory conditions to be discussed.

4. Traumatic Conditions: healed fractures, dislocations, mutilation.

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[4] It is important to note here that, since certain studies such as dental pathology are quite involved, they would have necessitated a specific and directed study that was beyond the scope and the means of this preliminary investigation. Although the presence of dental pathology was noted, no specific investigation was aimed at studying dental health. A description of the types of pathology affecting dentition will be presented for the purpose of completing the scope of disease types and for the purpose of directing interest toward this potential direction for future studies. Similarly there may be other types of specific studies such as those aimed at trace element analyses, transverse lines, stature etc. which may be deemed to have potential after the preliminary findings of this study are considered.

5. Acquired Disorders of Growth: acquired disorders of differentiation and growth including skeletal dysplasia/metaplasia and various neoplastic disorders.

6. Congenital and Developmental Disorders: congenital disorders of growth and development including severe malformations and congenital dysplasia as well as various complications of developmental defects.

7. Arthritic and Neuromechanical Conditions: degenerative changes and lesions of the joints, spinal curvatures and post-paralytic deformities.

8. Dental Pathology: caries, abscessing, attrition, pre-mortem tooth loss, alveolar resorption and periodontal infection. The only dental condition not treated here is dental hypoplasia. Since this condition is felt to be a marker of systemic disease it is listed and described along with the metabolic disorders.

In the Helligåndshus collection, the two most frequently observed pathology types were arthritis and dental disease. A number of patterns in disease prevalence can be discerned. Arthritis is, almost exclusively, a disease affecting the adult age groups with an expected predilection for mature and senile ages; the one exception to this predilection is the case of localised arthritis complicating a hip pathology in a juvenile. Dental conditions were also most often seen in the adult age groups, yet a number of children were also afflicted. However,

considering the fact that many individuals are not represented by their cranial or dental remains, the observed prevalence of dental pathology may be far lower than what may have been the actual prevalence. Most observable disease, aside from inflammatory and infectious conditions, appears to have spared the newborn and infant sector of the population. Changes due to inflammation and infection are observed in all age groups. Any clear predilections on the basis of gender are not apparent and would be presumptive, given the heterogeneous nature of this collection.

Dealing with the heterogeneity of skeletal representivity was one of the most significant problems faced when investigating the Helligåndshus population and when trying to establish diagnoses as well as an eventual health and disease profile for the population as a whole. Absolute direct comparison of all individuals is not possible because of the differences that preservation and retrieval of skeletal elements have incurred. Again, a good example of the problem would be the case of attempting to provide a dental health profile. Since 175 individuals in the G-series have either no cranium present or no dentition recovered and an additional 83 individuals have incomplete or fragmentary cranial and dental remains, a dental profile for the entire G-series population of 328 individuals would be conjectural at best. In this case either the results should be seen as purely descriptive or they should be considered relative to a smaller 'population'; i.e., the 'population' of individuals who do have some assessable dental remains.

Similar problems present themselves when other conditions are considered. In the case of vertebral arthritis, for example, the incidence of this condition and its epidemiological predilections for age, gender or other factors can only be fully realised in a population if all individuals can be assessed. In burial populations such as this one, incomplete preservation precludes total population assessment. Such is indeed the case for all health and disease considerations in this as well as other burial populations.

Deciding which skeletons provide the best material for diagnosis of pathology is highly problematic, especially since pathologically altered bone may be even more prone to post-mortem deterioration and thus selective "invisibility". Since an epidemiological approach requires that all members of a population be treated equally, incomplete individuals can not be simply excluded. The approach used in this research investigation is to provide totals and percentages according to what has been observed. There is no way to surmise how biased these numbers are in terms of the living population, therefore, they are reported only as the minimum number of cases. The emphasis of this pathological investigation is more on description of the range and character of disease expression in the population. This goal is more readily obtainable and more meaningful in terms of the "raw data" for this collection than would be the goal of trying to sort out the problematic implications of palaeopathological disease rates in a less than "typical" population.

5.1.1 Metabolic Disorders

The conditions assigned to the category of metabolic disorders are characterised by reduced or sub-standard bone or dental enamel quality. There are a total of 38 individuals, 11.6% of the 328 G-series individuals, diagnosed as having pathological conditions related to a metabolic disturbance (Table 5.1.1a). Three individuals showed possible signs of two separate or overlying disorders for a total of 41 pathological conditions identified on 38 individuals. Out of a total population of 154 individuals identified with signs of pathology, 24.0% show signs of one or more metabolic condition. Three categories were identified within the category of metabolic disorders: (5.1.1.1) dental hypoplasia; 25 cases, (5.1.1.2) reduced bone quality (i.e. i.- possible rickets, ii.- osteomalacia or osteoporosis); 17 cases and (5.1.1.3) possible scurvy; 2 cases. Table 5.1.1b provides an age and gender breakdown of individuals in each of these three sub-categories of metabolic disease.

5.1.1.1 Dental Hypoplasia (Dh)

Dental hypoplasia or enamel hypoplasia is a condition of disrupted and reduced enamel formation occurring as transverse striae, small furrows, deep grooves and occasionally as shallow pits in the tooth enamel (Ortner and Putschar, 1985; Goodman and Rose, 1991). The most common appearance of the condition in this collection were the transverse striae and grooves or, namely, linear enamel hypoplasia. Goodman and Rose (1991) contend that hyoplasias are

Table 5.1.1a

Metabolic Conditions

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-12	Dh						Av-t	Dc-gr	M	Ad1	30-40
G-153	Dh						Agv	Dcl-gr	F	AdS	50-72
G-48	Dh						Av-uplim	Dacwgr	F	Ad1	29-45
G-309	Dh		Im	2loc				Dac	F	Ad1	21-30
G-76	Dh		Isy	PFcl			Av-tl	Dclwgr	F?	Ad1~	27-38
G-2	Dh	*necro		Ffn*			Av-ct;!H*		F	Ad1~	21-46
G-15	Dh-----C							Dc-g~r	F	Ad1	17-24
G-301	Dh-----C								0	Ch2	6-9
G-60	Dh-----Ct								0	Ch2	4-8
G-157	Dh-----Ct								0	Jv	11-14
G-84	Dh*loc-C----------dent							Da	0	Jv	10-14
G-116	Dh*loc-C----------dent*----------*Dc								0	Ch1	2-4
G-65	Dh*pit----------?*pit							Dac	F??	Jv	15-20
G-79	Dh*pit------_Im_----?*pit								F?	Jv	16-20
G-99	Dh Sc*-------Im:D/P*----------_Av-ct_-----D*inf?								F	Ad1	27-33
G-130	Dh?Sc*-------Im----------_sacL6__AvtlNsTmj_-Dcl*er								M	AdM	32-48
G-52	Dh*----------Dc*								0	Ch1	3-4
G-229	Dh*----------Dc*								F	Jv	15-21
G-146	--Dh----Ct	?Im							F?	Jv	15-18
G-277	--Dh----Ct							?Da	0	Ch1	1-2
G-223	~Dh		Isy				ATmj		F?	Ad1	32-47
G-140	~Dh						A~v;~Tmj	Dac-gr	F	Ad1	25-35
G-46	~Dh						Av-ct;h;f	Dcwl-r	M?	AdM	33-53
G-256	~Dh								M	Ad1	20-27
G-143	Dh~Ppr				neo				F	AdM	46-59
G-251	P-pr							n/a	0	Ch1	4-8
G-74	P-pr						Agv	n/a	M	AdM	46-57
G-304	~P-pr							n/a	F?	AdM	36-45
G-89	~P-pr						Aav;wr	n/a	M	AdM	40-58
G-172	~P-pr							n/a	M?	FG	>15-20
G-245	PB----------?----Frib						Agv	n/a	F??	AdM	46-59
G-5	PB----------?----Frib						Agv-ctNs	Dcl-r	F	AdM	45-65
G-85	PB*----necro-ImI*---Ffn*----------AgvSm*!HNp							n/a	F	AdM	35-53
G-171	~PB							n/a	F	Ad1	30-39
G-9	B						Ash;k	n/a	F?	Ad?	>24+++
G-3	B			Fwr			Agv-c	Dcl-er	F?	AdM	50-59
G-200	~B								F	Ad1	30-40?

------- - Disease Association; indicates a posited relationship between metabolic and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified metabolic condition.

---?--- - Possible or questionable association.

_Im_ - Excluding this condition. In this case, inflammatory changes are not thought to be related to the metabolic condition suffered by this individual.

* - Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.

Dh - Double underlined conditions indicate those conditions counted as the second metabolic condition in the age and gender distribution table, 5.1.1b, below.

Metabolic Disease Codes:

Dh= Dental Hypoplasia;
B= Brittle Deformation (osteporosis);
P-pr= Plastic Deformation (post-rachitic deformities);
P= Plastic Deformation (Osteomalacia);
PB= Plastic and Brittle Deformation (Osteomalacia and/or Osteoporosis)

Table 5.1.1b

Metabolic Disease: Age and Gender Distribution

Age (in years)	(5.1.1.1) Dental Hypoplasia	(5. 1. 1.2) i. Rickets & Post- Rachitic Deformation	(5. 1. 1.2) ii. Osteomalacia Osteoporosis	(5.1.1.3) Scurvy	Total; all types
Category:Years	T: ♂/I/♀/p	T: ♂/I/♀/p	T: ♂/I/♀/p	T:♂/I/♀/p	T: ♂/I/♀/p
Ch1; 1-6	**3**: 0/0/0/3	**1**: 0/0/0/1^{r}	0	0	**4**: 0/0/0/4
Ch2; 6-12	**2**: 0/0/0/2	0	0	0	**2**: 0/0/0/2
Jv; 12-21	**6**: 0/0/4/2	0	0	0	**6**: 0/0/4/2
FG; ≥15-21	0	**1**: 1/0/0	0	0	**1**: 1/0/0
Ad?; ≥21	0	0	**1**: 0/0/1	0	**1**: 0/0/1
Ad1; 21-39.5	**10**: 2/0/8	**1**: 0/0/1	**2**: 0/0/2	1*:0 /0/1*	**13**: 2/0/11 +1*: 0/0/1* } 14
AdM; 39.5-57	**2** : 2/0/0 +1*: 0/0/1* } 3	**4**: 2/0/2	**4**: 0/0/4	1*:1*/0/0	**10**: 4/0/6 +2*: 1*/0/1* } 13
AdS; 57-79	**1** : 0/0/1	0	0	0	**1**: 0/0/1
Total all ages	**24** : 4/0/13/7 +1*: 0/0/1*/0 } 25	**7**: 3/0/3/1	**7**: 0/0/7/0	2*:1*/0/1*/0	**38** : 7/0/23/8 +3*: 1/0/2/0 } 41

(1*) indicates an individual counted twice, i.e. the individual was diagnosed a having more than one metabolic disorder. See Table 5.1.1a, above, for details.
(^{r}) indicates the subadult condition of osteomalacia resulting in the syndrome called rickets.
Age codes:Ch=child; Jv=late juvenile; FG= full grown; Ad=adult. (also refer to section 4.2.2 for details on age category codes).
Age and Gender breakdown (totals by age group: totals for age/gender group), where,
T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

the result of one of three conditions, hereditary anomaly, localised trauma or systemic metabolic stress, which are distinguishable on the basis of pattern and form of the defect(s). The pattern observed on the tooth or teeth will be severe and affecting the entire tooth crowns when hereditary anomalies are present; moderate to severe but affecting only one or a few adjacent teeth when localised trauma is the cause; and widespread and generalised over contemporaneously

developing teeth when systemic metabolic dysfunction is the cause (*ibid.*). In a few instances, larger defective pits and deep grooves were noted in the enamel surface. These cases, G-65, G-79, G-84 and G-116, are particularly interesting in that they may indicate localised developmental or post-traumatic defects in the tooth enamel in addition to systemic metabolic defects.

In the Helligåndshus collection dental hypoplasia was the most common of the observed metabolic disorders, yet it is one which may be the result of a number of different aetiologies including hereditary defects, infectious disease, metabolic or endocrine disturbance or malnutrition. This condition is described under the category of metabolic conditions since it is the end result of a metabolic insufficiency regardless of the aetiological precursor(s). Goodman and Rose (1991) consider dental hypoplasia to be one indicator of the nutritional status of an individual during tooth development. These authors emphasise that nutritional status is more than a direct reflection of dietary intake. Nutritional status is, instead, the end state of a variety of factors, such as disease stress and work load which interact or interfere with nutrient access and utilisation (*ibid.*). Aside from the localised hereditary or traumatic defects, generalised enamel hypoplasia is herein looked upon as an indicator of a period previous nutritional, infectious or other disease stress since it is not possible to differentially identify the underlying cause of this condition. Cases with concurrent infectious disease or other stress indicators such as cribra orbitalia are considered for possible association of overlying conditions.

Case Descriptions:

Dental hypoplasia was identified in 25 individuals. However, dental remains were recovered for only 153 individuals; 70 individuals had all or most dentition and an additional 83 individuals, had at least some dental remains, for a total of 153 individuals with dental remains available for assessment. Therefore, the total assessable population is considerably reduced because of lack recovery/ preservation of dental remains for almost two thirds of the G-Series. In any event, the occurrence of dental hypoplasia is 16.3% of the 153 'assessable' individuals. Since the total G-Series cannot be assessed, the percentage affected by dental disease cannot be determined. Although, this percentage could have been higher or lower than that observed in the 'assessable' population, the assessable percentage is probably a good estimate of the occurrence of dental pathology in the entire collection.

In 23 out of the 25 cases of dental hypoplasia, the generalised defects of linear enamel hypoplasia were seen (Plate 65-1; Plate 229-1; Fig. 5.1). These defects occurred as striae, lines or deep grooves depending on the severity of the underlying disruption of enamel formation. In six cases, the linear defects were light striae and the condition was considered to have been mild; the other 18 cases consisted of distinct striae, lines and grooves. In the majority of cases, enamel defects occurred during early childhood.

Except in three individuals, G-52, G-60 and G-277, enamel defects were seen in the secondary dentition. Secondary incisors, canines and pre-molars were

most commonly affected and in a few cases the first and second molars were involved. Since these secondary tooth crowns develop in the alveolus between the ages of 6 (± 3) months and 7 (± 2) years (Ubelaker, 1989; White, 1991:Fig 16.1, the location of the defects in relation to occlusal surface of the tooth bud, which forms first, indicates that few defects, if any, were formed before the age of one year. All enamel defects were between 4 and 6 millimetres up from the occlusal surface,

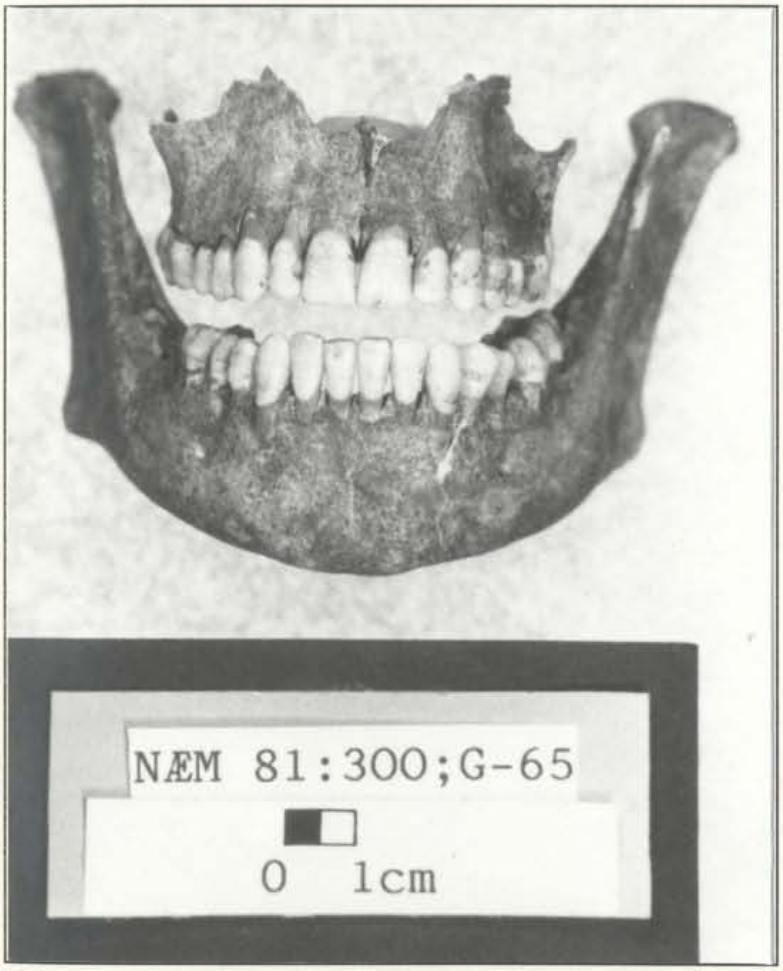

Plate 65-1: G-65
Dental Hypoplasia Linear and Pit Defects:
Juvenile aged 15-20 years, possible female. Enamel defects are present on the incisors, canines, pre-molars and the first molars in the maxilla and mandible. This case illustrates the appearance and generalised distribution of linear defects due to systemic metabolic disease, seen in 23 out of 25 cases of enamel hypoplasia. Pit form defects are also illustrated by this case. Shallow pit defects, probably due to systemic metabolic disease, are seen on the first mandibular incisors, near the occlusal surface. A deeper localised pit defect is seen on the right maxillary I2. This pit may represent a localised developmental defect, rather than a generalised metabolic defect. Refer to Fig. 5.1 for a schematic illustration of a similar of pit defect.

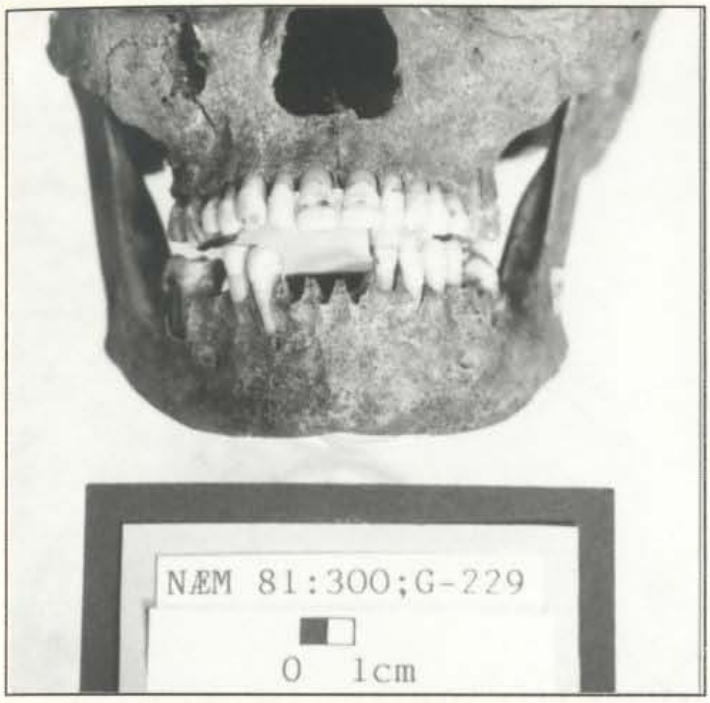

Plate 229-1: G-229
Dental Hypoplasia Linear Defects with Secondary Caries Development:
Female Juvenile aged 15-21 years. Skull deformation and tooth loss occurred post-mortem. Linear enamel defects are present on incisors and canines, were present in the maxilla and mandible. This case illustrates the appearance and generalised distribution of linear defects due to systemic metabolic disease, seen in 23 out of 25 cases of enamel hypoplasia. Linear defects are particularly deep in this individual. Secondary caries development is seen in the defect of the right maxillary I1.

such as is illustrated in Plates 65-1 and 229-1 and by Fig. 5.1; at this stage of the tooth crown's development, most individuals are over one year of age (*ibid.*).

Of the secondary teeth affected, enamel defects correlate to the tooth crown development between 3 (± 1) year and 5 (± 1.5) years of age in 14 cases; between 2 (± 8) months and 5 (± 1.5) years of age in five cases; and between 18 (± 6) months and 5 (± 1.5) years in one case. The three cases involving enamel defects of the primary dentition are correlated to tooth crown development between the ages of 7 (± 2) months in utero to birth age ± 2 months.

In the two remaining cases, enamel hypoplasia occurs as a localised condition affecting only one tooth, unlike the multiple and bilateral tooth involvement of the generalised condition noted above. These cases, G-116 and

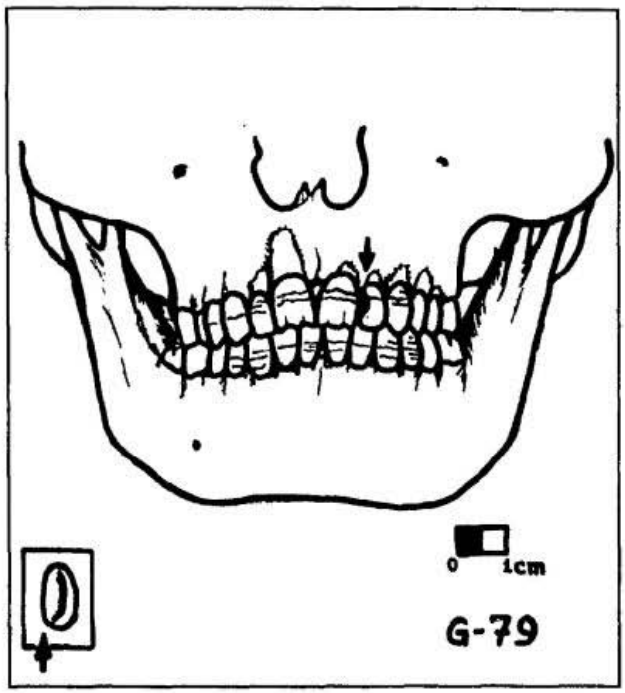

Fig. 5.1: G-79
Schematic Illustration of Enamel Defects (Linear and Pit). Juvenile aged 16-20 years; possible female. Enamel defects were observed on the incisors, canines, and first pre-molars. This diagram illustrates the location and linear form of generalised defects which are often difficult to discern in photographs. The generalised pattern is typical of the systemic metabolic enamel defects seen in 23 out of 25 cases of enamel hypoplasia. Also, a localised pit defect, similar to that seen in G-65 (Plate 65-1) was seen on the left maxillary I2. In contrast, however, the lingual aspect of this tooth (inset) has a longitudinal crease defect. Both the pit and crease are believed to represent localised developmental defects, rather than systemic defects due to metabolic disease.

G-46, exhibited a localised defect without any evidence of the generalised condition. In both instances, a groove or furrow was seen to circumscribe the crown of a molar tooth. In G-116, a child aged between 2 and 4 years, this groove is particularly pronounced and occurs in the right maxillary deciduous M2, approximately 4 mm up from the occlusal surface (Plate 116-1). The location on the crown is believed to coincide, chronologically, with the size of the tooth bud at or around the time of birth. Hence, the time of trauma or localised stress is thought to be perinatal (Verner Alexandersen, pers.comm., 1993).

Although all deciduous dentition was present, no other teeth exhibited enamel defects in this individual and thus a localised traumatic or developmental aetiology may be favoured over a systemic aetiology for this defect.

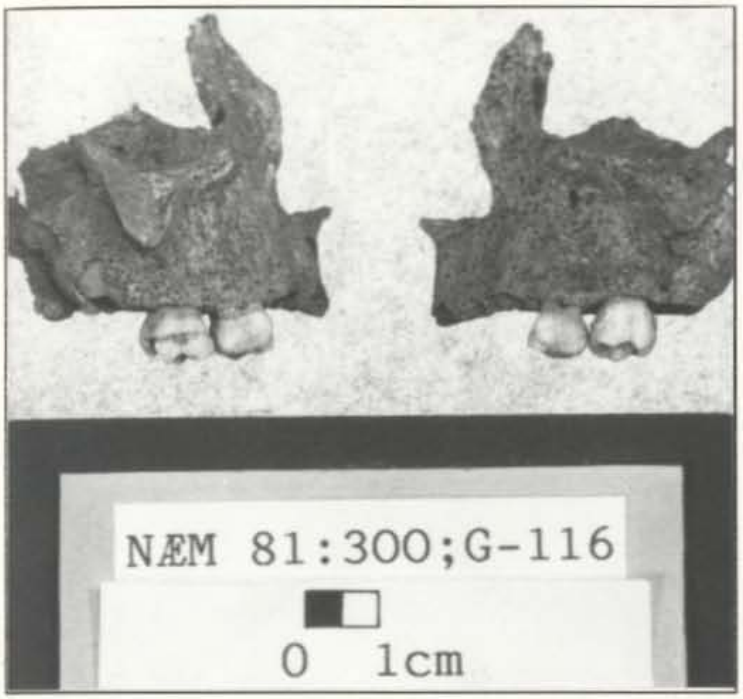

Plate 116.1: G-116
Dental Hypoplasia; Localised Enamel Defect.
Child aged 2-4 years; Frontal/lateral view of the maxilla, open at the intermaxillary suture. A single enamel defect is present on the second deciduous molar in the right maxilla. This linear defect circumscribes the molar; the location of the groove corresponds to the size of the tooth bud at or around the time of birth. A traumatic or developmental aetiology is posited for this defect.

In G-46, a mature adult aged 33-53 years, the circumscribed defect occurs near the neck of the secondary M2 in the left mandibular tooth row. The time of the defect is therefore correlated to approximately 6 or 7 (± 2) years of age, when this tooth crown is usually near complete. A localised traumatic or developmental aetiology is not certain in this case since tooth loss and attrition have impaired assessment of the other molar teeth in this individual. Although linear hypoplasia is not evident on any of the other teeth present, a systemic metabolic imbalance at or around 6 to 7 years of age can not be dismissed as a possibility.

Other localised defects were seen in the form of pits, however, these occurred along with the generalised condition and they may imply an overlay of the generalised condition with more acute and localised traumatic or

developmental defects. Large pit defects were seen in two cases. G-65 and G-79 both exhibited these pit defects in the labial surface of a tooth. Although G-65 had shallow pits in the two mandibular incisors, the most noticeable defect was a 1.5 mm X 1.0 mm pit in the right maxillary I2 (Plate 65-1). A pit defect of similar size and character was seen in the right maxillary I2 of G-79 and, on its lingual surface, this same tooth exhibited a longitudinal groove or crease for the entire length of the crown (Fig. 5.1). In these cases, in addition to the systemic metabolic imbalance which is indicated by generalised linear and shallow pit defects, an hereditary or acute developmental defect may account for the localised deep pit defects.

Some of the possible associations of dental hypoplasia to other overlying and/or complicating conditions include: various infectious conditions, cribra orbitalia and possible scurvy. Cribra orbitalia was identified in 8 individuals with dental hypoplasia. This overlay of the two conditions accounts for just over one third, or 38%, of all cribra orbitalia cases and just under one third, or 29%, of all dental hypoplasia cases. While both conditions are often viewed as indications of disease or nutritional stress in an individual, it is difficult to ascertain whether the two conditions relate to the same episode of endured stress. However, since the anaemia which commonly causes cribra orbitalia is prevalent in children during the first year of life (Wharton, 1989; Macey, 1992) and the observed enamel defects can be correlated to the time of early childhood in most cases, it is likely that the two conditions were endured together or in close succession.

Although certain infectious and vitamin deficiency conditions have been cited as contributing factors in the development of dental hypoplasia (Ortner and Putschar, 1985), establishing their contemporaneity and/or interaction is difficult. Of the 24 cases of dental hypoplasia, there are 5 individuals identified with signs of non-specific infection or inflammation and 2 individuals identified with signs of specific, treponemal, infection. Since all of these cases involve early childhood development of enamel defects and all survived into late teenage or adult age, the observed infectious changes would have to be of 15 to 30 years duration in order to have influenced the development of enamel defects. Instead of this being the case, it is believed that the development of non-specific inflammatory changes and the contraction and development of specific infections post-dated early childhood enamel hypoplasia. This assumption is based on the contention that the observed inflammatory changes did not originate from early childhood and, similarly, that the treponemal infections would not have been contracted at such an early age. The same is believed to be true of the lack of association between dental hypoplasia and possible scurvy lesions in this collection; while the affected individuals exhibit early childhood enamel defects, their lesions due to possible scurvy are considered a much later development.

A final consideration for associations between dental hypoplasia and other possible complicating conditions is the occurrence of dental caries coincident with the depressed grooves of enamel defects. In three cases, G-52, G-116 and G-229, dental caries are regarded as secondary complications of the original defect in the

tooth's surface. In G-229 the dental hypoplasia is generalised and grooves are particularly deep on the maxillary I1. A small carious lesion has developed in the groove defect of the right maxillary I1 (Plate 229-1). Both the physiography of the defect and the reduced integrity of enamel may have been responsible for an increased susceptibility to caries in the observed location. G-116 exhibits the same type of carious development in a localised defect; this defect occurs on the lingual aspect of the maxillary second left deciduous molar. G-52 is a somewhat different case in that no deep groove defects were observed, yet areas of shallow pitting or hypocalcification are seen on the surface of the incisors, canines and first pre-molars. These defects are particularly evident in the maxillary tooth row and caries observed on the labial aspect of maxillary incisors are thought to be secondary to these defects (Plate 52-1).

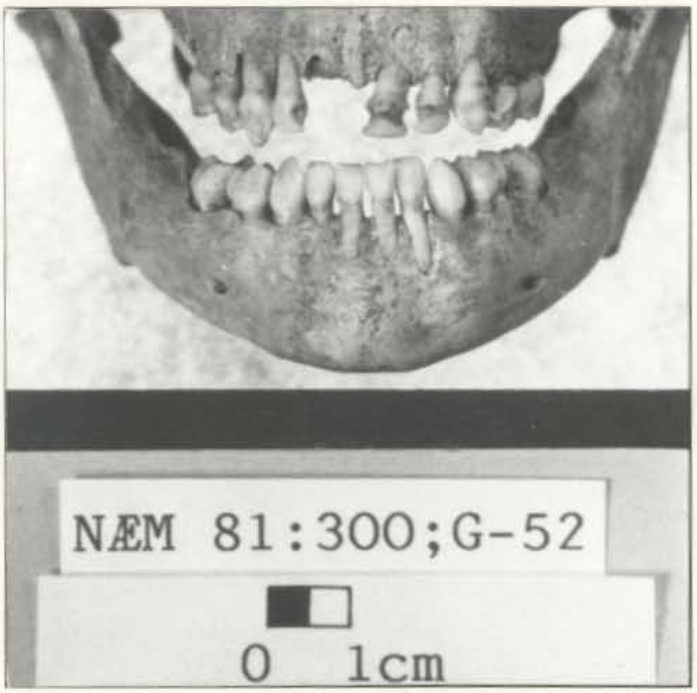

Plate 52-1: G-52
Dental Hypoplasia with Secondary Caries:
Child aged 3-4 years. Enamel quality is substandard on the deciduous incisors, canines, and the first molars in the maxilla and mandible. Areas of shallow pitting or possible hypocalcification are most notable on the maxillary canines and first molars. Caries in the maxillary incisors (except the right I1, lost post-mortem) are believed to be a secondary development in enamel defects.

The development of caries in this instance may be a function of the decreased integrity of the enamel over these defects. In all three of these cases, caries are located in enamel defects and not in the more common occlusal, pit and fissure, or the interproximal locations and thus enamel hypoplasia is considered to be a predisposing factor for the development of dental caries in these cases.

5.1.1.2 Conditions of Reduced Bone Quality (P-pr, P, PB, B)

There are three basic physiological disorders of bone which may result from metabolic deficiencies. These are, namely: inadequate osteoid production, inadequate osteoid mineralisation and excessive deossification of normal bone tissue (Steinbock, 1976:253). When chronic, these disorders may be manifested on dry bone as: reduced bone mass, plastic deformation (P) of bone, and brittle deformation (B) of bone, respectively. A chronic metabolic imbalance culminating in bone disease may result in one or all three of these disorders, manifested to varying degrees. For the present collection, diagnosis of metabolic conditions was decided from the observation and description of gross morphological features and is therefore offered with caution. In the case of apparent reduced bone quality of either a perceived plastic or brittle deformation, the influence of many factors, including genetic variability and post-mortem deformation, is difficult to extract from the equation. Some cases are described as questionable (?) diagnoses when either normal variation and/or post-mortem changes cannot be ruled out and supportive evidence is not conclusive.

Where bone quality is believed to be pathologically compromised, the conditions suspected are: rickets (P-pr), osteomalacia (P), and osteoporosis (B). Rickets and osteomalacia are conditions of altered growth and plastic deformation of bone due to inadequate calcification of the osteoid matrix, while osteoporosis is a condition of brittle deformation of bone due to a chronic imbalance of bone resorption over bone formation and thus an overall reduction in bone mass. Absolute diagnoses of conditions involving a perceived reduction in bone quality can be highly problematic from gross morphological observation alone, yet these conditions were suspect in the tabulated cases due to a number of indicators, including anomalous bending, cortical thinning and low density of bone. In the case of rickets or osteomalacia, the questionable cases were diagnosed on the basis of a perceived anomaly in structure/shape of long bones. Other cases were believed to involve anomalous bone bending such as flattening of the femoral shaft, reduction of the femoral neck to shaft angle and bowing of the long bones.

Diagnosis was based on the observation of bone changes signifying either (i) plastic deformation only; rickets, post-rachitic deformities or (ii) plastic and/or brittle deformation; osteomalacia and/or osteoporosis. In rickets, plastic deformation of bone is the predominant abnormality, while in osteomalacia a combination of plastic deformation and brittle deformation are often seen. The two terms, rickets and osteomalacia, represent the same disease process but differentiate between two syndromes of specific abnormalities. These abnormalities are specific to the stage of skeletal maturation, and thus the age of

those affected, at the onset of the disease. The disease is a disorder at any stage in the supply or conversion of Vitamin D in the body and it results in insufficient mineralization of newly formed bone. The disorder is particularly evident at the growth plate in developing children and in areas of bone remodelling in both adults and children. While Vitamin D deficiency in the skeletally immature can have affects in both areas of actively growing bone and in areas of already established bone, the affects at the growth plate are particularly diagnostic. The term "rickets" is applied to Vitamin D deficiency in the young and the resultant deformities are referred to as "post-rachitic deformities". Since the mature bones of the adult skeleton are not subject to the same kind of deformity as actively growing bones, the term "osteomalacia" is used to describe the demineralizing and remodelling defects of Vitamin D deficiency on the adult skeleton. In both cases the basic deformity of inadequate osteoid mineralization and/or excessive deossification of normal bone tissue leaves the bones "soft" and subject to plastic deformity under the strain of weight bearing and gravity (Ivanhoe, 1983; Steinbock, 1976).

Brittle deformation or reduced bone mass, on the other hand, may indicate either early osteomalacia or osteoporosis. Accordingly, descriptions and diagnoses are presented under three categories of observed bone changes; these are: plastic deformation of bone (post-rachitic deformity); plastic and brittle deformation combined (osteomalacia), and brittle deformation of bone (early osteomalacia or osteoporosis).

5.1.1.2 (i) Rickets: Post-Rachitic Deformities (P-pr)

The characteristic deformities of rickets result from an in interruption in the orderly mineralization and development of the growth plate, and are therefore seen only in the young prior to the closure of the growth plate (Pitt, 1991). Also in the young, areas of mature trabecular and cortical bone are subject to inadequate or delayed mineralization characteristic of osteomalacia. This means that theoretically, skeletally immature individuals may exhibit both rachitic deformities at the growth plate and osteomalacia deformities in areas of mature trabecular and cortical bone (Pitt, 1991). For practical purposes, the term rickets is used to describe the syndrome of skeletal deformities in the young while the term osteomalacia is used to describe the syndrome in the mature.

Because of the combined effect of rachitic and osteomalacia syndromes in the young, skeletal deformities are much more severe and more readily diagnostic. The characteristic features of rachitic deformities involve the disorganization of the epiphyseal growth plate and subadjacent metaphysis producing a grossly abnormal zone of maturation (Pitt, 1991). The cells in this zone are increased in number and do not assume the normal columnar pattern, thus resulting in an increase in the length and width of the growth plate (Pitt, 1991). At the same time, mineralization of the newly laid down bone is inadequate; the net result is the development of structurally and physiologically deformed bones prone to plastic deformation. The main diagnostic deformities depend on the child's age at the time of disease onset, but generally include: an increased porosity of the cortex

and thinning of trabecular bone visible upon radiographic examination as well as "cupping" or "flaring" of the epiphysial-metaphyseal area of long bones, plastic deformation due to pliability of growing bones and a retardation of growth (Mankin, 1974; Ortner and Putschar, 1985).

Case Descriptions:

Sub-Adult Post-Rachitic Deformities (P-pr)

Altered growth and plastic deformation of bone is suspected to have affected the long bones of one child, G-251. This condition is tentatively attributed to rickets, or more accurately post-rachitic deformity. The child's skeleton, G-251, consists of the right and left ischial bones and a portion of the right ilium from the pelvis; a few small bones from the hands and feet and all complete long bones from the legs. The age of the child is estimated as less than 8 years on the basis of non-fusion of the ischio-pubic ramus and greater than 4 years on the basis of long bone lengths.

Preservation of the bones is good and post-mortem structural alteration is not suspected. The outward appearance of the long bones appears to be anomalous in that the femora, tibiae and fibulae have short and rather "plump" diaphyses and expanded and somewhat flared metaphyses (Plate 251-1). A slight structural deformity in the form of a gentle medio-lateral "s" shaped curvature is observed in the architecture of the tibiae and fibulae. X-ray of these bones shows increased radiodensity in areas of slight concavity (Plate 251-2).

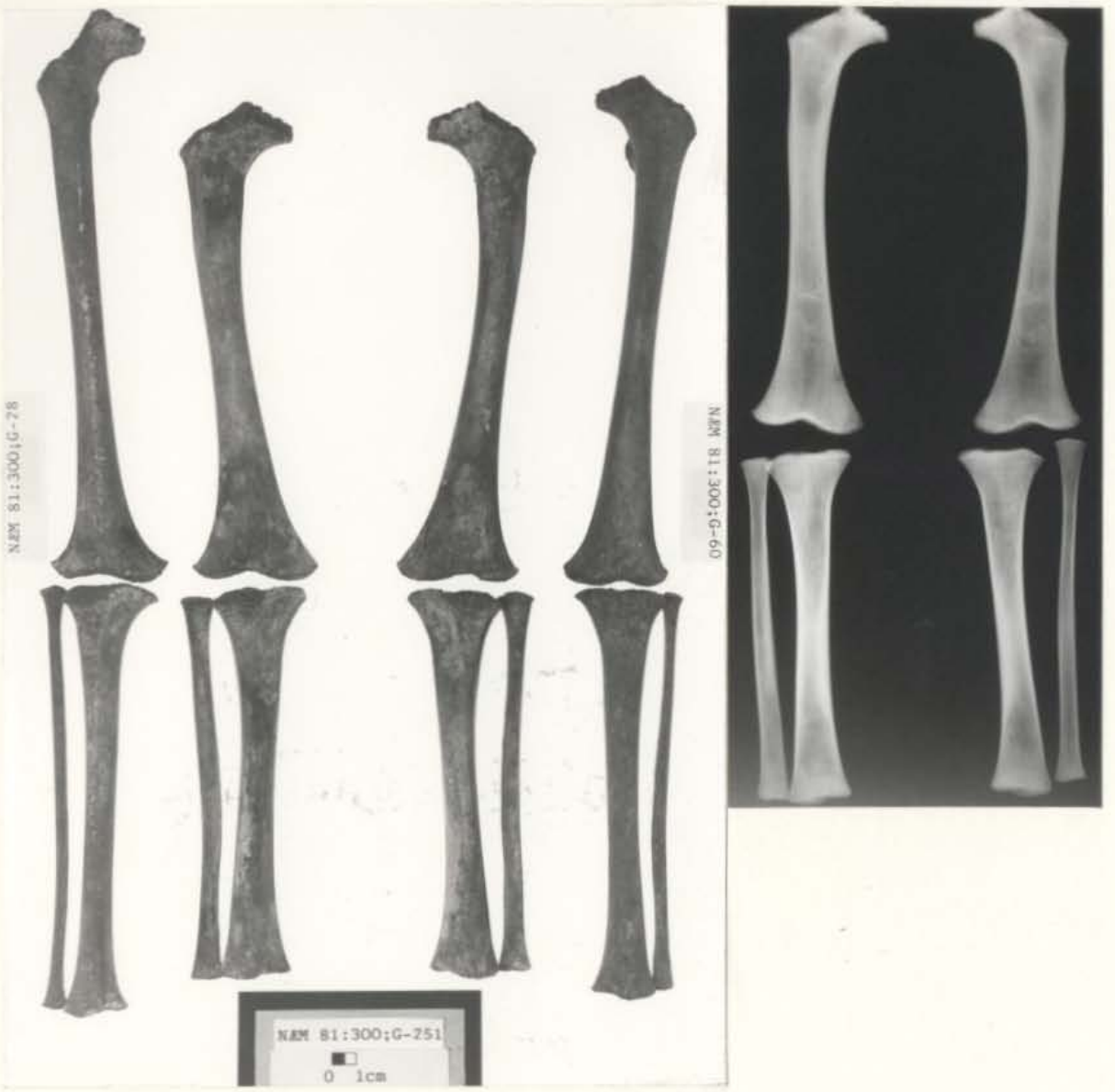

Plate 251-1: G-251 (Left)
Post-Rachitic Deformities; Child aged 4-8 years with mild medio-lateral curvature of the leg bones; flaring of the distal femoral and proximal tibial metaphyses; and "plump" shafts of reduced contour. Note especially the thickened appearance of the distal tibial shafts, where little contour is present. Comparison to the bones of two other children of the same estimated age (placed on either side) illustrates the shorter "plump" shafts of the G-251 child.

Plate 251-2: G-251 (Right)
X-ray of Leg Bones.
Areas of increased radio-density are seen at roughly mid-shaft, especially on the femora and tibiae. These areas coincide with areas of concavity or curvature of the shaft and indicate increased bone production in areas where stress is greatest along the shaft.

Structural aberrations observed on the femora include slightly expanded and cupped metaphyses at the distal ends, slight bowing of the diaphyses, and anterio-posterior flattening of the diaphyses at the proximal ends.

It is also suspected that growth may have been retarded in G-251 since, while long bone robusticity and width of metaphyses is greater for G-251 than for those of comparable age, these bones are noticeably shorter for G-251 (Plate 251-1). Although the cranial evidence is not present for this individual, the various indications of increased long bone pliability and linear growth retardation are consistent with the kind of deformities which may result from rickets. While the age of onset is difficult to determine, it is believed that this case best represents a condition of healed rickets. There is no indication of sub-periosteal hyperostosis to an active or early healing condition and few new cases of rickets are known to develop after the age of four years (Ortner and Putschar, 1985:274). By way of differential diagnosis, other explanations for the observed long bone curvature and thickness relative to length may include some combination of genetic variation and/or hyper-development of the bones in response to a prolonged endurance to great physical strain.

One additional case, G-87, in which anomalous bone morphology was noted, should be mentioned in relation to rickets. The changes are less obvious and thus a diagnosis of rickets should only be considered as one of a number of possibilities to explain the observed irregularities. Gross morphological observation and x-ray examination reveals flaring of the metaphyseal ends that

resemble the aforementioned changes due to rickets. However, another explanation such as a congenital metaphyseal dysplasia or congenital malformation of the joints is considered a more plausible explanation than rickets in this case. Aetiological considerations for these latter two possibilities, as opposed to rickets in G-87, are discussed more fully in section 5.1.6.

Adult Post-Rachitic Deformities (P-pr)

There are five cases where anomalous bending of long bones in adults may be indicative of post-rachitic deformities. The structural deformities which result from a chronic deficiency in usable vitamin D may be somewhat remodelled after healing, but the post-rachitic bending deformities will usually be permanent alterations of the skeleton (Ortner and Putschar, 1985:277). It is these types of deformities which are suspected in the following cases of long bone bending in adults: G-74, G-89, G-143, G-172 and G-304. The predominant feature in these cases is a slight to moderate curvature of the leg bones. This condition is most notable in G-74 (Plate 74-1; 74-2) where bending deformities affect the femora, tibiae and fibulae, and the sacrum. In G-89, G-143, G-172 and G-304 bending deformities of the tibiae and fibulae are suspected but questionable, as curvature is slight in these cases. In the case of G-143, the presence of coxa valga may be an additional indicator of post-rachitic deformation.

Aside from G-172 for which age could not be determined beyond the full grown (FG) category, all of the adults exhibiting signs of long bone bending were

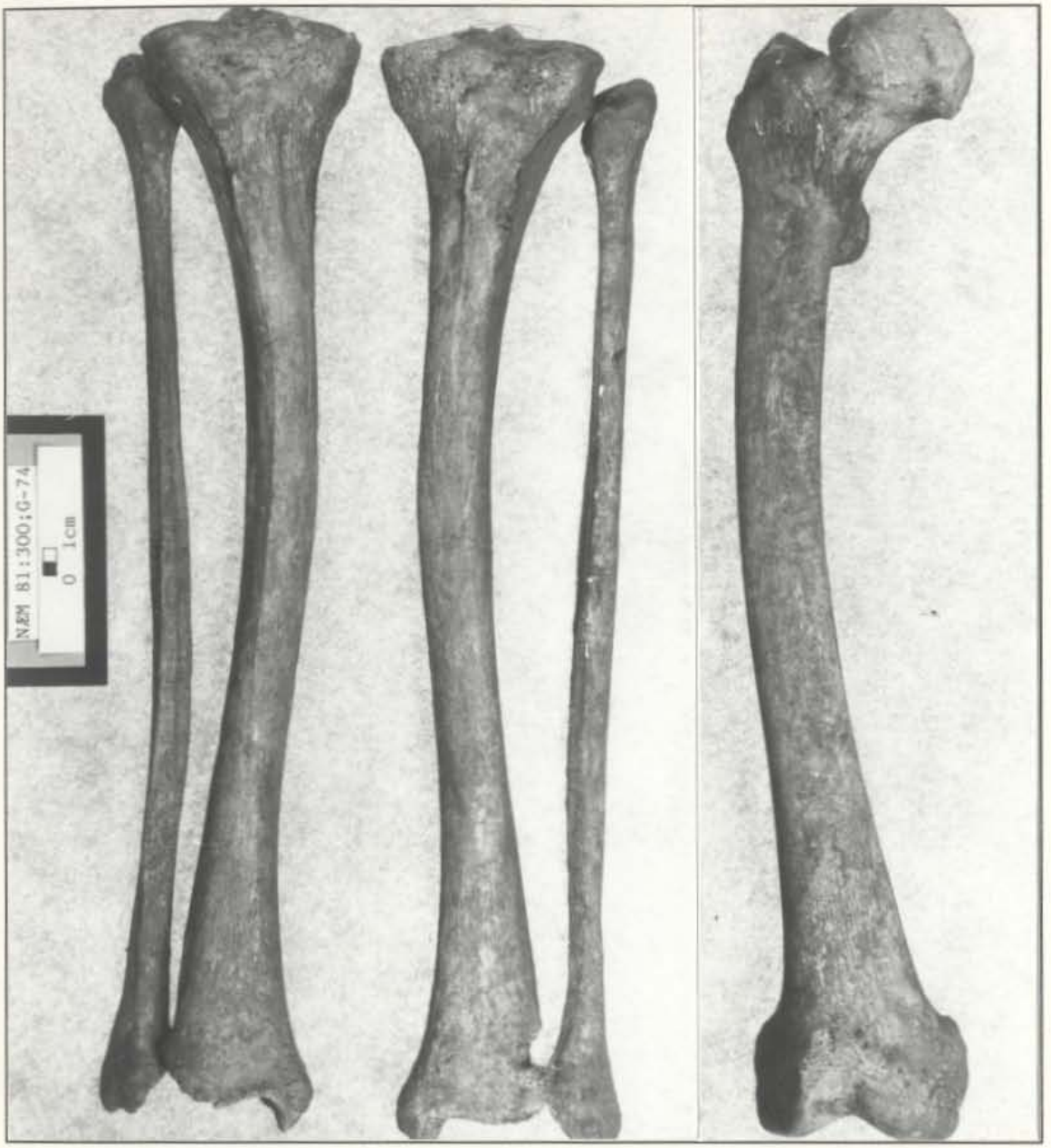

Plate 74-1: G-74 (Left)
Post-Rachitic Deformity of the Lower Leg Bones. Male adult, aged 46-57 years. Curvature of the tibiae, with a convexity at mid- shaft, is observed in this case of healed rickets. Only slight changes are seen in the fibulae.

Plate 74-2: G-74 (Right)
Post-Rachitic Deformity of the Femur. Medio-lateral bowing has endured in the shaft of the femur after the healing of childhood rickets in this individual. Note changes in the lower leg bones of the same individual, as seen in the previous plate.

aged between 36 and 59 years of age and were assigned to the mature adult category (AdM). Gender was equally divided between male and female for the AdM individuals and male for the FG individual. Relative to the entire skeletal population, 3.8% of males show signs of long bone bending while only 1.9% of females were identified with this anomaly.

Should a diagnosis of post-rachitic deformity be correct, the age of these individuals is significant in that it suggests that the active phase of the disease, suffered during childhood, was not a significant threat to the survival of those afflicted. An early period of metabolic stress was obviously overcome and those affected went on to survive for decades after the event. Healing of the condition also supports an aetiology of a childhood nutritional deficiency as opposed to a metabolic dysfunction which would not likely resolve without intervention.

The gender distribution of those affected may also be significant, especially in terms of differential diagnosis. The aetiology of perceived plastic deformation of long bones can be quite subjective and problematic on the basis of gross morphology alone. The influence and interplay of genetic factors and physical strain on the architecture of bone may indeed account for seemingly anomalous curvature in long bones. In the case of males, the musculature is normally much more developed than for females and thus it may be expected that the effect of increased muscle stress would be evident on bone. The possibility that these cases of long bone curvature may be the result of genetic and/or physical stress factors should not be dismissed.

5.1.1.2 (ii) Osteomalacia (P) and/or Osteoporosis (B)

Deformities of the osteomalacia syndrome are due to inadequate mineralization of mature trabecular and cortical bone and therefore defects are often manifested throughout the skeleton. The predominant manifestation of the disorder is a deposition of abnormal amounts of inadequately mineralized bone matrix on the surface of trabeculae and lining haversian canals (Pitt, 1991). The net result of this activity is the replacement of properly mineralized bone with poorly organized and inadequately mineralized bone leaving the bones weak and prone to bending and excessive callus formation. However, without radiographic evidence, osteomalacia is much more difficult to diagnose than rickets (Mankin, 1974; Pitt, 1991).

At the initial onset of the disease, osteomalacia is virtually indistinguishable from the early stage of osteoporosis. Both disorders affect the structural and mechanical quality of adult bone and they may often be overlain, especially when the underlying aetiology is that of prolonged and generalised malnutrition (Ortner and Putschar, 1985). During the primary stages of both diseases the predominant feature is a generalised reduction in bone density. On dry bone, both of these diseases may be indicated by a subjectively light weight and "cardboard-like" consistency, noted during gross morphological examination (*ibid.*:280). Since it is impossible to distinguish between the initial stages of osteoporosis and osteomalacia, the two diseases will be best discussed as one category, (O), of metabolic disease which results in decreased structural integrity of bony tissue.

In the cases where certain obvious features, such as bending deformities (B), are seen in areas of high stress greatest weight bearing, osteomalacia may be indicated but not isolated from possible co-existing osteoporosis.

There are four cases, G-5; G-85; G-171 and G-245, where signs of plastic deformation (P) and generalised reduced bone mass (B), were observed together in the same individual. Three additional cases, G-3; G-9 and G-200, were identified as having unusually light weight and brittle bones (B) without evidence of plastic deformation. The cases involving both brittle deformation and plastic deformation of bone, indicating both reduced bone mass and increased pliability of the bony structure, are believed to be good evidence for osteomalacia and possible evidence for concurrent osteoporosis. In contrast, the cases which involve indications of light and brittle bone quality are less evident in their aetiology and may indicate one or a combination of osteomalacia, osteoporosis or post-mortem demineralisation of the skeleton.

Case Descriptions

Plastic Deformation (P): Osteomalacia and/or Osteoporosis

In the four cases where plastic deformation is suspected, the predominant bending deformities included: anterio-posterior flattening and medio-lateral curvature of the proximal femoral shafts (Plate 85-1); reduction of the femoral neck to shaft angle (Plate 85-1 and Plate 5-1); anterio-posterior bowing of the femora (Plate 85-2); medio-lateral bowing of the tibiae; curvature and cross-

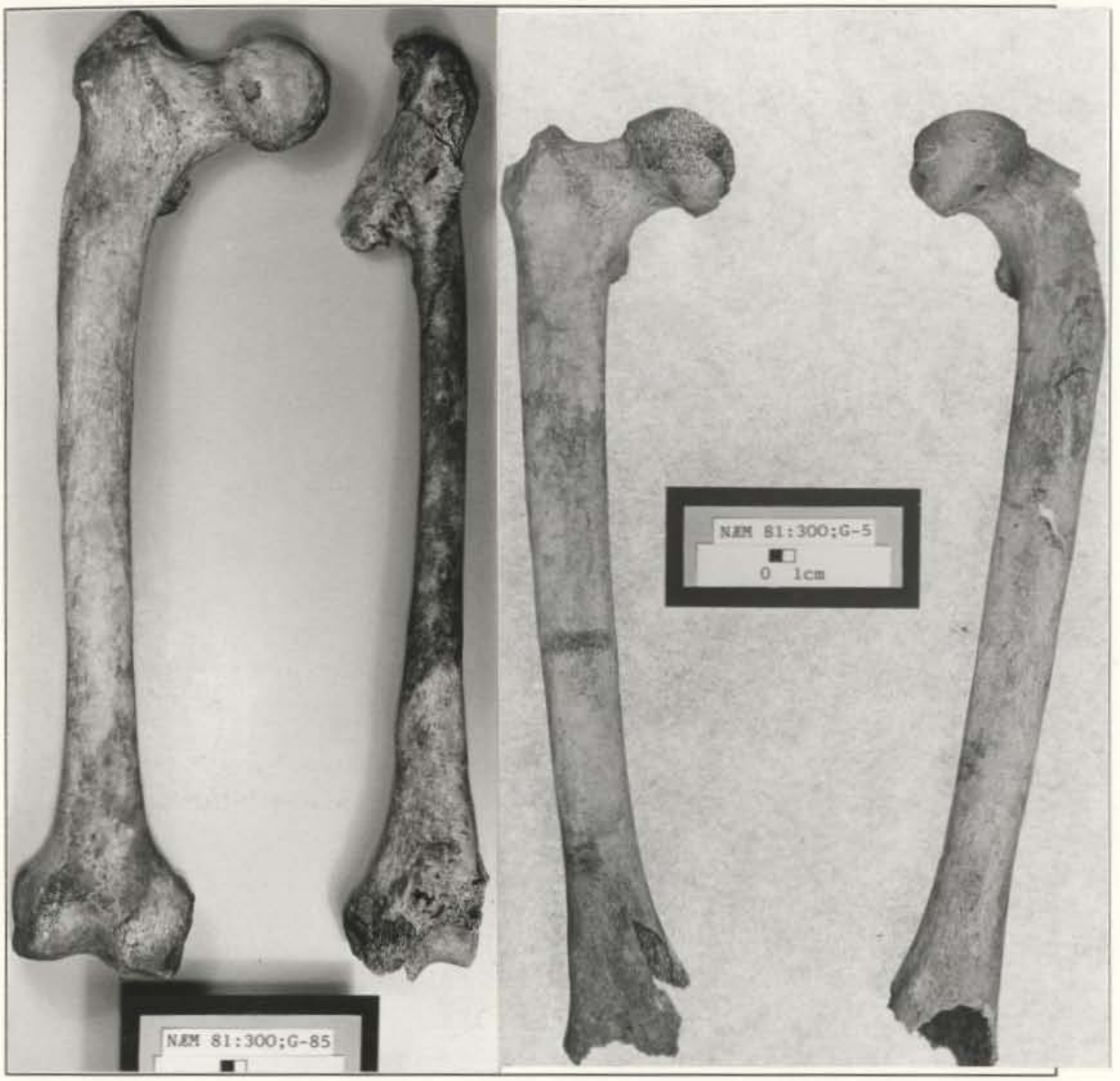

Plate 85-1: G-85; (Left)
Osteomalacia and/or Osteoporosis. Female; mature adult aged 36-53 years with bending deformities of the femur. Note the morphological changes seen in the right, weight bearing limb including: the reduced femoral neck to shaft angle of 96°; anterio-posterior flattening and medio-lateral curvature of the proximal femoral shaft. Either a dietary or endocrine deficit osteomalacia and/or osteoporosis is possible in this case. In the left femur, wasting of the bone is believed to be a feature of a stress deficiency osteoporosis, i.e. post-paralytic atrophy of the disused limb (see Steinbock, 1976:261).

Plate 5-1: G-5; (Right)
Osteomalacia and/or Osteoporosis. Female; mature adult aged 45-65 years with bending deformities of the femora. Note the anterio-posterior flattening with lateral expansion of the shaft at the proximal femur and the reduced femoral neck to shaft angle which measured 105°.

Plate 85-2: G-85
Anterio-Posterior Bowing of the Femur.
Lateral view of the right (top) and left (bottom) femora. The right, weight-bearing bone is slightly curved in the anterio-posterior plane. The left femur has been affected by trauma and post-paralytic wasting, but does not exhibit any anomalous curvatures.

sectional collapse of the fibular shafts; mild scoliosis; pelvic asymmetry and sacral angulation. The majority of the bending deformities were observed in G-5, G-85 and G-245. Flattening of the proximal femoral shaft (platymeria) is illustrated by the platymeric index which is as low as 67.6 in G-5, 69.7 in G-85 and 71.9 in G-245. The femoral neck to shaft angle was also below the female norm for these individuals, measuring 105° for G-5, 96° for G-85 and 115° for G-245. Anterio-posterior bowing of the femur is evident in G-5 and G-85 but not in G-245. Medio-lateral bowing and shape changes are evident in both the tibiae and fibulae of G-245; the tibiae are eurycnemic (platycnemia), having a platycnemic index of 80 and the fibular shafts appear to be collapsed along their lengths. Similar, yet less pronounced, collapse is seen in the fibular shafts of G-85. Other deformities such as mild scoliosis and sacral asymmetry were seen in G-5 and G-85, respectively.

Of the conditions described by metric indices, Wells (1975a:766) notes that platymeria and platycnemia have been interpreted as the physiological means by which bone economy may be achieved under conditions of calcium deficiency, such as in osteoporosis. Along with the other observed bending deformities and the light and brittle bone quality, these indicators are believed to be evidence for osteomalacia and/or osteoporosis in the given individual. Refer to Plates 5-1, 85-1 and 85-2 for illustration of the aforementioned bending deformities.

In all of the above cases exhibiting signs of plastic and brittle deformation of bone, the individual involved was female. Moreover, all except G-171, were mature adults aged between 35 and 65 years. G-171 was a young adult aged 30-39 years and the only sign of plastic deformation on this incomplete skeleton was a sharp anterio-posterior angulation of the sacrum. Nevertheless, all of the aforementioned, including G-171, exhibited a generalised light weight and brittle bone quality in addition to any observed bending deformities. Other possible signs of brittle deformation included healed rib fractures in G-5 and G-245 and vertebral compression in G-245.

Again, in all but G-171, there were indications of other pathology including generalised and vertebral arthritis and trauma (refer back to Table 5.1.1a). In G-85, a neuromechanical complication due to a fractured left femoral neck is believed to have resulted in paralysis and post-paralytic wasting of the limb involved. In this case the neuromechanical and metabolic conditions where most likely concurrent and may have resulted in the amplification of the deformities seen. The

added stress on the right, weight bearing limb, may indeed account for the most pronounced plastic deformation being seen in this case compared to the others.

Brittle deformation (B): Osteoporosis

In all cases where the code "B" is entered for metabolic disease, the observed anomaly consisted of a light weight and brittle quality of the bones suspected as indicating a generalised reduced bone mass in the skeleton. Three individuals, G-3, G-9 and G-200, were identified as having reduced bone quality without any signs of plastic deformation. Gender was determined as female in all cases and individuals were adults between the ages of 30 and 60. G-3 and G-9 are believed to be mature adults, although a specific age could not be determined for G-9, and G-200 is believed to be a young adult. The influence of post-mortem changes is not known and thus the diminished bone quality seen in these skeletons could possibly be due to demineralisation of the bone during burial.

While it is not surprising that all of the above cases are adults, most of whom are mature adults, it is interesting that all have been identified as females. However, in view of the fact that the identification and diagnosis of metabolic bone deficiency diseases is quite subjective, these results can not be seen as absolute. Osteomalacia is, by definition, a disease occurring in adults and the same is largely true of osteoporosis, which is most often seen in mature adults into their fifth decade of life (Ortner and Putschar, 1985). The age related predilection can be related both to the prolonged nature of these diseases and to

the normal process of aging which alters the balance between bone formation and bone resorption, favouring the latter more and more over the former. The very nature of these diseases is one of slow progression and expression based upon many factors that include such variables as: the original state of bony development prior to disease onset; the severity and duration of the deficiency condition; the draining effect of greater than average nutrient requirements such as pregnancy and prolonged lactation in the female; and the function of hormone levels in relation to bone resorption rates. Considering these aforementioned variables, it is understandable that these diseases are found to be more severe and more prevalent among females (*ibid.*). Hence, their greater "visibility" should be expected in a skeletal collection. The exclusive female predilection for these diseases in the present collection may be partly an artefact of their more clearly diagnostic expression on the relatively more gracile and impressionable bones of the female skeleton; or, in part, it may be due to an actual increased susceptibility in the females of this collection. Indeed, the increased stresses of child bearing, prolonged lactation, chronic malnutrition and decreased oestrogen in the later years are all factors which may have made these females highly susceptible to osteomalacia and osteoporosis. That these diseases did not affect the males in the population is probably an unlikely scenario and the lack of male diagnoses is probably best explained by a lack of diagnostic "visibility" on dry bone.

5.1.1.3 Scurvy (Sc)

Scurvy is a condition which results from a chronic dietary deficiency in Vitamin C (Steinbock, 1976). The deficiency undermines collagen connective tissue synthesis and affects both vascular and supportive tissues throughout the body. The condition becomes outwardly evident when the vascular and supportive tissues of the periodontal membrane become weak and inflamed. Bleeding gums, inflammation and degeneration of the periodontal tissues, alveolar osteitis and resorption and haemorrhaging of post-cranial soft tissues are some of the characteristic clinical outcomes of chronic scurvy. Most of theses as well as many of the other symptoms of scurvy, including muscle weakness and fatigue are only evident in living persons or on soft tissue. Yet while palaeopathological evidence may be often sparse and difficult to recognise, there are a number of signs that can facilitate a diagnosis (Wells, 1975a). On dry bone a diagnosis of scurvy may be indicated by such features as: alveolar osteitis which is not due to dental caries; premature exfoliation of teeth; and ossified subperiosteal haematomas of the long bones (Wells, 1975a; Steinbock, 1976; Ortner and Putschar, 1985). While the most secure diagnosis would include evidence from both the dental remains and the post-cranial skeleton, a combination of alveolar osteitis, atrophy and premature tooth loss not related to carious infection have been cited as evidence for scurvy (Wells, 1964; Wells 1975a; Ortner and Putschar, 1985).

Case Descriptions

There are two tentative diagnoses of scurvy. Both G-99 and G-130 individuals exhibit generalised and advanced alveolar resorption indicative of alveolar osteitis due to periodontitis. The aetiology of the periodontitis is not certain, however, scurvy may be indicated. In the case of G-130, gumline caries occur and thus infectious periodontitis may have ensued from caries as opposed to scorbic tissue degeneration. In G-99, on the other hand, there are no related caries and a diagnosis of scurvy is more strongly indicated. Post-cranial changes may also lend support to these diagnoses.

G-99, is a young adult female aged 27-33 years. Pathological observations include: alveolar osteitis; generalised and extreme retreat of the alveolar margin; premature tooth loss of several molars and incisors; and subperiosteal hyperostosis of the tibiae and fibulae. Dental changes are illustrated by Plates 99-1 and 99-2. The teeth are in good condition and exhibit only moderate wear and no caries. There is a thin film of calculus accumulated near the cervical margins of the teeth and the alveolus has retreated well above this. The line of the alveolus lies between 5 mm and 8 mm away from the cervical margin of the teeth and the tooth sockets are very shallow. Pre-mortem tooth loss, in the incisal region of the mandible (Right:I1; Left:I1, I2), is considered to be premature and not thought to be related to dental caries or abscessing. The porous appearance of the alveolus in this region indicates a peri-mortem loss of the teeth, without sufficient time elapsed for complete resorption of the pre-existing tooth sockets prior to death.

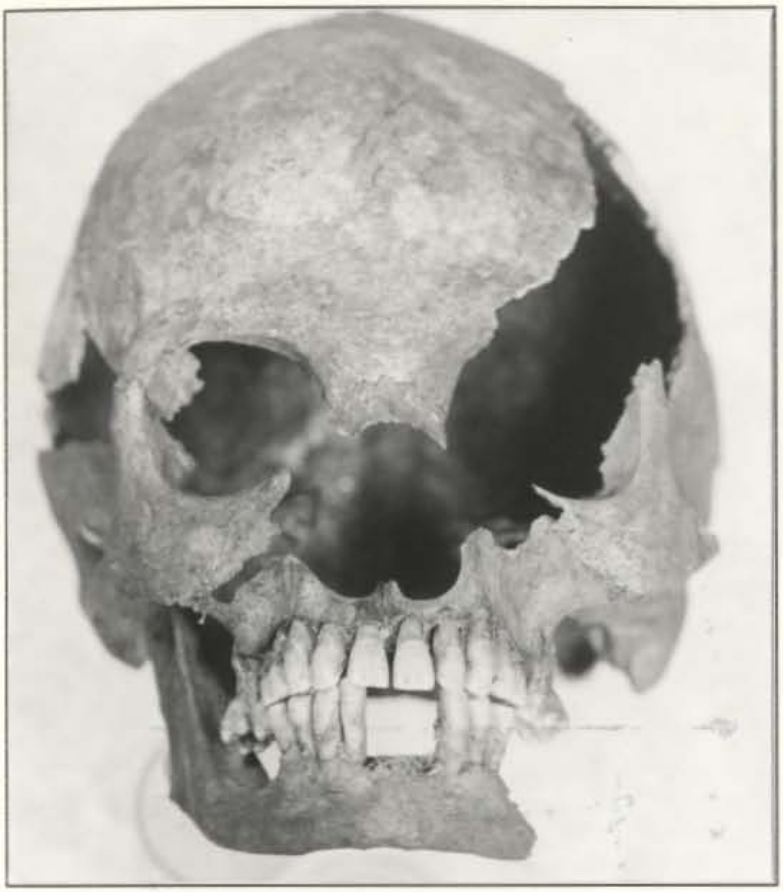

Plate 99-1: G-99; **Scurvy;Dental Changes.** Reconstructed skull of a young adult (Ad1) female, aged 27-33 years. The left mandible, posterior to PM2, was broken post-mortem and not recovered. Pathological changes include: alveolar osteitis; alveolar resorption and "shortening" of the tooth sockets; accumulation of calculus around the cervical margins of the teeth; and pre-mortem tooth loss of incisors and molars in the mandible.

Pre-mortem tooth loss has also claimed the first and second molars in the left mandible; in this location resorption of the tooth sockets is complete. No alveolus or dentition was recovered from the right mandible. There are no third molars present in the mandible or the maxilla, but whether this indicates pre-mortem tooth loss or congenital absence is not clear.

The porous, inflamed and greatly retreated bone of the alveolus is characteristic of alveolar osteitis secondary to periodontal disease. Considering the absence of dental caries and abscessing, this inflammation and atrophy of the alveolus may indicate increased vulnerability of these tissues. The role of

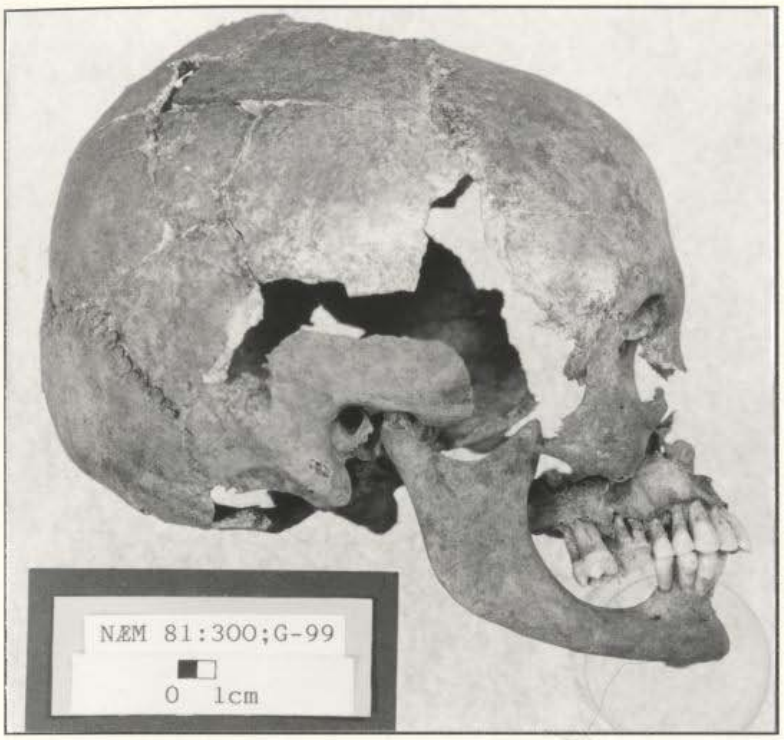

Plate 99-2: G-99
Scurvy: Dental Changes.
Right lateral view of the reconstructed skull, illustrating generalised and extreme retreat of the alveolar margin and pre-mortem tooth loss with complete alveolar resorption in the molar region of the mandible. Note that tooth sockets are extremely shallow in the molar region of the maxilla and teeth have been artificially secured in place for the photograph.

calculus as a periodontal irritant leading to inflammation and bone infection cannot be dismissed, however, a diagnosis of scurvy would also account for the increased vulnerability of supportive and vascular tissues. In the periodontium, increased vulnerability due to scurvy often results in easy irritation and inflammation of the gums, leading to chronic periodontitis with alveolar retreat and eventual tooth loss.

Elsewhere in the body, scurvy weakens vascular membranes and renders soft tissues susceptible to massive haemorrhaging. Ossified subperiosteal haemorrhages are the most characteristic skeletal sign of scurvy (Steinbock, 1976; Ortner and Putschar, 1985). In G-99, subperiosteal hyperostosis occurs on the tibiae and fibulae (Plate 99-3). The shafts of these bones, and in particular those

of the left leg, are altered by irregular accumulations of subperiosteal bone along the diaphyses and adjacent to the distal articular ends. Such irregular areas of subperiosteal bone apposition are characteristic of ossified subperiosteal haematomas and may lend support a diagnosis of scurvy in this case (Steinbock, 1076; Ortner and Putschar, 1985).

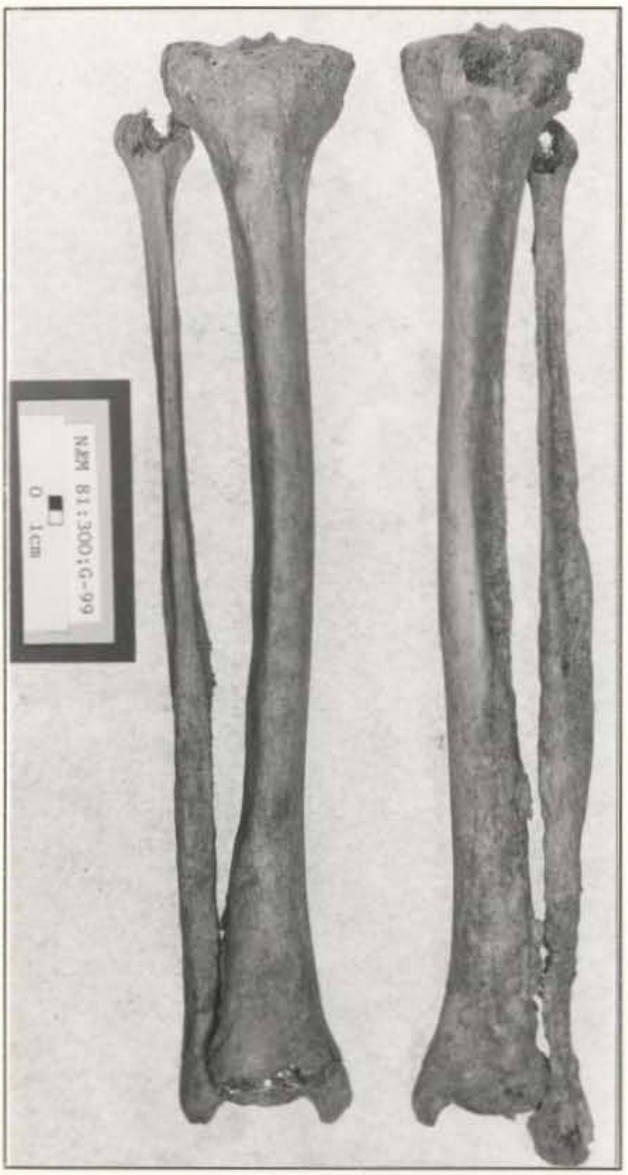

Plate 99-3: G-99;
Scurvy; Post-Cranial Changes.
Tibiae and fibulae of a young adult female with dental changes due to scurvy (see also Plates 99-1 and 99-2). Irregular areas of sub-periosteal bone apposition have been diagnosed as ossified sub-periosteal haematomas occurring as a result of vascular and tissue vulnerability due to scurvy.

While there is support for a diagnosis of scurvy, differential diagnoses may include other singular or overlapping conditions. It is possible that the dental pathology observed is merely a result of periodontitis due to the build up of plaque and calculus around tooth necks. Protein deficiency should also be considered, as this condition may also increase the susceptibility of periodontal tissues to irritation and inflammation (Ortner and Putschar, 1985). Metal poisoning due to toxic intake of bismuth, arsenic, mercury or lead are also known to cause ulceration of the mucous membranes and lead to atrophy of the alveolar bone (Robbins, 1967).

Post-cranial lesions of the tibiae and fibulae must be considered for a separate aetiology, which may include localised inflammations secondary to trauma or ossifying periostitis secondary to chronic leg ulcers. Differential diagnoses notwithstanding, the combination of dental and post-cranial lesions in G-99 are probably best explained by a diagnosis of scurvy. Both the dental and the post-cranial changes are characteristic of scurvy, while the other disorders are less appropriate. Calculus should be considered in any case of periodontitis, yet in all other cases where calculus was seen, alveolar resorption was not so extreme or unrelated to gumline caries. Protein deficiency, metal poisoning and localised trauma or infection, on the other hand, may explain only the dental or the post-cranial changes; none of these diagnosis allows a comprehensive understanding of the relationship of pathological changes throughout the body.

G-130 is another case where a diagnosis of scurvy may be appropriate. Pathological observations include: dental caries; alveolar osteitis; generalised and extreme retreat of the alveolar margin; premature tooth loss of several incisors, premolars and molars; and subperiosteal hyperostosis of the right tibia and fibula. Although the type and distribution of pathological changes is similar to G-99, the presence of gumline caries may indicate another aetiology for the periodontal infection. Plate 130-1 illustrates the generalised and extreme retreat of the alveolar margin with exposure of the tooth roots. Caries extend from the cervical margins of the teeth and onto the roots. Given this localisation of caries, it is possible that infection of the periodontium, leading to alveolar osteitis, was a consequence of carious activity along the gumline. However, scurvy is also possible in this case since the caries appear to be of early to moderate progression, yet the degree of alveolar involvement is severe and progressed. Again, in addition to the dental pathologies, there are post-cranial lesions. Lesions affect the shafts of the right tibia and fibula and are characteristic of subperiosteal bone apposition as in G-99. The left tibia and fibula bones were not recovered.

Differential diagnosis for the observed pathological changes which affect G-130 may include the same conditions as cited for G-99. Although calculus is not evident on the teeth, plague, calculus and gumline caries may have been a precursor to periodontal disease in the living individual. Protein deficiency and metal poisoning are also possibilities in the aetiology of soft tissue pathology leading to alveolar osteitis, shortening of tooth sockets and pre-mature tooth loss

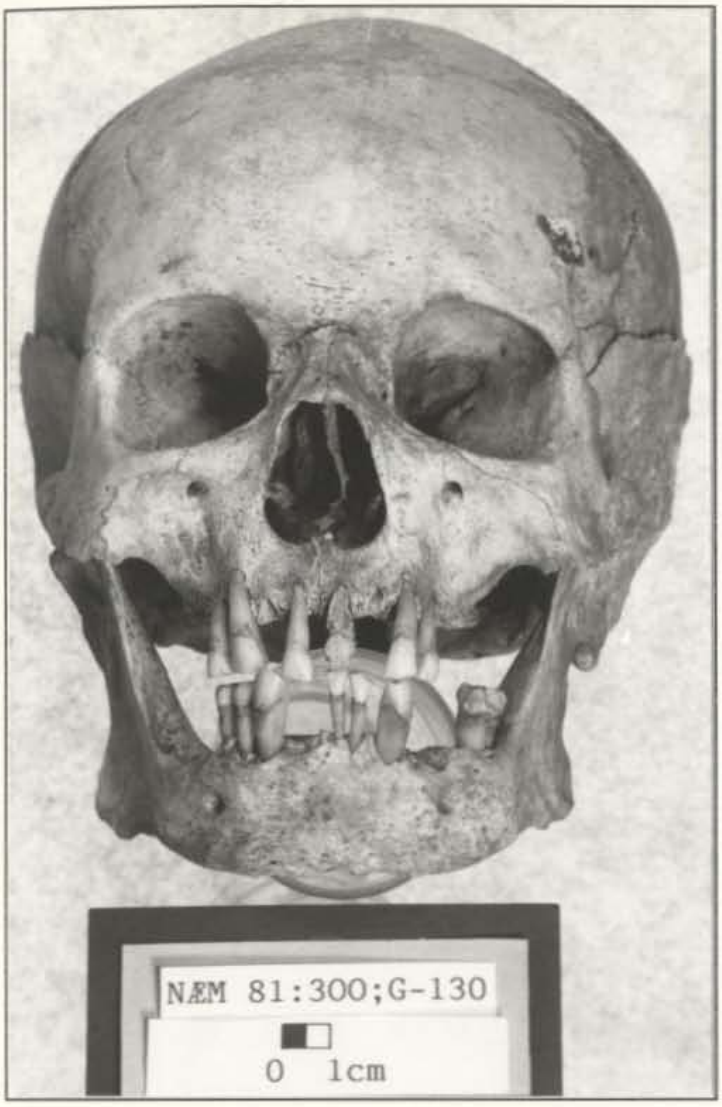

Plate 130-1: G-130; **Possible Scurvy; Dental Changes.** Mature adult (AdM) male, aged 32-48 years. Pathological changes include: alveolar osteitis; alveolar resorption and "shortening" of the tooth sockets; caries located around the gumline (cervical margins and adjacent roots of the teeth); and pre-mortem tooth loss of several incisors, pre-molars and molars. Although minor post-mortem damage is evident in the alveolus, alveolar retreat is, for the most part, pathological. Gumline caries notwithstanding, scurvy is a possible cause for the development of alveolar osteitis and subsequent tooth loss in this individual.

in this individual. Post-cranial lesions may have been caused by inflammation of the periosteum secondary to local trauma or deep tissue ulceration. Yet, to explain the combination of dental and post-cranial lesion and the severity of alveolar disease, scurvy remains a plausible diagnosis in this case.

One reason for maintaining the consideration of scurvy, for both of the above cases, stems from a comparative consideration of the other individuals in

the collection. If metal poisoning were responsible for the dental pathology, it is likely that it would not have been such an isolated condition, i.e. diagnosed in only two cases or approximately 1% of skeletons with dental remains. By the same token, calculus and gumline caries were observed in a number of individuals (refer to section 5.1.8), and in some cases with increased severity, yet alveolar disease is nowhere as severe as in these two cases. Both the severity of alveolar involvement and the presence of post-cranial lesions indicative of subperiosteal haematoma is best explained by a diagnosis of scurvy in these cases.

5.1.2 Vascular (Circulatory) Disorders

Vascular or circulatory disorders are those which result from an abnormal blood flow to, from or within bodily tissues (Underwood, 1992a). There are a total of 31 individuals, 9.5% of the G-series, with recognisable signs of vascular disorders (Table 5.1.2a). In relation to the 154 skeletons exhibiting signs of pathology, 20.1% of skeletons are affected by a disorder of a vascular nature.

In the Helligåndshus collection, skeletal signs of anaemic disease, i.e. porotic hyperostosis (Ph) and/or cribra orbitalia (C), were the most common type of vascular pathology observed. Of the 31 recognised circulatory cases, 24 were attributed to the anaemic disorders and the remaining 7 cases were attributed to various localised conditions due to interrupted blood flow to an area. Four of these localised conditions (with the code "necro" in Table 5.1.2a), are considered

secondary vascular complications due to a previous trauma or congenital malformation which may have predisposed the affected area to vascular complications. In the other three cases, osteochondritis dissecans ("oschr") was diagnosed. In Table 5.1.2b the vascular disorders have been divided into two sub-categories: (5.1.2.1) anaemic disorders and (5.1.2.2) localised disorders. The first sub-category deals with the skeletal manifestations of systemic anaemic disease, while the second sub-category includes localised conditions due to various disorders resulting in interrupted blood supply to an area. Each sub-category is further broken down to provide numerical values for the age and gender associations within.

5.1.2.1 Anaemic Disorders: Porotic hyperostosis (Ph) and Cribra orbitalia (C)

Porotic hyperostosis and cribra orbitalia are terms which describe the pathological bone changes due to a number of haematologic disorders which produce abnormal red blood cells. Depending on the specific aetiology of the condition, the abnormality may be genetic alterations of the cell's haemoglobin molecule (sickle cell anaemia and thalassaemia) or a reduced size or iron concentration of the cell (iron deficiency anaemias). On skeletal material, anaemic conditions are most commonly characterized by hypertrophy of haematopoietic bone marrow in the cranial diploë and its resultant pressure atrophy, i.e.thinning, of the outer cortical bone. The gross morphological appearance of these lesions is that of closely spaced porosities to large coalescing apertures occurring where the

Table 5.1.2a

Vascular (Circulatory) Disorders

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-72		C,Ph---	ImI	Rib				Dc	0	Ch2	5-9
G-40		C,?Ph							0	Ch1	4-5+/-
G-145		C	ImI*		Amp*				F	Ad1	21-29
G-127		C							0	Ch2	8.5-13
G-178		C							0	J-y	13-16
G-81		C----------						Da	M?	Jv	15-19
G-301	Dh----	C,?Ph							0	Ch2	6-9
G-116	Dh*---	Ct						Dc*	0	Ch1	2-4
G-84	Dh----	Ct						Da	0	Jv	10-14
G-15	Dh----	Ct						Dc-gr	F	Ad1	17-24
G-60	Dh----	Ct							0	Ch2	4-8
G-157	Dh----	Ct							0	Jv	11-14
G-277	Dh----	Ct							0	Ch1	1-2
G-146	?Dh---	Ct?Ph							F?	Jv	15-18
G-39	------	Ct-----Isy					Av-tl-S	Dac-gr	M	Ad1	30-44
G-129	------	Ct-----ImI	Rib					Dc-g	0	Ch2	5-7
G-215		Ct							0	Ch2	7-11
G-152		Ct							F	AdM	50-60
G-123		Ct							0	Ch2	5-8
G-67		Ct							0	Ch1	2-3
G-282		Ct							M	Jv	15-19
G-266		Ct							0	Ch2	6-7+/-
G-287		Ct							0	Ch2	5-7
G-185		Ct						Dw	0	Ch2	4-8
G-8		oschr			spL5		Av-t;e;k		M	Ad1	25-35
G-202		oschr	I?		T?		Ag~v	Daclwr	F	AdM	34-50
G-265		oschr					Av-S;~sc		F?	Ad1	24-30
G-2	Dh	*necr----------	Ffn*				_Avct_--*H		F	Ad1	21-46
G-270		*necr--Im------	?----------			hip*--*A!H			0	Jv	12-16
G-85	BO*	*necr--ImI*----	Ffn*				_AgvSm_--*Hnp		F	AdM	35-53
G-240		*necr---------	?Ffn*				Aav*h		F?	Ad?	mature

------- - indicates a posited relationship between vascular and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified vascular condition.

---?--- - possible or questionable association.

_BO_ - excluding this condition. In this case, metabolic bone disease is not though to be related to the vascular condition suffered by this individual.

* - indicates that a certain pathological condition may be considered to have more than one pathogenic component or aetiology is ambiguous; see asterisks for corresponding categories.

t - trace or healing condition.

Vascular Disease Codes:

C= Cribra Orbitalia
Ct= Trace Cribra Orbitalia;
Ph= Porotic Hyperostosis

oschr= Osteochondritis Dissecans;
necr= Ischaemic Necrosis (vascular disruption)

Table 5.1.2b

Vascular (Circulatory) Disorders:
Age and Gender Distribution

Age (in years) Category; years	(5.1.2.1) Anaemic Diseases T: ♂/I/♀/p	(5.1.2.2) Localised Disorders T: ♂/I/♀/p	Total: all types T: ♂/I/♀/p
Ch1; 1-6	**4**: 0/0/0/4	0	**4**: 0/0/0/4
Ch2; 6-12	**10**: 0/0/0/10	0	**10**: 0/0/0/10
Jv; 12-21	**6**: 2/0/1/3	**1**: 0/0/0/1	**7**: 2/0/1/4
Ad?; ≥21	0	**1**: 0/0/1	**1**: 0/0/1
Ad1; 21-39.5	**3**: 1/0/2	**3**: 1/0/2	**6**: 2/0/4
AdM; 39.5-57	**1**: 0/0/1	**2.**: 0/0/2	**3**: 0/0/3
Total all ages	**24**: 3/0/4/17	**7**: 1/0/5/1	**31**: 4/0/9/18

Age codes:
Ch=child; Jv=late juvenile; Ad=adult (also refer to section 4.2.2 for details on age category codes).
Age and Gender breakdown (totals by age group: totals for age/gender group), where,
T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

outer cortical bone has "worn away" and exposed the hypertrophied marrow beneath (Steinbock, 1976; Stuart-Macadam, 1989 and 1992). The lesions of cribra orbitalia are localised on the roofs of the eye orbits, while lesions of porotic hyperostosis most commonly affect the parietals of the skull vault.

Some authors refer to cribra orbitalia as the cribrotic form of porotic hyperostosis. On the basis of macroscopic, microscopic, radiographic and demographic findings from both clinical and palaeopathological studies, Stuart-Macadam (1989) concludes that porotic lesions of the orbit and vault are related

and share the same aetiology. Cribrotic lesions of the orbits and porotic lesions of the skull vault are considered two manifestations of a singular systemic disorder, namely anaemia and, most commonly, an iron deficiency anaemia (Stuart-Macadam, 1992). This conclusion is generally well accepted and, in fact, a total of three forms or manifestations of porotic hyperostosis are recognized: porotic or cribra crania; cribrotic or cribra orbitalia; and trabecular or postcranial. Stuart-Macadam (1989) has suggested that the cribrotic form may actually be the first outward manifestation of the anaemic condition. Since the compact bone of the orbits is much thinner than that of the skull vault, it is more prone to pressure atrophy and therefore lesions will appear in this location first (Steinbock, 1976; Walker, 1985; Stuart-Macadam, 1989). Herein, the cribra orbitalia is used to describe the orbital localisation of skeletal changes due to anaemia, i.e. porotic hyperostosis.

The third form of porotic hyperostosis is that which affects the post-cranial skeleton. This is referred to as the trabecular form by Jozsa and Pap (1991). Although these are less common manifestations of porotic hyperostosis, postcranial bone alterations can occur, taking the form of coarsened trabecular bone, marrow hyperplasia, cortical thinning and mottled osteoporosis (Zimmerman and Kelley, 1982). However, since only gross morphological observation was used in this investigation, post-cranial, trabecular, changes were not observed.

Case Descriptions

In the Helligåndshus collection, signs of cribra orbitalia were identified in 24 individuals, i.e. in all cases where anaemic disease is diagnosed. Porotic hyperostosis (Ph) of the cranial vault, on the other hand, is suspected in only four cases, G-40, G-72 and G-301, and in all cases it accompanies the cribrotic, orbital, form. However, the preservation of cranial material in the collection is not ideal and therefore many individuals could not be assessed for either orbital or cranial lesions. In any event, other osteological studies concur with this pattern, finding that vault lesions rarely occur in isolation of orbital lesions while orbital lesions often occur alone (Stuart-Macadam, 1992). The explanation of this phenomenon is that vault lesions of porotic hyperostosis are thought to be present only in the severely anaemic while cribra orbitalia appears as one of the earliest osseous indications of anaemia (Walker, 1985).

The occurrence of anaemic disorders may have been higher than 24 out of 328 or 7.13% of the G-series if all individuals were complete for assessment. Out of the 328 individuals in the G-series, 156 have no cranial remains and another 28 have no orbital regions preserved. The occurrence of anaemic disorders could only be investigated for those with complete skulls or incomplete skulls with orbital and/or parietal areas preserved. Of the 70 complete skulls and the 82 incomplete, crushed or fragmentary remains with orbital areas recovered, the 24 cases of bone changes due to anaemic disorder equates to 15.8% of the 152 individuals. This latter percentage of disease occurrence may be more significant in that it relates

to a population wherein all individuals could be assessed; yet, if anaemic disease is a factor in the selective deterioration of cranial material, it is not a valid percentage to extrapolate for the entire G-series.

In 24 cases of cribra orbitalia, there are varying degrees of severity of lesion expression. The reasons for differential expression are thought to relate to several factors including: the duration of the anaemic condition; the stage of the disease, whether active or healing, at the time of death; susceptibility of marrow architecture related to age of onset of the disease; individual variations in disease expression; and the time elapsed between the onset of healing, if initiated, and death of the individual. It has been concluded that there is no direct relationship between the severity of clinical anaemia and the severity of ensuing skull changes; individual variations in the skeletal expression of the disease appear to have more influence on the severity of skeletal changes than do varying degrees of disease severity itself (Stuart-Macadam, 1992). Of these various factors it is difficult, on the basis of skeletal changes alone, to establish which factors may have been functional and to what extent they may have influenced the resultant condition. Although little is known of the persistence of lesions after chronic childhood anaemia has resolved, it is believed that the traces of childhood anaemia do persist well into adulthood (Walker, 1985). In any event, the least problematic determination of porotic hyperostosis, with regard to skeletal lesions, is the recognition of an active versus a healing or healed condition. The principal criteria for this determination is the gross morphology of the lesions. Active lesions have

a fine lacy "coral like" appearance of the newly exposed hypertrophied marrow, while healing lesions begin to take on a smooth edged appearance as the hypertrophied marrow begins to resorb. Finally, the margins of the porosities smooth over and appear to fill in as the hypertrophied bone is resorbed and remodelled (Mensforth et.al., 1978; Walker, 1985).

The majority of the cribra orbitalia cases in the Helligåndshus collection may be considered as either healed or in an advanced stage of healing. The appearance of the conditions in these 17 cases, identified as "Ct" in Table 5.1.2a, is that of very fine, smooth edged porosity seen in the orbital roofs (Plate 15-1). In the remaining 7 cases, identified as "C" in Table 5.1.2a, the condition appears to have been an active or in an early stage healing at the time of death (Plates 72-1 and 81-1). Plate 72-1 illustrates an active condition, with the presence of lacy edged hypertrophied bone, while Plate 81-1 illustrate a severe case of the condition which was in the process of healing at the time of death.

Plate 15-1: G-15 **Cribra Orbitalia; Healed or "Trace" Condition (Ct).** Female adult aged 17-24 years. Inferior oblique view of the orbital roofs. Fine smooth edged porosity is indicative of bone remodelling after the cessation of the anaemic disease state.

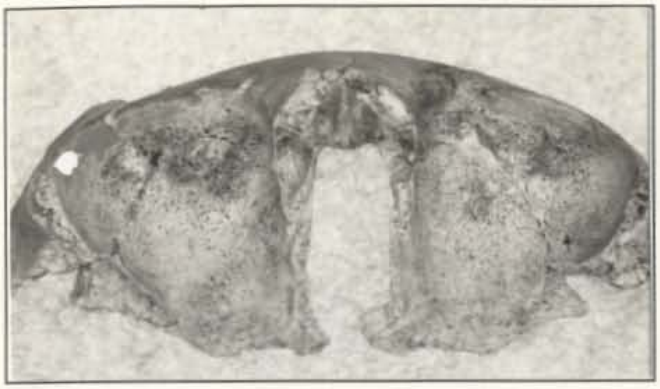

Plate 72-1; G-72
Cribra Orbitalia; Active Condition. Child aged 5-9 years. Inferior view of orbital roofs. Lacy "sharp edged" hypertrophied bone suggest the anaemic condition was active at or around the time of death.

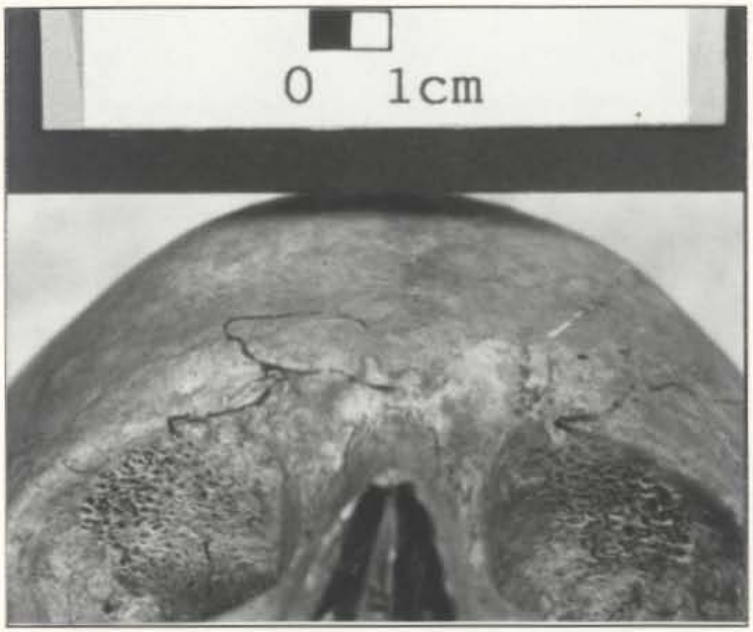

Plate 81-1; G-81
Cribra Orbitalia; Severe Healed Condition.
Adolescent male? aged 15-19 years. Inferior oblique view of the orbital roofs. Course porosity suggests a severe anaemic condition while the smooth margins suggest the condition was healed and the bone was remodelling at the time of death.

Some of the patterns and associations noted in relation to the occurrence of porotic hyperostosis are age and the occurrence of other pathological conditions. In relation to age, the majority, 20 out of 24 cases, were subadults. Children between the ages of 6 and 12 years were frequently affected, totalling 10 cases. Young children, between 1 and 6 years and juveniles aged between 12 and

21 years made up the other 4 and 6 cases, respectively. Of the 4 adult cases, 3 were young adults and one was middle-aged. The higher number cases of cribra orbitalia in subadults versus adults is not surprising (Walker, 1985). Anaemia is most prevalent in children because of the increased demands for iron during growth and development. The periods of most rapid growth, i.e. during infancy and puberty put the greatest demands on iron stores and thus it is children at these stages of development who are most prone to anaemia (Mensforth et.al., 1978; Wharton, 1989). While the age of onset and duration of anaemia cannot be ascertained for the aforementioned cases of cribra orbitalia, the age related data concur with a predilection for childhood and juvenile age of occurrence.

Predilections on the basis of gender cannot be established since the majority of the cases in this collection are pre-pubescent individuals for whom gender cannot be determined. For the small number of gendered individuals in this collection, there were 4 females (1 adolescent and 3 adults) and 3 males (2 adolescents and 1 adult). Although interpretations from this small gendered sample are inconclusive, other osteological studies which have included gendered individuals, have not established any gender related predilections for the occurrence of porotic hyperostosis (Walker, 1985).

Associated pathologies which appear to correspond to anaemic disease in this collection include the occurrence of dental hypoplasia in 7 out of 24 (29.2%) cases; the presence of infectious conditions in 3 out of 24 (12.5%) cases. Dental infections are present in 4 out of 24 cases, but only suffered concurrently in one

case. These associated conditions are considered significant with respect to the aetiology of anaemic conditions, in that they may share the same aetiology or one condition may have played a contributory role in the development of the other.

The association between cribra orbitalia and dental hypoplasia was brought up previously, during the discussion of the latter condition in section 5.1.1. To reiterate, both of these conditions are considered pathological indicators of stress. The particular types of stress, be they dietary insufficiency or pathogen load, are impossible to determine on the basis of skeletal material alone. In the case of both dental hypoplasia and anaemic conditions, the aetiological agents are multifactoral and most likely the result of a synergistic relationship between malnutrition and pathogen load (Ward, 1971; Scrimshaw, 1991; Macey, 1992; Stuart-Macadam, 1992). In any case, it may be that pathogen load is the most significant factor in the development of skeletal changes in response to anaemia. In a palaeo-epidemiological consideration of past populations, Stuart Macadam (1992) has found that where porotic hyperostosis is prevalent, high pathogen load appears to be responsible. It appears that those geographic areas, time periods and socio-cultural milieus which tend to have higher pathogen loads are those in which porotic hyperostosis will occur despite diets rich in iron and protein (*ibid.*). Pathogen load is also considered to be a significant factor in the development of dental hypoplasia and it may be that the development of porotic hyperostosis and dental hypoplasia are the result of the same episode of disease stress.

In all seven cases where cribra orbitalia and dental hypoplasia were seen in the same individual, the anaemic condition was either healed or in the process of healing. Dental evidence also suggests an episode of past stress. It may be that both conditions correspond to a period of disease stress exacerbated by increased metabolic demands during peaks in childhood and juvenile development.

Inflammatory and infectious changes, of a possible related nature, were seen in 3 out of 24 cases of cribra orbitalia. In one additional case, G-145, inflammatory and infectious bone changes were localised and related to a seemingly recent amputation; in this case infectious changes were not believed to be related to the condition of healed cribra orbitalia. In the three cases where infectious changes may be associated with cribra orbitalia, G-72, G-39, G-129, the infection is a chronic and systemic condition. While all three infectious conditions appeared to have active lesions at the time of death, the lesions of cribra orbitalia appeared to be active only in G-72. Yet, although only G-72 exhibits indications of both infection and anaemia in the active phase, there may still be reason to suspect that the chronic infections affecting G-129 and G-39, played a contributory role in the development of anaemia at some point during the pathogenesis of the infectious condition. It is possible that anaemia developed during an acute flare-up of the infection or during a period of high metabolic demands, as in an early childhood or juvenile growth spurt. The anaemia may have subsequently resolved, leaving only the traces of the healed condition. Pathogen load must be considered a factor in the development of cribra orbitalia in each of these three

cases. Where infectious changes are not seen, pathogen load may have been subclinical or totally resolved on skeletal material and thus its influence in the development of cribra orbitalia can neither be dismissed nor assured.

Dental infection, and dental abscess in particular was seen 3 out of 24 cases, G-39, G-81, G-84. In all cases, dental infection is present along with traces of cribra orbitalia. Yet, in only one of these cases, G-81, do the two conditions appear to have been active at the time of death and, thus, would have been suffered concurrently. G-81 has indications of dental hypoplasia, active or early healing cribra orbitalia and active dental abscess in one location. It is likely, in this case that dental infection added to the level of disease stress in the body and exacerbated the condition of anaemia manifested as cribra orbitalia. Dental hypoplasia, incurred during childhood is evidence of past disease and in this case cannot be directly related to the conditions considered active at the time of death. However, it is evident that this individual suffered more than one episode of chronic disease stress during its 15-19 years of life.

In the remaining two cases, it is difficult to say if the dental infection was present during the anaemic condition which resulted in cribra orbitalia. Since, in both cases, the cribra orbitalia appears to be in an advanced stage of healing, with only fine porosity remaining, there is probably no direct relationship between the two conditions.

5.1.2.2 Localised Circulatory Disorders: (oschr), (necr)

The localised circulatory disorders include conditions of either a primary vascular disruption (oschr) or secondary vascular disruption as a complication of another condition (necr). In three cases, G-8, G-202, and G-265, vascular disorder was diagnosed as osteochondritis dissecans (oschr), a type of primary aseptic necrosis commonly affecting the knee or other large joints. In the other four cases, G-2, G-85, G-270 and G-240, vascular disruption is believed to be a consequence of either a malformation or a fracture of the femoral head and occurs as a secondary complication of a pre-existing disorder (necr). G-270 is discussed in detail with the congenital disorders and G-2, G-85 and G-240 are discussed in the sections on trauma and as well with the neuromechanical disorders.

Case Descriptions

Primary Vascular Disruption (oschr)

Primary localised aseptic necrosis due to osteochondritis dissecans occurs as a result of a subchondral defect whereby a small sequestrum of necrotic cancellous bone and articular cartilage breaks away from the articular surface of the joint and becomes a loose body in the joint cavity (Ortner and Putschar, 1985). The defect leaves a small cribrotic depression on the bony articular surface, but if complicated by further mechanical stress or trauma, it may lead to premature arthritic degeneration of the joint (*ibid.*). Where present in the three aforementioned cases the defect is small and there is little, if any, arthritic

degeneration of the joint involved. Plate 8-1, G-8, illustrates the most common character and location of osteochondritis dissecans. In G-202 and G-265, lesions of a similar, character and appearance were seen on the left olecranon fossa and the lunate fossa of the left acetabulum, respectively. The only evidence of arthritic complications was a slight marginal lipping which was seen medial to the defect in G-8.

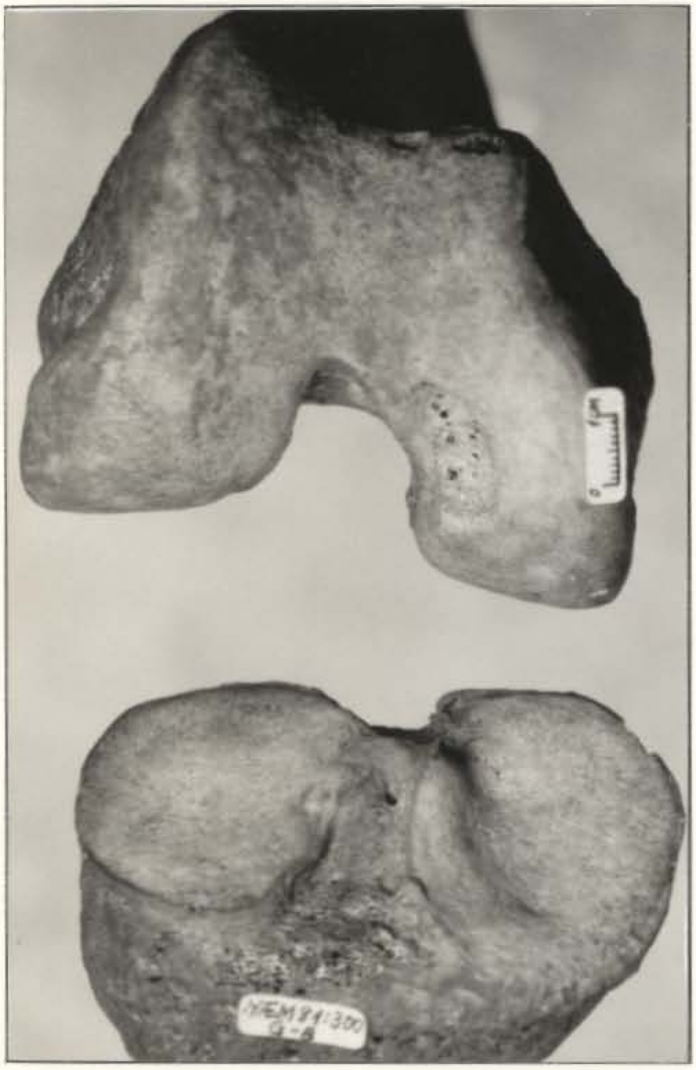

Plate 8-1: G-8
Osteochondritis Dissecans.
Adult male aged 25-35 years. Superior view of the articular surfaces of the knee joint. A roughly oval shaped detect on the medial condyle of the distal femur exhibits a cribrotic texture indicative of the pre-existing cartilage defect. Note the slight development of arthritic lipping along the margins of the joint surfaces.

Osteochondritis dissecans occurs in growing children and adolescents. It is one of several vascular disturbances which may result from repeated traumas or undue mechanical stress on the skeleton. The disease is much more common in males than in females (Ortner and Putschar, 1985). Of the three cases reported above, only G-8 was determined to be male and all are adults. Little can be said in terms of gender, since there are only three individuals involved. In all cases, the condition must be described as long standing, since all are adults and would have retained the defects since childhood or adolescence. Other than a minor arthritic development in G-8, no other pathological associations are posited for this condition.

Secondary Circulatory Disruption (necr)

There are three cases where vascular disruption has affected a localised area as a possible complication of trauma. In G-240, the neck and head of the right femur is degenerated. Vascular disruption is believed to have resulted in necrosis and almost complete atrophy of the right femoral neck and head (Plate 240-1). A fracture is suspected as the original cause of vascular disruption in this case. A similar pathology may have affected the femoral head in G-85 and G-2. Ortner and Putschar (1985:236) note that subcapital or transcervical fracture of the femoral neck, with damage to the main arterial vessels, are often complicated by necrosis of part or all of the femoral head. One rather odd finding in G-240 was that the acetabulum had not been notably altered to accommodate the degenerated

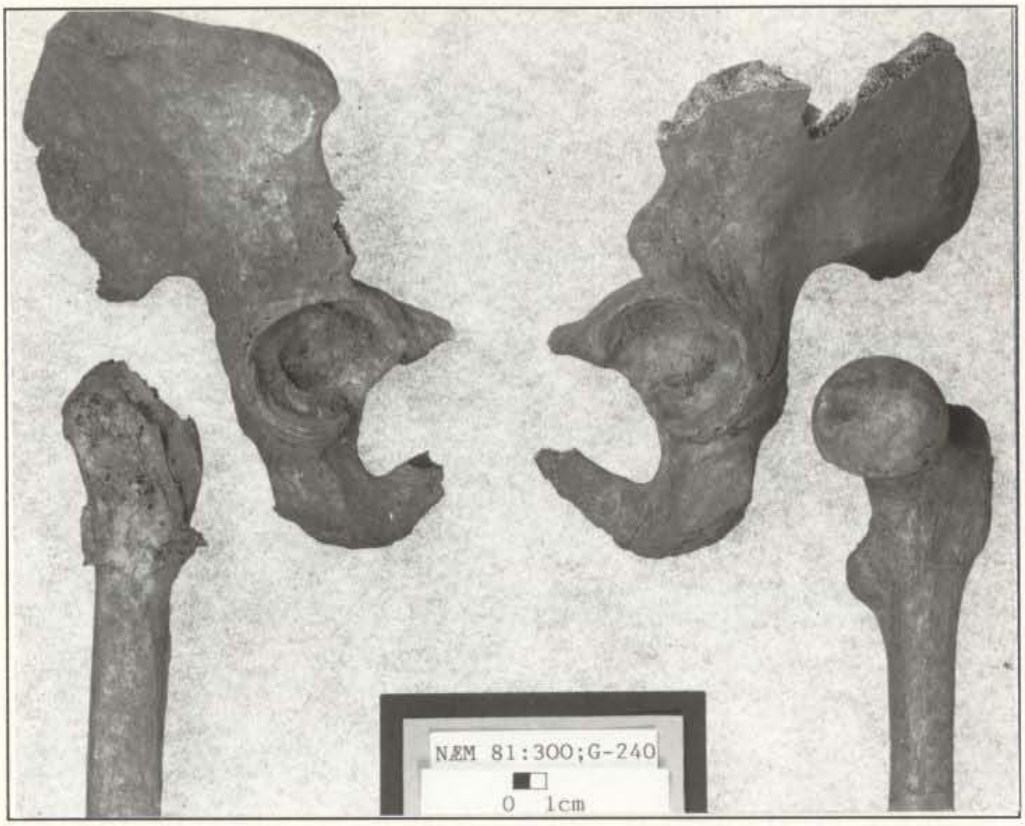

Plate 240-1; G-240
Circulatory Disruption; Avascular Necrosis of the Femoral Head. Mature female adult (specific age undetermined). Lateral view of innominate's, medial oblique view of femora. Absence of the femoral head and neck are believed to be a result of circulatory disruption to the femoral neck,possibly secondary to fracture or other trauma to the joint. Note the minimal changes to the adjacent acetabular surface. This may indicate that the joint was not used after the trauma or that the femoral head was present during life and perhaps held in place by ligamentous tissue.

femoral head. An explanation for this finding has not be ascertained but one possibility may be that the femoral head was retained in the acetabulum by the ligamentum teres during life, yet it was not recovered during excavation. In this case, it is posited that a pseudoarthrosis was present between the now absent head and the proximal femur where the bone appears porous, smooth and polished.

In the case of G-270, a congenital malformation of the joint is suspected but a localised tuberculosis infection of the joint is also a possibility. In any event, the end result of the disease process was an avascular necrosis of the femoral head and neck and complete deterioration of the acetabulum. This case is discussed and illustrated in detail in section 5.1.6 on Congenital Disorders.

5.1.3 Inflammatory and/or Infectious Conditions

Inflammatory and infectious conditions are those in which an inflammatory reaction is the major physiological response to tissue injury (Stephenson, 1992). Inflammation, alone, may be the result of reactions to infective agents, foreign bodies, trauma or chronic and extreme mechanical stress. Infection, on the other hand is the result of infective agents only, i.e. the proliferation of invasive micro-organisms in the body. Tissue destruction as a result of infection is the result of both the micro-organism invasion and the inflammatory reaction. Involvement of the bone is generally referred to as osteomyelitis, which strictly speaking denotes an inflammation of the marrow cavity, but in general usage inflammation of the periosteum (periostitis) and inflammation of the bone (osteitis) are included in the definition (Steinbock, 1976). Infection may appear as a mild inflammatory reaction to the pathogenic organism or it may progress into a profuse bony reaction leading to extensive invasive destruction of the periosteum, bone and marrow tissue. The severity of the infection will depend upon such factors as the virulence

and natural pathogenesis of the invasive organism, the route of entry and/or spread of the pathogenic organisms and the immune response of the host.

In this category, conditions due inflammation and infection are generally believed to be a result of infectious processes, however, some of the conditions noted for inflammation (Im) and slight inflammation (~Im) could be the result of trauma or other mechanical irritation. Differential diagnoses will be considered in the discussion of individual cases below. Although arthritis, strictly speaking, is an inflammatory disease of the joints, it will be discussed in the section on neuromechanical disorders, since the primary objective of the inflammatory and infectious category is to group together and discuss conditions of an infectious or possible infectious aetiology.

Conditions of an inflammatory and/or infectious nature were diagnosed in 45 individuals or 13.7% of the G-series (Table 5.1.3a). For descriptive purposes, the category has been divided into two sub-categories: 5.1.3.1, Non-Specific Inflammation and/or Infection and 5.1.3.2, Specific Inflammation and/or Infection.

Of the total number of diagnosed conditions in the inflammatory and infectious category, 30 appear to be of a non-specific nature and 15 are thought to be of a primary specific nature. Table 5.1.3b presents the total number of individuals in each sub-category in relation to age groups and further into gender affiliations within each age group.

Table 5.1.3a

Inflammatory and Infectious Conditions

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
5.1.3.1 NON-SPECIFIC INFLAMMATION AND INFECTION											
G-146	~Dh-?-Ct------		Im						F?	Jv	15-18
G-199			~Im				Ak		M	AdM	40-44
G-68			~Im				Agv	Dac	F	AdM	34-46
G-278			~Im				Aw		F?	FG	>25++
G-61			~Im						F	Ad1	22-32
G-192			~Im						F	Ad1	22-29
G-20			~Im						I	FG	>15-2
G-163			~Im						0	Ch2	6-8.5
G-296			~Im	T?*		C?*	*dslcHip		M	Ad1	27-37
G-309	Dh		Im	cervical				Dac	F	Ad1	21-30
G-79	*Dhpit		Im	?Dpit*----?D*,sb:oc					F?	Jv	16-20
G-243			Im				AvL;k;h		F	AdM	36-45
G-248			Im				AvLSmsh;e	Dacwlr	M	Ad1	30-43
G-23			Im						0	Nbn	0+/-2m
G-53			Im						M?	Jv	15-19
G-41			Im						F	Ad?	>21-2
G-250			Im						0	Nbn	0+/-2m
G-230			Im						0	Nbn	0+/-2m
G-99	Dh,Sc*-------		*Im2loc----------					*Dim	F	Ad1	27-33
G-252			I						M	Ad1	21-24
G-269			I						F	Ad1	31-44
G-273			I				Av;ky		M	AdM	47-58
G-274			I						0	Jv	14-18
G-138			I---?---?Ffib						I	FG	>15-2
G-310			I						F	AdM	30-40
G-249			I						M??	FG	>15-2
G-145			I-------Amp*						F	Ad1	21-29
G-85	*BO----------		I-------Ffn*----------				AahgP*		F	AdM	35-53
G-308			*?I						M	Ad1	20-24
G-202	oschr		*?I					Da	F	AdM	34-50
5.1.3.2 SPECIFIC INFLAMMATION AND INFECTION											
G-16			ImI Rib						0	Ch2	6-8
G-72		C,Ph---	ImI Rib						0	Ch2	5-9
G-129			ImI Rib						0	Ch2	5-7
G-177			Itb Rib				Av	Dl	I	AdM	43-63
G-170			Itb					Dc	F	Ad1	32-45
G-194			I?tb?----------				----------Aas-i	Da	F	Ad1	20-30
G-270			I?tb?*----------				*?----*Ah(P)		0	Jv	12-16
G-136			ImI?sy*----------				*congIsy		0	Inf	3mon+
G-39			Isy					Dac	M	Ad1	30-44
G-186			Isy						F	Ad1	22-30
G-313			Isy						F?	Ad1	32-42
G-280			Isy	?PFrib					F	Jv	16-20
G-223	Dh		Isy						F?	Ad1	32-47
G-76	Dh		Isy-----Pfcl						F?	Ad1	27-38
G-227			Isy-----PFul;c1						F?	AdM	36-45

------ - indicates a posited relationship between infectious and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified infectious/inflammatory condition.

---?--- - possible or questionable association.

_BO_ - excluding this condition. In this case, metabolic bone disease is not though to be related to the vascular condition suffered by this individual.

* - indicates that a certain pathological condition may be considered to have more than one pathogenic component or its aetiology may be ambiguous; see asterisks for other categories.

Inflammatory and Infectious Disease Codes:

Im=inflammation (Non-specific); Specific Infections: **ImIRib**= Actinomycosis(?); **Itb**= Tuberculosis
I=infection (Non-specific); **Isy**= syphilis (Treponemal Infection)

Table 5.1.3b

Inflammatory and Infectious Disease: Age and Gender Distribution

Age (age in years unless otherwise indicated) Category: numerical	(5.1.3.1) Non-specific Inflammation & Infection T: ♂/I/♀/p	(5.1.3.2) Specific Infection; Tb, syphilis, other... T: ♂/I/♀/p	Total; Specific and Non-specific Conditions T: ♂/I/♀/p
Nbn: 0±2mon	3: 0/0/0/3	0	3: 0/0/0/3
Inf: 2-12mon	0	1: 0/0/0/1	1: 0/0/0/1
Ch1: 1-6	0	0	0
Ch2: 6-12	1: 0/0/0/1	3: 0/0/0/3	4: 0/0/0/4
Jv: 12-21	4: 1/0/2/1	2: 0/0/1/1	6: 1/0/3/2
FG: ≥15-21	4: 1/2/1	0	4: 1/2/1
Ad?: ≥21	1: 0/0/1	0	1: 0/0/1
Ad1: 21-39.5	10: 4/0/6	7: 1/0/6	17: 5/0/12
AdM: 39.5-57	7: 2/0/5	2: 0/1/1	9: 2/1/ 6
AdS: 57-79	0	0	0
Total: all ages	30: 8/2/15/5	15: 1/1/8/5	45: 9/3/23/10

Age codes: Ch=child; Jv=juvenile; Ad=adult (also refer to section 4.2.2 for details on age category codes). Age and Gender breakdown (totals by age group: totals for age/gender group), where, T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.3.1 Non-specific Inflammation and/or Infection (Im), (Iml), (I)

A non-specific nature of inflammation and infection refers to the pathogenic organism. Whereas certain organisms such as treponema and mycobacteria develop into syndromes with specific symptoms such as syphilis and tuberculosis, respectively, non-specific infections may be due to variety of

organisms and may have a variety of disease outcomes. Non-specific infection of bone is referred to as pyogenic osteomyelitis, i.e. a purulent infection resulting from infection by various kinds of micro-organisms. It is reported that almost ninety percent of pyogenic osteomyelitis cases are due to infection by *Staphylococcus aureus* and the remaining ten percent are due to such suppurative organisms as streptococci, pneumococci, meningococci, and more rarely salmonella or colon bacilli (Steinbock, 1976). In order for infection to spread to bone, the bone must be exposed directly to the environment, for example: by severe trauma as in a compound fracture or deep penetrating wound or exposed to infective organisms by lymphatic or haematogenous transport from a soft tissue infection such as a boil, ulcer, skin lesion or sub-cutaneous abscess (*ibid.*; Grange, 1992a). In some cases, inflammatory and infectious conditions have been related to other conditions such as trauma, metabolic disease or neuro-mechanical dysfunction. These may be considered secondary complications, yet strictly speaking most bone infections arise as a complication of primary trauma or soft tissue infection. Unless direct exposure and primary infection of the bone can be demonstrated, bone infections must be considered to be a sequela of lymphatic or haematogenous spread from a primary infectious focus.

Case Descriptions

In this sub-category 18 out of 30 cases involve inflammatory (Im) changes only and 9 of these cases are mild or almost completely healed inflammatory

reactions (~Im). The other 12 cases in this sub-category exhibit predominately infectious changes (I). For descriptive purposes inflammation denotes periosteal reactions while infection denotes osteomyelitis with deformation or destruction of the cortex and/or marrow space as well and the formation of new, pathological bone in these locations.

The most common location of non-specific inflammatory and infectious lesions was the tibia, involved in 21 out of 30 cases (13 inflammatory and 8 infectious). Eleven of these cases involve one tibia; 5 cases involve both tibiae and/or the fibulae; and 5 cases involve all leg bones including both tibiae. Two of the latter five have a systemic distribution. The other cases not involving the tibia involve the following localisations: the skull in 3 cases; the clavicle, scapula, and ribs in 1 case; the humerus and scapula in 1 case, the femur in 2 cases; and the fibula in 2 cases.

Mild inflammatory changes (~Im) were diagnosed by the presence of a thin surface layer of fine periostitis without involvement of the cortex. The differential aetiology of these fine lesions may vary from the idiopathic new bone growth to remnants of a healed inflammatory condition or indications of mechanical stress. In relation the multiple involvement of long bones in children, it has been suggested (Bennike, pers.comm., 1993), that such fine surface periostitis in sub-adults may be a feature of rapid growth during childhood. In adult skeletons, mild periostitis may be related to tendinous or ligamentous development and increased mechanical stress at areas of their insertion; in the case of G-199, mild

periostitis is seen in the interosseous area of the tibiae and fibulae. This may be simply a feature of accommodation of the periosteum to increased ligamentous development between the tibia and fibula. In any event, the aetiology, whether stress or infection related, is decidedly difficult to establish in these marginal cases.

More progressed inflammatory changes (Im) were diagnosed when periosteal new bone deposits appeared more substantial in area of coverage, thickness and integrity with the underlying cortical bone. Plate 53-1 illustrates the surface morphology of this inflammatory bone. The normally smooth dense

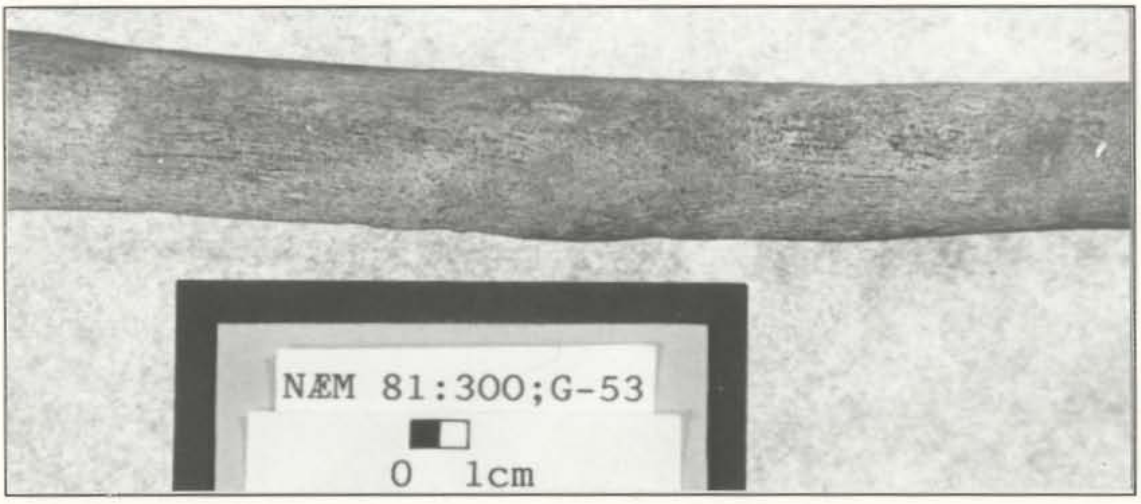

Plate 53-1; G-53
Periostitis: Surface Morphology of Inflammatory Bone. Adolescent male(?) aged 15-19 years. Anterior-medial oblique view of the right tibia at midshaft; close up view illustrating the striated and irregular topography of sub-periosteal bone apposition indicative of a non-specific inflammatory response.

surface of dry bone cortex appears striated and has a raised irregular surface due to the poorly organised structure of new bone apposition sub-periosteally, i.e.

above the cortex. In G-53, the right tibia and fibula exhibited these changes, whereas only slight changes were seen on the left side. The aetiology of these bone changes is thought to be an inflammatory response, which was likely secondary to soft tissue trauma and infection above the bone. G-61 and G-68, mild inflammatory cases involving the tibia, may also have been due to focal soft tissue infections above the bone lesion. G-309, noted as an inflammatory case, has a lesion localised on the left distal tibia which may also be secondary to a focal infection. In this case the shaft is expanded but, since there is no x-ray for this case, involvement of the cortex and marrow cannot be ascertained.

Four other cases of inflammatory lesions which are not exclusively localised to the tibiae are: G-248, involving the medial femoral shafts; G-99 involving the tibiae and fibulae as well as alveolar bone in the skull; and G-79 (Plate 79-1) and G-243, involving all of the leg bones. The aetiology of the lesions in these cases is uncertain. In G-248 there were no lower leg bones recovered so the extent of the condition cannot be established. Yet, in all three cases there are no periosteal lesions on the long bones of the upper limb. Although such non-specific, diffuse periosteal lesions are notoriously difficult to explain in terms of aetiology, there are a number of conditions which, potentially, may result in these type of lesions.

As previously mentioned, the mode of bone involvement secondary to inflammatory infectious processes is by either lymphatic or haematogenous spread from a primary infectious focus or an adjacent soft tissue infection. If the aetiology is infectious, such conditions may include: infected skin lesions due to trauma;

Plate 79-1: G-79
Diffuse Periostitis; Bilateral and Multiple Involvement of Long Bones. Adolescent female? aged 16-20 years. Anterior view of left (top) and right femur at midshaft illustrating bilateral sub-periosteal opposition. The lower leg bones were also affected in this individual.

infected leg ulcers as a complication of such conditions as diabetes; and possible systemic infection, syphilis in particular, which may be localised to the lower limbs. Alternatively, some of the non-infectious inflammatory conditions may include: inflammation due to the irritation and haemorrhaging of vulnerable periosteal connective tissue secondary to scurvy (see Plate 99-3, section 5.1.1.3); trauma or severe mechanical stress directly irritating the bone and its surrounding connective tissues; non-infectious inflammation secondary to conditions of venous congestion and oedema.

The possibility of venous congestion and oedema causing non-specific and diffuse periosteal lesions is particularly interesting in that it is the peripheral appendages, most notably the legs, which may be affected by venous oedema due to heart failure or venous obstruction (Underwood, 1992b:115; Bartlett, pers.comm., 1994). Thus both the skeletal distribution and the appearance of mild to severe tissue oedema and inflammation due to venous congestion may account for the development of diffuse periostitis, i.e. periostitis of the long bones. Oedema is a feature of inflammation. When the periosteum is involved, new bone apposition forms due to the highly vascular periosteum being lifted from the underlying cortex. Bilateral leg oedema, when due to venous oedema is more likely a result of congestive coronary disease than impaired blood flow due to venous obstruction (Underwood, 1992b). However, leg oedema may also be due to lymphatic congestion of inguinal lymph nodes due to infestation with filarial parasites, chronic bacterial infections, trauma or repeated acute infections (Scurr, 1992, Underwood, 1992b). Lastly, a third type of oedema, hypoalbuminaemic oedema in which plasma fluid drainage is impaired, may also involve the lower limbs and can result from a number of underlying disorders ranging from protein malnutrition to liver failure.

In short, lesions of diffuse periostitis are not specific to any one underlying disease and thus aside from considering the aforementioned possibilities a definitive diagnosis is not forthcoming from the dry bone morphological evidence alone. Categorisation of this condition is based on the lesions being representative

of an inflammatory response and since aetiological associations are speculative at best, the inclusion of these conditions into vascular, metabolic or even infectious categories would seem premature.

In a few cases, inflammatory periostitis was not so much irregular as in the aforementioned cases, but instead it occurred as a moderately thick layer forming a substantial coating with good integrity to the cortex. This kind of deposit is seen in the case of G-23, a newborn infant, where the lateral border and spinous process of the scapula, the anterior aspect of the clavicle and the anterior aspect of the ribs are all involved. The multiple bone involvement of the axial skeleton without peripheral long bone involvement would seem to preclude this as a feature of rapid growth, and thus an inflammatory reaction to some irritant is posited. The cause of this inflammatory reaction may relate to such conditions as newborn oedema or congenital infection and in this case, without evidence of fractures, conditions such as battered child syndrome or other traumas would be less likely causes. The non-specific nature of these lesions and their distribution make definitive diagnosis of aetiology problematic.

A similar thick periosteal coating with multiple bone involvement was seen in two other newborn infants, G-230 and G-250. Lesions occurred on the dorsal aspects of the right and left ribs, the posterior aspect of the ilium and the shafts of all long bones present. The thickness and area coverage of the new bone was more severe in the case of G-250 and there was also involvement of the posterior surface of the scapula and the superior surface of the clavicle. Aetiological

considerations for the inflammatory lesions seen in these cases would include the same conditions as those noted above for G-23, yet since the distribution is clearly systemic in these latter two cases and the possibility of a congenital infection may be more readily indicated. In both G-230 and G-250 newborns, tooth buds were present in the mandible, but no anomalies in development where noted. However, this would not preclude a consideration of congenital syphilis infection since it is the secondary dentition that is characteristically affected in late congenital syphilis (Steinbock, 1976). On the contrary, the presence of diffuse periostitis, affecting the diaphyseal portions of the long bones in particular, may be suggestive of the hyperplastic osteoperiostitis due to early congenital syphilis infection (Steinbock, 1976; Ortner and Putschar, 1985). Nevertheless, the lesions in these three newborn infants are not exclusively pathognomonic for any condition and thus are considered indications of non-specific inflammation.

The remaining conditions in the sub-category of non-specific inflammation and infection are those diagnosed as infections. These diagnoses are based on the identification of osteomyelitis, whereby infectious involvement of the bone and marrow is either demonstrated or strongly suspected. In the 11 cases where infection was diagnosed, the majority of cases are localised to one or two bones. Only two cases, G-138 and G-145, demonstrate involvement of more than two bones and in both cases the bones involved are localised to one area of the body. Of the seven cases involving only a single bone and two cases involving just two bones: two cases, G-252 and G-85, are localised to the right femur; three cases, G-

249, G-269 and G-310, are localised to one tibia; two cases, G-202 and G-308, are localised to the skull; one case, G-273, involves the right tibia and fibula; and one case, G-274, involves both tibiae.

In both cases of skull lesions, while the aetiology is uncertain and the lesion appears to be healed, focal infection is believed the most likely cause. Focal infections are also posited in the majority of leg bone involvements. Plate 252-1 clearly illustrates a chronic and severe focal osteomyelitis involving the cortex and marrow space and characteristic features of a chronic infection of bone with the development of a sequestrum and cloaca.

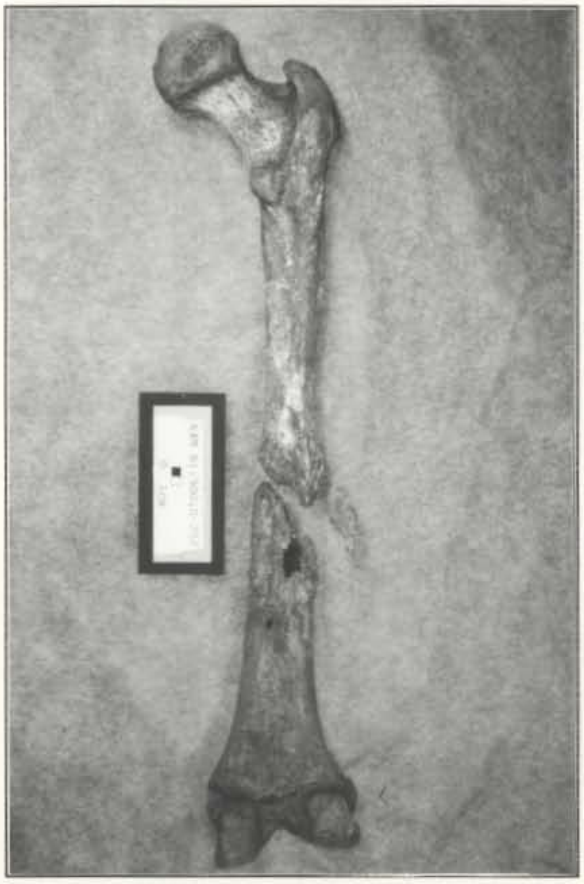

Plate 252-1: G-252
Osteomyelitis; Chronic and Severe Focal Infection; Adult male aged 21-24 years. Posterior view of the right femur showing a severe infection at midshaft. The femur is separated into proximal and distal portions and a sequestrum was found within themarrow space. The separation of the shaft at the focus of the infection may have been the result of a previous unhealed fracture or the result of destruction by the infection itself.

Other less severe focal osteomyelitis cases are illustrated in plates 85-1,273-1 and 310-1 where the appearance of the outer cortex is shown. X-ray for G-273 and G-310 demonstrated cortical and marrow space involvement thus facilitating a diagnosis of osteomyelitis for these cases. Plate 273-1 is an unusual flattened and sclerotic lesion which bears a striking resemblance to a lesion which Ortner and Putschar (1985:fig.182) attribute to ossifying periostitis beneath a skin ulcer.

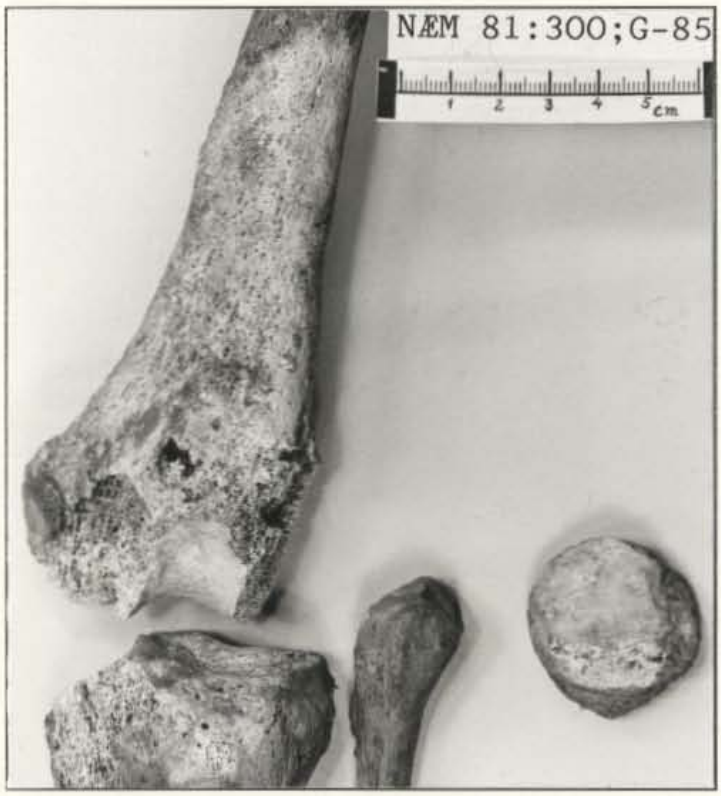

Plate 85-3: G-85
Focal Osteomyelitis; Localized Pyogenic Infection.
Mature adult female aged 35-53 years. Anterior view of the left femur and tibia (lateral view of fibula; posterior view of patella). The irregular sclerotic bone, most apparent on the distal femur, is suggestive of a focal pyogenic osteomyelitis. Venous congestion due to paralysis may have been a predisposing factor to infection in this case.

While there was no x-ray taken for G-85, pyogenic osteomyelitis is strongly suspected as a complication of paralysis in this limb. In G-249 and G-269 healing of a focal infection is posited; expansion of the tibial shaft is apparent in both these cases and x-ray revealed cortical osteosclerosis and mottled healing bone.

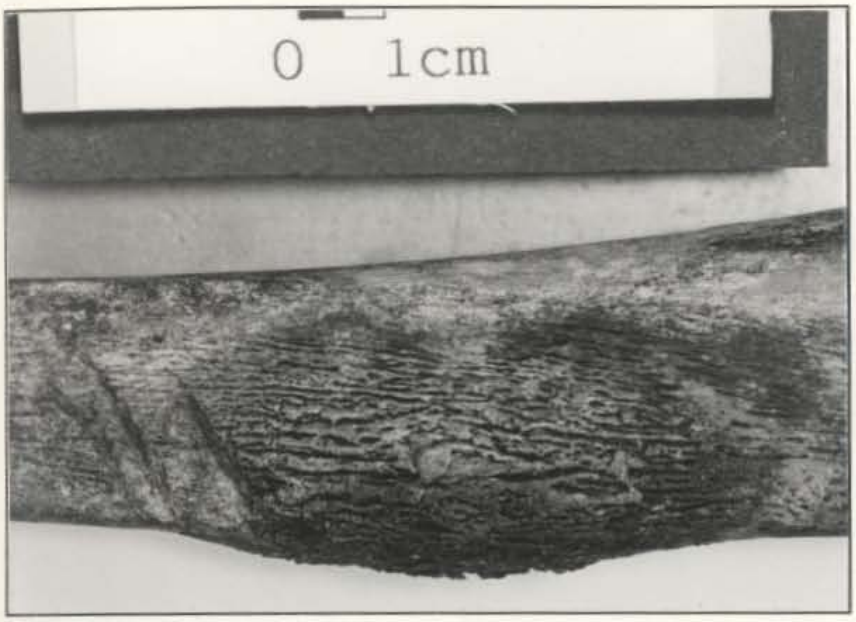

Plate 310-1: G-310
Osteomyelitis; Focal Infection.
Post-Adolescent (full grown) male of undetermined age. Anterior medial view of the right tibia.The raised and striated new bone over the anterior crest at mid-shaft illustrates the surface features of the infection. Marrow involvement was demonstrated by x-ray.

Plate 273-1: G-273
Ossifying Periostitis/Osteomyelitis (?); Localized lesion. Mature adult male aged 47-58 years. Medial view of the right fibula (top) and tibia. Irregular bone development,secondary to a localized infection, may have spread from an overlying skin ulcer. The flattened, roughly circular lesion on the tibia may be a result of ossifying periostitis. X-ray of these bones revealed marrow involvement, indicating osteomyelitis had developed (see Ortner and Putschar, 1985: fig.182).

The lack of necrotic bone in these latter two cases may also indicate a nonsuppurative osteomyelitis where osteoclastic activity is the predominant reaction to infection (Steinbock, 1976).

In G-274, shaft expansion is also the predominant pathological anomaly, yet in addition there is bilateral involvement of the tibiae with some anterior curvature of the shafts (Plate 274-1). X-ray revealed anterior osteosclerosis of the tibiae and a distal medullary bone infarct. Haematogenous osteomyelitis is posited in this case. The source and type of infection could be a non-specific pyogenic osteomyelitis, however, the blunting of the anterior tibial crests and the expansion and bowing of the diaphysis without involvement of the fibulae resemble the appearance of syphilitic sabre shin and thus warrants the consideration of treponemal infection in the differential diagnosis of this case (Steinbock, 1976).

G-138 and G-145 exhibited infectious changes involving several bones. In the case of G-138 there were no bones recovered above the knee, but infectious changes were seen in both tibiae and fibulae. Involvement of substantial portions of all lower leg bones are, by definition, diffuse changes and thus diagnostic considerations must include systemic conditions such as haematogenous osteomyelitis, venous or lymphatic congestion, or specific infection. Other possibilities may include bilateral trauma to the lower legs or metabolic bone disease such as post-cranial scurvy, however, the appearance of these lesions are by no means pathognomonic for these conditions.

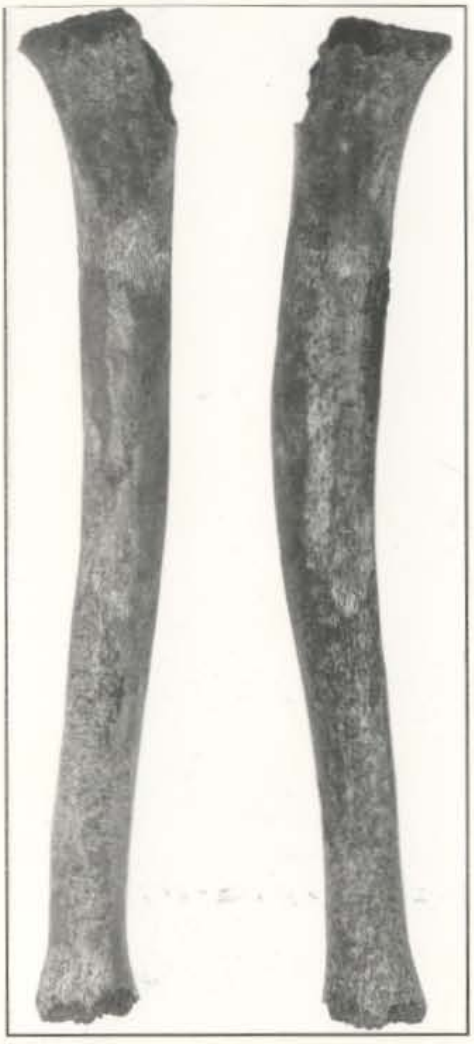

Plate 274-1: G-274
Osteomyelitis; Non-specific Pyogenic Infection. Adolescent of undetermined gender aged 14-18 years. Medial view of the left and right tibia.Shaft expansion and anterior new bone opposition occurs bilaterally but is especially noticeable on the right tibia (to the right). A non-specific pyogenic osteomyelitis may have been the cause of these changes. However, this medial view illustrates anterior bowing of the tibial shafts which bears a likeness to syphilitic "sabre shin".

The bones involved in G-145 include: the left clavicle, scapula and humerus. Infectious changes are believed to be secondary to an amputation of the left arm at the mid-shaft of the humerus. There is irregular reactive bone circumscribing the cut end of the humerus as well as on the lateral border of the scapula and the inferior and superior lateral aspects of the clavicle. The skeleton is missing only a few bones and no other infectious lesions were seen elsewhere. The early progression of the infectious lesions and their localisation around the shoulder and upper arm amputation are likely indicative of infection at the site

of the amputation with haematogenous spread to the scapula and clavicle. This case is discussed further in section 5.1.5.3 with respect to trauma.

It is apparent from these case descriptions that the majority of non-specific inflammatory and infectious conditions of bone in the Helligåndshus collection are localised conditions, many of which affect the tibia or other bones of the legs. The focal inflammations and infections may be related to any one of: soft tissue trauma directly above the bone lesion; venous oedema or congestion; haematogenous osteomyelitis due to remote local infections; systemic infections; or, in the case of mild inflammatory changes, possible non-infectious processes.

Table 5.1.3b shows that more non-specific inflammation and infection was seen in adults than in subadults and in females than in males. In the G-series population this equates to approximately 11% of adults compared to 6% of subadults and 15% of females as compared to 10% of males exhibiting signs of inflammation or infection. Both of these finding are interesting in that in relation to age, it is often found that osteomyelitis is much more common in children than in adults and, in relation to gender, males are most often affected, with great predominance in childhood and adolescence but less differential in adulthood (Steinbock, 1976; Ortner and Putschar, 1985; Grange, 1992a). It is difficult to establish the significance of the Helligåndshus findings because it is not the age of onset of the disease which is seen in a skeletal series, but conversely, it is the maintenance of the chronic disease or signs of the "healed" condition that are seen on dry bone. The greater number of cases of skeletal osteomyelitis in adults may be no more than traces of a disease acquired in childhood but retained as either an active chronic or a healed condition in adulthood.

The gender differential is more difficult to explain. It is often noted that males are more likely to develop osteomyelitis due to physical activity and trauma related to male lifestyle and occupations. The preponderance of osteomyelitis in females in this collection is thus somewhat unusual yet it may be no more than a coincidence or an artefact of error in gender determinations. In any event, the reason for a greater occurrence of osteomyelitis in females is not clear and given the small size of this sample any conclusions would be presumptive.

Aside from age and gender associations for the incidence of non-specific inflammatory and infectious conditions, a few associations to other pathologies appear to be indicated. Infection is believed related to scurvy in G-99; secondary to amputation trauma in G-145; and related to possible venous congestion and/or infarction in G-138, 174 and G-85. The presence of complications is particularly evident in G-85 where a fracture of the femoral neck, post-traumatic paralysis, arthritis, infection and metabolic bone disease all appear to have affected the structural integrity of the diseased limb. Other possibly related diseases occurring with non-specific inflammatory and infectious cases include dental hypoplasia in four individuals; cribra orbitalia in one individual and trauma in at least three individuals.

Although, cribra orbitalia and dental hypoplasia can have some association with infectious conditions, a direct relationship between these conditions is not clear in these cases. However, as previously noted, a direct relationship is indicated between trauma and infection in the case of G-145, where amputation

trauma is believed to have resulted in direct infection of the bone. Trauma should be considered as an aetiological factor in a number of other cases as well. While possibly related bony indications of trauma are only seen in two cases, namely fractures in G-85 and G-138, soft tissue trauma may have directly exposed or otherwise predisposed the bone to infection in many of the other inflammatory and infectious cases. In cases of localised bone infection, many of these involving the tibia which is an area prone to trauma, soft tissue trauma must be considered as a possible aetiological agent.

5.1.3.2 Specific Inflammation and Infection

Conditions of a specific inflammatory and/or infectious nature are those in which there has been a bony response to infection by specific pathogens. These conditions are identified on the basis of lesion morphology and skeletal distribution of lesions which correlate to the natural disease progression of specific pathogens. In the Helligåndshus collection, specific diseases syndromes have been diagnosed as (i) treponemal infection and (ii) respiratory diseases, including tuberculosis and possible brucellosis and actinomycosis. Specific diseases are discussed along with their respective case descriptions below.

5.1.3.2 (i) Treponemal Infection: (Isy)

Treponemal infection can manifest as one of four syndromes, known as: pinta, yaws, non-venereal endemic syphilis (treponarid) and venereal syphilis.

Pinta occurs in the semi-arid, warm climates of Mexico and Central and South America. Yaws is confined to humid, warm climates and is concentrated in the moist tropics of Africa, south-east Asia, the Western Pacific, South America, and the Caribbean. Endemic syphilis primarily occurs in arid, warm climates and is concentrated in the sub-saharan regions of Africa and in south-west Asia, yet historically endemic syphilis occurred in northern climates such as in Scotland, Ireland, Scandinavia, Bosnia and Russia (Steinbock, 1976). Lastly, and in contrast to the tropical treponemes, venereal syphilis is known to occur worldwide and thus has no apparent climate restrictions (Perine et.al., 1984). Given the north-temperate geographic provenience of the Næstved collection, individuals may have contracted one of two types of treponemal infection, namely non-venereal endemic syphilis or venereal (congenital or acquired) syphilis.

Both endemic syphilis and venereal syphilis are a chronic bacterial infections characterised by the development of lesions that may involve any tissue or organ (Woodruff and Wright, 1987). The pathogenic parasite, a spirochaete which has only human hosts, is known as *Treponema pallidum*. Transmission of the parasite in venereal syphilis occurs most often by way of direct contact during sexual intercourse or close physical contact; however, congenital transmission occurs occasionally and rare cases may be contracted from contaminated articles. Endemic syphilis is a non-venereal acquired disease and transmission occurs by way of close physical contact and contaminated articles in crowded and unhygienic living conditions. Perine et.al.(1984) report the overall transmissibility of venereal and endemic (treponarid) syphilis to be high.

The natural progression of acquired venereal syphilis involves three stages, primary, secondary and tertiary. In congenital and non-venereal acquired (endemic) syphilis progression of the disease is marked by early and late stages. In the acquired treponemal infections each progressive stage of the disease follows a period of dormancy and characterised by progressive and more severe organ involvement than its previous stage. However, as many as 65 percent of individuals with acquired venereal syphilis die with no anatomical evidence of the disease and only 10 to 20 percent of individuals from the pre-antibiotic era developed bone lesions (Steinbock, 1976). Yet, where present, skeletal involvement is a result of the late or tertiary stage which develops between 2 and 10 years after the initial infection (Ortner and Putschar, 1985). With few exceptions the skeletal manifestations of syphilis are very similar for venereal, late congenital and endemic forms and thus differentiation of these conditions may not be possible (Hackett, 1976; Anderson et.al., 1986). Nevertheless, differentiation of the former three conditions may be plausible if certain accessory information, such as age of the individual, disease frequency probabilities for the population and specific skeletal manifestations, is decisive (Anderson et.al.,1986).

The case of congenital syphilis differs in that it is an early, severe and often fatal onset of the disease in infants whereby bone lesions are often observed. Skeletal pathology primarily consist of osteochondritis, periostitis and diaphyseal osteomyelitis of a systemic and acute nature. While osteochondritis may not be preserved on dry bone, the latter two conditions can be readily diagnostic both in terms of gross morphology and skeletal distribution (Steinbock, 1976).

The distribution of syphilitic bone lesions is typically systemic and most often bilateral with a great predilection for the tibia, the bones around the nasal cavity and the cranial vault (Ortner and Putschar, 1985). However, any bone in the skeleton can be affected and, in approximate order, those next frequently involved include: the sternum, clavicles, vertebrae, femur, fibula, humerus, ulna and radius (Steinbock, 1976). Lesions are characterised by an excessive osteosclerotic response to infection as the result of either chronic nongranulomatous inflammation or granulomatous processes or, most commonly, a combination of the two processes (Ortner and Putschar, 1985). Hackett (1976; 1980) considers the certain characteristics of the syphilitic bone lesion to be diagnostic and, by his definition, "A diagnostic criterion is a change which occurs in one disease only and in no other." (Hackett, 1980:110). Hackett (1980) presents four developmental sequences of changes, three affecting the cranium and one affecting the long bones, for the recognition of acquired syphilis on dry bone. In the cranium, diagnostic criteria may include one of three degrees of caries sicca, depending on the progression of the infection from initiation (initial series) to discrete active or healed gumma (discrete series) or chronic reactivated and spreading gummas (contiguous series). In the long bones, expansion with superficial cavitation is proposed as the diagnostic criteria for syphilis. A combination of features such as an excessive osteosclerotic response, a lacy or smooth edged stellate scar and a propensity toward involvement of the outer cortex without penetration of the inner cortex, and the lack of typical pyogenic

infectious features, such as cloacae and sequestra, are specific diagnostic characteristics of both the cranial and post-cranial syphilis lesions (Steinbock, 1976; Hackett, 1980; Ortner and Putschar, 1985).

Case Descriptions

In the Helligåndshus collection there is evidence for both congenital and acquired syphilis. A total of eight specific infectious cases are attributed to treponemal infection. This translates to 2.4% of the G-series population. Early congenital syphilis is diagnosed in one case, 0.3% of the G-series, while the remaining seven cases, 2.1% of the G-series, are attributed to late congenital syphilis, venereal syphilis or non-venereal (endemic) syphilis. In actuality, the occurrence of syphilis may have been greater than 2.4% of the study population, for the following reasons: some cases may have been misdiagnosed as non-specific infections or other conditions, due to the absence of diagnostic criteria for syphilis; only 10-20% of clinical syphilis cases manifest on bone (Steinbock, 1976); and finally, due to incomplete preservation, evidence for syphilis may not have been preserved in all cases. In reference to this latter factor, the absence of neurocrania in 203 individuals is particularly discouraging for the diagnosis of treponemal infections.

Early congenital syphilis is diagnosed in one case, G-136, on the basis of generalised systemic periostitis involving essentially every bone of the skeleton except for the vertebral bodies and diaphyseal osteomyelitis in the long bones. In

particular, focal infection on the medial aspects of the proximal tibiae, which is known as Wimberger's sign, is strongly suggestive of congenital syphilis (see Plates 136-1 and 136-2 and refer to Steinbock, 1976:99, fig.36). The presence of osteochondritis is not certain, however, it is possible that radio-density adjacent to a zone of lucency, such as is particularly apparent in the distal humeri, left distal radius, left distal femur and proximal tibia seen in Plate 136-1, is a remnant of this condition. Periostitis with multiple bone involvement is seen in Plate 136-2. Plate 136-3 is a close up of the bones in the left thorax, upper limb and pelvis illustrating " periosteal cloaking", the massive periosteal reaction often associated with syphilitic osteomyelitis of the diaphyses (Steinbock, 1976:99).

In the remaining seven cases for which a diagnosis of syphilis has been put forward, the disease may have occurred as any one of three types: late congenital syphilis, acquired venereal syphilis or acquired non-venereal (endemic) syphilis. Although these three types or modes of initial infection can result in similar, if not identical, pathological changes on the skeleton, differentiation may be plausible where cranial evidence is present. While cranial lesions occur with great frequency in venereal syphilis they are decidedly rare and less diagnostic in non-venereal (endemic) syphilis (Steinbock, 1976; Anderson et.al., 1986). Cranial remains are present in three individuals, G-39, G-76 and G-280 and lytic lesions are present in all three cases. Lytic lesions diagnostic of syphilis occur as gummatous, osteoperiostitis lesions most commonly beginning in the frontal bone where they may spread to the adjacent parietal and facial bones (Ortner and Putschar, 1985).

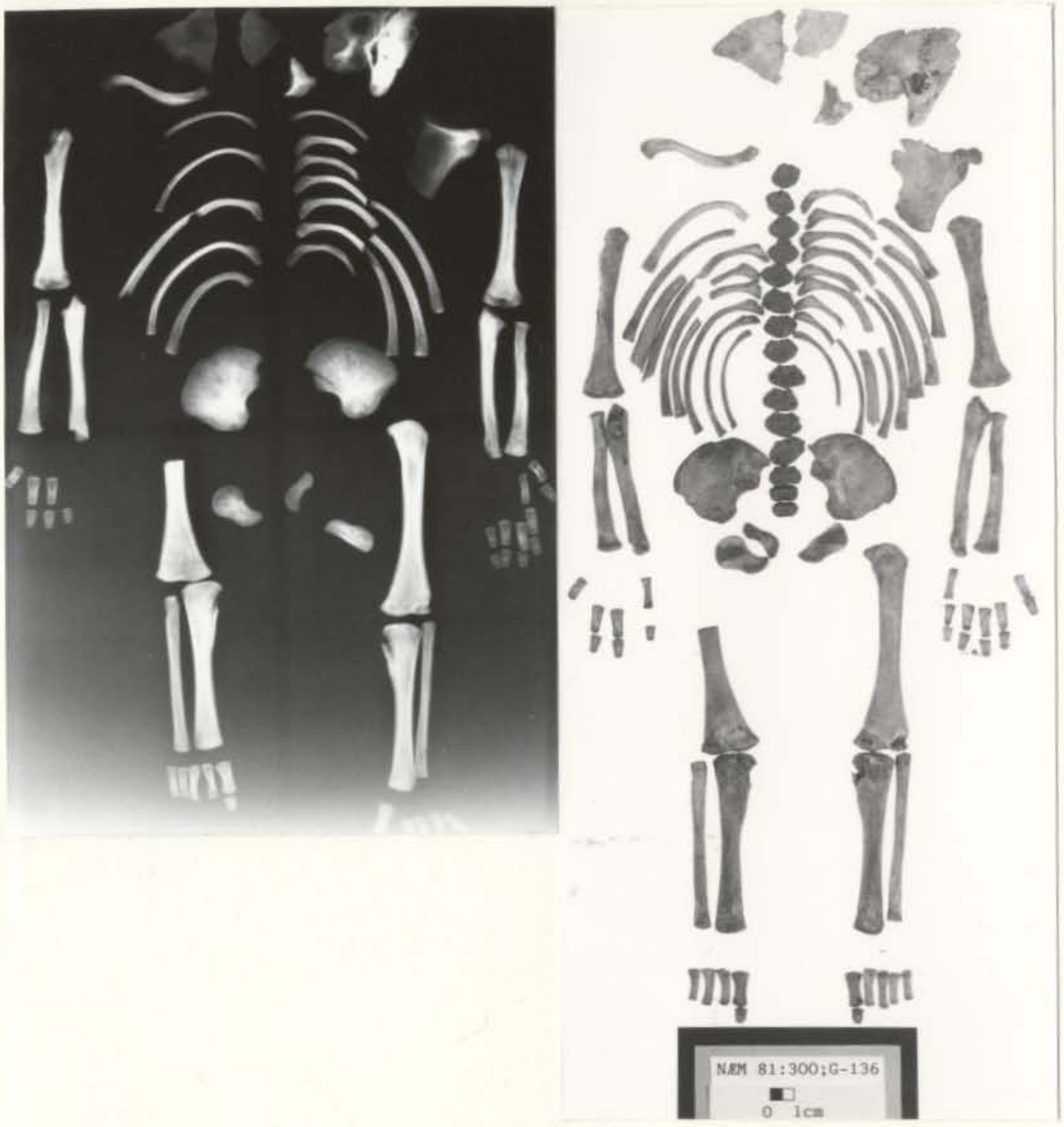

Plate 136-1: G-136 (Left)
Congenital Syphilis; Radiographic Features. Infant approximately 3 months of age. "Exploded" anatomical view of skeletal remains illustrating diffuse periostitis involving all bones and focal osteomyelitis. "Pinched out" areas of bone loss on the medial aspect of the proximal tibia resemble Wimberger's Sign of Congenital Syphilis Osteomyelitis. Radiodensity adjacent to zones of lucency on the distal humerus, left distal radius, left distal femur and proximal tibia may be indicative of infantile syphilitic osteochondritis.

Plate 136-2: G-136 (Right)
Congenital Syphilis; Multiple Bone Involvement. "Exploded" anatomical view (skull in pieces). Periosteal thickening is present on all bones except the vertebral bodies. New bone is thickest on the long bones where inflammatory response is accompanied by focal osteomyelitis. Note "pinched out" areas on the medial aspect of the proximal tibia and small cloacae on the long bone shafts.

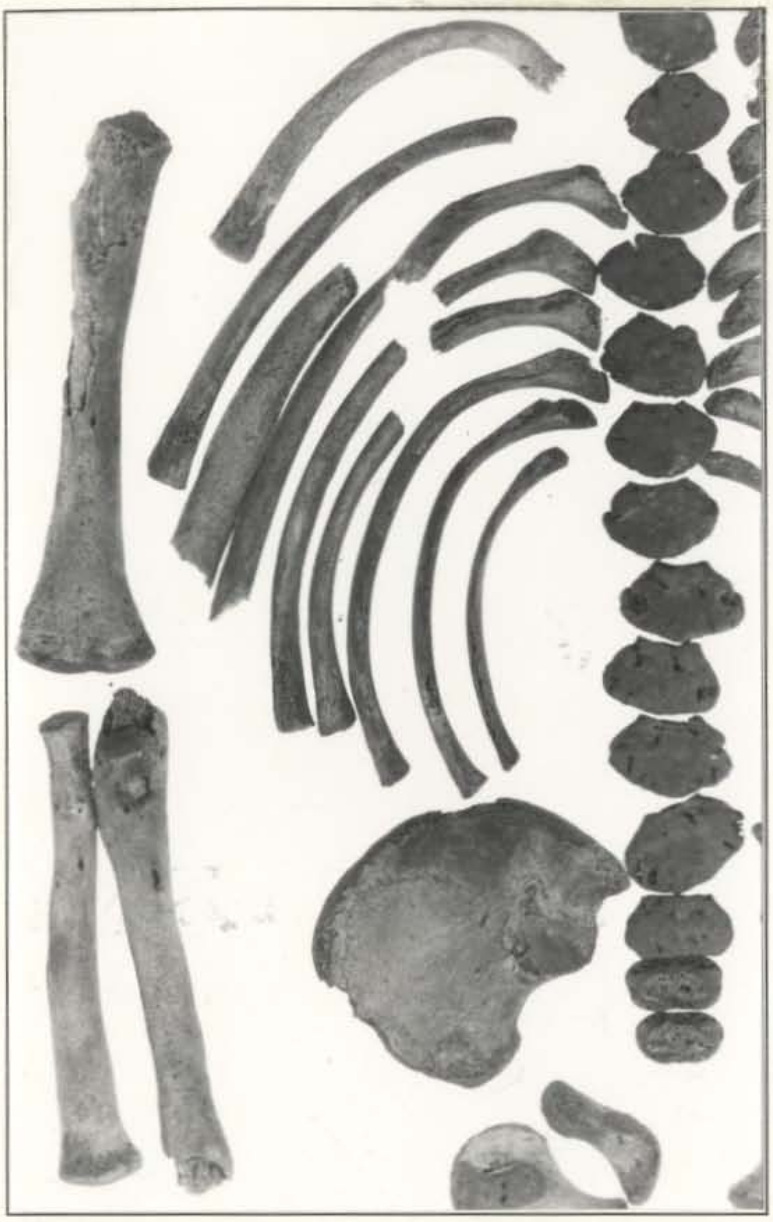

Plate 136-3: G-136
Congenital Syphilis; Periosteal Cloaking.
Close up "exploded" anatomical view. Periosteal apposition is seen to be closely attached to the underlying cortical bone; a feature described as "periosteal cloaking".

In the face the zygoma, the nasal bones, the hard palate, the maxillary sinus and the medial orbital walls may all become involved by direct extension from infection of the frontal bone (*ibid.*). In G-39 both the gross morphology and the localisation of lesions is in accordance with a diagnosis of cranial syphilis. Plate 39-1 and Fig. 5.2 illustrate the cranio-facial lesions which have been characterised,

using Hackett's (1976; 1980) terminology, as clustered pits and confluent clustered pits of the initial series and focal superficial cavitation of the discrete series.

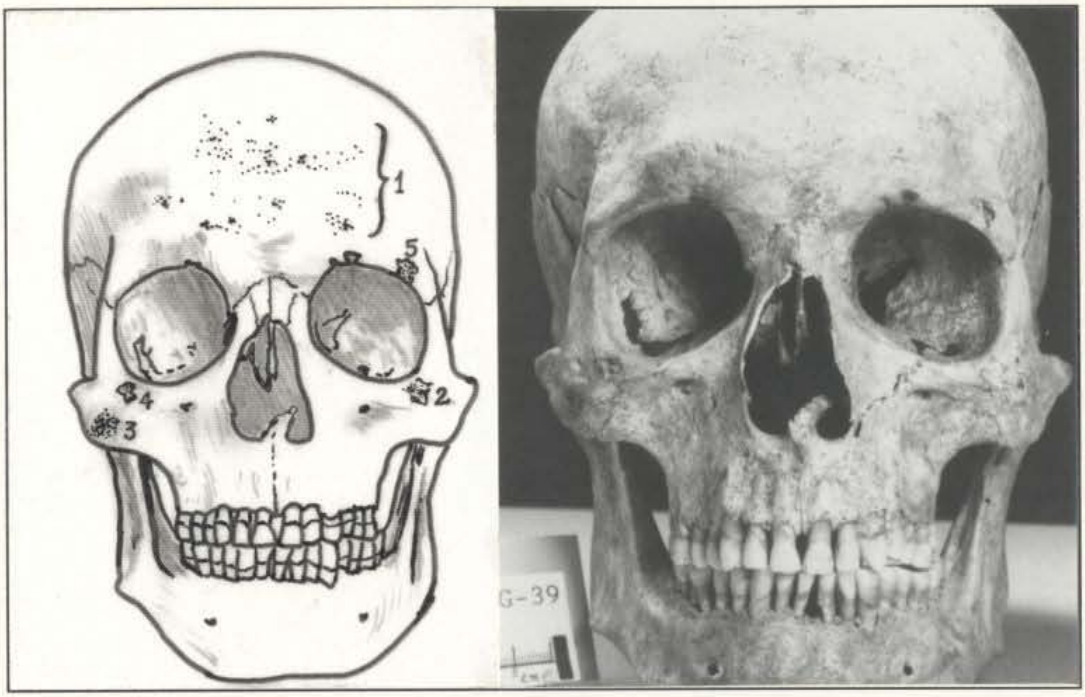

Figure 5.2: G-39 (Left)
Schematic Illustration of Cranio-facial Lesion Types. Numbers indicate the following active lesion characterisations using Hackett's (1976, 1980) terminology: **Initial Series**; 1 - clustered pits, 2 and 3 - confluent clustered pits. **Discrete Series:** 4 and 5 - focal superficial cavitation.

Plate 39-1: G-39 (Right)
Venereal Syphilis: Cranio-Facial Lesions. Adult male aged 30-44 years. Frontal view illustrating the distribution, surface morphology and margin characteristics of cranio-facial lesions due to Venereal Syphilis infection. Lesions are in various stages of active infection and/or healing. See figure 5.9 (on the right) for a schematic illustration of these lesions.

The involvement of the nasal bone is difficult to establish due to post-mortem damage and although the facial lesions are not localised in the areas of most frequent involvement, i.e. peri-nasally, their necrotic centres and lacy sclerotic edges agree with the diagnostic criteria of syphilitic lesions.

In G-76 there is generalised fine porosity over most of the cranium with multiple necrotic lesions located on the parietals, on the frontal bone above the right orbit and on the zygoma. Porosity is confluent around the larger necrotic lesions and lesion margins are superficial focal cavitations of the discrete series with smooth, sclerotic healing margins. While the nasal area and the left frontal/orbital region is missing, both the location and character of the lesions present are diagnostic of cranial syphilis.

The skull of G-280 is incomplete; the orbital, supra-orbital frontal bone, nasal, maxillary and proximal zygoma are missing, however, most of the calvarium is present. Necrotic lesions and confluent clustered pits of the discrete series are located on the frontal and parietal bones. Again the character and distribution of these lesions are suggestive of cranial syphilis.

In each of the above cases, post-cranial lesions are also present and of a character akin to treponemal infection. The skeletal distribution of post-cranial lesions in G-39 and G-76 is in accordance with the frequent locations of venereal syphilis lesions (see Steinbock, 1976:114). In G-39 the clavicle, left distal humerus, radii, ulnae, metacarpals and phalanges of the hands, tibiae and fibula are involved. In G-76 the left distal clavicle, left scapular acromion, left distal femur, the tibiae and the fibulae are involved.

In G-280, the distribution of post-cranial lesions is also characteristic of venereal syphilis with lesions occurring on the right clavicle and scapula, the distal right humerus, the radii and ulnae, the right femur, and the tibiae and

fibulae (Plate 280-1). Bilateral involvement of many bones can not be ascertained since many bones from the left side of the body were either broken or not recovered. There are also lesions localised in atypical areas, including: a large

Plate 280-1: G-280 **Treponemal Infection; Multiple Bone Involvement.** Adolescent female aged 16-20 years. Left to right: anterior view of the right humerus, radius and ulna, right clavicle (inferior portion broken away), right clavicle (with pathological and post-mortem damage), right femur; mandible, two ribs, right fibula and tibia, left tibia and fibula, left distal ulna and radius. Post-mortem damage has occurred, however both shaft expansion and focal osteomyelitis suggestive of treponemal infection are present on all bones.

sinus-like necrotic lesion in the mental eminence (Plate 280-2) and a large lytic lesion separating one of the right ribs into two parts just proximal to its angle

(Plate 280-3). While the mandible and ribs are not frequent sites of syphilitic bone lesions, their involvement has been observed in acquired syphilis (Steinbock, 1976:112).

Plate 280-2: G-280
Treponemal Infection; Facial Lesion. Inferior oblique view of the mandible illustrating a large sinus-like necrotic lesion in the mental eminence.

In any case, one factor in this case conflicts with a diagnosis of venereal syphilis, that being the adolescent age of the individual. The age of G-280 is estimated between 16 and 20 years and thus it is somewhat questionable whether venereal syphilis would have been acquired then incubated to the tertiary stage in this individual. Alternative diagnoses in this case include late congenital syphilis or endemic syphilis. Differential diagnosis between these latter two conditions is difficult owing both to the similarity of bone lesions and the poor preservation of the skeleton (Plate 280-1). There are no dental stigmata to support a diagnosis of congenital syphilis (maxillary incisors are the most frequently involved) and the fusiform osteoperiostitis combined with gummatous osteomyelitis is typical of both conditions. However, a diagnosis of either venereal

or late congenital syphilis is believed most likely on at least two counts: first, cranial involvement is very rare in endemic syphilis and when present it consists of localised osteitis unlike the multiple destructive lesions which often characterise venereal or congenital syphilis (Steinbock, 1976; Anderson et.al., 1986); and second, joint lesions are rare in endemic syphilis, while involvement of at least one joint, the right elbow, is present in this case (Plate 280-4).

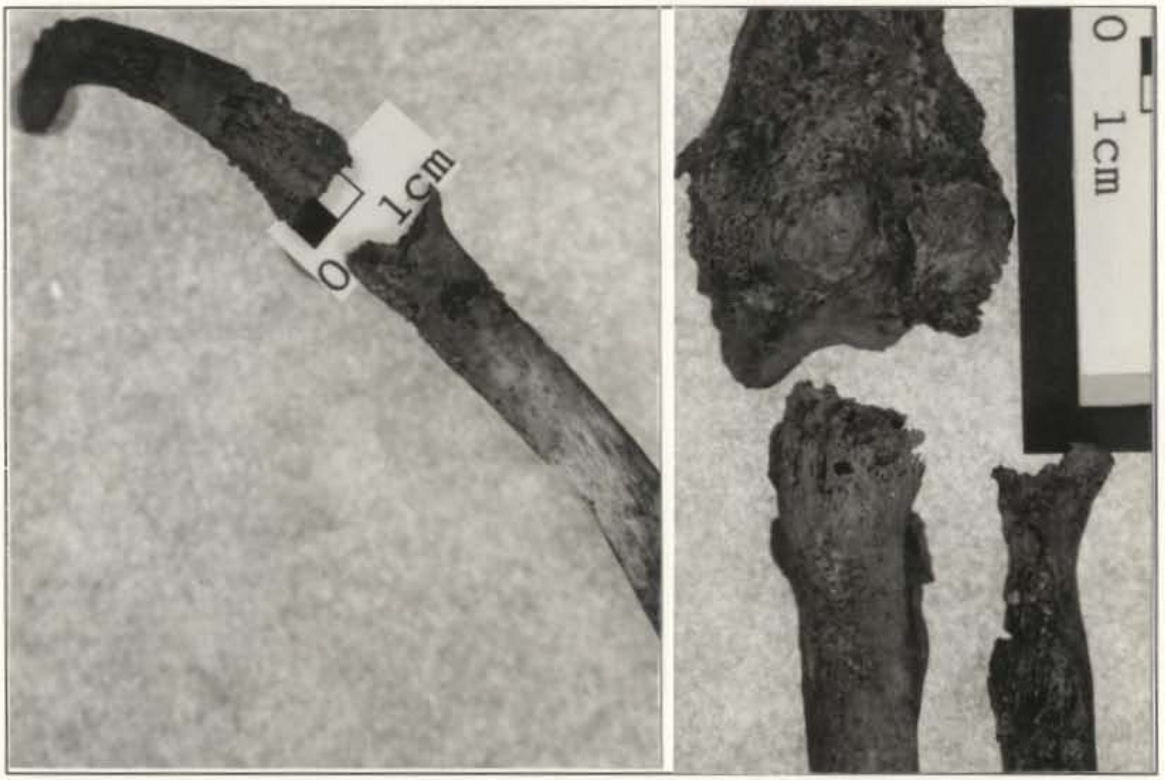

Plate 280-3: G-280 (Left)
Treponemal Infection; Rib Lesion. Dorsal aspect, right rib. A large necrotic lesion has resulted in a pathological "fracture" of the rib shaft.

Plate 280-4: G-280 (Right)
Treponemal Infection; Lesions Adjacent to a Joint. Posterior view of the right humerus, ulna and radius. Some post-mortem damage has occurred at the terminal ends of these long bones. Lytic and sclerotic lesions are present on all these bones adjacent to the joint.

In the remaining four cases of suspected treponemal disease, G-186, G-223, G-227, G-313, there are no neurocrania, however, two individuals have mandibles present. Lesions are only observed on the post-cranial remains. However, in G-186 only the bones of the left pelvis and lower limb and the bones of the right lower leg are present. Pathology consists of massive shaft expansion and gummatous osteoperiostitis of the leg bones and osteitis of the posterior ilium (Plates 186-1; 186-2). This is characterised as the "expansion with superficial cavitation" which is considered a diagnostic criterion of syphilis in long bones (Hackett, 1980:113). Although sclerosing osteomyelitis and periostitis of non-specific aetiology cannot be precluded in this case, the bilateral and multiple bone involvement as well as the lack of sequestra and cloaca suggest syphilis is a more likely diagnosis. Post-cranial lesions in the case of G-313 are also characterised by shaft expansion and superficial cavitation, but the sclerotic response is much less massive than in the case of G-186. Plate 313-1 illustrates the irregular surface of the bones and the concomitant loss of normal shaft shape due to diaphyseal expansion. Differential diagnosis must include non-specific infection but, again, the bilateral and multiple bone involvement and lack of cloacae and sequestra are more characteristic of syphilitic infection.

Lastly the cases of G-223 and G-227 are quite similar in terms of the gross morphology of lesions and the bones involved. For both individuals, the lesions were observed in the following bones: the clavicle, scapula, humerus, radius, ulna, femur, tibia and fibula (Plate 227-1; 227-2). Bilateral involvement occurs in G-223,

Plate 186-1 (Left) and Plate 186-2 (Right)
Treponemal Infection; Gummatous Osteoperiostitis. Adult female aged 30-44 years. Anterior view of innominate and long bones. The predominant pathological feature is shaft expansion and course irregular surface pitting described as "superficial cavitation", a diagnostic feature of syphilis in long bones (Hackett, 1980:113).

Plate 313-1; G-313
Treponemal Infection; Multiple Bone Involvement. Adult female aged 32-42 years. Posterior view of the left femur, scapula and clavicle; left and right tibia and fibulae; and the right humerus, radius and ulna. Shaft expansion and superficial cavitation are the dominant pathological features.

but in G-227 this can not be ascertained since none of the bones from the left side of the body were recovered. In addition to those bones mentioned, there is involvement of the sternum and several ribs in G-227. Lesions are characterised as mild shaft expansions with superficial cavitation typical of syphilitic gummatous osteoperiostitis and osteomyelitis. Although venereal syphilis is likely given this geographic area, endemic syphilis was also known in Scandinavia (Anderson et.al., 1986) and should also be considered in these cases. The argument for a non-venereal aetiology is based on the significance of the skeletal

distribution of lesions. The involvement of the diaphysis of the humerus and the femur are much more common in yaws, which endemic syphilis mimics in relative frequency of bone involvement, than in venereal syphilis. These areas are involved bilaterally in G-223 and, at least, unilaterally in G-227. While skeletal distribution is not exclusively diagnostic of one aetiology or the other, it is at least reasonable to consider the possibility of an endemic aetiology in these two cases.

Plate 227-1: G-227
Treponemal Infection, Multiple Bone Involement;
Mature adult female? aged 36-45 years. Anterior view of the long bones. Right to left are: the right radius, humerus, ulna, femur, fibula and tibia. Pathological features include shaft expansion, superficial cavitation and pathological fracture (distal ulna).

In any event, without cranial evidence a differential diagnosis of venereal versus endemic syphilis can not be secured. In the differential diagnosis of syphilis the following conditions should be considered: non-specific haematogenous osteomyelitis, tuberculosis infection, metastatic carcinoma, and other miscellaneous rare conditions such as the hereditary anaemias and Paget's disease (Steinbock 1976:137). However, in the above cases, multiple and often bilateral

Plate 227-2: G-227 **Treponemal Infection; Pathological Fracture.** Superior view of the right clavicle. Lytic lesions have resulted in extensive destruction and alteration of the normal bone structure.

bone involvement and, most importantly,the presence of diagnostic criteria for syphilis render all of these alternate diagnoses less likely than a diagnosis of osseous syphilis (Steinbock, 1976; Hackett, 1980; Ortner and Putschar, 1985; Anderson et.al, 1986).

In relation to demographic factors, the majority of the cases were diagnosed in female adults. Six adults, one adolescent (juvenile) and one infant were all

affected and five out of six adults were determined to be females. The age groups affected substantiate the existence of at least two forms of syphilis, i.e. congenital and venereal. The youngest age groups affected by syphilis are the newborns and infants under one year who may develop the severe form of congenital syphilis which either proves fatal in infancy or goes dormant beyond early infancy. Those ages next affected by treponemal infections are children and juveniles between 5 and 15 years of age who may develop late congenital syphilis or acquired non-venereal (endemic) syphilis. In adulthood, the late childhood diseases may continue their chronic course or primary treponemal disease may be acquired in the venereal form. With the maintenance of chronic childhood disease and the development of chronic venereal disease both occurring in adulthood, it is not surprising that the greatest number of cases involve adults.

Although the overall number of those affected is small, the higher incidence of female cases is puzzling. Increased incidence of syphilis, the venereal form in particular, is associated with high risk behaviour, i.e. sexual promiscuity, which tends to be more prevalent among males than females (Blount and Holmes, 1976; Perine et.al., 1984). An explanation for the opposite gender preference in the Næstved collection must firstly be attributed to the demographic and social context of the research "population" itself. Since the collection was excavated from a cemetery where the burial population is a not a cross section of the urban community but merely a reflection of those in the lower social class who were in need of charity and healthcare, prevalence rates for population norms are not

directly translatable. A greater number of female cases may have more to do with the charitable needs of female syphilis victims than with any biological predilection for females.

Disease associations within the category of treponemal infections include two cases of pathological fractures and two cases of dental hypoplasia which are probably unrelated to the infectious condition. In G-76 a healed fracture of the left distal clavicle appears in direct association to gummatous osteomyelitis. The distal angle is improperly healed at an angle approximating 90°. Fracture is believed to have occurred as a result of pathological weakening of the bone at a site where mechanical stress, attachment of the deltoid muscle and the coracoclavicular ligament, put great demands on the structural integrity of the clavicle. The second case of pathological fracture was seen in G-227, where a healed fracture of the right distal ulna (Plate 227-1) also appears in direct association to gummatous osteomyelitis of the bone.

Dental hypoplasia occurs in G-76 and G-223 but there is not likely any relationship to the infectious condition since dental defects would have developed in early childhood, most likely long before the onset of treponemal infection.

5.1.3.2 (ii) Respiratory Infections: Tuberculosis I(tb); Actinomycosis (ImIrib)

Osseous changes are attributed to respiratory infections in five individuals. Two cases, G-170 and G-177, exhibit a number of diagnostic criteria for tuberculosis. The three other cases, G-16, G-72, G-129, are not diagnostic of

tuberculosis; however the disease should be considered as a differential diagnosis in these cases as well. One additional case, G-194, is included in this section as a possible infection of a respiratory nature. Although no rib lesions were observed on the partially recovered skeleton, large abscess-like lesions of the lumbar vertebrae are suggestive of tuberculosis or another chronic respiratory infection.

The primary evidence for respiratory infection in all but G-194 were rib lesions, the nature of which varied from purely osteoblastic to osteolytic or a combination of both in different individuals. Rib lesions have been the subject of much speculation in recent years (Kelley and Micozzi, 1984; Pfeiffer, 1991; Wakely et.al., 1991; Roberts et.al., 1994). The general consensus of these articles is that rib lesions are suggestive of a respiratory infection. Ng et.al.(1992) find that rib lesions, including rib erosion and osteomyelitis, have been under evaluated in clinical medicine due to poor detection in radiography. Recent use of bone window displays with computed tomography (CT) scans is now enabling the detection of even mild bone involvements. The observations of palaeopathology may now find increased correspondence and support from clinical medicine in terms of previously undetected subtle bone involvements with chronic respiratory disease.

Although a great number of respiratory infections may result in inflammation of the parietal pleura, a number of authors contend that tuberculosis is the major cause of rib lesions (Kelley and Micozzi, 1984; Wakely et.al.,1991; Roberts et.al.,1994). However, while these authors argue for the diagnostic efficacy

of rib periostitis in relation to tuberculosis, Pfeiffer (1991) cautions that a generalised pattern of rib periostitis is not pathognomonic for tuberculosis. Alternatively, Pfeiffer (1991) concludes that rib periostitis may reflect an inflammation of the parietal pleura secondary to traumatic rupture, fluid accumulation or fibrinous pleuritis and, at present, the only conclusion that is justified is "...to interpret the frequency of rib lesions as a non-specific indicator of chronic respiratory disease stress within a population." (*ibid.*:197). Thus, a differential diagnosis of respiratory infections must rely on the full pattern of osseous manifestation. Diffuse periostitis of the ribs is interpreted herein as an indication of respiratory disease stress. Beyond this, the diagnosis of specific infections is based upon distribution and character of rib lesions in combination with diagnostic post-cranial changes, such as Pott's disease of the spine in tuberculosis. In any event, a differential diagnosis of any respiratory infection must include tuberculosis as it remains a major cause of chronic respiratory disease.

Tuberculosis (Itb)

Tuberculosis is termed the "prototypic" granulomatous infective disease of humans (El-Najjar, 1981). It is a disease which may take either an acute or, more commonly, a chronic course. The most common causative agent of human tuberculosis today is M.*tuberculosis*. Infection is less commonly due to M.*bovis*, however this may have been different in the past (N.T.and R.D.A., 1969; Hare,

1967). Tubercle bacilli grow best in tissues of high oxygen concentration, optimally at a partial pressure of 140 mm Hg equivalent (Moulding, 1988). Therefore blood-rich tissues, such as lung tissue, are the most prone to the development of primary infection.

The usual route of infection is through the respiratory tract and transmission is characteristically of the droplet type. The bacillus-containing droplet leaves the respiratory tract of the host and is carried, airborne, to the respiratory tract of the person to be infected (Bates, 1984). A less common mode of infection is that of gastrointestinal ingestion of the bacilli. This latter mode of transmission is thought to have been most common for infection by M.*bovis*, especially in the case of young infants drinking infected cow's milk (*ibid.*). Although the primary sites of human and bovine type infection most often differ according to the route of entry, all tubercular bacilli have the ability to disseminate widely in tissues of high oxygen content so that the primary site of infection can not be differentiated. Consequently, the granulomatous reaction and immune response are generally the same for the bovine and human strains of the pathogen.

The pathogenesis of tuberculosis is a prolonged process characterized by two bacillary proliferation stages, namely: primary infection and post-dormancy reactivation, which may range from two years to several decades in duration. The disease may truncate at the primary stage with complete resolution, yet with the maintenance of immunity due the activation of cell-mediated-immunity (CMI)

upon infection. In this case, the host will be left healthy and, furthermore, immune to tuberculosis and to some degree to other mycobacterial infections (Manchester, 1991). On the other hand, the disease may not resolve at the primary stage and the primary infection may progress and become reactivated as a "...disseminated, fulminating and fatal disease with distant organ involvement or miliary lesions" (*ibid.*:26). It is in the latter chronic phase of the disease that the skeleton may be affected. The ultimate course of tuberculosis, like that of other infectious diseases, is dependant on a multiplicity of factors related to the susceptibility of the host, the virulence of the pathogen and the contribution of social and/or environmental factors (Middlebrook, 1956).

Case Descriptions

Skeletal tuberculosis was diagnosed in two individuals, or 0.6% of the G-series. In a number of other cases, tuberculosis infection is suggested as a differential diagnosis. The two diagnostic cases of tuberculosis, namely G-170 and G-177, show similar and typical manifestations of the disease. In G-170 there are lytic and sclerotic lesions involving the right distal inferior clavicle, left ribs, vertebrae, sacrum and left ilium. Vertebral involvement is extensive and characteristic of tuberculosis Pott's disease. Vertebral segments T5 through L5 exhibit progressive and coalescing porosities with adjacent and encircling osteosclerosis (Plate 170-1 and 170-2). A lytic lesion, approximately 1 cm in diameter, occurs in left anterior aspect of T9 and extensive destruction of the

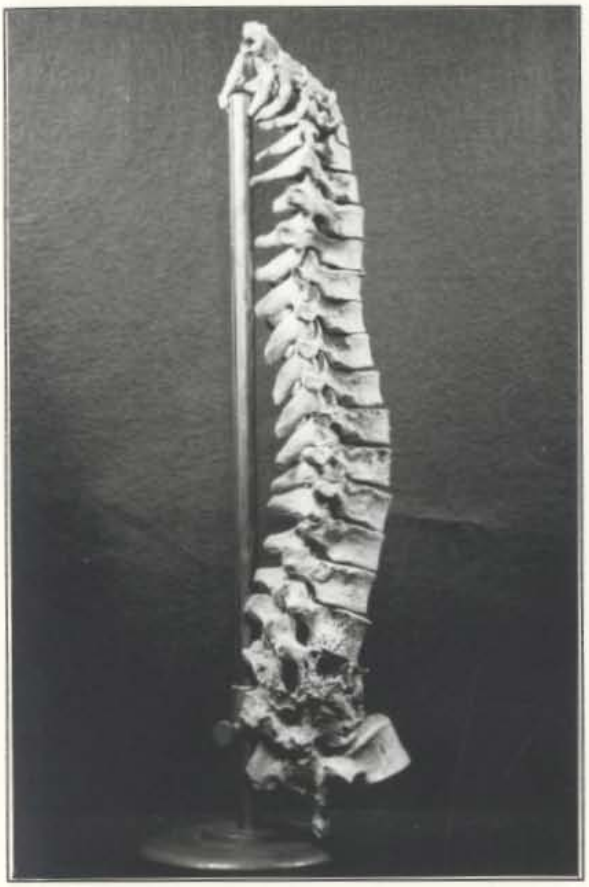

Plate 170-1: G-170
Tuberculosis; Pott's Disease of the Spine. Adult female aged 32-45 years. Right lateral view of the spine demonstrating lytic and sclerotic lesions (T5 through L5) and collapse of vertebral bodies L2 through L4.

anterior bodies of L2-L4 has resulted in their complete collapse. The fifth lumbar vertebra has not collapsed, however, a large abscess is present in the left side of the corpus. Involvement of the left ilium in the region of the posterior blade and around the sacro-iliac joint appears to be an extension of lumbar involvement. The sacrum is also involved and seems to have been the seat of a large abscess, which conceivably held drainage from the vertebral infection. The left ribs show the

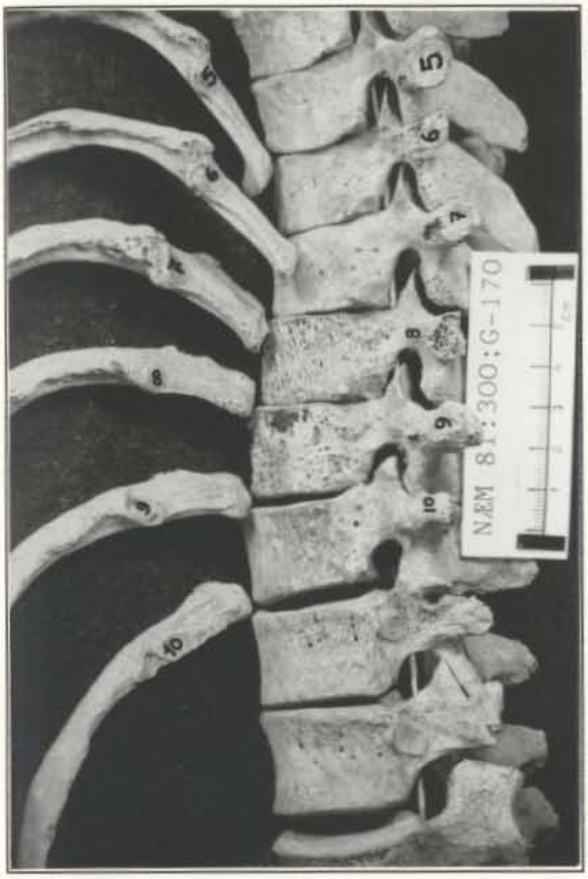

Plate 170-2: G-170
Tuberculosis; Vertebral and Rib Lesions. Close up inferior view of the left ribs (5-10) and left lateral view of vertebra T4 through L1. Coalescing porosities with sclerotic margins are present in the vertebral bodies. Involvement of the adjacent ribs is illustrated by the inferior view. In anatomical position areas of greatest involvement on the spine would have corresponded to the most severe rib involvement, indicating a mid-lobe lung abscess.

same lytic lesions with sclerotic emargination as do their adjacently affected vertebrae. Rib lesions are localised in the head and neck region (Plate 170-2). Generalised rib periostitis is not present in this case. However, this is not surprising in light of Pfeiffer's (1991) contention that the only lesions which are potentially diagnostic of tuberculosis infection are the resorptive type lesions that correspond to paravertebral involvement.

The pathogenesis of tuberculosis infection in G-170 likely involved a primary aspiration infection of the left lung, followed by the development of a large abscess in the lung and spread of the infection by direct extension to the underlying rib and vertebral tissues. With the progression of the infection in the thoracic cavity the purulent products likely drained downward to involve the lumbar, sacral and pelvic areas.

The second case of tuberculosis, G-177, is less readily diagnostic due to the influence of post-mortem damage on the skeleton, yet several changes support the diagnosis. Pathological changes include: lytic and sclerotic rib lesions and plaque-like deposits; lytic and sclerotic lesions of the transverse and corporal rib facets on numerous thoracic vertebrae; sclerotic lesions on poorly preserved fragments of vertebral segments T4 through L4 and a large calcarious accretion found in association with the skeleton (Plates 177-1 and 177-2). One seemingly unrelated anomaly of unknown diagnosis is an endocranial cribrotic quality of the cortex as well as a rather thick dense quality of the cranial bone and delayed suture closure despite the mature age of this adult. A diagnosis of tuberculosis is posited on the basis of lytic sclerotic lesions on the ribs and vertebrae at the costal-vertebral articulations; porosities with emarginating osteosclerosis on preserved vertebral bodies; and calcified sclerotic plagues on several ribs.

Diffuse periostitis of the ribs was not observed in this case and thus lesions on the ribs are more likely an indication of bacillary action by direct extension of the infection as opposed to a diffuse inflammatory response. Pathogenesis of the

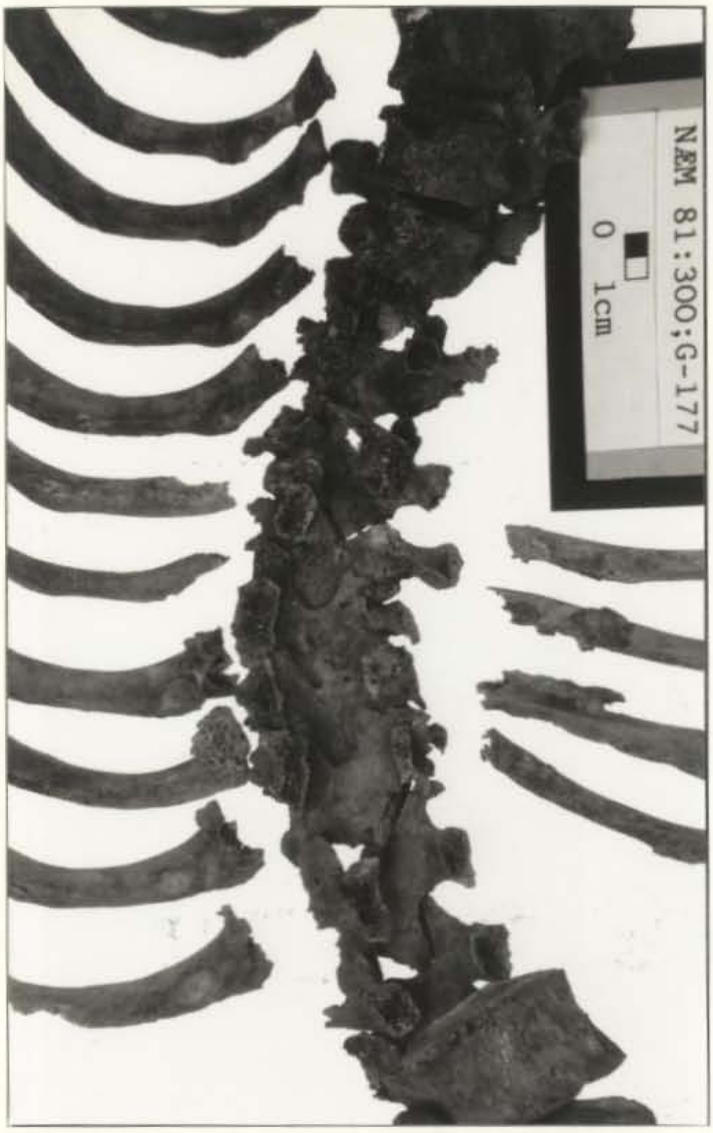

Plate 177-1: G-177
Tuberculosis; Thoracic Lesions. Mature adult of indeterminate gender, aged 43-63 years. Close up ventral view of the thoracic spine and ribs. Post-mortem damage is extensive, however this close up illustrates porosity and osteosclerosis on the proximal ribs as well as on the remnants of the adjacent thoracic vertebrae (note: vertebral segments were assembled in place for the photograph).

disease in this case is believed to be similar to that of G-170, where primary infection of the lung has lead to the development of chronic granulomatous disease and haematogenous metastases to adjacent bony tissues in the chest wall and vertebral column.

Tuberculosis infection is a possibility in a number of other cases as well; however, in the absence of diagnostic criteria these cases remain uncertain.

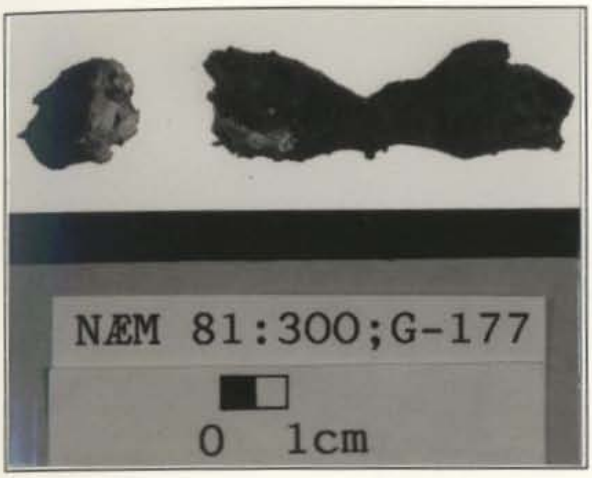

Plate 177-2: G-177
Tuberculosis; Pleural Mass?
This calcareous accretion was found in the storage box with the skeleton of G-177. While the origin, endogenous or foreign, is not known, the possibility of a pleural mass due to tuberculosis infection is considered.

Categorised within this section on respiratory infections G-16, G-72, G-129 and G-194 are cases where tuberculosis should be considered. The first three cases exhibit rib lesions suggestive of respiratory disease while the last case, G-194, has lytic lesions which may be seen in tuberculosis infection of the vertebral bodies. None of the pathological changes observed are exclusively diagnostic of tuberculosis. While tuberculosis is regarded as by far the most common cause of rib lesions due to inflammatory disease, the three aforementioned rib involvements are atypical of tuberculosis in both the character of rib lesions and the location and character of post-cranial lesions which occur concurrently in these cases. For this reason. these three cases will be presented under the category of "other" respiratory infections. Actinomycosis infection is of particular interest as a diagnosis in these cases but a variety of other chronic and recurring acute conditions including tuberculosis cannot be dismissed.

In regard to G-194, vertebral lesions seen in this case are analogous to the circumferential, paradiscal and central cavitations (Kelley and El-Najjar, 1980)

which occur as a result of spinal tuberculosis (Plate 194-1 a and b). However, a number of other conditions such as secondary malignant neoplasms, non-specific pyogenic infection, brucellosis, actinomycosis and fungal diseases may produce lesions of an identical appearance (*ibid.*; Ortner and Putschar, 1985).

Plate 194-1a and b (top and bottom): G-194. **Tuberculosis Infection?;** Vertebra Abscesses. Adult female aged 20-30+- years. A) Anterior view of vertebral segments L1 through L5 illustrating porosity with sclerotic margins and a large abscessing on the right anterior-lateral body of L3. B) Close up view of vertebral body abscesses; inferior L3 (left) and superior L4 (right), illustrating osteolysis with marginal osteosclerosis.

Differential diagnosis is based upon a consideration of disease pathogenesis with regards lesion distribution and lesion combinations throughout the body as well as epidemiological characteristics. The former consideration is believed by Kelley and El-Najjar (1980) to be useful for establishing a diagnosis of tuberculosis; such lesion combinations as spine-rib, spine-rib-sternum and spine-hip are believed characteristic of tuberculosis pathogenesis and may provide grounds for the elimination of all or most other possible aetiologies. The latter consideration of epidemiological variables such as age of onset and geographic range among other variables may provide support for certain diagnoses while providing grounds for the exclusion of certain others.

In the case of G-194, the bone altering fungal diseases are an unlikely possibility since none are indigenous to the area concerned. Non-specific pyogenic infection is unlikely due to the lack of characteristic bony changes such as a profuse osteoblastic response and the formation of cloaca and sequestra. Secondary malignant neoplasm, while a possible aetiology, is unlikely given the young adult age of this individual; the predominant carcinomas which metastasize to the skeleton rarely develop before the fifth decade (Kelley and El-Najjar, 1980). The remaining possibilities include the bacterial infections, tuberculosis, brucellosis and actinomycosis. Actinomycosis is probably the least likely of the three in that bones lesions are usually the result of direct extension from a soft tissue abscess, typically resulting a combination of periosteal inflammation and superficial erosive cavitations (Ortner and Putschar, 1985). A differentiation between

tuberculosis and brucellosis can not be made on the grounds of lesion form, lesion site or age, gender and geographic predilections. The only grounds for differentiation, albeit tenuous, is the greater prevalence of tuberculosis infections over brucellosis infections and thus the greater probability of tuberculosis as an aetiological agent for this lesion type in a given skeletal series. .

In any event the number of those actually affected by tuberculosis may be under evaluated due to such problems as: incomplete skeletal preservation for pathological evaluation and misdiagnosis of tuberculosis infection as non-specific infection, neuro-mechanical deformity or other conditions. In terms of misdiagnosis, the most suspect conditions are synovial joint pathology and in particular hip pathology with evidence of infectious changes.

G-270 is one such case where severe deformation of the right femoral head and acetabulum is seen in an adolescent. Although post-mortem erosion has occurred, there is evidence of trabecular sclerosis which is seen in chronic tuberculosis infections. Complete destruction of the acetabulum and avascular necrosis of the femoral head which characterise this case, are also features of chronic tuberculosis of the hip joint (Tuli, 1991). However these changes are not diagnostic for tuberculosis and a number of other conditions could be responsible. Such conditions may include: traumatic synovitis, non-specific pyogenic infection, congenital malformation with secondary infectious complication, Perthe's disease, as well as other joint or soft tissue diseases (*ibid.*:42).The poor preservation and lack of diagnostic criteria in this case renders a specific diagnosis improbable and

thus this case has been categorised as a neuro-mechanical disorder of uncertain aetiology.

Other cases of hip disease which are similarly non-diagnostic for specific infection are also discussed under the category of neuro-mechanical disorders. In all, six cases of hip pathology, G-36, G-80, G-85, G-101, G-170, and G-257, exhibit involvement of the acetabulum and femoral head with degeneration of the joint and some evidence of inflammatory reactive bone occurring. Tuberculosis arthritis warrants consideration in the differential diagnosis of these cases. Other localised joint arthritis of the major synovial joints in this collection do not exhibit any characteristics thought to be indicative of tuberculosis infection.

Actinomycosis and/or Other Respiratory Infections: ImIrib

A number of other respiratory infections can result in lesions of the ribs as a result of direct extension of parenchymal infection, indirect involvement due to mechanical irritation, or secondary bone involvement due to haematogenous metastases. Whereas tuberculosis infection of the ribs, like other forms of bone tuberculosis, is primarily due to haematogenous dissemination of the infection some other infections, such as actinomycosis in particular, cause bone lesions primarily by direct extension from infected soft tissues. Differential pathogenesis is often reflected in the form and distribution pattern of lesions. Tuberculosis infection of bone is typically and primarily a destructive process which results in almost purely lytic lesions (Tatelman and Drouillard, 1953). The osteoblastic

response which often accompanies lytic destruction occurs in the form of dense emarginating osteosclerosis. Thus predominantly lytic lesions, when occurring as an inflammatory response, are most frequently due to tuberculosis infection and hence they are potentially diagnostic of tuberculosis (Tatelman and Drouillard, 1953; Pfeiffer, 1991; Roberts et.al, 1994). Conversely, a purely blastic or predominantly blastic with combined lytic destruction is not considered characteristic of tuberculosis infection. On this basis, osteoblastic lesions of the ribs, occurring without or without osteolytic destruction, are subject to the consideration of lung infections other than tuberculosis.

Actinomycosis is a chronic granulomatous bacterial infection which is of particular interest for establishing specific aetiologies of rib lesions in this collection. Bone changes as a result of direct extension of lung infection are characterised by periosteal proliferation with combined osteolytic destruction in late chronic cases (Tatelman and Drouillard, 1953; McQuarrie and Hall, 1968; Flynn and Felson, 1970; Ortner and Putschar, 1985; Light, 1990; Molto, 1990; Wilson and Redmond, 1990; Ng et.al.,1992). The disease has a worldwide distribution with no exclusions on the basis of age, gender or race (Flynn and Felson, 1970). *Actinomycosis israeli* is the most common pathogenic organism responsible for the development of the infection in humans; however, infection by the A.bovis and other rare species has been demonstrated (*ibid.*). *A.israeli* is an common oral inhabitant of humans from which respiratory infection may ensue due to aspiration of the bacteria from carious teeth, infected gums or infected tonsils (Light, 1990).

Thoracic actinomycosis generally accounts for about 15% of actinomycotic infections in humans; however an incidence as high as 23% was recognised in one Norwegian case series (Bates and Cruickshank, 1957). Upon infection the clinical course of the disease is a chronic bronchopneumonic suppurative infection leading to abscess and sinus track formation (*ibid.*). Lung tissue is commonly surrounded by dense cellular fibrosis with marginal pneumonia resulting in a proliferative granulomatous inflammation that destroys tissue planes, causes fibrosis and thickening of the pleura (McQuarrie and Hall, 1968). For the recognition and understanding of ensuing bone involvement in this disease, the important features in the pathogenesis of actinomycosis include: a chronic suppurative inflammation; frequent pleural involvement with the development of fibrous tissue; frequent complications of pleural effusion or empyema; a propensity to destroy tissue planes leading to involvement of the chest wall from parenchymal disease (i.e. bone involvement by direct extension).

The most common involvement of the skeleton in thoracic actinomycosis is a periosteal proliferation with or without accompanying superficial bone destruction on the visceral surfaces of the ribs adjacent to infected lung tissue (Flynn and Felson, 1970; McQuarrie and Hall, 1968; Ortner and Putschar, 1985; Light, 1990; Molto, 1990; Wilson and Redmond, 1990; Ng et.al., 1992). Of diagnostic value, Flynn and Felson (1970) report that rib periostitis may have a certain wavy configuration which is highly suggestive of actinomycosis. Most authors would agree that a combination of osteoblastic and osteolytic lesions is

equally suggestive of actinomycosis and Ortner and Putschar (1985), in particular, note that bone infection starts on the periosteal surface and is frequently limited to it. Thus the character and form of actinomycotic lesions are a reflection of chronic inflammation and bone involvement by direct contact irritation and extension of the infectious process; the purely lytic lesions of haematogenous bacillary action, as commonly seen in tuberculosis, are not characteristic in actinomycosis. Thus, differential diagnosis between tuberculosis and actinomycosis is possible. In a similar fashion, a great number of other infectious and neoplastic diseases, which may affect the respiratory tract and thoracic wall, can be eliminated from the final diagnosis.

Case Descriptions

Rib lesions occurring in three individuals are predominantly osteoblastic and in two of these cases osteolytic lesions occur in combination with the osteoblastic lesions. These cases involve all or most ribs on one side of the thorax as well as some post-cranial bones. The form and pattern of lesions is not characteristic of tuberculosis, however, the lesions are believed indicative of a chronic respiratory infection. Actinomycosis is posited in all three cases on the basis of lesion type, form and distribution as a reflection of actinomycosis pathogenesis.

In G-16, diffuse periostitis involving the pleural aspect of all left ribs is indicative of a chronic respiratory infection (Plates 16-1 and 16-2). There are no

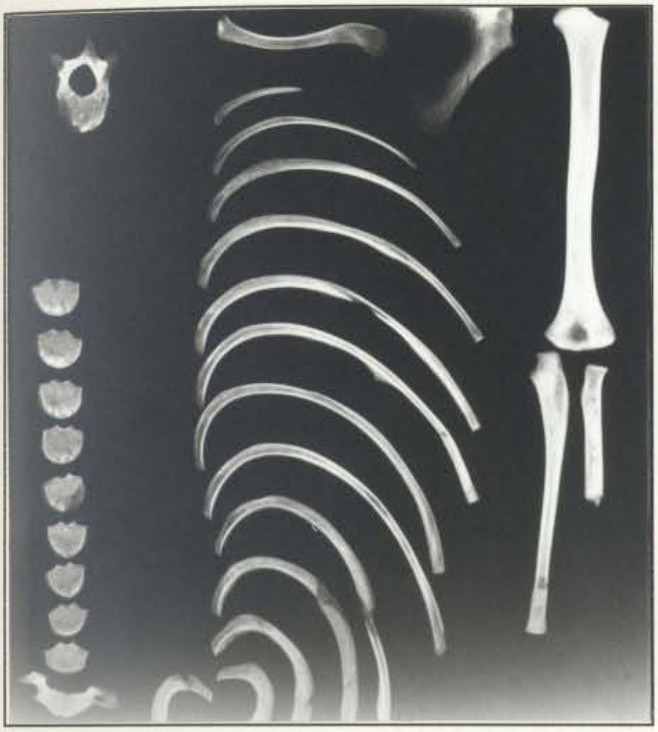

Plate 16-1; G-16
Actinomycosis; Diffuse Periosteal Reaction. Child aged 6-8 years. Left to right: x-ray of vertebral bodies (lumbar, top, to thoracic, bottom); first right rib; left clavicle; left ribs (12, top, 1, bottom); left scapula and long bones of the left arm. Light radiolucent periosteal opposition can be seen on the pleural (lower side in the x-ray) aspect of the ribs and is especially thick on the mid-lobe ribs, Note the "peak" of new bone on rib #7.

ribs from the right thorax, except for the first, thus a unilateral versus a bilateral involvement can not be established in this case. Post-cranial lesions consist of periostitis occurring as a thin coating over the cortex of the left posterior clavicle and scapula and expansion of the diaphysis is observed in both the left humerus and ulna. There are no bones from the cranium, the right side of the body or below the left thorax, thus distant and bilateral metastases can not be ascertained. In any case, the presence of diffuse rib periostitis indicates non-specific chronic respiratory stress which may facilitate the diagnosis of a specific disease only if considered along with the post-cranial lesions. Involvement of the clavicle, scapula and long bones in this case, and especially the occurrence of diaphyseal expansion would indicate systemic metastases of the infection. In light of the involvement

of the entire left thorax, a respiratory infection with secondary systemic metastases is a likely pathogenesis for the condition. Contrary to the case of tuberculosis haematogenous metastasis, which typically develops in the synovial joints and may involve adjacent bone by direct extension from a chronic abscess, the distribution of lesions in this case appear to be limited to the periosteal surfaces of the flat bones and long bone shafts.

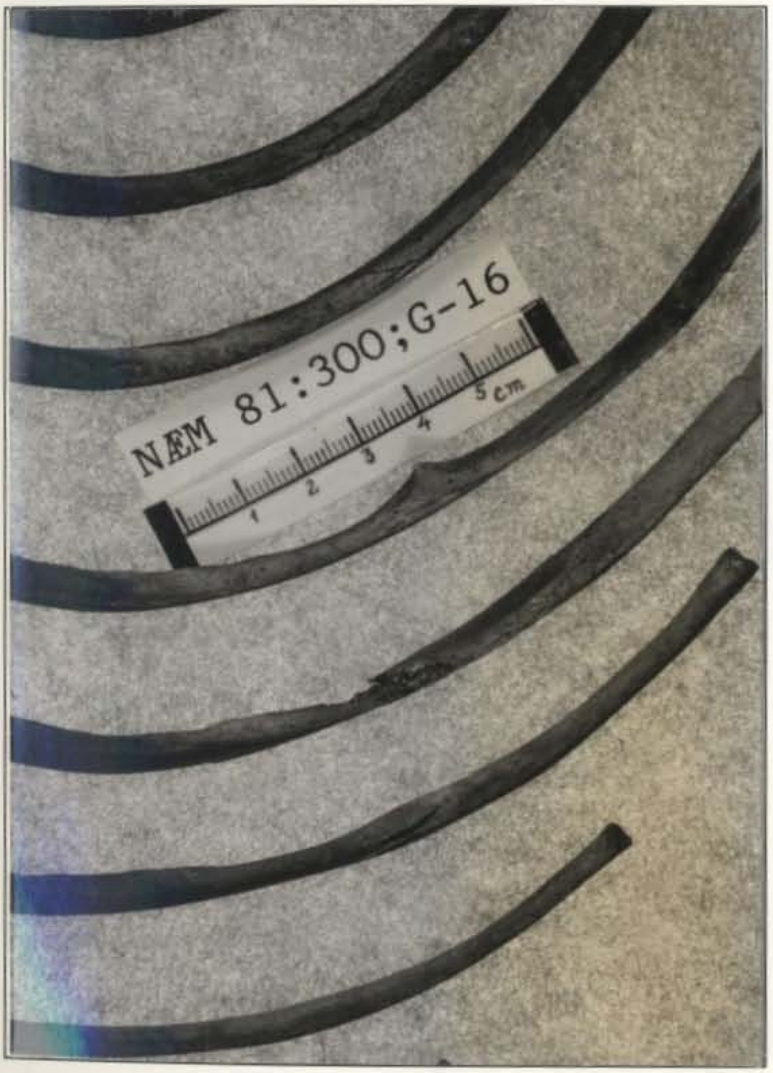

Plate 16-2: G-16
Actinomycosis Infection.
Close up; oblique ventral (pleural) view of the left "mid-lobe" ribs, illustrating the irregular surface morphology of periosteal new bone. Note the peak on rib #7 just below the scale.

Actinomycosis is considered a good possibility in this case on the basis of periostitis on the visceral aspect of the ribs which reflects a chronic inflammatory response as opposed to direct (haematogenous) bacillary action more typical of tuberculosis. In specific, periosteal lesions appear to have a wavy configuration due to variable thickness in reactive bone build up along the length of the shaft; this feature is particularly evident on the seventh and ninth ribs (Plates 16-1 and 16-2). In particular, on the seventh rib, variability in periosteal thickening appears as a sharp peak at one point along the shaft. This wavy appearance is said to be highly suggestive of thoracic actinomycosis (Flynn and Felson, 1970). In addition the post-cranial lesions, limited to the periosteal surface of the bones in this individual, are also supportive of a diagnosis of actinomycosis. Differential diagnosis may include a myriad of infectious and neoplastic diseases of the lung and these considerations will be discussed for all three cases following the case descriptions. However, in terms of population occurrence as well as lesion type, form and distribution, this case is thought to reflect the epidemiology and pathogenesis of actinomycosis in particular.

The other two cases, G-72 and G-129, are quite similar in terms of lesion type and distribution and it is felt that they represent an even better diagnostic picture of actinomycosis infection. Lesions affect all or most ribs unilaterally in each case and the lesion type is of a combined osteoblastic and osteolytic nature in several or most ribs (Plates 72-2; 129-1 and 129-2). In G-72, ribs of the left thorax are affected, while in G-129 ribs of the right thorax are affected. In both

Plate 72-2: G-72 **Actinomycosis; Rib Lesions.** Child aged 5-9 years. Superior view of right and left ribs. Thickening of the rib neck, angle and shaft, due to periosteal opposition, can be seen on the left ribs (right side of photograph). The deposits affect only the pleural aspect of the ribs and they are thickest on the ribs of the mid-thorax. None of the right ribs are affected.

cases, periostitis appears to have been the initial response and all ribs of the affected side are involved. Bone destruction seems to have occurred later, creating discrete oval areas of bone erosion in G-72 and discrete oval lacy edged necrosis in G-129 (Plates 129-3 and 72-2). In both cases osteolytic lesions do not extend beneath the periosteal accumulation. Post-cranial lesions are present in both cases and are localised to long bone diaphyses.

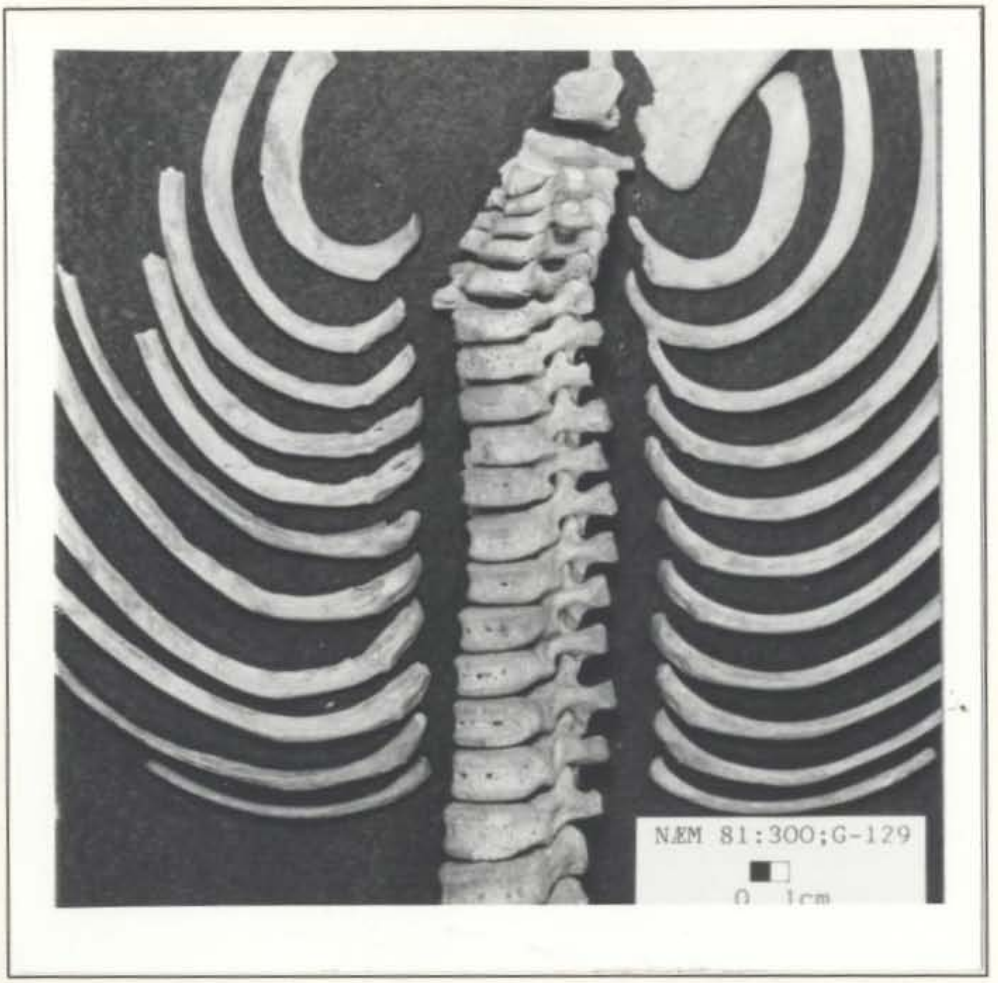

Plate 129-1: G-129
Actinomycosis; Rib Lesions. Child aged 5-7 years. Inferior view of the ribs and left anterior lateral view of the vertebral column. Osteoblastic and superficial osteolytic lesions can be seen on the pleural aspect of the right ribs. Periosteal bone loosely adheres to the underlying cortex (note head/neck region of ribs 4 and 5). Osteolytic lesions penetrate the periosteal deposits but not the cortex giving the surface a "wavy" morphology.

In G-129, post-cranial involvement is limited to a fine surficial periostitis in the region of the attachment site for the gluteal tuberosity on the posterior right femur. This condition may or may not be related to the thoracic pathology; its nature is such that it may be a normal feature of young growing bone. The only other long bones present for this individual are the bones of the right forearm and there are no lesions on these bones.

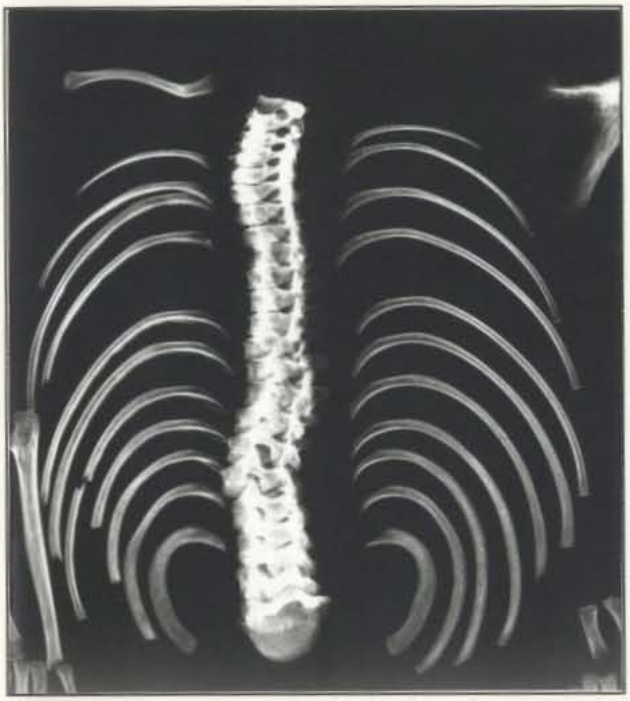

Plate 129-2: G-129
Actinomycosis; X-ray of Rib Lesions. X-ray illustrating radiolucent periosteal deposits on the pleural surface of the right ribs. The underlying cortex is not involved.

Plate 129-3 G-129
Actinomycosis; Rib Lesions. Close up view; pleural aspect "mid-lobe" ribs (approximately 6 to 9; specific numbers unknown). Combined osteoblastic/osteolytic nature of lesions is illustrated. Osteolytic lesions are oval shaped and have "lacy" edged margins. The cortex is not penetrated.

In G-72, the post-cranial lesions are clearly pathological. Lesions are located on the left posterio-lateral femur at mid-shaft and the right posterior humerus

(Plate 72-4). On the femur, the lesion is purely osteoblastic and consists of a relatively thick periosteal apposition which has resulted in a build up of new bone on the posterior mid-shaft. The lesion on the posterior aspect of the distal humerus is a combination of an osteoblastic (periostitis) and osteolytic lesion. A central area of necrosis is surrounded by proliferative bone lying over the cortex. This latter lesion is of a typical character for a chronic granulomatous infection.

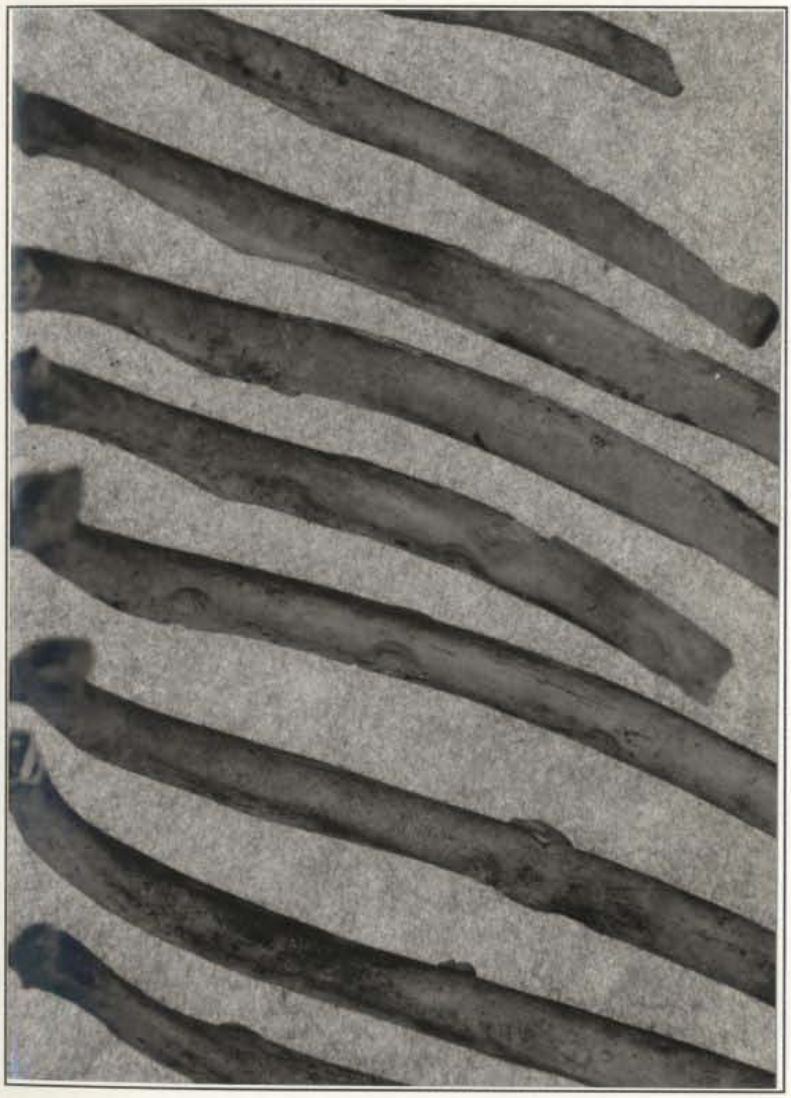

Plate 72-3: G-72 **Actinomycosis; Rib Lesions.** Close up view; pleural aspect of left ribs (12, top, to 4, bottom). The osteoblastic response is diffuse and involves the pleural surface of the entire rib shaft. Osteolysis is more discrete; lytic lesions are roughly oval in shape and do not extend below the periostitis. The pleural surface has a "wavy" topography. Lesions are smooth edged and may be healing compared to G-129 (plate 129-3).

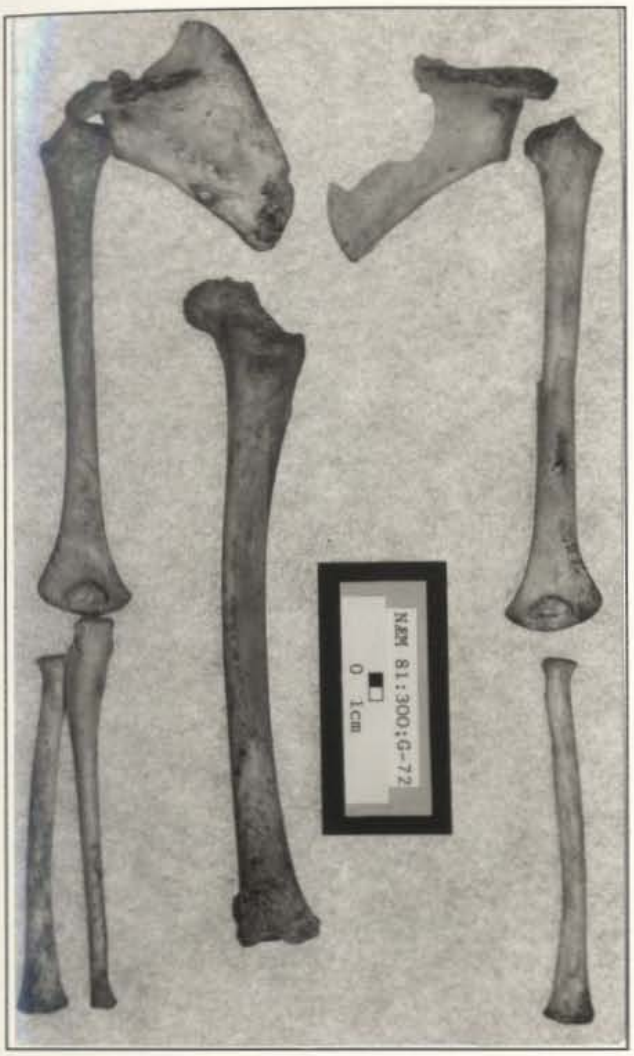

Plate 72-4: G-72
Actinomycosis; Post-Cranial Lesions. Posterior view of the upper limbs (except extremities and left ulna) and lateral view of the left femur. Lesions are localized to the left lateral posterior femur at mid-shaft and the right posterior humerus. On the femur the lesion is characterized by a purely osteoblastic response. Periostitis covers the entire mid-shaft on the lateral side and extends posteriorly but not crossing the posterior midline.

Both the rib lesions and post-cranial lesions in these two cases are consistent if not characteristic of an actinomycosis infection. There is evidence of chronic respiratory disease with inflammatory and erosive extension to the ribs and haematogenous or lymphatic metastasis to the post-cranial skeleton. While the rib lesions are not identical in appearance, in one case lytic lesions are erosive and in the other they are necrotic, there is a similar pattern of diffuse periostitis as well as a similar localisation of areas of bone build up and/or osteolysis with

respect to rib anatomy and location within the thorax. Periostitis occurs on all ribs and it is thickest in the head and neck region. The uppermost and lowermost ribs are least affected, while those between four and nine are the most affected.

In G-72, periostitis is thickest on ribs 5, 6, 7, 8 and 9 and erosive lesions are most evident on ribs 6, 7 and 8, corresponding to the lower lobe of the left lung. In G-129 ribs 4 or 5 through 10, corresponding to the middle and lower lobes of the right lung, have the thickest periosteal apposition; one rib is missing from each side of the rib cage and it is not certain which number is not present. Osteolytic lesions occur in combination with the periosteal lesions on ribs 2 through 10 but the greatest number and extent of shaft area involved occurs on ribs 6 or 7 through 10. The pathogenesis of infections in both individuals is believed to have followed a similar pattern; i.e., a primary infection of the relevant lung with the development of a chronic suppurative infection which spread to the pleura and ribs, resulting in an inflammatory bone response later complicated by mechanical or infectious erosion and/or cavitation of adjacent bony tissues.

Chronic actinomycosis often results in pleural effusion or empyema, fibrosis and thickening of the pleura, and chest wall abscesses with draining sinuses or adhesions. These disease processes may lead to proliferative and secondary erosive osteitis via mechanical irritation such as pleural friction rub or direct irritation of periosteal tissues adjacent to infected parenchyma and pleura (McQuarrie and Hall, 1968; Light, 1990; Wilson and Redmond, 1990; Pfeiffer, 1991; Ng, et.al., 1992). Although the lesions are not identical for the three cases

involved. it should be noted that this is not unusual. McQuarrie and Hall (1968:907) note that each of their 28 cases was unique in terms of clinical presentation and anatomic extent of the infection; these authors attribute the variable extent of the disease to a like variation of tissue response to the infection. Kwong et.al.(1992:191) add that radiographic findings are dependant upon the chronicity of the disease. Thus, it is entirely possible that all three cases represent actinomycotic infections of the lung and that the three manifestations are a reflection of variable tissue response and different degrees of chronicity.

In terms of aetiology of the primary infection, poor dental health is often regarded as a high risk factor for aspiration of actinomycotic cultures into the lung (Light, 1990; Kwong et.al., 1992, Filice, 1993). In young children in particular, tonsillitis is considered a high risk factor (Bates and Cruickshank, 1957). Dental caries are present in both G-72 and G-129 (Plates 72-5 and 129-4), but the absence of cranial and dental material for G-16 precludes determination of a like association to dental caries in this individual. In addition, all three individuals are young children between the ages of 5 and 9 years; therefore tonsillar infection is also a possible source of infection in these individuals. Hence the epidemiology and pathogenesis of actinomycosis would concur with the particulars of these three cases.

Regardless of the likelihood of actinomycosis infection, differential diagnosis is warranted since a great number of conditions may produce similar changes on bone. Of the many diseases which may affect the lung and rib cage

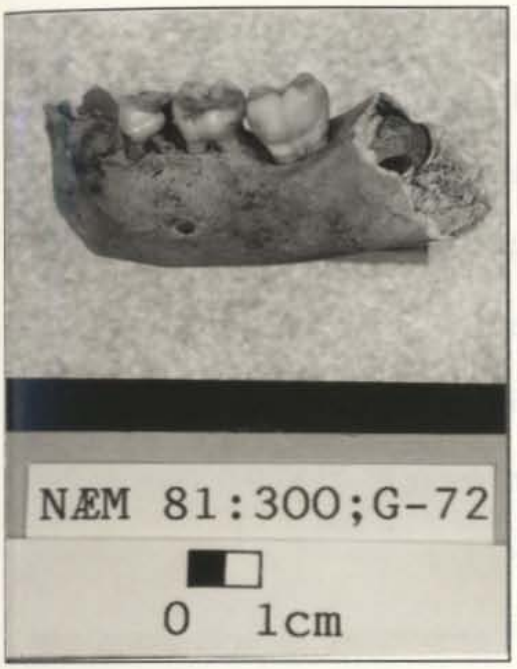

Plate 72-5: G-72
Actinomycosis; Dental Origin (?) Superior-lateral oblique view of the left mandibular ramus with the deciduous m1, m2 and secondary M1 in place. Sub-periosteal hyperostosis in the alveolus, adjacent to the distal interproximal caries in m1, is indicative of an inflammatory and/or infectious response in the bone. It is posited that this may have been the primary seat of an actinomycosis infection, leading to aspiration of the bacteria and secondary development of the lung infection.

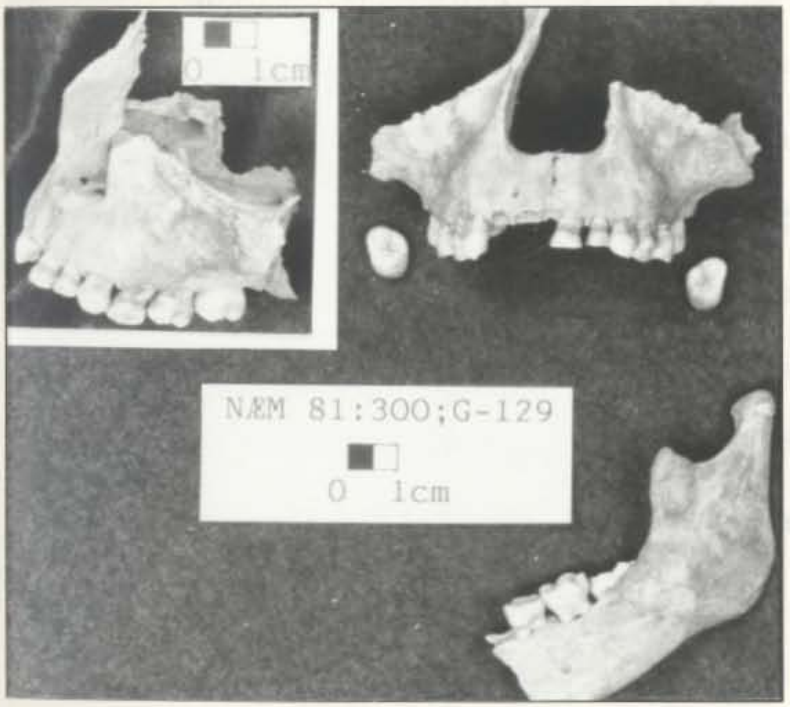

Plate 129-4: G-129
Actinomycosis; Dental Origin (?) Composite photo: frontal view of the maxilla, lateral view of the left mandibular ramus, and inset lateral oblique view of the maxilla. Carious lesions are demonstrated along the cervical margins of several tooth crowns as well as adjacent tooth roots. These dental infections along the "gumline" are believed to be source of an aspirated actinomycosis infection of the lung in this child.

the following should be considered in a differential diagnosis for these cases: primary malignancy of the lung; Ewing's sarcoma, fibrosarcoma and other malignant tumours of bone; Histiocytosis X, Schüller-Christian disease, of the lung; cryptococcus, sporotrichosis, aspergillosis and other possible fungal infections of the lung; tuberculosis, brucellosis, and syphilis; pneumonia, bronchiectasis and other complications of non-specific infection in the lung; sarcoidosis and other non-bacterial granulomatous inflammations; pulmonary sequestration and other developmental disorders; and chronic obstructive airways disease due to a wide variety of predisposing conditions.

Many of these conditions are far less likely and less typical explanations than actinomycosis for the disease manifestation seen in G-16, G-72 and G-129 on the basis of age of occurrence, frequency in a population, propensity toward bone involvement and typical bony manifestation. Primary malignancy of the lung, although regarded as a major cause of lytic rib lesions, is exceedingly unlikely in those under 30 years of age (Howat, 1992). Ewing's sarcoma often occurs in children, but as a rule rib lesions do not occur in children, lesions are punched-out areas of bone lysis and the typical form of proliferative bone has a distinctive "onion peel" appearance (Steinbock, 1976). Fibrosarcoma and other more rare malignant tumours of bone rarely occur in children and rib lesions are not common (Ortner and Putschar, 1985).

The non-neoplastic benign condition known as Histiocytosis X often affects young children and may involve bone directly as eosinophilic granuloma or

indirectly by involvement of adjacent tissues such as the lung (Steinbock, 1976). The chronic disseminated form of the disease is referred to as Schüller-Christian disease, but either form may be applicable for differential diagnoses. In any case, Histiocytosis X is probably unlikely in these cases due to the fact that the process is usually purely lytic and bones of the skull are most often involved.

Fungal infections result in chronic suppurative inflammation, as is characteristic of these cases, however, few fungi are indigenous to Scandinavia. Cryptococcus, aspergillosis, sporotrichosis and possibly coccidiomycosis may occur but lesions are often purely lytic in cryptococcus; typically localised to the paranasal and orbital regions in aspergillosis; localised to soft tissues in sporotrichosis and uncommonly affecting the ribs in most cases (Ortner and Putschar, 1985; Taber's Cylc. Med. Dict., 1989).

Where specific infection may be possible, the unlikelihood of tuberculosis has already been discussed. Brucellosis is known to predilect the spine and pelvis as opposed to the ribs and children are usually spared (Ortner and Putschar, 1985). Syphilis may involve one or more ribs; however, not only is rib involvement rare, but a diffuse involvement is very unlikely. A number of more rare conditions such as infection by Rickettsiae, Q Fever in particular, may result in respiratory complications but diffuse and pronounced bone changes are not characteristic, nor are post-cranial lesions.

Pneumonia, bronchiectasis and other complications of non-specific infections of the lung may result in one or a combination of pleural effusion,

empyema, pleural thickening, and fibrosis. It is conceivable that periostitis could result from either the mechanical irritation of fibrotic pleural friction rub or an inflammatory reaction to an indolent infection (Pfeiffer, 1991). Kelley and Micozzi (1984) contend that no clear evidence exists for pneumonia induced bone lesions; however, the potential for diffuse rib involvement as an extension from organised lobar pneumonias should not be dismissed. Mycoplasma pneumonia is one such condition that tends to result in a low-grade pneumonia that may result in organised inflammation and pulmonary fibrosis (Howat, 1992). The body's natural defense to pleural effusion and empyema is the development of fibrinous tissue (Hurt, 1992). This process proceeds from fusion of pleural fibrin deposits to the chest wall to progressive thickening and fibrosis around the empyema and culminates in secondary changes to adjacent tissues due to contraction of the fibrous tissues. The ribs may become involved as they are mechanically drawn together as a result of fibrous contraction (*ibid.*;837). The prerequisites for bone involvement due to pneumonia and related conditions are chronicity of the disease and pronounced irritation of adjacent bony tissues from parenchymal infection. Yet, while some pneumonias may fulfil these criteria and result in rib lesions, it is unlikely a pneumonia could be responsible for the post-cranial lesions seen in these three cases.

The non-bacterial granulomatous inflammations should be considered on the basis of their ability to incite a chronic inflammatory response in many tissues, including the lung (Howat, 1992). However, they are unlikely in these cases since

the most common of the disorders, sarcoidosis, is uncommon in children and rarely affects the ribs (Ortner and Putschar, 1985). Chronic granulomatous disease of childhood is a rare inherited disorder which affects many organs and leaves the body open to invasive infections of bone, liver or blood (Finn et. al., 1990). The rarity of this latter disease renders it an unlikely possibility.

Developmental disorders of the lung such as, in particular, pulmonary sequestration may cause chronic inflammation in the lung which can lead to fibrosis and inflammation (Howat, 1992). However, in these as well as other conditions such as trauma induced lung inflammation, there is little likelihood of post-cranial involvement.

Lastly, localised and chronic obstructive airways disease due to a wide variety of predisposing conditions such as benign neoplasms of the bronchi (bronchial adenoma), foreign body aspiration, chronic bronchitis, and asthma must be considered in the diagnosis. These conditions lead to localised or diffuse respiratory impairment, respectively and can result in secondary pneumonia but the occurrence of bony involvement as a severe complication is not reported. Similarly, it is unlikely that post-cranial lesions would ensue from these conditions.

In conclusion, the most likely diagnosis would appear to be actinomycosis, but the possibility of fungal infection, tuberculosis, organised lobar pneumonia, and a variety of more rare conditions can not be dismissed.

5.1.4 Traumatic Conditions

Traumatic conditions are bone and joint injuries caused by direct or indirect insult to the bone or joint resulting in fracture, joint dislocation or other bone damage. Other bone damage may include surficial bone insult such as depressed fractures and abrasions extended from primarily soft tissue injuries or more severe damage such as mutilation due to amputation.

In the Helligåndshus collection trauma was diagnosed in 19 individuals or 5.8% of the G-series. Primary fracture (5.1.4.1) accounted for fifteen of these cases, pathological fracture (5.1.4.2) accounted for three cases and other (5.1.4.3, namely amputation, accounted for one case. No surface trauma was conspicuous on any of the bones, thus bone injury due to deep soft tissue trauma can not be ascertained for this collection. However, surface trauma may remodel quickly, leaving little if any evidence on dry bone. In a number of cases of bone infection, trauma was mentioned as a possible means of direct or indirect involvement of bone. The unequivocal cases of trauma are presented in Table 5.1.4a. Age and gender associations are presented in Table 5.1.4b.

Table 5.1.4a

Traumatic Conditions

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE YEARS
G-11				Fcl			Ar;v-tp	Dac	F	Adl 20-30
G-268				Fcl			Aav	Dacl-r	F	Ad? 30-50+-
G-273			Imtib	Frib			Av;ky/sc		M	AdM 47-58
G-5	BO----------			-Frib			Agv-ctsc	Dcl-r	F	AdM 45-65
G-245	BO----------			-Frib			Agv		F??	AdM 46-59
G-149				Frib					M?	AdM 44-56
G-131				Ful			Avas-i;e		M	AdM 46-57
G-3	O			Frd			Agv-c	Dcl-er	F?	AdM 50-59
G-246				Fpv	-------?--------		Av-l		M	Adl 28 39
G-164				Ffib					I	FG >15-20
G-24				Ffib	asymcondy				M	Adl 27-47
G-257				Fank	----------		_Aah_;-f		I	AdM 35-45
G-8		oscdr		spL5			Av-t;e;k		M	Adl 25-35
G-299				spL5	--------	spb----	AL5;k;h		M	Adl 33-44
G-2	Dh	*----------		-Ffn*			Av-ct;*h		F	Adl 21-46+-
G-85	BO*----------		*I-----	*PFfn	----------		AgvSah*Pr		F	AdM 35-53
?G-240		*necr---------		?Ffn*		----------	Aav*h		F?	Ad? mature
G-76	Dh		Isy-----	PFcl			Av-tl	Dclw-gr	F?	Adl 27-38+?
G-227			Isy--PFul;cl						F?	AdM 36-45
?G-280			Isy	?PFrib					F	Jv 16-20
G-145		C	*ImI----	Amp*					F	Adl 21-29

-------- Disease Association; indicates a posited relationship between trauma and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified traumatic condition.

---?---- Possible or questionable association. ?G-240: Questionable trauma (case mentioned, not counted).

Aah Excluding this condition. In this case, arthritis and ankylosis of the hip are not thought to be related to the metabolic condition suffered by this individual.

* Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.

Traumatic Disease Codes:

F= Fracture;
PF= Pathological Fracture;
Amp= Amputation;
sp= Spondylolysis;
cl= clavicle;
rib= rib fracture(s);
ul= ulna;
rd= radius
fib= fibula;
ank= ankle;
fn= femoral neck
L5= Lumbar vertebra #5
pv= pelvis

Table 5.1.4b

Traumatic Conditions: Age and Gender Distribution

Age (age in years) Category: numerical	(5.1.4.1) Primary Fractures T: ♂/I/♀/p	(5.1.4.2) Pathological Fractures T: ♂/I/♀/p	(5.1.4.3) Other: Amputation T: ♂/I/♀/p	Total; all types (.1),(.2),(.3) T: ♂/I/♀/p
FG: ≥15-21	1: 0/1/0	0	0	**1**: 0/1/0
Ad?: ≥21	1: 0/0/1	0	0	**1**: 0/0/1
Ad1: 21-39.5	6: 4/0/2	**1**: 0/0/1	**1**: 0/0/1	**8**: 4/0/4
AdM: 39.5-57	7: 3/1/3	**2**: 0/0/2	0	**9**: 3/1/5
Total: all ages	**15**: 7/2/6	**3**: 0/0/3	**1**: 0/0/1	**19**: 7/2/10/0

Age codes: Ch=child; Jv=juvenile; Ad=adult (also refer to section 4.2.2 for details on age category codes). Age and Gender breakdown (totals by age group: totals for age/gender group), where, T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.4.1 Primary Fractures (F)

Primary fracture is used here to indicate any of the variety of structural and anatomical bone injuries, occurring in otherwise normal bones, due to the application of excessive external forces. On dry bone, fracture is diagnosed in the healed condition when there has been incomplete reduction of the break and callus bone is present. X-rays were taken for a small number of individuals as a diagnostic aid, but fracture was not evident in any of these cases. Hence, when the diagnosis is a primary fracture, the conclusion was based on gross morphological observations.

Case Descriptions

Rib fractures were the most common primary fracture seen in the G-series of the Næstved collection. There are four individuals exhibiting one or more rib fractures. In two cases, G-5 and G-245, there is a possibility of pathological vulnerability of the bone due to osteoporosis and or osteomalacia. However, trauma may have been unrelated to underlying pathology in these cases. The ribs are poorly preserved in both of these cases and thus rib numbers could not be determined. In G-5, two healed rib fractures of the right thorax were diagnosed on the basis of a slight incongruity of the rib shaft with adjacent incompletely remodelled callus. In G-245, one healed fracture was similarly diagnosed on a shaft fragment from a left rib.

G-149 and G-273, exhibit at least two healed rib fractures which do not appear to have any association to reduced bone quality or other pathology. Ribs number 7 and 8 from the left thorax are involved in G-149 (Plate 149-1). In G-273 both ribs are from mid-thorax of the right side, but the exact rib numbers could not be determined due to post-mortem damage. There does not appear to be any related pathology in G-149, but vertebral arthritis and slight kypho-scoliosis affecting the vertebral column in G-273 may have some relation with the trauma involving the rib cage.

Other localised fractures affected the following areas: the right distal clavicle in G-11; the left distal clavicle in G-268; the right distal ulna in G-131; the left distal radius in G-3; the right iliac blade in G-246; the distal tibia and fibula

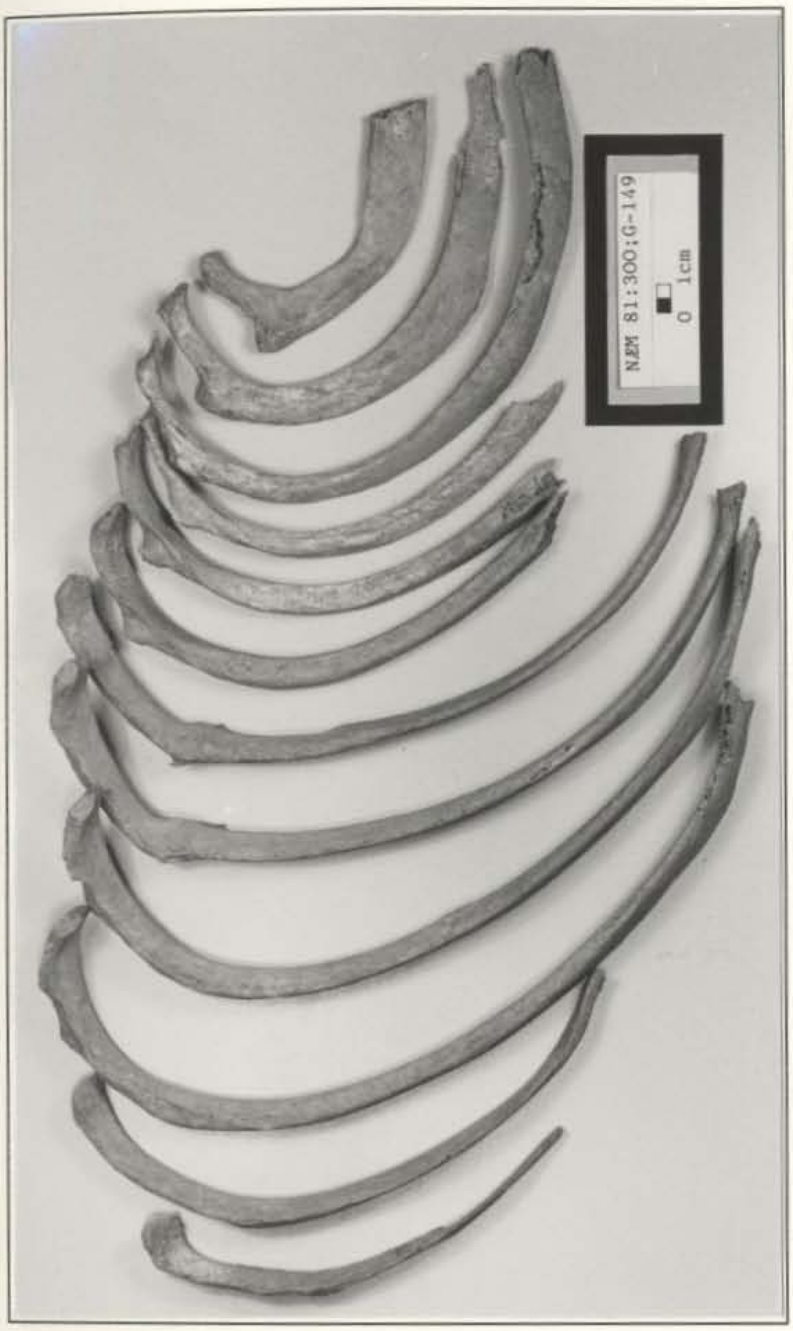

Plate 149-1: G-149 **Fracture: Healed Rib Fractures**. Mature adult male? aged 44-56 years. Inferior view of the left ribs illustrating two healed fractures (rib 7 and 8) Incompletely remodelled callus bone remains at the rib angles where the fractures occurred.

in G-257; the femoral neck in G-2 and possibly G-240; and the proximal shaft of the left fibula in both G-24 and G-164. In addition, spondylolysis, or fracture of the neural arch, was seen in two cases. In both, G-8 and G-299, the fractures were

localised to the pedicles of the fifth lumbar vertebra. In all cases, fractures were healed and in the process of remodelling at the time of death. Complications, such as poor reduction of fracture angles, profuse callus build up and peripheral neuromechanical deformity, were seen in a few of these aforementioned cases.

Although incomplete reduction of the fracture angle was present in all cases, it was very slight in most and did not likely cause such complications as limb shortening or severe mechanical disability in the area affected. In one case, G-11 poor reduction of the fracture angle may have resulted in muscle and joint problems. Plate 11-1 and 11-2 illustrate the deformation of the right distal clavicle due to fracture. In Plate 11-1, a projection of callus bone is seen to extend inferiorly. Although the scapula was not recovered, this callus growth on the inferior clavicle is thought to have formed a pseudo-articulation with the acromion process of the scapula. Arthritic developments involving the upper thoracic costo-vertebral joints are also believed to be complications of the fracture. Arthritis affects the right costo-vertebral joints of ribs 1 through 4.

Considering the muscle attachments in the region of the fracture, it is possible that muscle damage and a sustained structural deformity could have predisposed adjacent joints to arthritis. In particular, the pectoralis major, the pectoralis minor and the trapezius muscles have attachments sites on the clavicle and ribs; the ribs and scapula; and the clavicle, scapula and spines of thoracic vertebrae, respectively (Carola et. al., 1990). It is posited that damage and mal-alignment of these muscles may have put undue stress on the adjacent costo-

vertebral joints resulting in premature arthritic deterioration of the joints of the right torso and shoulder. However, bilateral involvement could not be investigated since the bones of the left side of the body were not recovered.

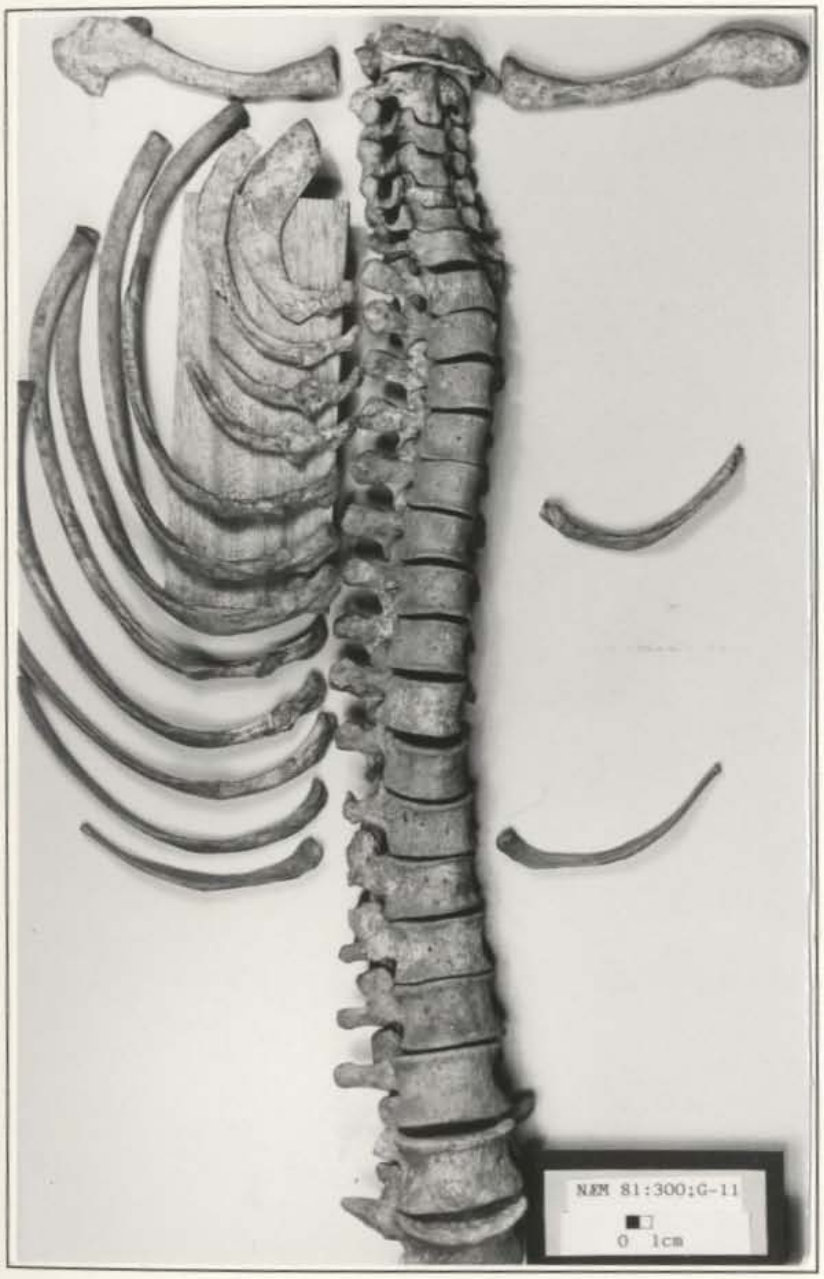

Plate 11-1: G-11 **Fracture; Clavicle Fracture with Adjacent Complications**. Adult female aged 20-30 years. Superior view of the clavicles (note healed fracture and deformation of the right distal clavicle). The inferior view of the right ribs and partial right lateral view of the spine illustrates arthritic lipping of the right costo-vertebral joints (1 through 4), possibly due to improper healing and/or muscle damage related to the fractured clavicle.

Plate 11-2: G-11
Fracture: Callus Bone. Posterior view of the clavicles. The right clavicle (bottom) exhibits incomplete remodelling of fracture callus. The inferior extension of this irregular bony build up may have "falsely" articulated with the acromion process of the scapula.

Callus build up may have caused complications in G-246. A fracture of the right iliac blade resulted in liberal callus formation on the posterior aspect of the blade (Plates 246-1 and 246-2). This area of the blade is the attachment site for several large muscles, and in particular, the gluteus maximus, gluteus medius and gluteus minimus. These muscles are responsible for extension and rotation of the hip joint, abduction of the hip joint and stabilization of the pelvis (Carola et. al., 1990). It is likely that the callus bone in this location interfered with muscle function. There are no severe pathological associations to suggest that debilitating deformity resulted from fracture complications, but it is possible that the development of arthritis on the lower lumbar bodies may be associated with increased structural-mechanical stress due to improper healing of the fracture.

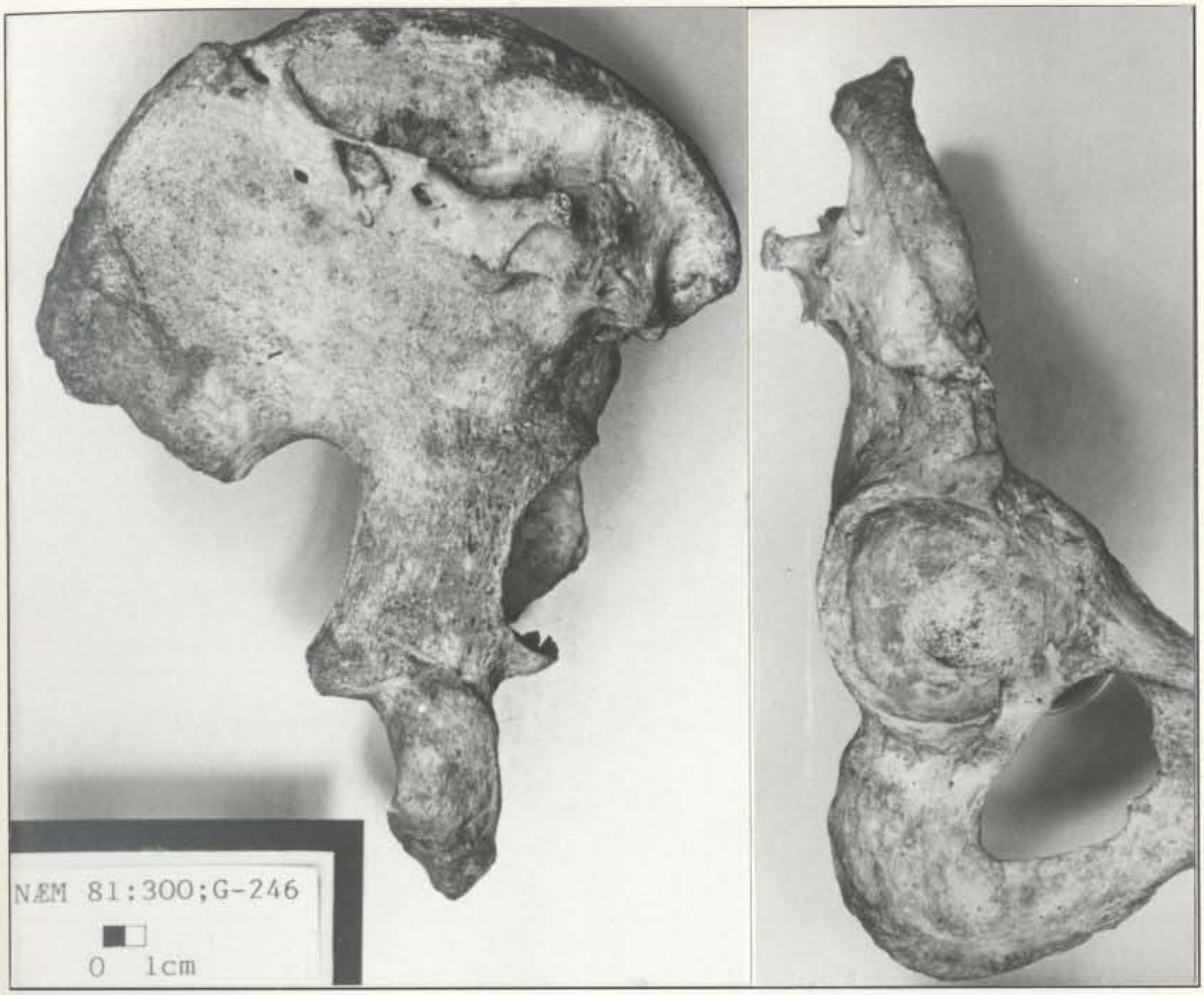

Plate 246-1: G-246
Fracture: Iliac Blade. Male adult aged 28-39 years. Posterior view of the right ilium illustrating a slight lateral-inferior offset of the superior iliac blade above the fracture. Liberal callus bone remains along the line of the blade fracture. This incompletely reduced fracture and poorly remodelled callus bone likely put added stress on adjacent muscles and connective tissue.

Plate 246-2: G-246
Fracture: Callus Bone. Lateral-anterior view of the right ilium illustrating the perpendicular projection of fracture callus. This area of iliac blade is the site of attachment for several large muscles which may have been damaged or stressed due to the fracture and improper healing.

Arthritic complications due to fracture are suspected in four other cases. Two of these cases, G-8 and G-299, involve spondylolysis of the fifth lumbar vertebra and the other two cases, G-2 and G-257, involve fractures at the distal ends of long bones. In the first two cases, fracture of the neural arch of the fifth

lumbar vertebra has likely resulted in some instability of the lumbo-sacral articulation. In G-8, compensatory pseudoarticulations have formed between the inferior facets of L4 and the pedicle "stumps" on the fifth lumbar body. The inferior facets of the L5 neural arch articulate inferiorly with S1 as per usual but superiorly the neural arch appears to have articulated falsely (pseudoarticulation) over the L4-L5 facet-pedicle articulation (Plate 8-2). The individual is a young adult and aside from porosity at the site of the pseudoarticulation, there are no other arthritic developments associated with the fracture.

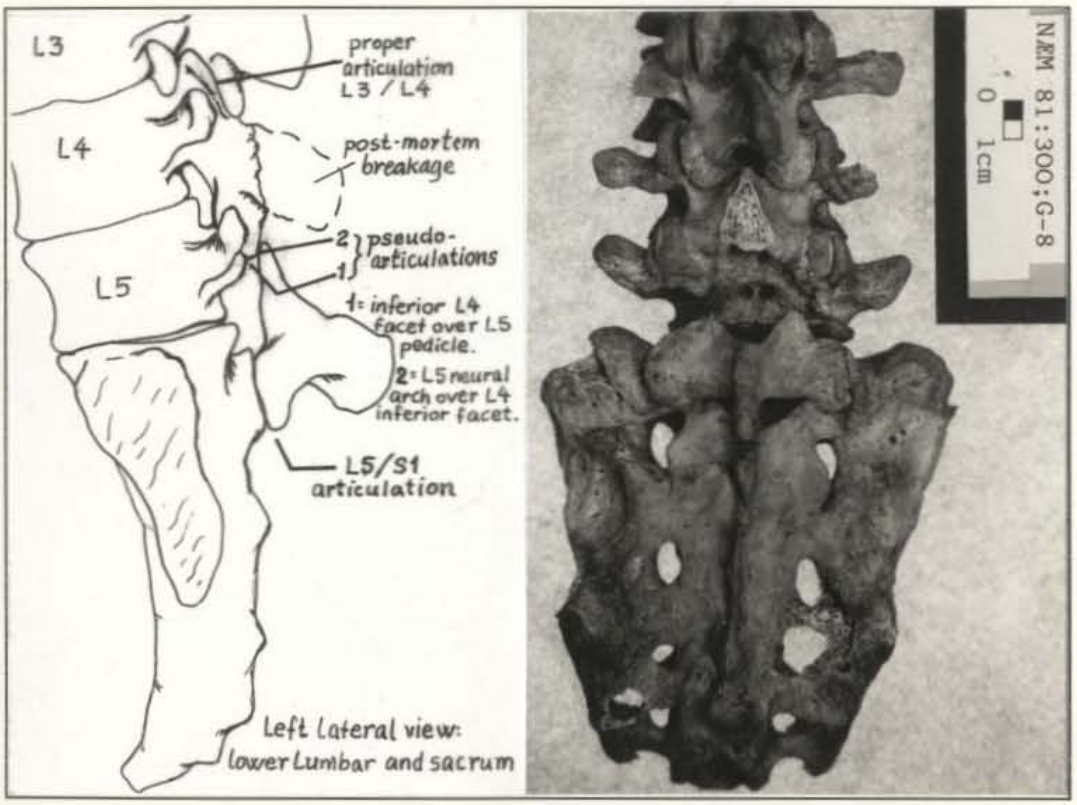

Plate 8-2: G-8 (Right):
Spondylolysis; L5. Adult male aged 25-35 years. Posterior (dorsal) view of the sacrum lumbar spine. The dorsal spine of the 4th lumbar vertebra has been broken post-mortem. Below this, a gap can be seen where the spondylolysis occurred. The body of the 5th lumbar vertebra can be seen through the gap and posterior neutral arch/dorsal spine is seen to articulate independently with the sacrum, while the inferior facets of L4 falsely articulate with the pedicle "stumps" of L5.

Figure 5.3: G-8 (Left): **Schematic Diagram;**
Illustration of the pseudoarticulations which developed secondary to spondylolysis of L5.

The development of arthritis is more advanced in G-299, as the spondylolysis is in association with spina bifida of L5 and the entire sacrum. Arthritic eburnation is present at the dorsal facet articulation between L5 and S1 and on the posterior aspect of the L5 inferior facets (Plate 299-1). This latter location suggests a pseudoarticulation of some spinous element over the inferior facet, but in the absence of the lumbar spine, the articulating element is unknown.

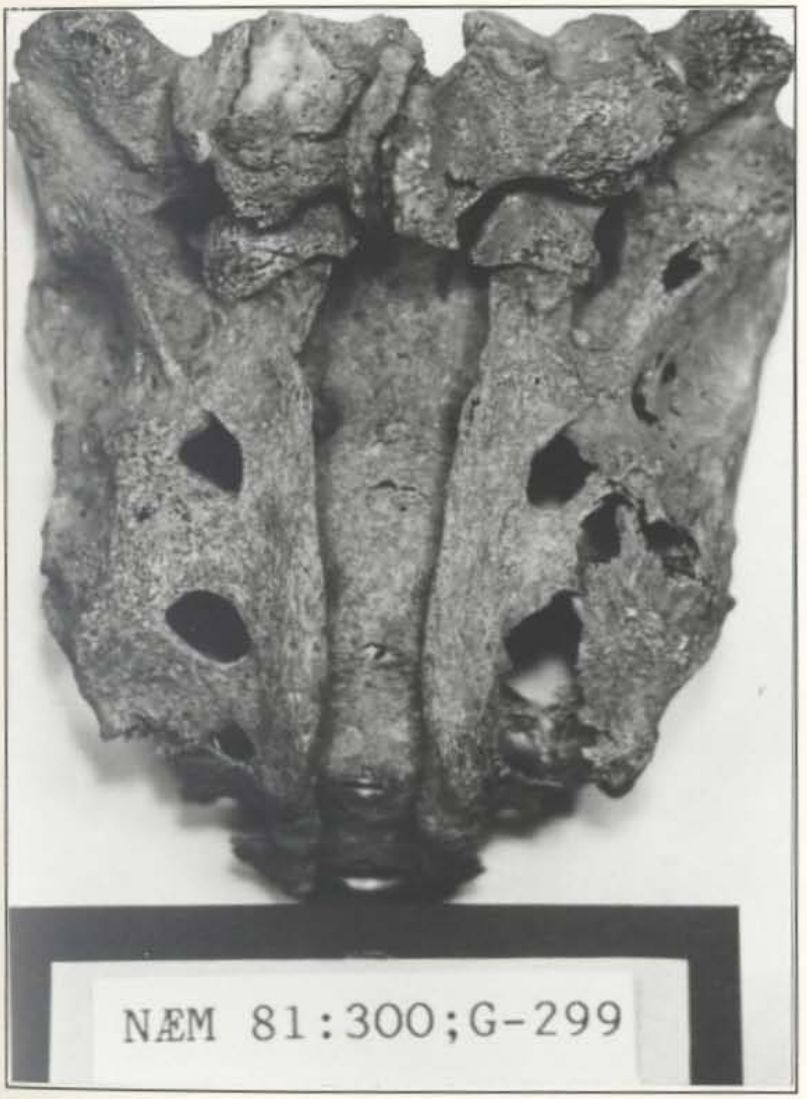

Plate 299-1: G-299 **Spondylolysis with Spina Bifida**. Mature adult female aged 33-44 years. Posterior view of the sacrum and sacralised 5th lumbar. The neu ral arch/dorsal spine of the 5th lumbar vertebra is independent from the vertebral body (spondylolysis) and falsely articulates with the degenerated and eburnated pedicles of L5 over which it lies in the photo. Spina bifida of this dorsal spine with pseudoarthrosis between the two holes as well as, superior areas of false articulation (eburnation) can also be seen in this photo.

De-stabilisation of joints adjacent to fractures in a long bone may also predispose a joint to arthritic degeneration. In G-2 the left femoral neck was fractured and healed with maintenance of a slight anterio-posterior angulation to the neck. Arthritic developments on the left femoral head and acetabulum are attributed to the improper healing of the fracture. In the second case, G-257, a Pott's fracture (Carola et. al., 1990:204) of the distal fibula and the medial malleolus of the tibia is thought to have resulted in de-stabilisation of the right ankle joint. Arthritis occurring in the navicular and other right tarsal bones below the fracture is unilateral and most likely a result of increased mechanical stress due to the imperfectly healed fracture and de-stabilised joint. Severe arthritis also affects the right hip joint, but a relationship to the Pott's fracture is not suspected.

5.1.4.2 Pathological Fractures (PF)

In a few cases traumatic fractures are believed to be directly related to pathological weakening of the bone involved. Thus, unlike normal healthy bone, pathologically weakened bone may be unable to stand up to minor trauma or otherwise normal musculo-skeletal demands. Pathological weakening may be due to metabolic bone disease, infection, neoplasm or various other conditions that result in deterioration or destruction of bone. In the Næstved collection, pathological fracture was the result of one of two types of pathology, infection or metabolic bone disease.

Case Descriptions

Pathological fracture due to metabolic bone disease is posited in one case, G-85. An overlay of osteomalacia and osteoporosis is thought to have weakened the structural integrity of the skeleton in this individual and predisposed to a fracture of the left femoral neck. Alternatively, the possibility that the fracture was a primary occurrence and metabolic bone disease followed cannot be dismissed. In any case, a number of complications are believed to have resulted from the fracture. Avascular necrosis, which was most likely a direct result of disrupted blood supply due to the fracture, has resulted in complete destruction of the femoral neck and head (Plate 85-4). Arthritic degeneration of the hip joint and paralysis of the limb ensued as severe neuro-mechanical complications.

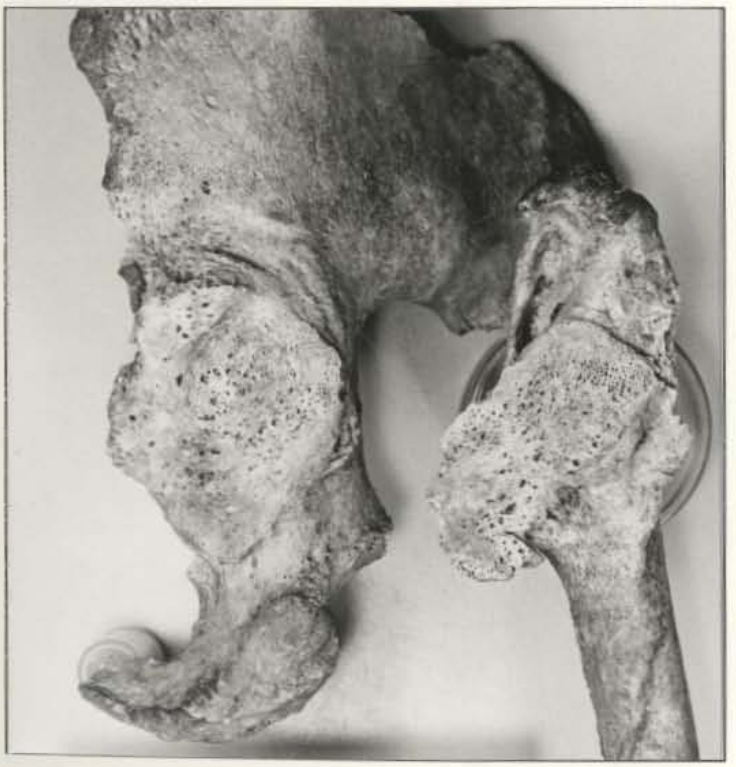

Plate 85-4: G-85 **Pathological Fracture; Secondary to Metabolic Bone Disease**. Mature adult female aged 35-53 years. Lateral view of the left innominate; medial view of the left femur. The severe degeneration of the acetabulum and the femoral neck and head are thought to be due to avascular necrosis following a fracture to the femoral neck. Osteoporosis and/or osteomalacia is considered a possible predisposing factor to fracture in this case.

Note: Other aspects of this case are discussed and illustrated in section 5.1.2 (localised vascular disruption) and section 5.1.7 (arthritis and neuromechanical disorders).

In the other two cases of pathological fracture, the predisposing condition was diagnosed as a treponemal infection. A healed fracture of the distal clavicle occurs in association with infectious lesions in G-76, while in G-227 infectious lesions appear to have had a direct association with a healed fracture of the distal ulna (Plate 227-3) as well as the clavicle (see Plate 227-3, section 5.1.3.2i).

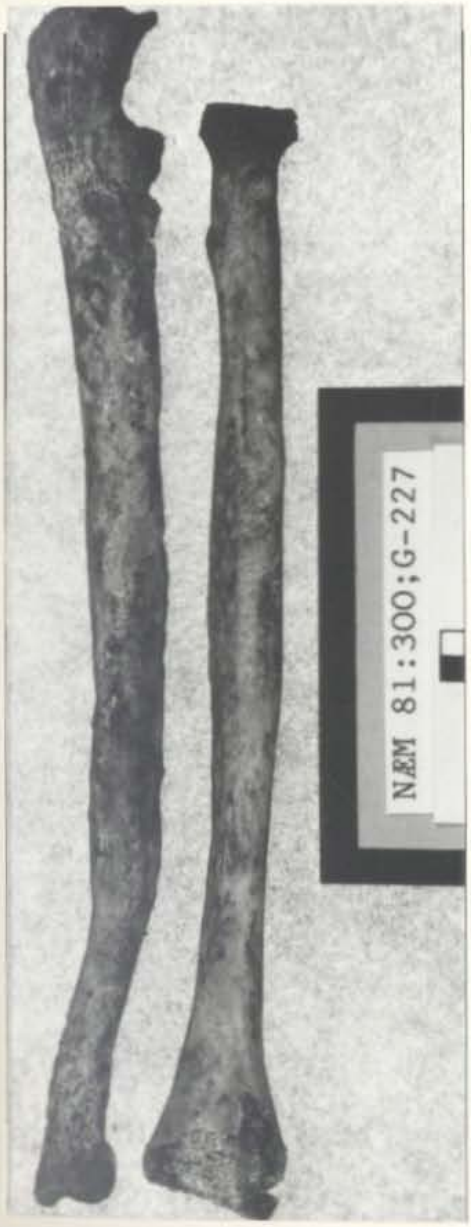

Plate 227-3: G-227
Pathological Fracture; Secondary to Treponemal Infection. Mature adult female aged 36-45 years. Posterior view (with a slight medial oblique) of the right ulna and radius, illustrating a healed pathological fracture of the distal ulna (note the incomplete reduction of the fracture angle). Fracture is believed to be a direct result of pathological weakening of the bone due to lytic destruction by syphilis infection.

Pathological fracture is a possibility in one other case. In G-280, which has been discussed fully in section 5.1.3.2i, Treponemal Infection, a rib may have sustained a fracture due to pathological weakening of the bone from an infectious lesion. The rib has a large lytic lesion which has "broken" or separated the shaft in two (see Plate 280-3, section 5.1.3.2i). This case is not counted with the trauma cases since a traumatic aetiology cannot be differentiated from a purely infectious aetiology for the rib lesion. Furthermore, in all cases of pathological fracture, the possibility of a primary fracture followed by secondary development of infection cannot be entirely dismissed.

5.1.4.3 Other Trauma: Amputation (Amp)

Of the numerous forms of trauma which may result in lesions of the bone surface or severe mutilation only one case was categorised in this section. An amputation of the left humerus, at approximately mid-shaft, was observed in G-145. Microscopic examination of the cut end revealed the presence of fine striations suggesting the amputation was a deliberate medical procedure and not an accidental severing of the limb. Plate 145-1 (with inset) illustrates adjacent periosteal irritation but lack of progressed remodelling. Hence, it is likely that death occurred relatively soon after the amputation, perhaps within a week (see Steinbock, 1976:35). Complications of this type of trauma may have included a post-operative infection. The periostitis adjacent to the amputation is not, in itself, clearly indicative of an infectious aetiology. However, considered together with

the presence of periostitis occurring on the left clavicle and left lateral border of the scapula, these inflammatory lesions are at least suggestive of an haematogenous spread from a possible post-operative infection.

Plate 145-1: G-145
Amputation; Secondary Inflammation. Adult female aged 21-29 years. Medio-anterior oblique view of the left humerus. An amputation at approximately mid-shaft was not long survived. The inset in the upper right corner illustrates the flat surface of the cut with some minor inflammatory bone development. The absence of any progressed remodelling of the cut end suggests that very little time elapsed between the amputation and death.

5.1.5 Growth Disorders

Acquired disorders of growth may include metaplasia, dysplasia and neoplasia, i.e. those disorders of differentiation and growth which have some environmental stimulus and ultimately result in improper differentiation, abnormal or uncoordinated development or uncontrolled growth of tissue (Parsons, 1992). Metaplasia refers to a condition of altered differentiation of cells while dysplasia is characterised by atypical morphology and cell differentiation and neoplasia is characterised by abnormal, excessive and uncontrolled growth of cells. In the Helligåndshus collection conditions due to neoplasia were the only type of acquired growth disorder identified.

Four individuals or 1.2% of the G-series were diagnosed with acquired growth disorders. All four disorders are believed to be benign conditions of a mild and uncomplicated nature. Cases are presented in Table 5.1.5a and age and gender categorisation is displayed in Table 5.1.5b.

Table 5.1.5a

Growth Disorders

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-53			Im		**exost**			Dc	M?	Jv	15-19
G-154					**exost**				0	Jv	10-15
G-306					**osteom**		A;h;f	Dacler	F	AdM	36-58+
G-143	Dh;Ppr				**ostchd**				F	AdM	46-59

Growth Disorder Disease Codes:

exost= exostosis; **osteom**= osteoid osteoma; **ostchd**= osteochondroma

Table 5.1.5b

Growth Disorders: Age and Gender Distribution

Age (age in years) Category: numerical	(5.1.5.1) Neoplasia T: ♂/I/♀/p	Total; all types T: ♂/I/♀/p
Jv: 12-21	**2**: 1/0/0/1	**2**: 1/0/0/1
AdM: 39.5-57	**2**: 0/0/2	**2**: 0/0/2
Total: all ages	**4**: 1/0/2/1	**4**: 1/0/2/1

Age codes:Ch=child; Jv=juvenile; FG= full grown; Ad=adult. (also refer to section 4.2.2 for details on age category codes).
Age and Gender breakdown (totals by age group: totals for age/gender group), where, T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.5.1 Neoplasia

Acquired disorders of growth due to neoplasia are characterised by abnormal, uncontrolled and excessive cell growth (Parsons, 1992). The gross tissue manifestation of this type of disorder is an irregular lump or swelling in the affected tissue, referred to as a neoplasm or tumour. Tumours are classified according cellular differentiation and ability to metastasize and secondly according to the type of tissue from which the tumour originates. In the Helligåndshus collection all identified tumours were classed as benign, i.e. of a non-metastasizing, well-differentiated tissue nature. Three of the four tumours were diagnosed as chondroblastic, or having originated from cartilaginous tissue, and one was identified as osteoblastic, or having originated from bony tissue.

Case Descriptions

The three chondroblastic tumours were classified as osteochondromas or cartilaginous exostoses. An osteochondroma on the middle phalanx of the 4th left finger of G-143 extends from the palmar aspect at midshaft. This benign tumour is a 1 cm outgrowth with a mushroomed head measuring 1 cm in diameter. The other two cases of exostoses occur adjacent to a metaphyseal area in a long bone. Both are relatively small 1-2 cm outgrowths perpendicular to the long axis of the diaphysis. In G-53 the exostosis occurs on the lateral aspect of the right proximal humerus and in G-154 the exostosis occurs on the distal metaphysis of the left fibula. In the latter case, the individual is a young adolescent between 10 and 12 years of age. Fusion of the distal epiphysis of the fibula has occurred on the left side but not the right. While the metaphyseal line has not yet obliterated on the left, it is possible that premature fusion of this epiphysis is related to abnormal enchondral ossification that may also be responsible for the adjacent exostosis.

The one osteoblastic tumour was identified as a button osteoma. This small lesion is the most common of the osteoblastic tumours (Ortner and Putschar, 1985). The lesion occurs on the right parietal of G-306 and appears as a small slightly raised growth, circular in outline and measuring 8 mm in diameter.

All of these neoplastic growths are considered uncomplicated disorders with no suspected association to other pathological conditions. The causative environmental factors for tumours growth may include mechanical irritation or trauma, chemical irritants, chronic inflammation among a variety of other possible

factors (Parsons, 1992). None of these factors can be implicated as risk factors for neoplasia in this collection due to the lack of clear associations and the small number of cases.

5.1.6 Congenital and Developmental Disorders

Congenital and developmental disorders are structural anomalies or more serious defects which are initiated at birth (Underwood, 1992a). Congenital defects which are detectable at birth are severe and often fatal disorders (Barnes, 1994). However, a greater number of defects are undetectable at birth. Some of these "undetectable" defects only become clinically apparent and symptomatic when exacerbated by growth and development during childhood and adolescence; these are more accurately referred to as developmental disorders (Barnes, 1994). Beyond the defects which immediately or eventually result in clinical disorders, many more defects are entirely subclinical and asymptomatic of any disorder (*ibid.*).

Any tissue may be affected; however, for those defects which may be seen on dry bone, only congenital defects of the skeleton are relevant. The skeleton may manifest a wide range of defects which can vary greatly in their severity and propensity to cause direct or indirect clinical complications. Many of the anomalies or minor defects of skeletal development occur in population specific frequencies. Both the type of defect and the range of severity for certain defects can be population specific (Barnes, 1994).

Developmental defects occurring with greater or lesser frequency in certain populations are commonly referred to as morphological variations. These include discrete cranial traits such as metopism, divided mastoid, os inca and other wormian bones as well as many other minor non-symptomatic defects. Minor post-cranial defects of the axial skeleton include cleft vertebrae, segmentation defects of the vertebrae and ribs and vertebral border shifting between the cervical, thoracic, lumbar and sacral borders. In the peripheral skeleton, minor post-cranial defects include minor defects of the articular surfaces and minor structural variations. Only the very serious defects or mild defects exacerbated by growth and development, trauma or repeated mechanical stress will result in complications and symptomatic disorders. While the occurrence of mild skeletal variations may be significant for the understanding of population frequencies and range of variation, these defects have little relationship to clinical disease states.

The cases categorised in this section are those in which congenital and/or developmental disorders are due to serious defects or to complications of less severe defects. A total of four individuals or 1.2% of the G-series were diagnosed with congenital and/or developmental disorders. Other minor defects or structural variations are mentioned in the case descriptions below but they are not included in the Tables or discussion of clinical disease states. Defects considered as predisposing to clinical disease symptoms are presented in Table 5.1.6a. Age and gender associations for these cases are presented in Table 5.1.6b.

Table 5.1.6a

Congenital Anomalies and Disorders

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-87						**dyspls**			0	Ch2	4-8
G-130	Dh?Sc		Im			**scrL6**----AL6scTmj		Dclr	M	AdM	32-48
G-299				spL5		**clfL5↓scrL5**	A;k;h		M	Ad1	33-44
G-270		*	?Itb	*?-----?----		**acetab***	--Ah(P)		0	Jv	12-16

------- - Disease Association; indicates a posited relationship between the congenital/developmental defect and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified traumatic condition.

---?--- - Possible or questionable association. ?G-240= Questionable trauma (case mentioned, not counted).

* - Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.

Congenital/Developmental Disease Codes:

dypls= skeletal dysplasia
scr= sacralisation of a lumbar vertebra (**L6**= Lumbar vertebra #6; **L5**= Lumbar vertebra #5)
clf= cleft defect of a vertebra (**L5**= Lumbar vertebra #5)
acetab= acetabulum (localised congenital malformation of a joint)

Table 5.1.6b

Congenital/Developmental Disorders: Age and Gender Distribution

Age (age in years) Category: numerical	(5.1.6.1) Dysplasia (systemic) **T**: ♂/I/♀/p	(5.1.6.2) Localised Defects **T**: ♂/I/♀/p	Total; all types **T**: ♂/I/♀/p
Ch2: 6-12	**1**: 0/0/0/1	0	**1**: 0/0/0/1
Jv: 12-21	0	**1**: 0/0/0/1	**1**: 0/0/0/1
Ad1: 21-39.5	**0**: 0/0/0	**1**: 1/0/0	**1**: 1/0/0
AdM: 39.5-57	**0**: 0/0/0	**1**: 1/0/0	**1**: 1/0/0
Total: all ages	**1**: 0/0/0/1	**3**: 2/0/0/1	**4**: 2/0/0/2

Age codes:Ch=child; Jv=juvenile; FG= full grown; Ad=adult. (also refer to section 4.2.2 for details on age category codes).
Age and Gender breakdown (totals by age group: totals for age/gender group), where, **T**: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.6.1 Congenital Dysplasia (Dyspls)

Congenital dysplasia is a disorder due to a defect or abnormality of developing tissue. As opposed to congenital defects in a specific embryonic developmental field, dysplasias may cause systemic disturbances in the affected tissue type (Barnes, 1994). A single case of dysplasia was identified in the Helligåndshus collection.

Case Description

In G-87, a child of 4-8 years, no epiphyses had united to the long bone diaphyses and number of abnormal diaphyseal surfaces were observed. In this case a congenital metaphyseal dysplasia is suspected. The joints believed to be affected by the disorder include the distal femora and the proximal tibiae. The most notable anomalies are a 2-3 cm deep cavity in the right diaphyseal surface of the proximal tibia (Plate 87-1) and a corresponding furrow or indented crease in the right diaphyseal surface of the distal femur. In addition, the diaphyseal ends of the femur and tibia about the right and left knee appear to be splayed or laterally expanded (Plate 87-2). The glenoid fossae also appeared to be anomalous in that they were slightly rotated posteriorly. These conditions suggest a disorder of the developing cartilage at the zone of cartilage formation in the metaphysis. The external morphology of the cavity in the right tibia is illustrated by Plate 87-1. Radiolucency, appearing in the x-ray of the long bones, illustrates the involvement of the metaphysis and proximal diaphysis of the right tibia (Plate 87-2). Other

areas of circumscribed radiolucency are present in the metaphyseal areas of the distal femora. Radiodensity, on the other hand, appears greatest in the right tibial diaphysis. It is uncertain whether the mottling seen in the shaft of the left tibia and the distal right femur is due to abnormal bony development or post-mortem mineral inclusions. However, it should be noted that these bones were well preserved and without erosion or breaks in their outer cortices.

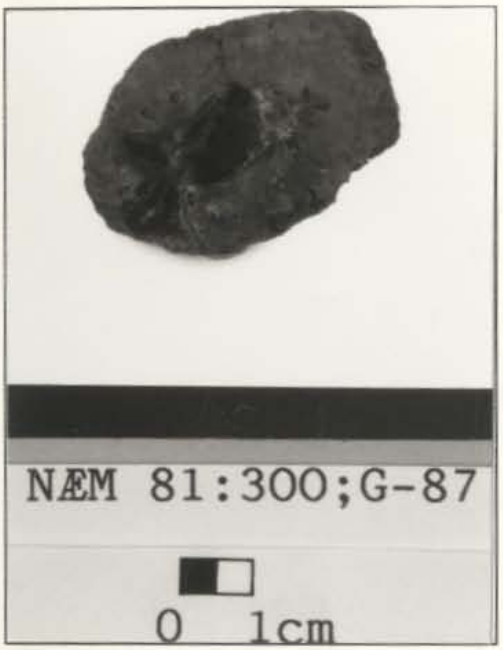

Plate 87-1: G-87
Congenital Metaphyseal Dysplasia. Child aged 4-8 years. Superior view of the right proximal tibia (metaphyseal surface). A 2 cm deep cavity extends down into the shaft. Structural defects in this and several other of the metaphyses indicate a dysplasia such as metaphyseal dysostosis.

The aetiology of these structural defects is consistent with a diagnosis of metaphyseal dysplasia such as metaphyseal dysostosis or dyschondroplasia in particular (Jacobs, 1975). Metaphyseal dysostosis is a congenital disorder characterised by splaying and irregularity of the metaphyses (Jacobs, 1975). The

mild, 'Schmid', type of the disease is the most common form affecting the metaphyses of the major long bones affected (*ibid.*). Splaying, cupping, radiolucency and other mild structural irregularities of the metaphyses resulting from this type of disorder are consistent with the radiographic findings in G-87 (Jacobs, 1975:13; 25 and fig 1.48).

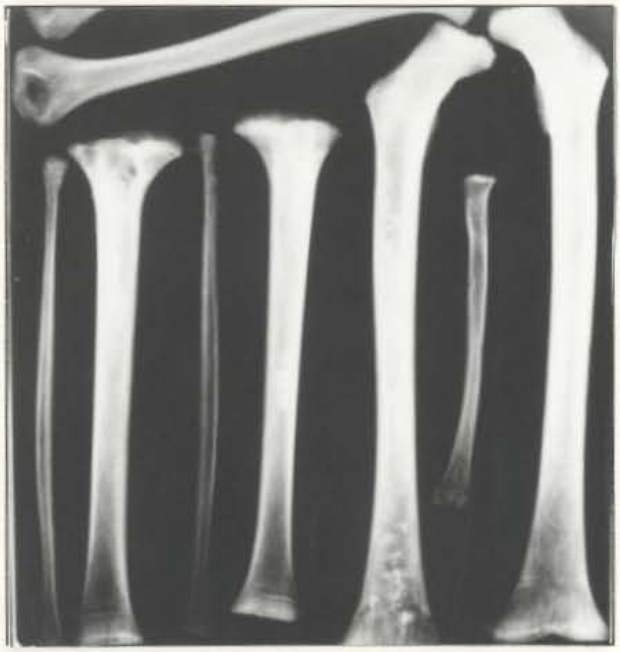

Plate 87-2: G-87
Metaphyseal Dysplasia; X-ray of the Long Bones. Left to right are: the distal right humerus (top); right fibula and tibia, left fibula and tibia, right femur, right radius, and left femur. The zone of radiolucency in the right proximal tibia demonstrates the involvement of the metaphysis and the proximal diaphysis. Radiodensity occurs in the diaphyses especially below the metaphyseal defect in the right tibia. Note the mottling in the right proximal tibia and distal femur and the splaying of metaphyses about the knee (especially those of the right knee).

Dyschondroplasia should also be considered since it is a similar congenital disease which results in disordered growth of the metaphyses of long bones (Jacobs, 1975). Characteristic features such as multiple metaphyseal area defects due to the accumulation of unossified cartilage and splaying of long bone ends due to improper remodelling may explain the deformities seen in G-87 (Ortner and Putschar, 1985; Grange, 1992b). However, dyschondroplasia most often involves the tubular bones of the extremities and when the larger long bones are

involved, growth retardation and bowing deformities often result from the disordered and uneven growth (Ortner and Putschar, 1985).

Neither of the above congenital disorders are exclusively diagnostic of the abnormalities seen in G-87, yet they remain as the most probable diagnoses. Other possibilities such as post-rachitic deformity, normal variation and post-mortem changes have been considered elsewhere and cannot be entirely dismissed from the differential diagnosis.

5.1.6.2 Localised Congenital Defects

This sub-category of congenital defects includes a wide variety of skeletal defects which may result from improper or imperfect development of embryonic skeletal elements or developmental fields. Skeletal elements describe developmental areas of individual bones whereas developmental fields describe closely related embryonic tissue which develop into specific structures or closely related structures such as the skull, vertebral column or ribs (Barnes, 1994). Many defects, whether localised or field type, can manifest on a continuum from mild and clinically undetectable to obvious, severe and lethal (*ibid.*).

Most of the mild defects are more commonly referred to as morphological variations. In the Helligåndshus collection some of the localised defects or morphological variations which were observed consist of: developmental defects of the skull including: metopism, divided mastoid, os inca, tympanic dehiscence and various sutural wormian bones; defects of the sternum including sternal

aperture; defects of the vertebral column and ribs including: sacralisation of the last lumbar segment, lumbarisation of the first sacral segment; vertebral fusion and bifid rib; and various defects of the long bones including sternal aperture of the humerus and fossa of allen in the femur. Most of these defects would have been clinically undetectable and asymptomatic but a few may have been exacerbated by growth, development, stress and trauma so as to cause symptoms of a disorder.

Case Descriptions

Only those defects which may have caused symptomatic disorders either directly or indirectly through related complications such as premature arthritis are relevant to the description of congenital disorders. Aside from the minor arthritic developments which may or may not have been associated with the cases of vertebral border shifting defects, only four cases of congenital defects were considered as potentially detectable and/or symptomatic of a clinical disorder in the living individual.

In the three cases where congenital/developmental defects are believed to have caused symptomatic disorders or related complications, two are the result of minor developmental defects with secondary complications and one is the result of what may have been a serious congenital defect. G-130 and G-299 are two cases of vertebral border shifting defects whereby a minor developmental delay at the lumbo-sacral border resulted in the sacralisation of the terminal

lumbar segment (Barnes, 1994). G-270, on the other hand, could be a case of a serious congenital defect whereby a major developmental delay resulted in the malformation of the right hip joint. However, localised infection or vascular disruption due to trauma are two other possible aetiologies which cannot be dismissed in this latter case.

In G-130, a supernumerary lumbar segment with a defect of vertebral border shifting has resulted in the complete bilateral sacralisation of L6. This supernumerary lumbar body appears to be slightly less developed on the left half of the vertebral corpus. The complications of this condition are a slight asymmetry of the sacrum with less height on the left side, compensatory arthritis on the L5-L6 articulation with severe osteoarthritic eburnation affecting the right dorsal articulation in particular (Plate 130-2) and a slight compensatory scoliosis in the thoracic spine.

In G-299 there is a vertebral border shifting defect without a supernumerary vertebral body. The lumbosacral border has shifted cranially with complete bilateral sacralisation of L5. In this case, the defect is further complicated by neural arch defects in L5 as well as down the entire sacrum. The neural arch defects have resulted in a bifid spinous process in L5 and a complete sacral cleft from S1 through S5 (see Plate 299-1, in trauma section 5.1.5 and Plate 299-2, below). In addition to the bifid spinous process in L5, spondylolysis has occurred (Plate 299-1; Plate 299-3). The unstabilised spinous process exhibits a pseudoarticulation between the right and left half of the bifid process (Plate 299-3)

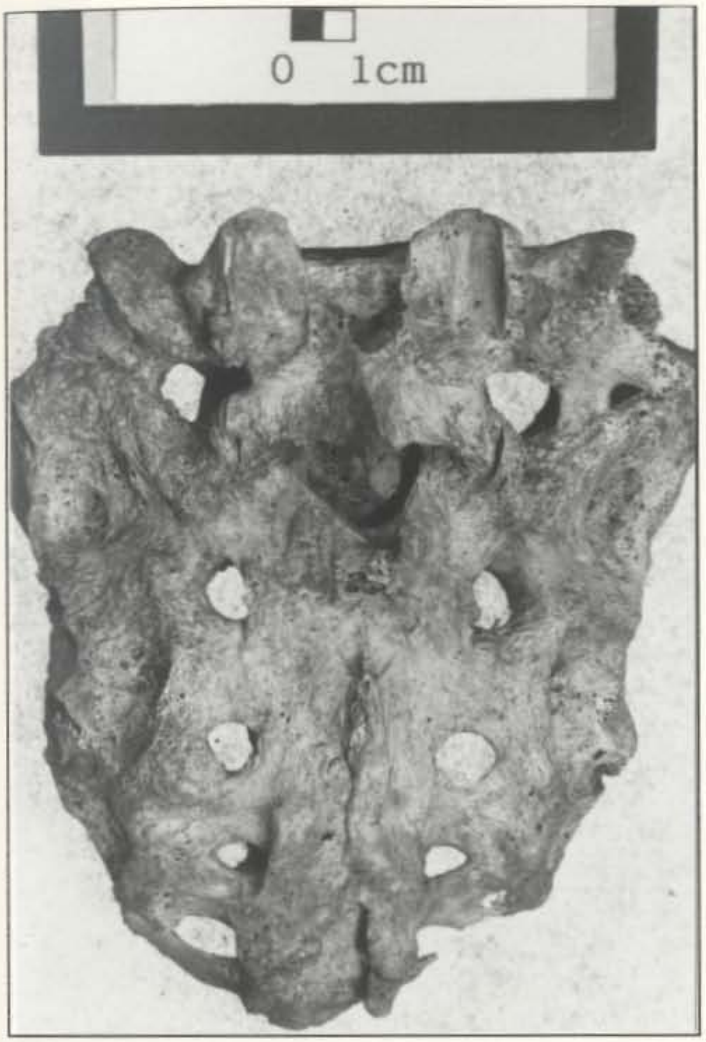

Plate 130-2: G-130
Bilateral Sacralisation; Supernumerary L6. Mature adult male aged 32-48 years. Posterior view of the sacrum illustrating complete bilateral sacralisation of a supernumerary lumbar vertebra (L6). Slight asymmetry of the sacrum occurs due to less height (underdevelopment) on the left side of L6. Osteoarthritic eburnation, most severe on the right superior dorsal facet of L6, is indicative of compensatory arthritis.

as well as between the proximal neural arch and the sacralised lumbar body "pedicles", where the spondylolysis fracture would have occurred (Plates 299-1 and 299-2). Eburnation also occurs on the proximal superior surface of the bifid neural arch, suggesting a pseudoarticulation with vertebral elements above (Plate 299-1). However, since the spine was not recovered for this individual, the nature of this faulty articulation and any other related defects of the spine cannot be determined.

Plate 299-2: G-299
Neu ral Arch Defects.
Mature adult male aged 33-44 years. Posterior view of the sacrum illustrating cleft defects of the neu ral arches, L5 (sacralised) through S5. The uppermost eburnated "facets" are the flattened pedicles of L5 where the spondylolysis occurred and a pseudoarticulation with the independent spinous process later developed.

In contrast to spina bifida occulta, a serious defect of the neural tube, this individual exhibits a comparatively mild defect of the neural arch which would have been compensated by tough fibrous tissue closing the gap between the

missing neural arches (Barnes, 1994). The complications of this defect, including spondylolysis and arthritis, may be have been predisposed by the increased flexibility of fibrous tissue as opposed to bony structure, but trauma and mechanical stress would have been responsible for the ultimate development of these pathologies.

Plate 299-3: G-299
Bifid Spinous Process with Medial Pseudoarticulation.
Spinous process of L5; opened medial view of the bifid spinous process with a secondary pseudoarthrosis. The spinous process is independent from the vertebral body due to spondylolysis. See also plate 299-1 in Section 5.1.5 (trauma).

In the last case, G-270, the pathology is unilateral, involving only the right hip joint. Although the acetabulum and femoral head have suffered post-mortem breakage, reconstruction of the joint clearly demonstrates severe pathology

affecting both elements. The femoral head is degenerated and has an anomalous shape, while the acetabulum is severely malformed (Plate 270-1). There is no proper acetabulum; the ilium, ischium and pelvis come together in a "ring" or rim of bone with a central hole where these three bones normally join to form the joint socket, or acetabulum. This is clearly not an artefact of post-mortem erosion since compact bone is intact over the "acetabular" surface of the ilium, ischium and pubis.

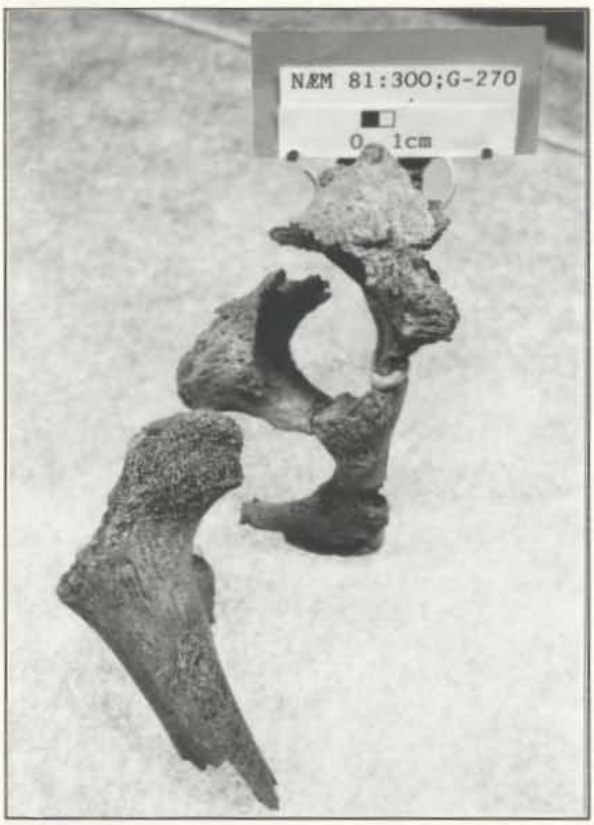

Plate 270-1: G-270
Congenital Malformation of the Hip Joint. Adolescent aged 12-16 years. Right hip joint: lateral view of the perforated acetabulum (pubic bone resting in stabilising puddy on the table top) and anterior oblique view of the proximal femur. Reconstruction of the acetabulum illustrates the malformation of the seat of the joint socket. Instead of a proper seat, the acetabulum is just a rim of bone. Although post-mortem damage is evident, compact bone over the surface of the acetabular "rim" demonstrates that this malformation is not a post-mortem feature.

On the left side, all corresponding elements and epiphyses appear normal and without pathological changes. On the left side, where normal development

can presumably be judged, fusion of the acetabulum has not yet begun. The age of this individual is estimated at 12-16 years. At this age and stage of development in a normal individual, the ischio-pubic ramus is fused, billowed surfaces of union are present on the ilium, ischium and pubis and fusion of the acetabulum is imminent (Bass, 1987). On the right side, not only has fusion not begun, but the acetabular extensions and billowed surfaces are absent from the ilium, ischium and pubis. Where the three bones normally come together in a "Y" shaped union at the centre of the acetabulum (Bass, 1987:187), there is a wide opening. The malformation and/or degeneration of this joint is believed to have originated due to a congenital malformation whereby the normal development of the acetabular cartilage of the ilium, ischium and pubis did not occur.

Differential diagnosis for this case include a possible infectious aetiology such as a localised tuberculosis infection or a possible trauma leading to avascular necrosis of the femur and acetabulum. Of these two possible alternative diagnoses, tuberculosis infection is the most likely. The hip joint is a common site of tuberculosis infection and destruction can be both severe and localised to the joint. Trauma and avascular necrosis is less likely in this case because of the severity of destruction of the acetabulum. While destruction of the femoral neck and head are often result from trauma and disrupted blood supply to the femoral head, destruction of the acetabulum, especially to the extent that it occurs in this case, is unlikely.

Developmental Defects Occurring as Morphological Variations

Although this investigation was not designed specifically to record and study the mild developmental defects which are generally referred to as morphological variations, a number of traits were recorded during the general observation of all skeletons. It has been suggested that a detailed study of the range of congenital/developmental defects may both serve as a genetic marker for a past population as well as an indicator of the population's susceptibility to severe congenital defects. Hence, this is a potential area for further directed study of the collection (Barnes, 1994). Table 5.1.6.2c lists the minor developmental defect/morphological variations and their occurrence of in the Helligåndshus G-series skeletons. The total number of observed defects/traits is presented as opposed to frequencies in the population, since variablity in skeletal preservation renders different "assessable populations", relative to each trait and the skeletal element on which it can be observed. Therefore, frequencies have been omitted from this preliminary overview of developmental defect/morphological trait occurence in the G-Series (also refer to the note "*" below Table 5.1.6.2c).

Table 5.1.6.2c

Minor Congenital/Developmental Defects

Developmental defect/ Morphological trait: by developmental FIELD; type	Individuals exhibiting trait: (by grave number G-...)	Total* number of individuals exhibiting trait
SKULL;		
metopism	24,91,140,177,289,309	6
divided mastoid	5,140,306	3
os inca	39,140	2
accessory ossicles	5,79,157,248	4
tympanic dehiscence	60,301	2
condyle asymmetry	24	1
STERNUM;		
Sternal aperture	93	1
VERTEBRAL COLUMN AND RIBS;		
lumbar sacralisation: ↔:bilateral.←;unilateral right. →;unilateral left	↔:130,197,241, 257,267,299 ←:74,314. →:215	9
supernumerary vertebra (L6)	74, 130	2
cleft neural arch (vertebrae involved)	42(C1),125 (C2), sacrum: 79,299	4
fused vertebrae (#'s)	124 (C4/C5)	1
fused ribs (bifid:# & side)	210 (3rd left)	1
PERIPHERAL SKELETON;		
septal aperture	117,175,206,273	4
fossa of allen	99,175,186,199	4

* The total number of individuals exhibiting a given developmental defect is a minimum number for the occurence of the defect in the total G-Series population. Because of the great variability in the preservation and recovery of skeletal elements, the total number of individuals for which the different defects could be assessed varies according to the recovery of the skeletal element(s) concerned. Therefore, frequencies of the different defects observed in the collection are misleading underestimates of the actual or potential occurence calculated from variable denominators (i.e. the total population of recovered skeletal elements for the defect). For this reason frequencies are not presented here; however, a detailed and directed study of developmental defects may reconcile this problem.

5.1.7 Neuromechanical and Degenerative Disorders

Neuromechanical and degenerative disorders include those conditions which affect the structural and mechanical integrity of the skeleton. Neuromechanical conditions include spinal curvature, paralysis and various other conditions which result from structural and mechanical deformities of the skeleton and their related neurological complications. Degenerative disorders include tissue deteriorations due to pre-existing disease, or increasing age of the individual (Underwood, 1992b). Although tissue degeneration may affect any tissue, connective tissues are the most prone (*ibid.*). On skeletal material, few disorders of tissue degeneration will be manifested. However, arthritis, a degenerative inflammatory disease of the joints, is readily diagnostic on bone and exceedingly common in the general population. The following discussion is divided into two sub-categories: arthritis (i) and neuromechanical disorders (ii).

The following tables 5.1.7a, 5.1.7b and 5.1.7c list all identified cases of arthritis. Table 5.1.7a lists those cases in which the spine is the main localisation of arthritis and any extra-vertebral changes are primarily localised conditions. Table 5.1.7b, lists cases in which arthritis affects the spine as well as all or most joints of the peripheral skeleton; the arthritic condition is described as a combination of vertebral arthritis and degenerative joint disease generalised throughout the peripheral skeleton. Table 5.1.7c, lists cases in which arthritis occurs as a localised condition affecting only one or few localised joints in the skeleton. Age and gender associations for all arthritic conditions are summarised in Table 5.1.7d.

Table 5.1.7.1a

Arthritis: Vertebral Arthritis +/- Localised Peripheral Joint Involvements

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-1							†Av-c;Tmj	Dacl	F?	AdM	30-50
G-254							Avc8m;sh		F?	Ad?	30-50?
G-99	Dh?Sc	*	Im;D/Pc				Av-ct	Dlegrl	F	Adl	27-33
G-94							†Av-ct		I	Ad?	>23+
G-124							†Av-ct		I	Ad?	>23++?
G-2	Dh	*----------		Ffn	*----------		†Avct-l*H		F	Adl	21-46+-
G-46	Dh						†Avct;h;f	Dcwl-r	M?	AdM	33-53
G-12	Dh						†Av-t	Dc-gr	M	Adl	30-40
G-314							Av-t		F	Adl	20-25+-
G-262							Av-t,8m		F	AdS	50-70
G-102							†Av-t;r		I	Adl	24-46
G-8		oschr		spL5			†Av-t;s;k		M	Adl	25-35
G-125							†Av-tl		M	AdM	40-44+-
G-177			Itb Rib				Av-tl	Dwl-er	I	AdM	43-63
G-76	Dh		Isy	PFcl			Av-tl	Dclwgr	F?	Adl	27-38+?
G-130	Dh?Sc		Im				AvtlNsTmj	Dcl!er	M	AdM	32-48
G-39		C	Isy				†Av-tl,8m	Dac-gr	M	Adl	30-44
G-279							Av-l		F	Adl	23-30
G-246				FPv			†Av-l		M	Adl	28-39
G-155							†Av-l,8m		M	Adl	30-42
G-195							Av-l;sh		F	AdM	35-45+-
G-243			Im				†Av-l;k;h		F	AdM	36-45
G-248			Im				Avl8m;sh;s	Daclr	M	Adl	30-43
G-140	Dh						Av;Tmj	Dac-gr	F	Adl	25-35
G-10							Av		1	Ad?	>21-24+
G-214							Av		M	Adl	27-42
G-104							Av		F	AdM	40-44+-
G-158							Av	Dwl-r	M?	AdM	38-50?+
G-234							Av;cl	Dl-r	F	Adl	32-45
G-131				Ful			Av;s		M	AdM	46-57
G-48	Dh						Av;uplim	Dacwgr	F	Adl	29-45
G-184							AvTmj;sh	Dcwl-r	M??	AdM	38-59
G-75							Av-8m;sh		F	Adl	35-39+-
G-36							Av;k;IH		F	Ad?	>30+old
G-268				Fcl			Aav	Dacl-r	F	Ad?	30-50+-
G-89	?B						Aav;wr		M	AdM	40-58
G-240		*necr----		Ffn	*----------		Aav_-l*H		F?	Ad?	mature+
G-273			I	Frib			Av;Ns		M	AdM	47-58
G-265		oschr					AvSmj-Ns		F?	Adl	24-30
G-42							AvSmNs;f	Dal	F?	AdM	35-45

------ - Disease Association; indicates a posited relationship between arthritis and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified arthritic condition.

---?--- - Possible or questionable association.

Aav - Excluding this condition. In this case, vertebral arthritis with ankylosis is not thought to be related to the arthritic condition suffered by this individual.

* - Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.

IIINp - special case; i.e. localised severe hip degeneration with neuromechanical complications, see detailed discussion.

† - vertebral column was incomplete; localisation of arthritis is an artefact of preservation.

Disease Codes; See code descriptions below Table 5.1.7c

Table 5.1.7b

Vertebral Arthritis and Generalised Peripheral Joint (DJD) Combined

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-3	O			Fwr			†Agv-c	Dcl-er	F?	AdM	50-59
G-121							Agv-c	Dl-er	F?	Ad?	>24++?
G-5	BO			Frib			†Agvct;Ns	Dcl-r	F	AdM	45-65
G-117							†Agav-ct	Dl-r	F?	AdM	40-68
G-162							Agv-tlSm	Dcl	M	Ad1	29-42
G-68			Im				Agv-tlSm	Dacl-r	F	AdM	34-46
G-85	BO*-----*----ImI*----Ffn*----------						AgvSm*!HNp		F	AdM	35-53
G-74	B						Agv		M	AdM	46-57
G-202		oschr	I	?			Ag-v	Daclwr	F	AdM	34-50
G-245	BO			Frib			Agv		F??	AdM	46-59
G-153	Dh						Agv	Dcl-gr	F	AdS	50-72
G-319							Agv	Dl	F	AdM	35-60+-
G-182							Agv	Dl-er	F?	AdM	47-59
G-101							Agv;!H		M	AdS	51-69
G-109							Agv;Ns	Dcl-er	F	AdM	46-57
G-91							!Aav;g	D-l	M	AdM	38-56

Table 5.1.7.1c

Arthritis: Localized Joint Involvements

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEARS
G-223	Dh		Isy				ATmj		F?	Ad1	32-47
G-71							Ae		M	Ad1	30-42
G-224							Ae	Dac-g	F?	Ad1	>21-24+
G-261							Ae		M	Ad?	>25+?
G-19							Ae		I	Ad1	33-42+-
G-278			Im				Awr		F?	Ad?	>25++?
G-9	O						Ash;k		F?	Ad?	>24+old
G-188							Ash;h	Dl-er	F	AdM	41-66
G-312							Ak		I	FG	>15-21+
G-199			Im				Ak		M	AdM	40-44+-
G-197						scrL5---	AlocL5		F	Ad1	31-44
G-11				Fcl----------			Ar/v-t	Dac	F	Ad1	20-30
G-26							Af		F?	FG	>15-20+
G-306				Neopls			Ah;f	Dacler	F	AdM	36-58+?
G-260							Ah		F	Ad?	>25+?
G-226							Ah		F	Ad1	35-40+-
G-299				spL5--------clfL5↓			AL5;k;h		M	Ad1	33-44
G-194			I?tb?br				As-i	Da	F	Ad1	20-30+-
G-257				Fank			AlH;f		I	AdM	35-45
G-80							AlH		M	Ad1	30-40+-
G-270	------*------		Im------*?			----------hip*--	*AlH		0	Jv	12-16

Arthritis and Neuromechanical Disease Codes:

A= Arthritis; **v**= vertebral (**c**=cervical, **t**=thoracic, **l**=lumbar); **Sm**=Schmorl's nodes;
loc= localised (singular joint involvement) **g**= generalised (diffuse peripheral joint involvement)
Multiple location specifications:
Tmj= Temporo-mandibular joint; **sh**=shoulder; **h**=hip; **f**=feet; **e**=elbow; **k**=knee; **wr**=wrist; **uplim**= upper limb; **cl**= clavicle; **r**= rib; **r/v**=costo-vertebral joints; **s-i**= sacro-iliac joint(s); **L5**= 5th lumbar vertebra
Complications:
a= arthritic ankylosis; **!H**= severe hip pathology with ankylosis and/or contracture
Ns= Neuromechanical deformity of the spine (scoliosis and/or kyphosis)

Table 5.1.7.1d

Arthritis: Age and Gender Distribution

Age (age in years) Category: numerical		5.1.7.1 (i) Vertebral Arthritis T: ♂/I/♀/p	5.1.7.1 (ii) Vertebral and Generalised T: ♂/I/♀/p	5.1.7.1 (iii) Localised Only T: ♂/I/♀/p	Total; all types (i),(ii),(iii) T: ♂/I/♀/p
Jv:	12-21	0	0	**1**: 0/0/0/1	**1**: 0/0/0/1
FG:	≥15-21	0	0	**2**: 0/1/1	**2**: 0/1/1
Ad?:	≥21	**7**: 0/4/3	**1**: 0/0/1	**4**: 1/0/3	**12**: 1/4/7
Ad1:	21-39.5	**18**: 7/1/10	**1**: 1/0/0	**10**: 3/1/6	**29**: 11/2/16
AdM:	39.5-57	**14**: 8/1/5	**12**: 2/0/10	**4**: 1/1/2	**30**: 11/2/17
AdS:	57-79	**1**: 0/0/1	**2**: 1/0/1	0	**3**: 1/0/2
Total:	all ages	**40**: 15/6/19	**16**: 4/0/12	**21**: 8/3/12/1	**77**: 24/9/43/1

Age codes: Ch=child; Jv=juvenile; Ad=adult (also refer to section 4.2.2 for details on age category codes). Age and Gender breakdown (totals by age group: totals for age/gender group), where, **T**: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.7.1 Arthritis (A...)

In the Helligåndshus population, arthritis was observed in 77 individuals or 23.5% of the G-series. It is the most prevalent of the observed pathological conditions. A total of 77 individuals, 50.0% of the 154 pathological skeletons, exhibited arthritic lesions at one or more joint locations. Due to great variability in skeletal preservation and representivity as well as the broad scope of this investigation, arthritis was studied only in terms of the presence or absence of degenerative joint changes; the complicated or uncomplicated nature of the

condition; and the relative severity of any bony alterations. In the case of vertebral arthritis, results are not reported per vertebral segment. Due to the poor comparability of skeletal representivity between individuals, the spine is treated as one type of joint location affected by arthritic degeneration. The discussion of arthritis and presentation of cases is separated into three observed presentations of the disease: (i) arthritis of the vertebral column (Tables 5.1.7.1a and 5.1.7.1b); (ii) generalised Degenerative Joint Disease (DJD) of the peripheral joints (Table 5.1.7.1b); and (iii) localised Degenerative Joint Disease (Table 5.1.7.1c).

Except for one juvenile, all those with observed signs of arthritis, were categorised as full grown or adult individuals. In the case of the subadult, arthritis is believed to be a secondary result of septic tuberculosis arthritis or a severe congenital hip pathology and its resulting malformation of the joint. Hence, it would seem that arthritis occurred as a degenerative age-related condition in this collection. This does not preclude the influence of other factors such as physical strain from occupational activities but may suggest that causative factors were cumulative with age.

5.1.7.1 (i) Vertebral Osteophytosis/Osteoarthritis: (Av-...) (Agv-...)

The aetiology of the observed vertebral arthritis is thought to be of a generally age-related degenerative type, namely, vertebral osteophytosis or spondylosis deformans where articulating surfaces of the vertebral corpi and the dorsal facets become progressively porous and lipped due to a gradual

degeneration of the joints involved (Steinbock, 1976; Ortner and Putschar, 1985). In other cases, where the joint disease is further progressed and involves ankylosis in one or several areas, the aetiology may be more complicated than an age and mechanical stress related cause. Several of these conditions were found, ranging from isolated areas of fusion to massive inflammatory bone growth and fusion of multiple vertebral bodies.

An age related predilection for vertebral osteophytosis is supported by patterning within the adult age category. The frequency of those affected appears to increase with age; i.e., while only 18 out of 102 (17.6%) young adults (Ad1) are affected, 26 out of 47 (55.3%) mature adults and 3 out of 3 (100%) senile adults are affected. In relation to gender, patterning indicates a slight preference for females. Whereas 30 out of 103 (29.1%) females exhibited signs of vertebral osteophytosis only 19 out of 79 (24.1%) males exhibited lesions. In the indeterminate gender category, 6 out of 34 (17.6%) individuals showed signs of vertebral osteophytosis. However, to some extent age and gender figures may be affected by poor preservation; with incomplete preservation in many individuals, signs of the disease may be "invisible" due to post-mortem damage or loss.

Vertebral Osteophytosis or Spondylosis Deformans is a degenerative arthritic condition of the intervertebral joints which are not true synovial joints, but rather secondary cartilaginous joints lacking a synovial membrane. Degenerative changes of the apophyseal joints are not included in this diagnosis proper because these joints are true synovial joints and the condition is thus

referred to as vertebral osteoarthritis. In practise, however, a distinction is not always made, nor is it always deemed necessary on anatomic or pathologic grounds (Steinbock, 1976). For this reason, vertebral arthritis involving either or both joint types has been described under the same aetiological description of degenerative vertebral arthritis.

Arthritis of the apophyseal joints is marked by porosity, eburnation and marginal lipping of the articulating surfaces (Ortner and Putschar, 1985). Where the vertebral bodies are concerned, arthritis develops as a result of degeneration of the intervertebral disc. Erosion, porosity and marginal osteophytes are sequelae of anterior disc compression, disc herniation and the stress on adjacent ligaments. As osteophytosis progresses, disc herniations may result in areas of lytic erosion, namely Schmorl's nodes, and osteophytes may coalesce between vertebral bodies resulting in bony ankylosis of vertebral segments (Ortner and Putschar, 1985). Schmorl's nodes (Sm) and vertebral ankylosis (av) are considered as complications of degenerative arthritis in the spine. both conditions are noted by their abbreviations "Sm" and "av" in Tables 5.1.7.1a and 5.1.7.1b.

Case Descriptions

Referring to Tables 5.1.7.1a and 5.1.7.1b, there a total of 56 cases of vertebral osteoarthritis (Av); 40 of these cases involve few or no peripheral joints while 16 cases exhibit concurrent generalised arthritis of the peripheral skeleton. Ankylosis (Aav) of two or more vertebral bodies was observed in 6 cases and

Schmorl's nodes (Sm) were observed in 11 cases. Neuromechanical deformities (Ns) of the spine accompanied arthritis in 6 cases; in these individuals, it is quite probable that arthritis was exacerbated by the increased mechanical stress of the neuromechanical deformity. These cases are discussed in the sub-category of neuromechanical conditions, where arthritis may be considered in relation to the specific spinal deformity.

Arthritic changes occur throughout the spine (**Av** and **Agv**) in 27 out of 56 cases. In other cases, localisations to the cervical, thoracic or lumbar areas of the spine are noted as Av-..."c", "t" or "l", respectively. However, in many cases this is an artefact of incomplete preservation (†) as opposed to differential development of arthritis in the noted area. A total of 40 individuals from the two tables had complete or nearly complete preservation of the vertebral column. Distribution of arthritic changes for these individuals was as follows: 1 cervical localisation; 1 cervical-thoracic localisation; 2 thoracic localisations; 5 thoracic-lumbar localisations; and 4 lumbar localisations.

In the Helligåndshus collection, the character of arthritic lesions in the spine follow the usual pattern of erosion and marginal osteophyte development on vertebral bodies and porosity and marginal osteophytes on the superior and inferior apophyseal joints (Plate 182-1). The severity of arthritic lesions ranged from mild +1 porosity and lipping to severe +4 porosity and conjoining osteophytes. Severity was variable for different individuals and for different areas of the vertebral column. In general, severity was seen to increase with the age of

the individual and with greater stress and weight bearing regions of the vertebral column. Plate 182-1 illustrates the common features of vertebral osteoarthritis and osteophytosis as seen in the Næstved G-series collection. In this individual, arthritis occurs throughout the spine affecting both the vertebral bodies and the posterior facets. Early development of Schmorl's nodes may have begun in the lower thoracic and lumbar spine but erosion is minimal and not clearly diagnostic.

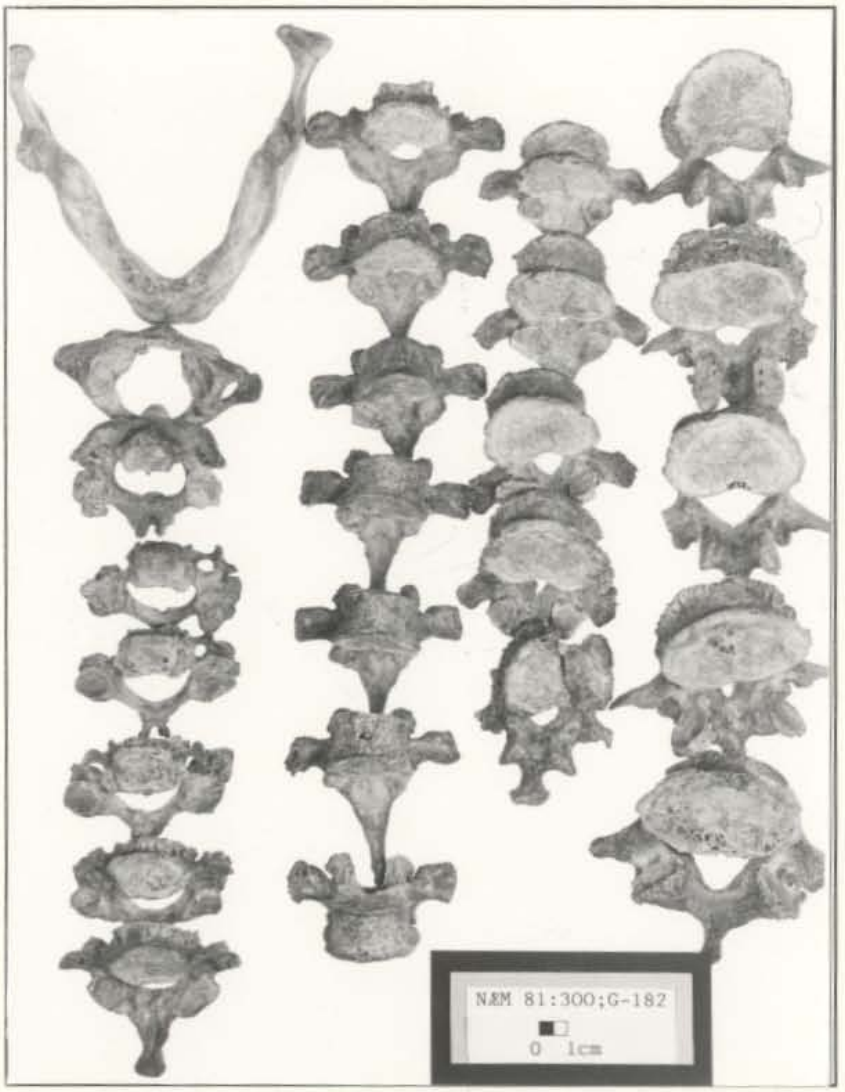

Plate 182-1: G-182 **Arthritis; Osteophytosis and Degenerative joint Disease (DJD).** Mature adult female? aged 47-59 years. Superior oblique view of the mandible and inferior oblique view of vertebral bodies (running left to right and top to bottom C1-C7; T1-T8; T8-T12; L1-L5). Changes due to DJD are seen as erosion and porosity on the mandibular condyles and lipping and porosity on the apophyseal joints surfaces of the vertebrae. Changes due to osteophytosis are seen as porosity and marginal lipping of vertebral bodies.

In the Helligåndshus G-series, well defined lytic lesions characteristic of Schmorl's nodes were observed in thoracic and lumbar locations. This is consistent with the usual pattern of disc herniations and bony erosion due to greater weight bearing stress in the mid and lower spine (Ortner and Putschar, 1985). Ankylosis also appears in the thoracic and lumbar spine as opposed to cervical locations. Like Schmorl's nodes, ankylosis is a consequence of disc degeneration which most often occurs in the weight bearing areas of the spine. In specific, ankylosis is a result of progressive anterior and lateral osteophyte development secondary to pulling and irritation of ligaments by the protruding intervertebral disc.

Aside from the common pattern of age related degenerative arthritis in the spine, there are a few cases which exhibit complications and/or unusual features. G-5, G-42, G-109, G-130 and G-273 have co-existing neuromechanical deformities of the spine. These cases all exhibit arthritic degeneration which is more pronounced and severe in areas of the greatest structural deformity. These cases will be discussed under neuromechanical conditions. In G-91 and G-117 ankylosis is pronounced and extensive, resulting in the fusion of several vertebral bodies. Both of these conditions were considered for differential diagnosis from diffuse idiopathic skeletal hyperostosis (DISH) and ankylosing spondylitis in particular.

In G-91 arthritic lesions occur throughout spine and the peripheral skeleton. Articular surfaces of the temporo-mandibular joint, clavicles, scapulae, and long bones all exhibit early signs of Degenerative Joint Disease. In the vertebral column, joint changes are confined to the vertebral bodies, sparing the apophyseal

and costo-vertebral joints. Changes affecting the vertebral bodies include liberal syndesmophytes on the right anterio-lateral side of several thoracic and lumbar bodies. Conjoining syndesmophytes has resulted in ankylosis of the following vertebral bodies: T6 and T7, T9 and T10, T12 and L1, L2 and L3 (Plate 91-1).

Plate 91-1: G-91

Vertebral Osteophytosis. Mature adult male aged 38-56 years. Anterior view of the vertebral column. Conjoining osteophytes have resulted in ankylosis of T6/T7; T9-T10; T12/L1; L2-L3. The smaller are characteristic of the "parrot beak" outgrowths of vertebral osteophytosis. The larger massive conjoining lesions suggest a long standing condition with remodelling of beaked osteophytes into smoother masses of bone.

Ankylosis of vertebral bodies may be the result of advanced vertebral osteophytosis, diffuse idiopathic skeletal hyperostosis (DISH) or the one of the seronegative spondyloarthropathies (SNS) such as ankylosing spondylitis. In this case the SNS disorders were dismissed from the diagnosis because characteristics features of these conditions, including sacro-iliac fusion and involvement of the apophyseal and costovertebral joints, among others are absent in G-91 (Steinbock, 1976; Arriaza, 1993).

Vertebral osteophytosis and DISH are the most appropriate diagnostic considerations for this case. Vertebral osteophytosis is considered since the conjoining osteophytes may result in the observed broad asymmetrical bridging between vertebrae without the involvement of apophyseal or costo-vertebral joints. Conjoining osteophytes are very often asymmetrical and right sided; on the left side, the overlying descending aorta prevents the development of hyperthropied bone (Ortner and Putschar, 1985). Vertebral osteophytosis is a common condition, both in this collection and in humans populations in general; degenerative changes may begin as early as the third decade and by the sixth decade almost all persons are affected (Steinbock, 1976).

The primary characteristics of DISH include: thick osseous bridging between vertebral segments occurring asymmetrically and usually to the right side; preservation of intervertebral disc space; sparing of the sacro-iliac, apophyseal and costovertebral joints; and irregular enthesial (joint capsule insertions, tendons and ligaments) ossification or "whiskering" (Arriaza, 1993). All

of these features are consistent with the findings of G-91; the spinal changes are confined to the vertebral bodies, bony ankylosis is massive, bridging and right sided between vertebral segments, and ligamentous "whiskering" was observed on the greater trochanter of the femora as well as to as lesser degree elsewhere. The age of onset for DISH is normally the fifth decade and the gender preference is predominantly male (*ibid.*). This individual is a male between the ages of 38 and 56 years and thus fits the demographic profile for DISH as well.

None of the bony changes in G-91 are pathognomic for one disease or exclusive of the other. Differentiation between DISH and vertebral osteophytosis is often based on the appearance of the hypertrophied bone on the spine. With DISH the lesions are usually thicker paravertebral ossifications, whereas with vertebral osteophytosis bony outgrowths are often horizontal "parrot beak" ossifications (Steinbock, 1976; Arriaza, 1993). In G-91 the smaller lesions resemble the "parrot beak" outgrowths of vertebral osteophytosis, but the larger lesions are quite massive and smooth, not unlike the lesions of DISH. However, it is possible that the larger massive bony lesions are observed in long standing and remodelled vertebral osteophytosis as well (Ortner and Putschar, 1985). Considering the absence of extensive multi-level flowing hyperostosis which is pathognomonic of DISH and the presence of arthritis elsewhere in the peripheral skeleton, long standing vertebral osteophytosis is the preferred diagnosis in this case.

Differential diagnosis between vertebral osteophytosis and ankylosing spondylitis is indicated in the case of G-117. In this individual skeletal

preservation and recovery was incomplete but degenerative changes observed on articular elements of the temporo-mandibular joint, clavicles, sternum, shoulder, elbow and vertebral column suggest that arthritis was generalised throughout the skeleton. Changes affecting the vertebral column include porosity, erosion, syndesmophyte formation with bony ankylosis and intervertebral osteochondrosis of several thoracic vertebrae; porosity of the apophyseal joints; and marginal lipping and porosity of the costo-vertebral joints (Plate 117-1). The lumbar spine, sacrum and pelvis are missing; thus, involvement of the sacro-iliac joint cannot be established or precluded.

Vertebral osteophytosis in combination with osteoarthritis of the apophyseal and costovertebral joints may explain the aforementioned vertebral changes but enthesial ossifications may indicate a more complicated aetiology. The SNS disorders are characterised by arthritis, erosions, enthesial ossifications, spinal ankylosis and sacro-iliac fusion. Most of these disorders can be dismissed from the differential diagnosis on the basis of character and skeletal distribution of lesions (Arriaza, 1993;269). Ankylosing spondylitis remains a possibility on the basis of: thin symmetric and ankylosing syndesmophyte formation, apophyseal and costo-vertebral involvement, and reduction of normal anterio-posterior curvature of the spine seen in this case. Enthesial ossification is excessive at the sternal ends of the ribs and between the vertebral bodies (Plates 117-1: note inset, left, and vertebral surfaces, right). Arriaza (1993) describes the spinal changes as beginning in the outer fibres of the annulus fibrosus of the vertebral disc and resulting in

syndesmophytes and bony ankylosis of a few to all vertebral bodies. Extensive vertebral ankylosis results in rigidity of the spine and a reduction of the anterio-posterior curvature which are described by the colloquialisms "bamboo spine" and "poker spine". It is possible that vertebral ankylosis, apophyseal and costo-vertebral changes and especially enthesial ossifications which were observed in G-117 are the result of ankylosing spondylitis.

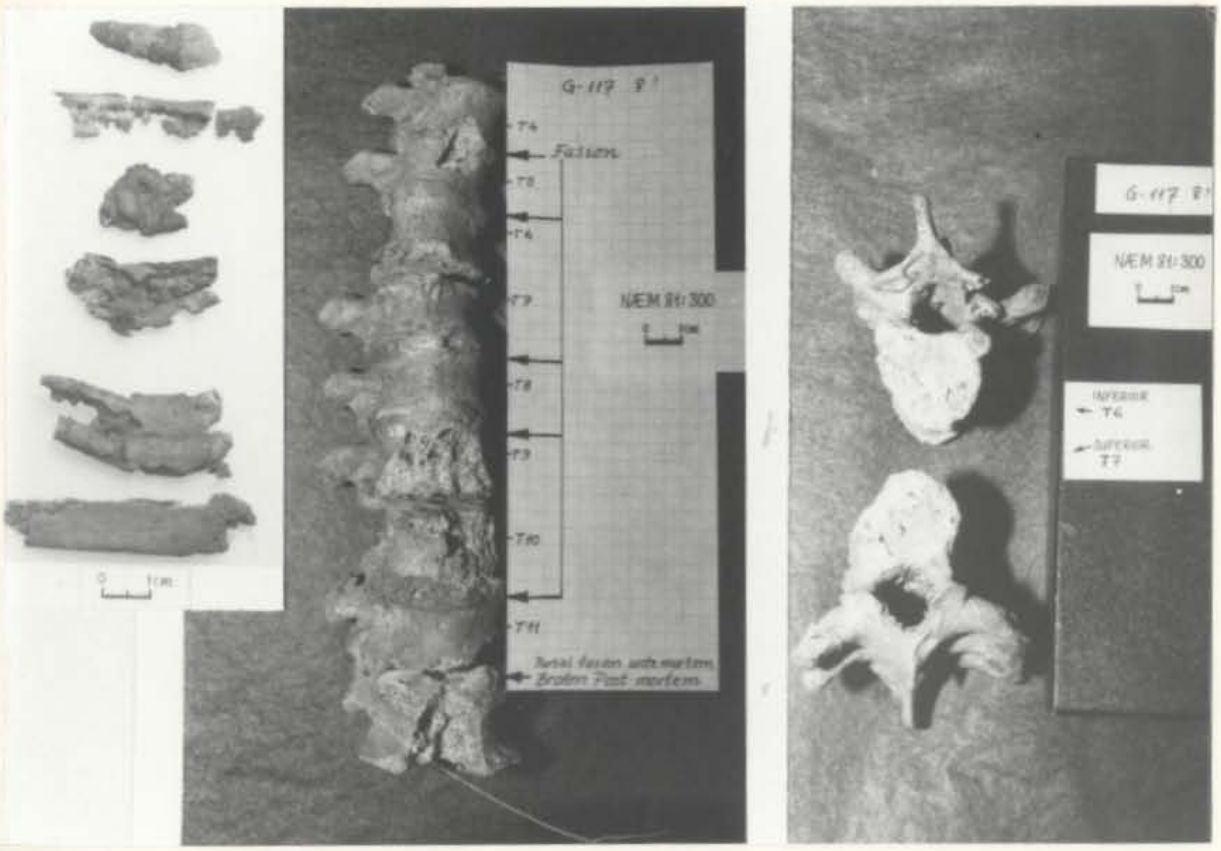

Plate 117-1: G-117
Ankylosing Spondylitis (?). Mature adult female aged 40-68 years. Left to right the plate illustrates a superior view of enthesial ossifications from the sternal ends of the ribs; anterior view of T4-T12 with invertebral fusion (indicated by arrows); and an invertebral view of T6-T7 . Intervertebral Syndesmophytes are thin and symmetric and enthesial ossification is considerable both intervertebrally and at the sternal ends of the ribs. Vertebral ankylosis of the normal anterio-posterior curvature of the thoracic spine.

However, the absence of the sacro-iliac region prevents confirmation of sacro-iliac involvement which is always present with ankylosing spondylitis. Due to the incomplete preservation of the skeleton, differential diagnosis is inconclusive; osseous changes may be a result of either vertebral osteophytosis in combination with vertebral osteoarthritis or ankylosing spondylitis.

5.1.7.1 (ii) Generalised Degenerative Joint Disease; Peripheral Skeleton (Ag)

In all cases where Degenerative Joint Disease (DJD) is described as generalised or affecting all or most major synovial joints in the skeleton, vertebral osteophytosis was concurrent. This is not surprising in that both joint diseases are known to occur with great frequency in older individuals. As a result of accumulative micro-traumas and aging connective tissue, the skeleton begins to manifest signs of DJD and osteophytosis throughout (Steinbock, 1976; Ortner and Putschar, 1985; Arriaza, 1993). In the Næstved collection, individuals with combined vertebral and peripheral joint arthritis are older on average than those with primarily vertebral or localised arthritis. Aside from one adult of indeterminate age, all individuals in this division are mature or senior adults between the ages of 34 and 72 years of age.

Degenerative joint disease, in the strict sense, is an arthritic condition of the synovial joints as opposed to the analogous degeneration of the vertebral synchondroses discussed above. This discussion is limited to generalised peripheral joint changes which were seen to accompany the vertebral conditions.

Case Descriptions

There are 16 cases of degenerative arthritis with generalised or multiple peripheral joint involvement. In order of greatest observed occurrence, joint locations for the generalised conditions included the following: the shoulder, temporo-mandibular, hip, clavicle, elbow, hands, wrist, knee, feet, and ankles. However, incomplete skeletal preservation is a hinderance to the establishment of the actual frequency of the different joint involvements; thus the observed order of frequency may be partly an artefact of differential preservation.

The observed joint changes consisted of varying degrees of the following: lipping along the margin of the articular surface, porosity adjacent to the articular surface and some degree of erosion of the articular surfaces. Eburnation, which results from mechanical erosion in severe cases of degenerative arthritis, was seen in only a few cases in the Helligåndshus collection. Arthritic changes of the observed generalised conditions are primary joint degenerations not believed to be related to predisposing conditions such as certain inflammatory, metabolic, traumatic, congenital or acquired joint disorders. However, in two cases, G-101 and G-85, there is localised severe degeneration in one hip joint in addition to moderate arthritic changes elsewhere. These two cases indicate a severe osteoarthritis secondary to trauma, vascular interruption or infection with subsequent neuromechanical deformity in the case of G-85. A number of similar hip disorders occurred as solitary localised conditions. The localised hip disorders of G-85 and G-101 are special cases of secondary arthritis described along with the localised conditions below.

5.1.7.1 (iii) Localised Degenerative Joint disease (A: Tmj; sh; e;...)

Arthritic changes may be localised in areas of greatest wear and tear such the knee, hip, shoulder and elbow or areas previously disposed to trauma, infection or other localised disorders. In most cases the former aetiology is suspected, but in a few cases trauma, infection or congenital malformation may have predisposed to arthritic degeneration in an isolated joint.

Case Descriptions

Solitary localised joint changes involving only one or a few isolated joints in the skeleton were observed in 21 individuals. An additional 19 cases, from Table 5.1.7.1a (Vertebral Arthritis), exhibited localised peripheral joints changes in association with vertebral osteophytosis and two cases from Table 5.1.7.1b (Generalised and Vertebral Arthritis) exhibited secondary localised arthritis in association with primary arthritis of the peripheral skeleton and the vertebral column. In order of observed frequency, the joints exhibiting localised arthritis in different individuals, from Tables 5.1.7.1a and 5.1.7.1b, included: the hip, shoulder, elbow, knee, temporo-mandibular joint, feet, sacro-iliac joint, ribs and clavicle. However, differential preservation has likely influenced these findings.

In 32 out of 42 cases of localised joint disease, from Table 5.1.7.1a, 5.1.7.1b and 5.1.7.1c, degenerative changes in the affected joint are attributed to primary arthritis as a result of mechanical attrition. A variety of factors may be responsible for mechanical attrition but for the most part repetitive movements are commonly

responsible for joint degeneration. Joints predisposed to attrition are generally those of heavy weight bearing stress and/or repeated use (Steinbock, 1976; Ortner and Putschar, 1985; Kennedy, 1989). The hip and knee are frequent sites of joint degeneration due to weight bearing stress, while the temporo-mandibular joint and joints of the upper limb and extremities are often subject to wear and tear by repetitive movements. These are the type of processes thought to be responsible for most localised joint changes in the Helligåndshus collection. However, in a number of cases, other factors are believed responsible.

The ten remaining localised conditions are severe joint degenerations attributed to secondary arthritic degeneration of traumatized or otherwise diseased joints. In two cases, G-299 and G-11, arthritis is considered secondary to trauma. Both of these cases have been described in detail in the section 5.1.5 on trauma. In G-299, both a congenital cleft defect in the spinous process and a spondylolysis trauma of the neural arch in the fifth lumbar are considered predisposing factors to the development of localised arthritis. In G-11, a fracture of the clavicle and related muscle damage are believed responsible for localised arthritis in several adjacent ribs and costo-vertebral joints.

The other eight cases of secondary arthritis involve the hip joint. Three of these hip pathologies, G-2, G-85 and G-240, have been attributed to avascular necrosis of the femoral head. The vascular complications are considered in section 5.1.2 on vascular disorders. In each case the severe arthritic degeneration of the joint is considered to be the end result of possible trauma and consequent vascular

disruption in the joint. The primary aetiology is difficult to establish for certain, but trauma such as a fracture of the femoral neck and vascular disruption such as aseptic necrosis of the femoral head are good possibilities.

Congenital malformation or local tuberculosis infection of the hip joint are considered in the case of G-270; the description and aetiology of the condition is considered under both of these categories. Total degeneration of the acetabular seat and partial degeneration of the femoral head and neck is attributed to secondary osteoarthritis complicating either a congenital or infectious joint disorder.

Four final cases, G-36, G-101, G-80 and G-257, are of uncertain aetiology. In G-36, severe degenerative arthritis in the left hip is accompanied by vertebral osteophytosis and uncomplicated DJD of the knee and right hip joint. In G-101, severe degeneration of the left hip joint is accompanied by both vertebral osteophytosis and generalised peripheral joint involvement. Few bones were recovered for G-80 and G-257 but in both cases, the right hip was the only joint affected by severe degenerative arthritis. Minor arthritic wear was observed in the left hip of G-257 but the absence of this area in G-80 precluded assessment of bilateral involvement.

The similarity in all four cases was the localised and severe nature of arthritic inflammation of the hip joint without avascular necrosis. In all cases the femoral head was "mushroomed" and porous with areas of eburnation and marginal lipping. Changes in the acetabulum were similar, with shape distortion,

macro-porosity, eburnation and marginal lipping occurring to a greater or lesser degree in each case. G-36 and G-101 exhibited massive bony build up in the form of marginal lipping, as illustrated by Plate 36-1 and Plate 101-1.

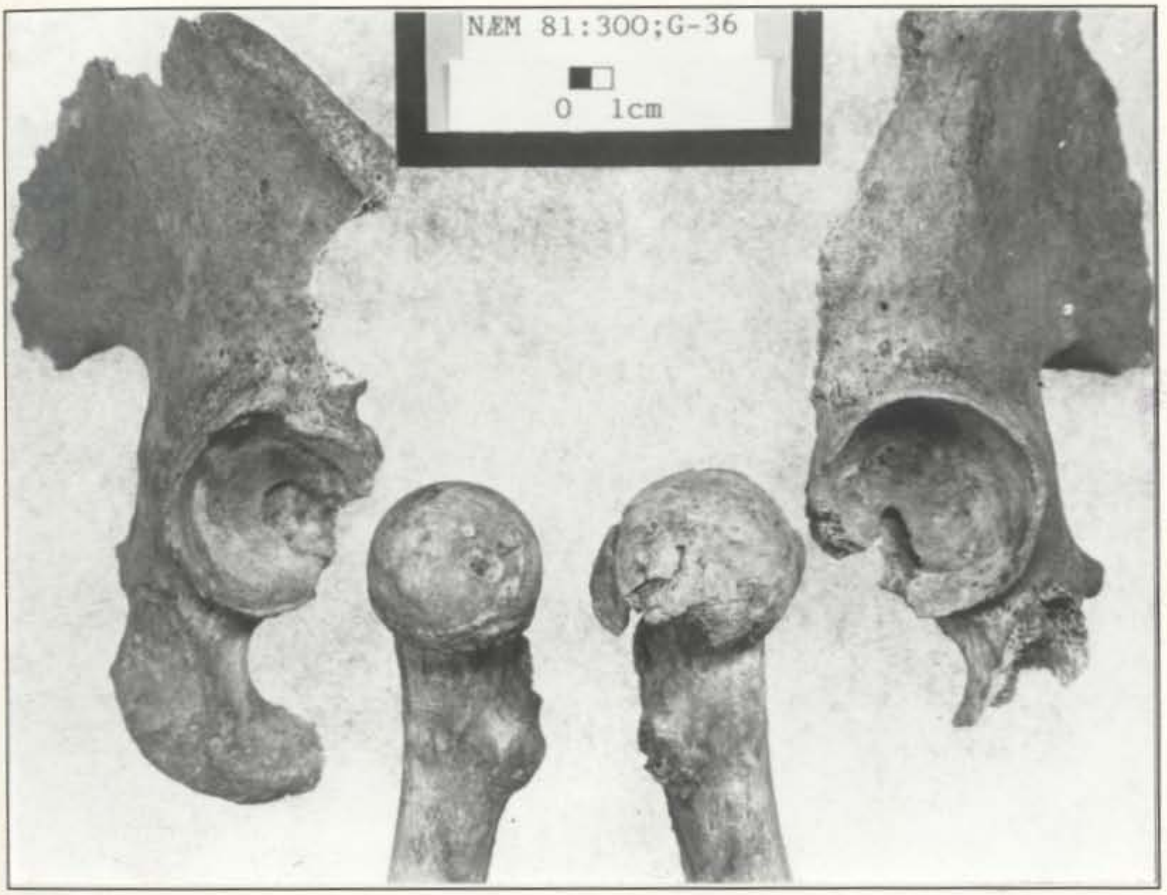

Plate 36-1: G-36
Arthritis: Localized Severe Degeneration in a Joint. Adult female over 30 (possibly 30-50 years), specific age unknown. Lateral view of acetabula, medial view of femoral heads and proximal shafts illustrating degenerative arthritis; early progression in the right hip and advanced progression in the left hip.

A raised and separated "shelf" of new bone circumscribing the inferior acetabulum and inferio-posterior femoral head in G-101 suggests a possible sub-luxation of the joint in this individual (Plate 101-1). A similar but less severe

development of new bone indicates a possible subluxation in G-36 as well (Plate 36-1). Mushrooming and eburnation of the femoral head were most prominent in G-80 and G-257. These degenerative changes in the femoral head are illustrated by Plate 80-1. The downward "slippage" of the femoral head may represent a healed fracture of the femoral neck or a healed epiphysiolysis in these cases (Bennike and Bro-Rasmussen, 1989).

Plate 101-1: G-101
Arthritis: Degenerative Changes of the Hip Joint. Adult male aged 51-69 years. View of the left acetabulum and femoral head illustrating severe degeneration of the joint with porosity and marginal lipping. A shelf-like growth of new bone circumscribes the inferior acetabulum and the inferior-posterior femoral head suggesting a possible subluxation of the joint may have occurred.

Although bony ankylosis was not demonstrated in any of the nine cases of severe arthritic degeneration in the hip, some degree of soft tissue or fibrous ankylosis and contracture of the joint is suspected in several cases. While bony ankylosis does not occur in the normal course of degenerative arthritis (Ortner and Putschar, 1985), fibrous ankylosis may occur as a result of pain or restricted movement (Bennike and Bro-Rasmussen, 1989). Indications for contracture of the hip joint are derived from burial position, configuration of the bones in the joint, and correlation of eburnated surfaces and marginal lipping.

The burial positions for G-85 and G-240 showed the affected femur flexed at approximately 90° in the hip joint. Fibrous contracture of the hip joint is postulated in both cases and in G-85 the shapes of the opposing joint surfaces approximate a linear groove and furrow configuration which would suggest inhibition of normal joint rotation (Plate 85-5). Paralysis, apparent from the unilateral atrophy of the affected limb, may have been the ultimate reason for hip contracture in G-85. However, as in most cases, other factors such as pain or various muscle and connective tissue contractions and shortening cannot be overruled.

Plate 85-5: G-85
Degenerative Joint Disease (DJD) of the Hip Joint with Secondary Contracture.
Adult female aged 35-53 years. Lateral view of the left innominate and femur illustrating 90° contracture of the hip joint. Wasting of the femur indicates disuse atrophy due to possible paralysis of the limb.

Poor preservation and possible grave disturbance hampers the determination of body position in the other individuals. However, on the basis of the osteological findings, some degree of joint contracture is strongly suspected in the case of G-80 and possible in G-36, G-101 and G-257. Right angled joint contracture is supported in G-80 by the shape and configuration of the femoral head in the acetabulum as well as the matching of eburnation and marginal lipping on both joint elements when in the contracted state. Once the femoral head is fitted into the acetabulum it is both difficult to move or remove due to an angular projection on the slipped femoral head (Plate 80-1).

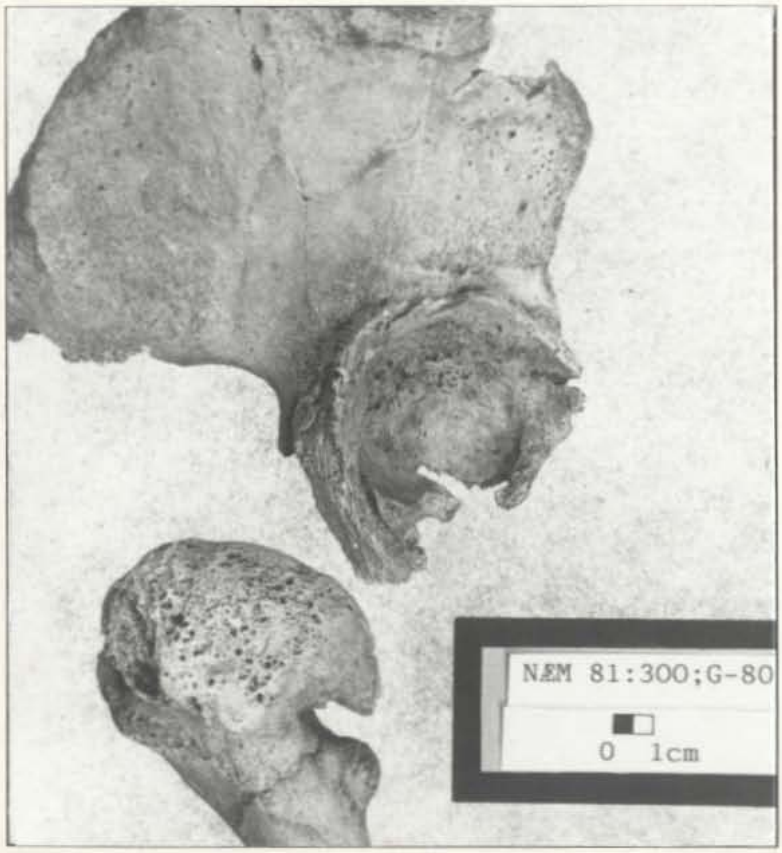

Plate 80-1: G-80 **Localised Degeneration of the Hip Joint.** Adult male aged approximately 30-40 years. Lateral view of the acetabulum and medial view of the right proximal femur. Localised severe degeneration of the joint has resulted in porosity, eburnation and structural deformation of the acetabulum and the femoral head. Note the "mushroomed" appearance of the femoral head.

When fitted, in the acetabulum, the femur rests in the joint socket at an approximately 90° angle (Plate 80-2). Similar correspondence of marginal lipping and eburnation between the femur and the acetabulum are seen the G-36, G-101 and G-257 when in the right angle contraction state. Immovable contracture is less certain in these cases since the joint does not "lock" as in the case of G-80.

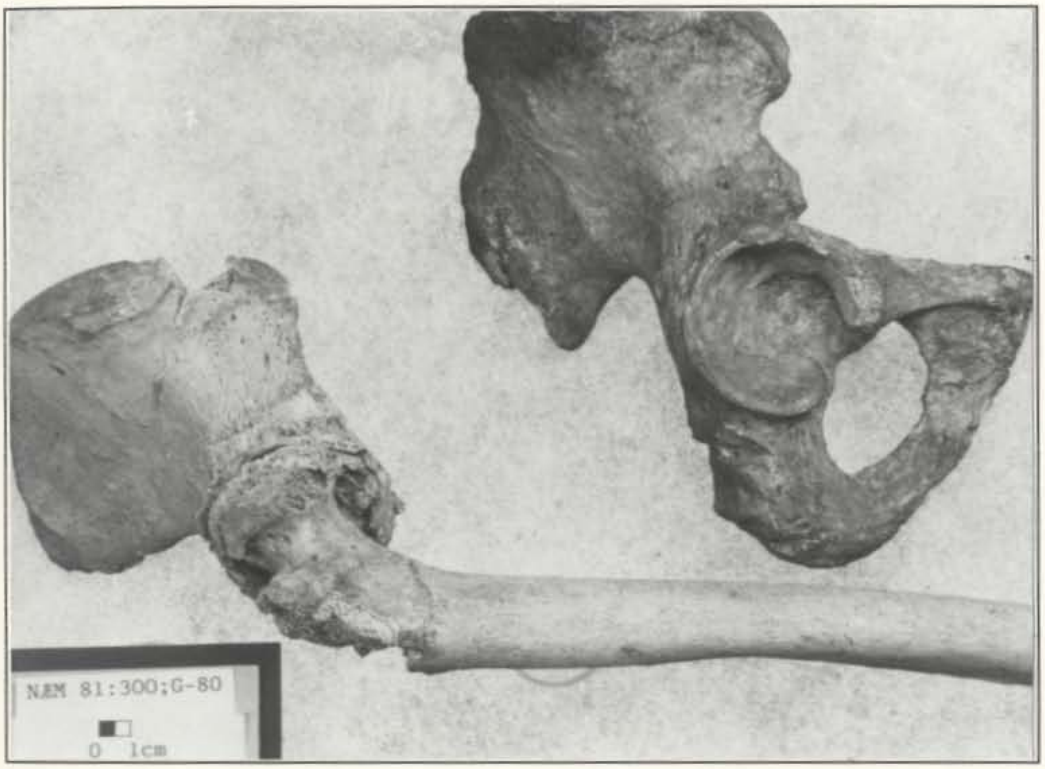

Plate 80-2: G-80
90° contracture of the Hip Joint. Lateral view of the right hip with femur in 90° "locked" position; The femoral; head, mushroomed anterio-medially, does not rotate out of the illustrated position. A healthy innominate (upper left) is shown to demonstrate the normal "sitting" position of the innominate. The G-80 innominate which has been broken post-mortem is in the same "sitting position" orientation, demonstrating the 90° contracture of the hip joint

However, it is possible that joint contracture was elected to reduce pain in the joint (Bennike and Bro-Rasmussen, 1989). Either elected contracture or moveable

soft tissue tightening could have been reduced after death, thus explaining the lack of clear evidence of contracture from the burial position. In any event, these localised and severe arthritic conditions would likely have presented pain and physical challenge during life.

5.1.7.2 Neuromechanical Deformities (Ns, Np)

Neuromechanical deformities were observed in seven individuals or 2.13% of the G-series. Deformities of this nature may develop early in life as juvenile conditions in the adolescent or late in life as a senile condition. The deformity originates as a structural defect in one or more bones and results in a deviation of the muscular, mechanical and neurological functioning of the affected structure. Juvenile deformities tend to be more severe due to subsequent growth disturbance (Ortner and Putschar, 1985). In the elderly, deformities may be secondary to or complicated by senile osteoporosis and other tissue degenerations. Structural collapse and osteoarthritis of individual bones are more prominent features in the aged than the gross structural deformities which often develop from juvenile conditions of long duration (Ortner and Putschar, 1985).

In the Helligåndshus collection deformities consisted of spinal curvature and post-paralytic deformity. In all cases there were observable signs of joint degeneration in the affected skeletal area. Table 5.1.7.2a summarizes all neuromechanical deformities also noted in first three tables on arthritic conditions. Age and gender associations appear in Table 5.1.7.2b.

Table 5.1.7.2a

Neuromechanical Conditions and Deformities

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	A	NEUROMEC	D"NTAL	SEX	AGE	YEARS
G-42							AvSm;	f-**Ns; scolio**	Dal	F?	AdM	35-45
G-265							Av;	-**Ns; scolio**		F?	Ad1	24-30
G-5	BO-				Frib-		Agv-ct-	**Ns; scolio**	Dcl-r	F	AdM	45-65
G-109							Agv-	**Ns; scolio**	Dc	F	AdM	46-57
G-130	Dh		Im				Av-tl-	**Ns; scolio**	Dcl!er	M	AdM	32-48
G-273			I		Frib		Av;	-**Ns; kyphos**		M	AdM	47-58
G-85	BO*	-*	-*I		-Ffn*		Aahg*	**Np; Paraly**		F	AdM	35-53

------- - Disease Association; indicates a posited relationship between arthritis and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified arthritic condition.

---?--- - Possible or questionable association.

Aav - Excluding this condition. In this case, vertebral arthritis with ankylosis is not thought to be related to the arthritic condition suffered by this individual.

* - Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.

!HNp - special case; i.e. localised severe hip degeneration with neuromechanical complications, see detailed discussion.

† - vertebral column was incomplete; localisation of arthritis is an artefact of preservation.

Arthritis and Neuromechanical Disease Codes:

A= Arthritis; **v**= vertebral (c=cervical, t=thoracic, l=lumbar); **Sm**=Schmorl's nodes;
loc= localised (singular joint involvement) **g**= generalised (diffuse peripheral joint involvement)

Multiple location specifications:

Tmj= Temporo-mandibular joint; **sh**=shoulder; **h**=hip; **f**=feet; **e**=elbow; **k**=knee; **wr**=wrist; **uplim**= upper limb; **cl**= clavicle; **r**= rib; **r/v**=costo-vertebral joints; **s-i**= sacro-iliac joint(s); **L5**= 5th lumbar vertebra

Complications:

a= arthritic ankylosis; **!H**= severe hip pathology with ankylosis and/or contracture
Ns= Neuromechanical deformity of the spine (**scolio**= scoliosis; **kypho**= kyphosis)
Np= Neuromechanical deformity; post-paralytic (**paraly**= paralysis)

Table 5.1.7.2b

Neuromechanical Conditions: Age and Gender Distribution

Age (age in years) Category: numerical	(Ns) Spinal Curvature T: ♂/I/♀/p	(Np) Peripheral Skeleton T: ♂/I/♀/p	Total; all types T: ♂/I/♀/p
Ad1: 21-39.5	1: 0/0/1	0	1: 0/0/1
AdM: 39.5-57	5: 2/0/3	1: 0/0/1/0	6: 2/0/4
Total: all ages	6: 2/0/4	1: 0/0/1/0	7: 2/0/5/0

Age codes:Ch=child; Jv=juvenile; FG= full grown; Ad=adult. (also refer to section 4.2.2 for details on age category codes).
Age and Gender breakdown (totals by age group: totals for age/gender group), where,
T: ♂/I/♀/p = Total: Male/Indeterminate gender/Female/pre-pubescent

Case Descriptions

Spinal curvatures included thoracic scoliosis in six individuals, G-5, G-42, G-109, G-130, G-265, and G-273 with co-existing kyphosis in the latter two cases. Post-paralytic deformities were observed in one individual, G-85. The severity of the deformity was evaluated on the basis of localised bone changes, structural deviations of the skeleton and secondary complications such as osteoarthritis or bone atrophy.

Scoliosis, or lateral deviation of the spine, usually commences in childhood and results in various bone deformities due to altered growth and modelling during skeletal development (Ortner and Putschar, 1985). Bone changes and structural deformities characteristic of scoliosis were observed in the upper

thoracic spine of G-5, G-42, and G-265; the lower thoracic spine of G-130, and G-273; and the thoracic and lumbar spine of G-109.

Mild thoracic scoliosis was recognised by the slight to moderate lateral wedging of vertebral bodies at the apex of the concavity in G-5, G-42, G-130, G-265, and G-273. In G-265 and G-273 there is also a slight kyphotic component which may be a result of anterior body wedging due to the development of Schmorl's nodes (Plate 273-2).

Plate 273-2: G-273
Thoracic Kypho-Scoliosis.
Adult male aged 47-58 years. Anterior view of the spine illustrating marginal lipping due to vertebral osteophytosis and left anterio-lateral compression of vertebral bodies with consequent kypho-scoliosis of the thoracic spine. Vertebral compression the result of the Schmorl's nodes which developed in the thoracic vertebral bodies.

Spinal curvature seems to have been a primary neuromechanical deformity in G-42, G-130, G-265, and G-273 since bone quality is good and the development of osteophytosis and apophyseal arthritis appears to be secondary. In accordance with arthritis secondary to spinal curvature, vertebral osteophytes are most pronounced at the apex of the concavity and apophyseal and costo-vertebral changes are greater at the convexity. A similar distribution of secondary arthritic changes was seen in G-5. However, since this is an older female, aged 45-65 years, and there is evidence of reduced bone quality, it is possible that vertebral wedging and slight scoliosis are occurred secondary to demineralisation and brittle deformation in the bones.

In the last case of spinal curvature, G-109, both thoracic and lumbar scoliosis was observed. This condition is considered to be a primary curvature of the spine as well. The curvatures occur in the upper thorax, the lower thorax and the upper lumbar spine with obvious wedging of the following vertebrae: T3, T4, T5; T9, T10, T11; L2 and L3 (Plate 109-1). Although arthritic changes were observed throughout the spine, osteophytes are most prominent at the apex of the curvatures and thus these degenerative changes are considered secondary to the deformity.

Neuromechanical complications in the case of G-85, the post-paralytic deformities, are considered to be much more severe and complicated than the aforementioned spinal curvatures. In this case the primary aetiology of the condition is thought to have been a trauma to the head or neck of the femur.

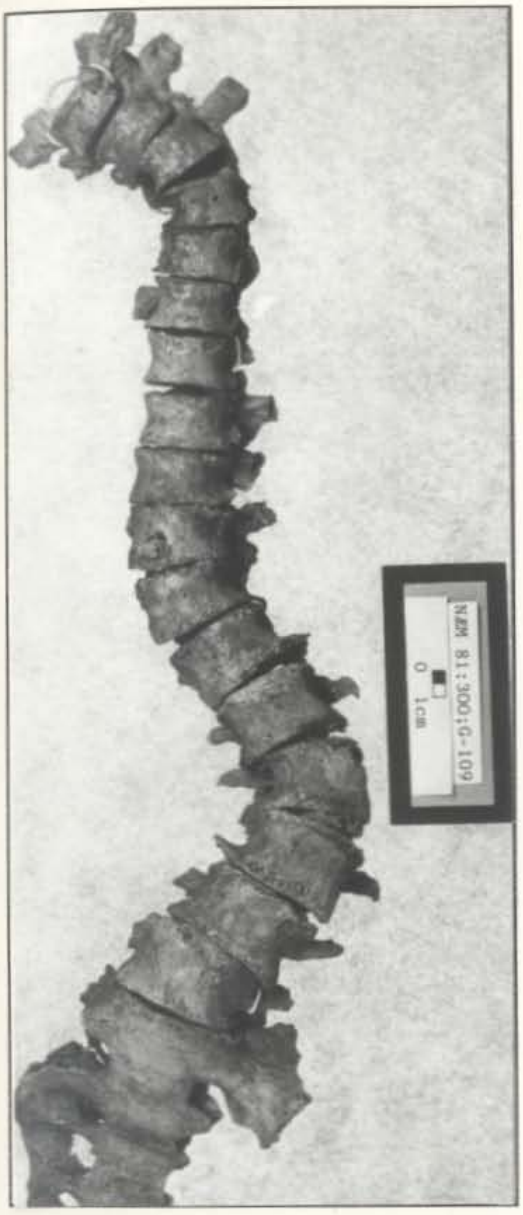

Plate 109-1: G-109
Vertebral Wedging and Scoliosis. Adult female aged 46-57 years. Anterior view of the thoracic and lumbar spine illustrating vertebral wedging and scoliosis. Wedging, due to unilateral compression of the affected vertebral body, is accompanied by marginal osteophytes. Lateral curvatures in the upper thorax, lower thorax and upper lumbar originate at sites of vertebral wedging and where marginal osteophyte development is most severe.

Avascular necrosis of the femoral head and neck has occurred and paralysis and/or disuse of the limb appears to have been the end result. The principal neuromechanical deformity which supports a diagnosis of paralysis and/or disuse is the unilateral atrophy of the bones in the affected limb, especially the femur

(Plate 85-6). The lack of muscle tension reduces the amount of surface remodelling in the limb and the consequent decrease in periosteal bone formation results in a smooth and slender shaft (Ortner and Putschar, 1985). Since the lengths of the limbs are comparable, paralysis/disuse would have occurred during adulthood.

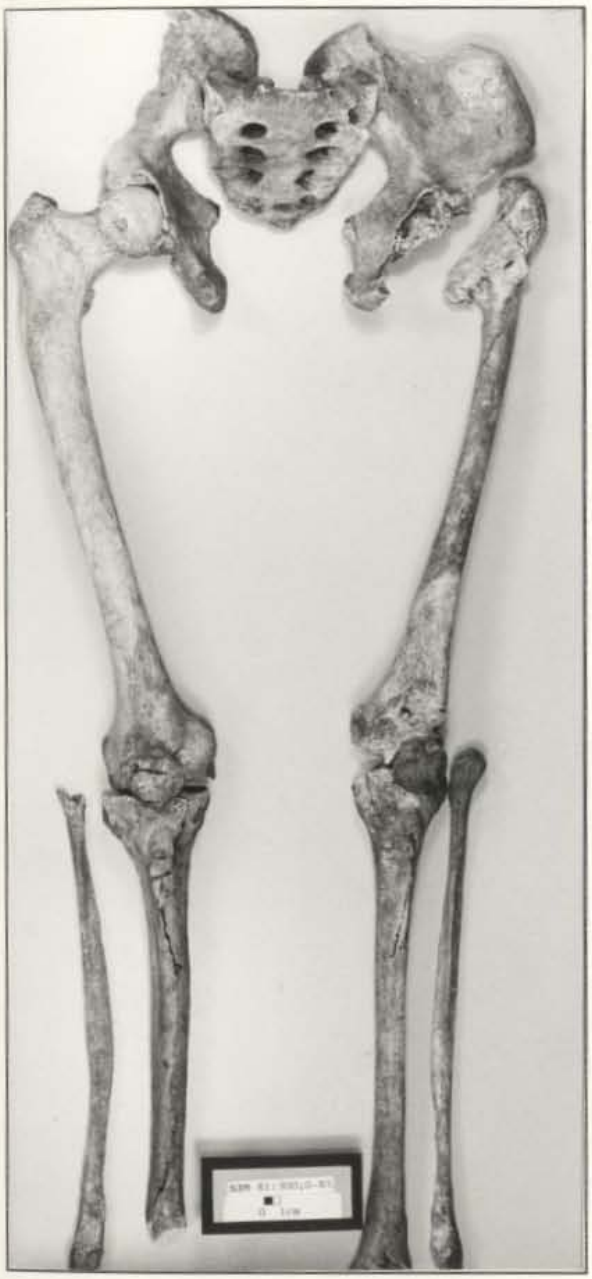

Plate 85-6: G-85
Post-Paralytic Deformities. Adult female aged 35-53 years. Anterior view of the pelvis and the long bones of the lower limbs. Unilateral wasting of the left leg bones is believed to be a result of paralysis or disuse of the limb following a fracture to the left femoral head and neck and a 90° contracture of the left hip joint (Plate 85-5). Osteomyelitis of the left distal femur (above the knee area) has also developed in the disused limb. While the shafts of the left leg bones are straight, slender and smooth due to disuse atrophy, the right bones have thicker more textured and curved shafts. However, lateral curvature of the right proximal femur may be indicative of osteoporosis and/or osteomalacia.

Other related complications in the diseased limb of G-85 include: secondary osteomyelitis in the distal femur, osteoarthritis and possible fibrous contracture of the deformed hip joint. Osteomyelitis may have developed from a minor local infection which could have taken a chronic course due to decreased circulation in the disused limb. Osteoarthritis of the hip joint was probably an early and ongoing complication in the deformed joint. Its onset probably traces back to the original trauma and the ongoing degeneration of the joint may have been concurrent with and/or contributory to avascular necrosis of the femoral head and neck. Arthritis may even be a factor in the eventual paralysis as the structural integrity of the joint was destroyed, ultimately resulting in mechanical and neurological damage.

The suspected contracture of the joint, as discussed with localised arthritic complications above, may have been a consequence of pain, muscle and connective tissue shortening or fixing of the paralytic limb. Alternatively, it may be possible that the limb was not paralysed but instead it was contracted and not used because of pain and mechanical disability in the joint.

5.1.8 Dental Conditions

Conditions which affect the dentition include caries and abscess infections of the tooth and tooth root, periodontal infections of the alveolar bone, alveolar resorption, attrition, and tooth loss. A detailed and directed dental study was not

followed but a preliminary overview of the dental health of the population was carried out to investigate and describe the occurrence of the aforementioned conditions. In this section a descriptive account of the types of conditions encountered is given and possible epidemiological relationships are considered. Dental conditions are described under five diagnostic sub-categories as follows: 5.1.8.1 Caries; 5.1.8.2 Abscessing; 5.1.8.3 Attrition; 5.1.8.4 Tooth loss and 5.1.8.5 Alveolar Conditions (resorption, inflammation, other).

A total of 58 individuals were diagnosed with one or more dental condition. However, considering that only 70 skull and dental remains are complete, 55 skulls are present but incomplete (i.e. missing some part of the vault or face) or crushed, and another 28 skulls consist of only the maxilla and/or mandible, the occurrence of dental pathology should be considered relative to a population of no more than 153 individuals.

Dental pathology occurs in 37.9% of the 153 assessable individuals from the G-series. However, since as many as 85 of these skulls are incomplete, dental pathology may be somewhat under-reported even in the 153 individuals. Accounting of presence, absence, antemortem and postmortem loss was not carried out for individual teeth and thus the absolute degree of possible under-reporting is not available. Table 5.1.8a lists all observed dental conditions while Table 5.1.8b summarizes the observed age and gender associations.

Table 5.1.8a

Dental Conditions

GRAVE	METAB	VASCL	INFLAMM	TRMA	GROWTH	CONGEN	NEUROMEC	DENTAL	SEX	AGE	YEAPS
G-6								Dc	0	Ch2	5-9
G-53			Im		exos			Dc	M?	Jv	15-19
G-302							AalocC2	Dc	F?	Ad1	30-44
G-65	Dh*pit			?pit*		dentpit*		Dc	F??	Jv	15-20
G-116	Dh----C		---------Dent*----------					Dc*	0	Ch1	2-4
G-52	Dh*---		----------					Dc*	0	Ch1	3-4
G-129		Ct	ImI Rib----------			?----------		Dcgw	0	Ch2	5-7
G-15	Dh	C						Dcg;r	F	Ad1	17-24
G-12	Dh						Av-t	Dcg;r	M	Ad1	30-40
G-162							Agv-tl;S	Dcl	M	Ad1	29-42
G-173								Dcl	M	Ad1	30-42
G-46	Dh						Agv-ct	Dcgwlr	M?	AdM	33-53
G-184							AvTmj;sh	Dcwl-r	M??	AdM	38-59
G-153	Dh						Agv	Dcgler	F	AdS	50-72
G-76	Dh		Isy	PFcl			Av-tl	Dcglwr	F?	Ad1	27-38
G-109							Agv;sc	Dcl-er	F	AdM	46-57
G-130	Dh?Sc*		-*Im----------				__AvAsTmj_-	Dcl-er	M	AdM	32-48
G-81		C						Da	M?	Jv	15-19
G-194			I?tb?br				Aas-i	Dac	F	Ad1	20-30
G-11				Fcl			Ar/v-tp	Dac	F	Ad1	20-30
G-289								Dac	F	Ad1	22-27
G-72		C,Ph	*ImI Rib----------			?----------		DacIm*	0	Ch2	5-9
G-42							AvSsc;f	Dal-r	F?	AdM	35-45
G-309	Dh		Im					Daclr	F	Ad1	21-30
G-224							Ae	Dacgor	F?	Ad?	>21-24
G-176								Dacglr	F?	AdM	43-58
G-170			Itb					Dacl-r	F	Ad1	32-45
G-202		oschr	*I	?*				Daclwr	F	AdM	34-50
G-3	O-----		-------__Fwr__------?-----__				Agv-c__--	Dcwler	F?	AdM	50-59
G-5	BO----		-------__Frib__-----?-----__				Ag-ctsc_-	Dcwler	F	AdM	45-65
G-24				Ffib				Dacwlr	M	Ad1	27-47
G-248			Im				AvlSsh;e	Dacwlr	M	Ad1	30-43
G-68			~Im				Agv-tl,S	Dac-lr	F	AdM	34-46
G-268				Fcl			Aav	Dacl-r	F	Ad?	30-50
G-306					Neopls		A~h;f	Dacler	F	AdM	36-58
G-1							Av-c;Tmj	Dacglr	F?	AdM	30-50
G-39		C	Isy				Av-tl,S	Dac;r	M	Ad1	30-44
G-140	Dh		~				A~v;Tmj	Dacg;r	F	Ad1	25-35
G-48	Dh						Av;uplim	Dacgwr	F	Ad1	29-45
G-91							Aav!;g	D~l	M	AdM	38-56
G-303								Dl	F??	Ad1	33-46
G-319							Agv	Dl~r	F	AdM	35-60
G-234							Av;cl	Dl~r	F	Ad1	32-45
G-158							Av;s-i	Dlw~r	M?	AdM	38-50
G-182							Agv	Dl-r	F?	AdM	47-59
G-255								Dl-r	F	Ad1	mixed
G-54								Dl-r	F	Ad1	22-30
G-55								Dl-r	F	Ad1	31-43
G-188							Ash;H	Dl-er	F	AdM	41-66
G-121							Agv-c	Dl-er	F?	Ad?	>24++?
G-185		Ct						Dw	0	Ch2	4-8
G-241								Dwc	M	Ad1	31-42
G-179								Dwl~r	M	AdM	41-64
G-117							Aav-ct;g	Dwl-r	F?	AdM	40-68
G-177			Itb Rib				Av-tl	Dwl-er	I	AdM	43-63
G-325								Dwl-er	F	AdM	33-51
G-99	Dh?Sc*		-*Im,2locs----------				__Av-ct---*	DI;erl	F	Ad1	27-33

------ - Disease Association; indicates a posited relationship between dental disease and other observed conditions.
---?--- - Possible or questionable association; _Agv_ - Excluding this condition.
* - Indicates that a pathology may be considered to have more than one pathogenic component or aetiology.

Dental Disease Codes:

D=dental condition; c=caries (o-occlusal, g-gumline); a=abscess; w=attrition; r=generalised resorption (~=mild,e-extreme); l=extensive tooth loss; I=alveolar infection; Im= alveolar inflammation

Table 5.1.3b

Dental Conditions: Age and Gender Distribution

Age (age in years) Category: numerical	Total Number of Individuals with dental pathology T: ♂/I/♀/p	(5.1.8.1) Caries T: ♂/I/♀/p	(5.1.8.2) Abscessing T: ♂/I/♀/p	(5.1.8.3) Severe Attrition T: ♂/I/♀/p	(5.1.8.4) Tooth loss T: ♂/I/♀/p	(5.1.8.5) Alveolar:Resorption Inflammation,other T: ♂/I/♀/p
Ch1: 1-6	**3**: 0/0/0/3	**2**: 0/0/0/2	0	0	0	0
Ch2: 6-12	**4**: 0/0/0/4	**3**: 0/0/0/3	**1**: 0/0/0/1	**2**: 0/0/0/2	0	**1**: 0/0/0/1
Jv: 12-21	**4**: 2/0/1/1	**3**: 2/0/1/0	**1**: 0/0/0/1	0	0	0
Ad?: ≥21	**3**: 0/0/3/0	**2**: 0/0/2	**2**: 0/0/2	0	**2**: 0/0/2	**3**: 0/0/3
Ad1: 21-39.5	**23**: 7/0/16	**17**: 7/0/10	**10**: 3/0/7	**5**: 3/0/2	**13**: 4/0/9	**16**: 4/0/12
AdM: 39.5-57	**21**: 6/1/14	**11**: 3/0/8	**6**: 0/0/6	**10**: 4/1/5	**21**: 6/1/14	**20**: 5/1/14
AdS: 57-79	**1**: 0/0/1	**1**: 0/0/1	0	0	**1**: 0/0/1	**1**: 0/0/1
Total: all ages	**59**: 7/0/10	**39**: 12/0/22/5	**20**: 3/0/15/2	**17**: 7/1/7/2	**37**: 10/1/26	**40**: 9/1/29/1

Age codes: Ch= child; Jv= juvenile; FG= full grown; Ad= adult. (also refer to section 4.2.2 for details on age category codes).

Age and Gender breakdown (totals by age group (T): totals for age/gender group), where, T: ♂/I/♀/p =
Total: Male/Indeterminate gender/Female/pre-pubescent

5.1.8.1 Caries (D...c)

Dental caries are lytic lesions which penetrate the tooth enamel and may ultimately invade the dentin and pulp chamber. The development of dental caries involves a chemical reaction between food, endogenous oral bacterial and bacterial enzymes (Carola, et.al., 1990). Caries may occur on the occlusal or smooth surface of the crown, including interproximal areas, or the roots of the tooth. As a rule, occlusal, crown and interproximal localisations occur more frequently and have a more rapid clinical course in children and young adults (Shafer et.al., 1983).

The caries of childhood, adolescence and young adulthood apparently progress more rapidly because once the enamel is penetrated the open and non-sclerosed dentinal tubules quickly spread the infection throughout the pulp chamber, thereby destroying the tooth (*ibid.*). In later adulthood, fewer caries will develop in the crown and caries usually progress much more slowly, allowing time for secondary dentin to be deposited. The secondary dentin protects the tooth from further decay and, in some cases, arrests the destruction entirely (*ibid.*). Root caries, on the other hand, tend to be a more common problem during adulthood than during childhood (Ash, 1992). By adulthood the crown is less prone to decay, but the natural effects of tissue degeneration and years of mechanical erosion of the gums may leave the roots exposed and thus prone to decay.

In Table 5.1.8a, above, a notation of dental caries (**Dc**) generally indicates crown localisations, unless root caries are indicated by the code "**g**", meaning caries of the root located at the cervical margins or "gumline". Caries were

identified in one or more teeth in a total of 37 individuals or 24.2% of the 153 individuals with dental remains. The following case descriptions are discussed in relation to the observed localisation of caries and the possible complications of chronic caries in the population.

Case Descriptions

Dental caries were observed in thirty-one adults and eight subadults. Many of the adult cases exhibited more than one dental condition, including any combination of the following: abscessing, attrition, tooth loss, alveolar inflammation and alveolar resorption. Dental conditions observed in the subadult included singular uncomplicated caries of the tooth crown in G-6 and G-53; localised caries in hypoplastic defects of the enamel in G-116 and G-52 (see Plate 52-1, section 5.1.1.1); caries leading to abscess in G-72 and G-81; and caries of the cervical margin and proximal root in G-129 (see Plate 129-4, section 5.1.3.2 ii).

Other associated dental conditions including abscessing, attrition, alveolar resorption and tooth loss often occur in later adulthood as a result of chronic caries and age related changes of the teeth and periodontal tissues. However, while these other dental conditions are more common in later adulthood, many of them may occur as complications of severe acute caries in children and young adults (Shafer et.al., 1983; Bhaskar, 1986; Ash, 1992). Abscess formation, alveolar osteitis and eventual tooth loss may occur as a result of caries in the younger population; however, these conditions are often localised as opposed to the

generalised tooth loss and alveolar resorption of senior adulthood. Localised advancement of caries leading to abscess formation, seen in G-72 and G-81, is discussed below, under sub-category (ii) on abscessing.

In G-129, caries were observed along the gumline area of the roots and/or cervical margins of the left maxillary incisors and canine (see Plate 129-4, section 5.1.3.2 ii). There are at least two aetiological explanations for this condition occurring in a child, where presumably and by the normal healthy condition of the alveolus there was no periodontal infection: 1.the condition called "nursing bottle caries" or "baby bottle syndrome" and 2. perinatal nutritional metabolic deficiency. Nursing bottle caries is a carious condition which affects the deciduous dentition as a result of habitual ingestion of cariogenic beverages before naptime or bedtime (Shafer et.al., 1983; Ash, 1992). Beverages such as milk and fruit juices leave a cariogenic residue in the mouth and, when taken habitually after one year of age, they can lead to rampant destruction of the teeth. However, although possible, there is no specific predilection of the cervical margin and roots of the teeth. In the case of the second explanation, a peri-natal disturbance of nutrition or metabolism could have caused hypoplastic enamel defects at the cervical margins, which form soon after birth (Walsh, pers. comm., 1995). This second explanation then proposes that the cervical margins of the teeth were prone to caries and root involvement occurred by direct extension. Both explanations remain a possible cause of root site caries in G-129.

Actinomycosis infection of the lung was also diagnosed in G-129, but a direct association to dental infection is not certain. However, it is known that bacterial of the *Actinomyces* genus are the predominant inhabitants of dental plaque and root surfaces (Ash, 1992). Thus *Actinomyces* sp. colonisation is quite possible at this site of caries development and thus the observed caries may be a source of the lung infection in this case.

In the adult cases, ten out of twenty-one or almost one half of all carious conditions demonstrated root involvement adjacent to the cervical margin of the teeth (see Plate 130-1, section 5.1.1.3). In the adult cases, root involvement is believed to be related to periodontal disease since in all ten cases there was some degree of alveolar resorption demonstrated. Considerable calculus, present in four of these individuals, G-12, G-48, G-65 and G-162, suggests that plaque and/or calculus may have been an important factor in the development of periodontal disease and root caries.

As expected, chronic dental disease appears to be more common in the adult portion of the Næstved population. The chronic condition is marked by slow lingering caries and gum disease leading to abscessing, periodontal infection, tooth loss and alveolar resorption. Caries which affect the crown in adults are large surface destructions consistent with the appearance of chronic caries (Shafer et.al., 1983). As a result of chronic caries and subsequent periodontal disease, tooth loss may be extensive and thus caries may be under-reported in the adult population. A total of sixteen adults demonstrated tooth loss and moderate to

severe alveolar resorption without evidence of caries. It is likely that many of these adults also suffered chronic caries but, along with the teeth, evidence of caries was lost.

5.1.8.2 Abscessing (D...a)

Dental abscessing is an infection of the alveolar bone which surrounds the tooth. It is usually a result of chronic caries with necrosis and infection of the dental pulp (Taber's Cycl. Med. Dict., 1989). Severe and rapid attrition is another factor which may be responsible for exposure and subsequent infection of the pulp chamber. When attrition is rapid, secondary dentin does not have time to develop and seal the pulp chamber from exposure to bacteria and other external irritants.

Chronic infection due to abscessing can sometimes have serious complications such as the development of a systemic infection secondary to aspiration of oral infection. In modern populations this is a rare consequence, but before medical and dental treatments where available, chronic dental abscess could pose a mortal threat.

Case Descriptions

Dental abscessing was observed in two subadults and eighteen adults. Fourteen of these adults exhibited caries and alveolar resorption in addition to the abscess condition, with considerable intravital tooth loss occurring in nine of these

cases. The other four adults included three young adults with caries and abscessing but no tooth loss or alveolar involvement and one mature adult aged 35-45 years with abscessing and considerable intravital tooth loss. Tooth loss is extensive in this latter case, G-42, thus caries can not be demonstrated as the cause of dental abscessing. However, caries is the most likely cause since attrition does not appear to be a factor in this case.

The majority of the adult abscess cases are attributed to advanced caries with invasion of the dentin and pulp chamber, resulting in periapical infection. Plate 39-3 illustrates periapical abscess as a result of advanced caries in a molar tooth; mild generalised regression of the alveolar bone was also observed in this case. Local tooth loss and alveolar resorption may occur as an end result of abscessing, but generalised tooth loss and alveolar resorption most likely involve an accompanying periodontal infection.

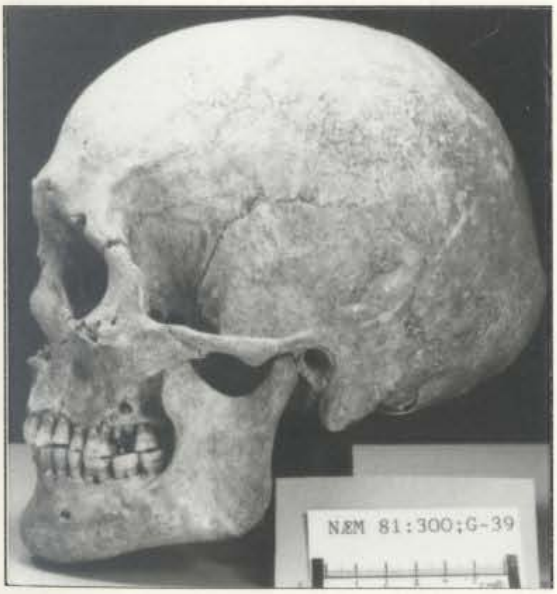

Plate 39-2: G-39
Dental Abscess Accompanied by Periodontal Disease. Adult male aged 30-44 years. Left lateral view of the cranium illustrating a periapical dental abscess of the second maxillary molar. A mild generalized regression of the alveolus is evident along both the maxillary and the mandibular tooth row suggesting early periodontal disease.

Plate 11-3 illustrates tooth loss and localised alveolar resorption at the site of the left maxillary M1. The abscess probably developed as a result of caries; interproximal caries is demonstrated in the distal surface of the adjacent tooth, pm2, still present in the alveolus. There is no evidence of generalised alveolar resorption in this case.

Plate 11-3: G-11
Dental Abscess with Tooth loss and Localized Alveolar Resorption. Adult female aged 20-30 years. Close up left lateral view of the facial skull illustrating tooth loss and localized alveolar resorption of the tooth socket due to a periapical abscess of the first maxillary molar.

G-72 was the only subadult in which caries clearly demonstrated advancement to abscess and localised alveolar osteitis with some bone resorption. A large carious development is observed on the distal interproximal surface of the first deciduous molar in the right mandibular tooth row (Plate 72-6, also see Plate

72-5, section 5.1.3.2 ii). Inflammation of the alveolus and localised resorption of the bone about the roots of the carious tooth has occurred. It is suggested that the infectious abscess about the carious tooth was the source of an aspirated actinomycosis infection in this case (section 5.1.3.2 ii). As noted above in the case of caries in G-129, *Actinomyces* bacteria are the main bacteria to be found on or around the roots and thus abscessing demonstrates a possible source of actinomycosis infection in the oral cavity of this individual. Respiratory and possible systemic infection may have been secondary complications in this case of dental abscess.

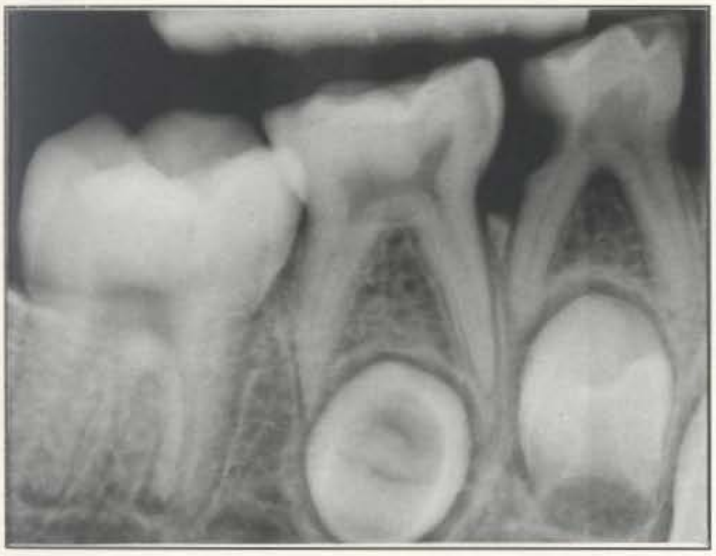

Plate 72-6: G-72
Dental Abscess with Localised Alveolar Osteitis. Child aged 5-9 years. X-ray of the left mandibular molars (left to right: secondary M1 and deciduous m1 and m2). A large carious lesion in the distal interproximal region of the first deciduous molar is the suspected source of a localised infection in the surrounding tooth socket. Alveolar osteitis and localised resorption is illustrated in Plate 72-5 (section 5.1.3.2). This dental infection may have been the primary seat of an actinomycosis infection which later developed into a lung infection via aspiration of the bacteria.

In at least four cases, G-24, G-48, G-202, and G-248, severe attrition was demonstrated and may be considered a predisposing factor to the development of abscessing. Rapid and complete wear of the tooth crowns in these cases, has resulted in the exposure of the pulp chamber without the deposition of secondary dentin. The exposed pulp chamber is prone to bacterial infection which readily

spreads to the apical end of the root, resulting in a periapical abscess. Plate 24-1 illustrates severe attrition with periapical abscesses above the first and second premolar in the maxilla.

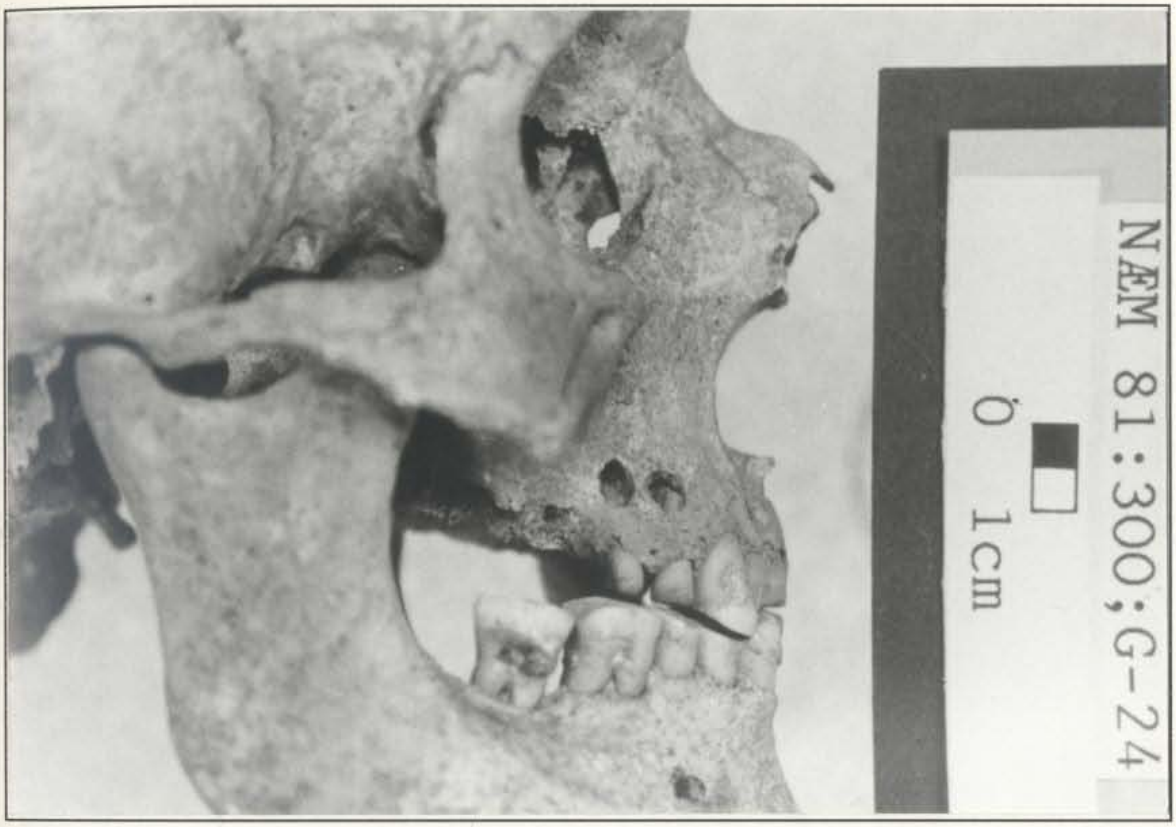

Plate 24-1: G-24
Dental Attrition and Periapical Dental Abscess. Adult male aged 27-47 years. Close up; right lateral view of the facial skull illustrating severe attrition with partial to complete destruction of the tooth crowns exposing the pulp chamber to infection. Dental caries are also present along the gumline (right mandibular molars) and alveolar regression has begun.

In all of the adult cases, abscessing may be contributed to or complicated by periodontal disease. Accumulation of plaque and calculus, recession of the gingiva and development of infection in periodontal bone may complicate existing caries and pulp chamber infections, leading to local abscessing and tooth loss as

well as generalised alveolar resorption. The loss of teeth with alveolar resorption may be a factor in the under-reporting of abscess conditions in the adult population of the Næstved collection.

5.1.8.3 Attrition (D...w)

A certain amount of dental attrition, or tooth wear, is a normal consequence of the physical abrasion brought on by the mastication of food. However, attrition referred to as "pathological attrition" is that which is extreme and predisposing to infection of the exposed dentin, pulp chamber and root (Ortner and Putschar, 1985). Pathological attrition may be caused by a variety of factors including: mal-alignment of the jaw and teeth, long term use of mechanical abrading devices such as tobacco pipes or toothpicks, abrasive food additives such as in stone-ground bread and the habit of tooth grinding. The quality of the teeth may also influence the likelihood of attrition (*ibid.*).

In the Helligåndshus collection, attrition was considered pathological when localised or generalised wear of the teeth had resulted in exposure of the dentin and/or pulp chamber. The development of apical abscessing distal to the surface of attrition was noted as the primary complication of pathological attrition.

Case Descriptions

Attrition was considered severe or pathological in two children (Ch2) and fifteen adults. In the children, G-129 and G-185, some of the primary dentition

shows excessive wear. Plate 129-5 illustrates the loss of enamel from areas of the occlusal surface on the deciduous molars. In G-185, the molar cusps were also very worn and the right mandibular canine and left mandibular I2 were worn flat. It is possible that a mal-alignment of the jaw caused the problem in G-185, but since many of the primary dentition have been lost antemortem and secondary dentition is erupting, it is difficult to determine the full extent of the condition. In G-129, tooth wear is believed to be a result of mechanical attrition, probably due to abrasives in the diet (Walsh, pers.comm., 1995). There were no obvious infectious complications of tooth wear in these subadults.

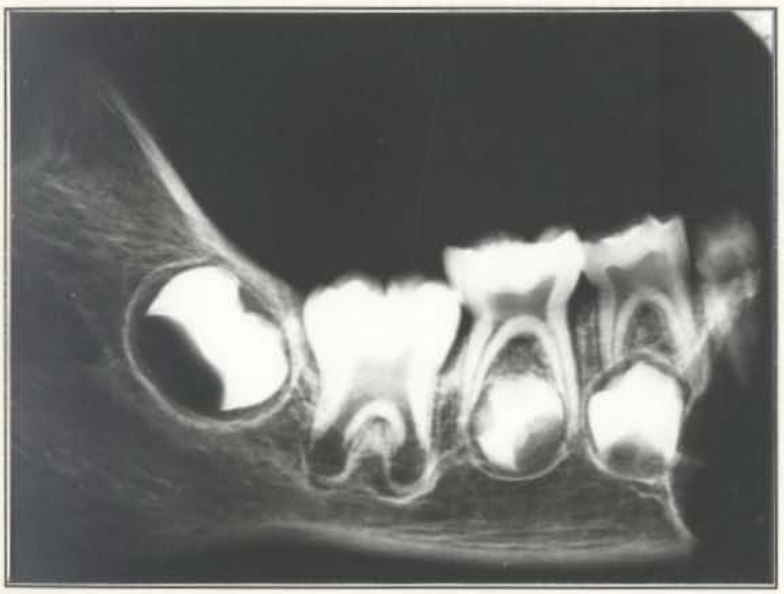

Plate 129-5: G-129
Dental Attrition:
Mechanical Abrasion. Child aged 5-7 years. X-ray of the left mandibular tooth row including C1, m1, m2, a partially erupted M1 and the unerupted cusp of the developing M2. The thickness of enamel (radiodensity) on the erupted deciduous molars is considerably thinner than on the secondary molars. Enamel has been completely worn away from areas on m1 where there is a lack of radiodensity on the occlusal surface (especially the distal occlusal surface of the tooth).

In the adult cases, tooth wear may be a result of mechanical attrition due to a combination of factors such as years of heavy mastication of food, abrasion from gravel in wheat products and possibly tooth grinding or using the teeth as a vice for certain practices. However, in a few cases abnormal occlusion of the

teeth may have played an important role in the rapid and severe wear of tooth surfaces. Plate 24-1 and 24-2 illustrate the uneven wear of opposing teeth which may indicate improper occlusion of the teeth or mal-alignment of the jaw during life. G-24 exhibits differential wear in different teeth, while G-48 exhibits bevelled wear surfaces between opposing maxillary and mandibular molars.

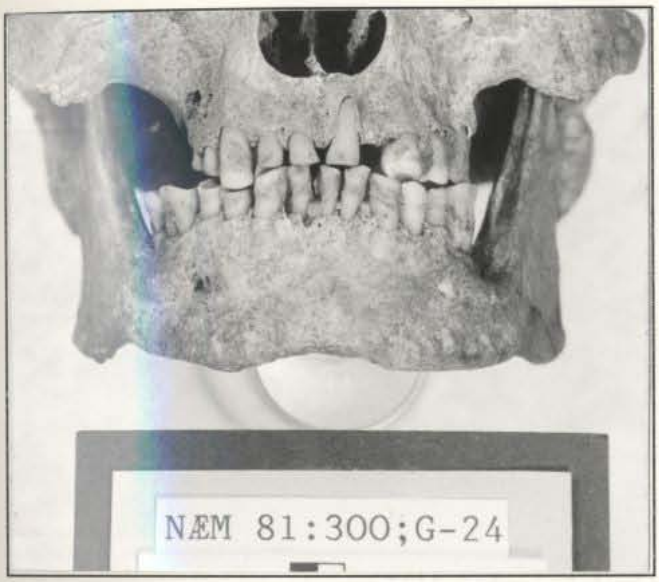

Plate 24-2: G-24
Dental Attrition: Uneven Wear.
Adult male aged 27-47 years. Frontal close up of the Dentition illustrating differential wear of the teeth. Many of the teeth have been worn down to their roots with little or none of the tooth crown remaining. Wear is uneven both laterally from tooth to tooth as well being greater lingually than labially on the incisors and canines (Plate 24-1). This uneven wear may be a result of improper occlusion of the teeth.

Of the other dental conditions which occur in association with or as complications of dental attrition, occlusal caries were seen in seven individuals, with abscessing in three of these and loss of most teeth in two others; considerable tooth loss was seen in most cases but five mature adults exhibited evidence of only tooth wear; and tooth loss with alveolar resorption was seen in all but one individual. The possible role of attrition in the development of caries and abscessing has been discussed in a number of cases above (section 5.1.8.2). It is

likely that advanced attrition was either a direct or contributing cause of caries and tooth loss in G-3, G-5, G-184 and G-241 and of caries leading to abscessing and tooth loss in G-24, G-202 and G-248 (Plate 24-3). While tooth loss is probably a direct result of caries, abscessing or periodontal disease, the advanced tooth wear exhibited on the remaining teeth, suggests that attrition may have been a preliminary factor in the advancement of dental disease and eventual tooth loss.

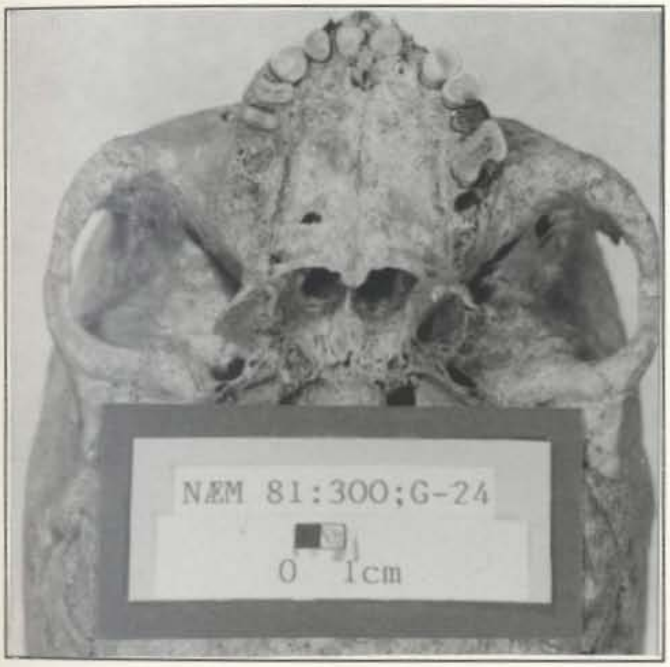

Plate 24-3: G-24
Dental Attrition with Caries, Abscessing and Tooth Loss.
Inferior view of the palate and the maxillary tooth row illustrating advanced dental attrition and related complications. Dental caries of the exposed tooth root are evident in the left PM1, PM2 and M1. The socket of the left M2 was the site of a periapical abscess resulting in tooth loss. Tooth loss accompanied by alveolar resorption has occurred at several other locations. These changes are probably the result of caries and abscess infections which developed in the exposed pulp chambers.

Those individuals exhibiting advanced attrition, considerable tooth loss and generalised alveolar resorption in the absence of any signs of dental caries or abscessing, are all mature adults between 33 and 64 years of age, or of a mean age of 48 years. Dental disease in these individuals probably included caries and abscessing but tooth loss and alveolar resorption have likely "erased" the evidence

for these conditions. Attrition, present on those teeth which were not lost intravitally, suggests a generalisation of tooth wear and a probability that tooth wear was a factor leading to dental infection and tooth loss (Plate 117-2).

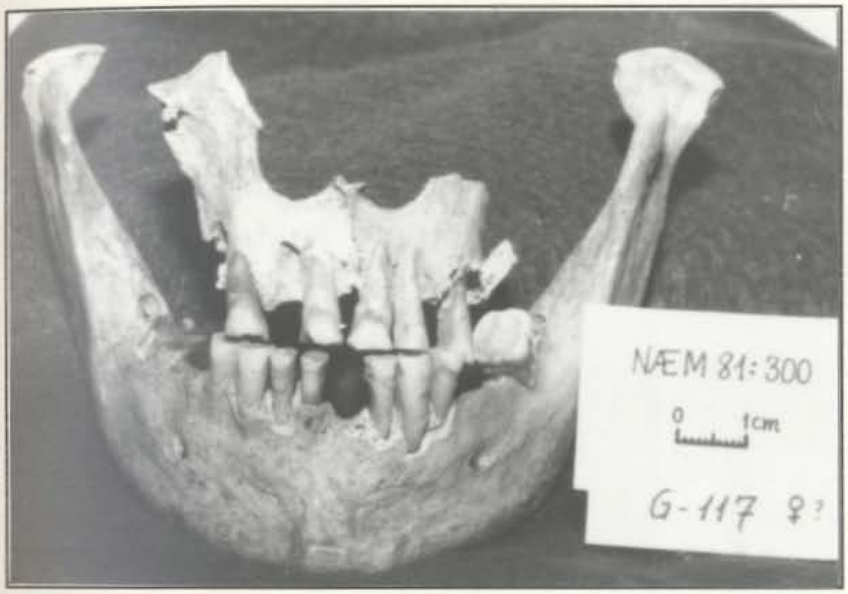

Plate 117-2: G-117 **Generalized Dental Attrition.** Adult female (?) aged 40-68 years. Frontal view of the maxillary and mandibular dentition illustrating advanced generalized attrition and alveolar regression. No caries or abscessing were observed but tooth loss and alveolar resorption may have "erased" any evidence for these dental conditions.

5.1.8.4 Tooth Loss (D...l)

Antemortem tooth loss of the secondary dentition is most often a result of dental infections in the form of cavities, abscessing and/or periodontal infections. Extensive tooth loss is commonly associated with the older adult population. Loss of one or a few teeth is a fairly common finding where caries and other tooth infections are found in a population, but loss of many or most teeth indicates very

poor dental health as well as a vulnerability to other systemic health problems such as malnutrition and starvation.

Case Descriptions

Considerable antemortem tooth loss was observed in 37 adults. In the Helligåndshus collection, tooth loss is considered to be an age related consequence of chronic dental disease including caries and abscessing of the tooth and periodontal disease. In 10 out of 37 cases caries occur in association with tooth loss. In one case abscessing is present and in another 10 cases both caries and abscessing occur. The remaining 16 cases exhibit tooth loss without evidence of infection. Advanced attrition accompanies tooth loss in a total of ten of the aforementioned individuals.

The association of attrition, caries, abscessing and periodontal disease to tooth loss has been discussed in the previous case discussions. All cases involve adults and in all, except perhaps two, tooth loss is considered to be the end result of each of these conditions, alone or in combination, as a result of a chronic dental disease course. The two questionable cases are G-99 and G-130. In both of these individuals, tooth loss may be a result of chronic dental disease but scurvy is another possibility. See section 5.1.1.3 for a discussion of these cases in relation to scurvy. Tooth loss, occurring in these cases, is considered below in section 5.1.8.5 in relation to associated periodontal disease.

In the fifteen cases where tooth loss is considerable but no evidence for caries or abscessing was observed, there is moderate to advanced resorption of the alveolus at the site of the lost teeth. Some of these individuals have few or no teeth and thus the evidence for caries or abscessing has been lost or remodelled. In most of the younger adults, tooth loss has occurred in the molar and premolar regions, while in many of the older adults, tooth loss is extensive with few teeth remaining in the alveolus. While the loss of a number of molar teeth would interfere with proper mastication of food, loss of most teeth would pose a direct problem to eating and acquiring the necessary nutrients from food. The loss of most or all teeth has occurred in G-121, G-182, G-188 and G-177, but there is no clear evidence of nutritional deficiency on the skeleton.

In G-3 and G-5, intravital tooth loss was extensive and in both cases only two teeth were present in the alveolus. In these two cases, tooth wear and caries affected the remaining teeth, suggesting that caries may have been a factor in the tooth loss. Plate 5-2 illustrates the extensive tooth loss and subsequent alveolar resorption in the mandible of G-5. The maxilla of G-5 contained just one tooth and marked alveolar resorption was observed elsewhere; a similar pattern of tooth loss was observed in G-3. The advanced nature of alveolar resorption in both these cases suggests that tooth loss may have occurred quite some time before death. The question of obtaining proper nutrition is thus relevant to these cases. In light of skeletal indications of reduced bone quality, which were observed in these individuals and discussed in section 5.1.1.2, it is suggested that the condition of

deteriorated dental health may have been a factor leading to poor nutrition and, ultimately, metabolic bone disease.

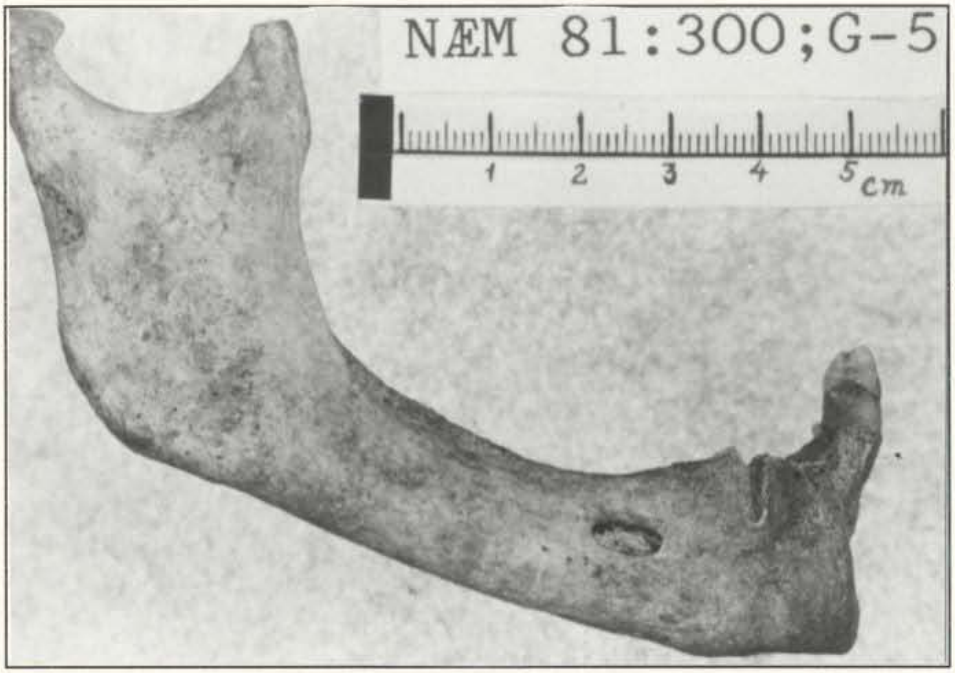

Plate 5-2: G-5
Intravital Tooth loss and Alveolar Resorption. Adult female aged 45-65 years. Right lateral-anterior oblique view of the mandible illustrating generalized and progressed tooth loss and alveolar resorption. The interproximal caries at the cervical margin of the only remaining tooth (left C,) suggests a history of caries and possible periodontal disease may have predisposed to tooth loss in this individual. The degree and extent of alveolar resorption further suggests that the edentulous state was chronic and likely interfered with eating and optimal nutrition.

5.1.8.5 Periodontal Conditions

Periodontal conditions include inflammation, infection and atrophy of the bone around the tooth roots and cervical margins. Inflammation and/or infection of the periodontal tissues may be the result of a number of factors including:

bacterial infection, metal poisoning, scurvy, dental calculus or various other physical and mechanical irritations causing erosion of the gums (Bhaskar, 1986).

The adult population is most often affected with periodontal conditions. The recessing of the gums due to the build up of dental plaque and calculus is a common problem in adulthood. Coupled with the age-related degeneration of gingival and periodontal tissues, dental plaque harbours pockets of bacteria which gradually lift the gums away from the teeth. The bacterial infection and physical separation of the gums from the teeth results in episodic inflammation of the periodontal tissues and recessing of the alveolar bone, respectively (*ibid.*).

Case Descriptions

Periodontal conditions were identified in 39 adults and one child. The case of the child, G-72, has been discussed above as a case of caries leading to the development of an abscess. Localised alveolar osteitis and resorption about the abscessed tooth is considered a consequence of a long standing infection of the tooth. The periodontal "pocket" of the infection was suggested as a source of a serious systemic complication, namely, aspirated thoracic actinomycosis.

In most of the adult cases, periodontal conditions consisted of a generalised resorption of the alveolar bone in response to chronic dental disease. Plate 12-1 illustrates a mild but generalised expression of the alveolar resorption or regression. Despite post-mortem damage, regression of the alveolar processes between the teeth is demonstrated. In this case, there is also an appreciable

amount of calculus on the cervical margins and adjacent root surfaces of the teeth. The presence of calculus at this location, the "gumline" during life, suggests a mechanical irritation of the gums during life. Calculus may been an inciting factor to alveolar regression in this case. Although the accumulation of any considerable amount of calculus was only identified in four other individuals with alveolar resorption, G-48, G-65, G-99 and G-162, it may have been lost from many teeth due to post-mortem erosion. Calculus may easily chip away from the dry tooth and thus its possible presence may be under-reported. In any event, calculus and its uncalcified precursor, plaque, should be considered one of the predisposing factors to alveolar resorption in adults (Bhaskar, 1986; Ash, 1992).

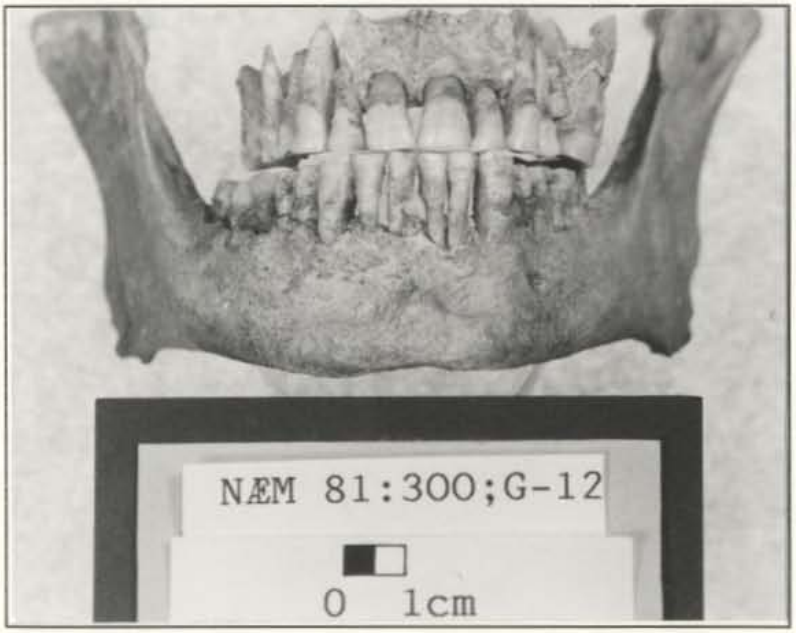

Plate 12-1: G-12
Mild Generalized Alveolar Regression.
Adult male aged 30-40 years. Frontal close up of the maxillary and mandibular dentition. Although some areas exhibit post-mortem damage (between the mandibular incisors and the right maxillary premolars and molars), other areas exhibit root exposure due to a generalized regression of the alveolus. This mild generalized condition may represent an early case of periodontal disease due to calculus and/or gingival infection.

In the advanced state, alveolar regression and tooth loss are considerable. Plate 5-3 illustrates the advanced state of the disease which probably resulted from a protracted course of poor dental health including caries, plague build up and consequent periodontitis. Alveolar regression is the end state of chronic periodontitis and tooth loss results from the lack of alveolar support, if not already lost due to rampant decay of the tooth itself. Most of the adults exhibiting extensive resorption (**er**) are thought to have suffered from this disease course. However, two adults, G-99 and G-130, may have suffered periodontitis due, entirely or in part, to a separate aetiology than that of bacterial plaque induced periodontitis. In these individuals, scurvy was considered as a possible cause of

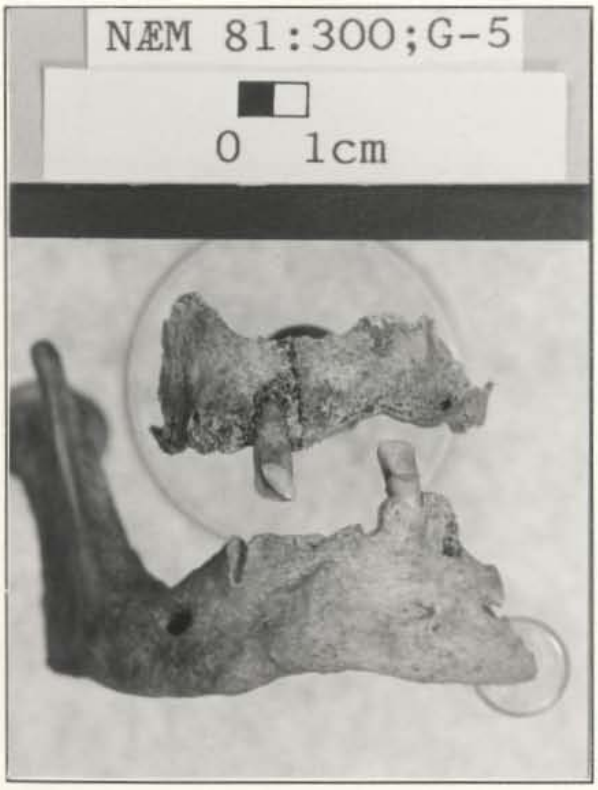

Plate 5-3: G-5
Advanced Alveolar Resorption. Adult female aged 45-65 years. Frontal close up of the maxillary and mandibular remains illustrating an advanced case of alveolar resorption. Pre-existing dental conditions likely include a chronic course of poor dental health including caries, plague, gingivitis and periodontal disease culminating in tooth loss and progressive alveolar resorption.

periodontal inflammation, alveolar regression and tooth loss. Scurvy is a systemic disease due to a deficiency in vitamin C. The periodontal tissue are often involved as the deficiency causes a weakening of connective tissues in the body (Steinbock, 1976; Goepel, 1992; Underwood, 1992b). These cases are illustrated and discussed in detail in section 5.1.1.3. Metal poisoning was also considered in the differential diagnosis of periodontitis in these cases, but scurvy was the preferred diagnosis on the basis of post-cranial lesions occurring in association with dental disease.

6.0 DISCUSSION

The data collected from observations of 328 G-Series skeletons from Næstved's Helligåndshus have been presented in the previous chapters. The final evaluation of this information warrants both a discussion of theoretical and methodological considerations as well as a discussion of the palaeopathological interpretation of the data in light of these considerations. The overriding implications of the data, which follow from the aforementioned discussions form the conclusions of this investigation, presented in Chapter 7.

6.1 Theoretical and Methodological Considerations

An archaeological study may never determine or explain the absolute possible range and complexity of variation relative to the burial population in question, let alone that of the living population for which it represents. The archaeological exploration thus seeks relevance and aims to answer to the best of its ability the secrets of the past. For the history of the town of Næstved and for its Helligåndshus, this type of research is both valid and important. Knowledge gained from the skeletal remains provides a basis for the interpretation of the history of the Helligåndshus residents: their ages at death, their gender, the types of diseases they suffered and the possible health risks in the individual and in the population as a whole.

The primary objective for the palaeopathologist is to consider areas of potential relevance for the particular skeletal collection under investigation. The Helligåndshus collection has been described as a rather select group of individuals who most likely belonged to the lowest socio-economic classes of the late mediaeval and post-reformation society in Næstved and used one or more of the charitable and 'healthcare' resources offered by the chapel hospital. Thus, in light of the nature of the collection, the investigation has focused on not only the basic demography of the collection, but also on the occurrence of disease in the population and the associations between the two.

Demographic and palaeopathological investigations aim to recreate the vital statistics and the level of health experienced by the living analogues of the skeletal populations they study. However, these two seemingly simple goals employ theory and methods borrowed from the social, biological and medical sciences that, when applied to skeletal populations, are plagued with problems and often erroneous assumptions (Angel, 1969; Russell, 1980; Waldron, 1991; Wood et.al., 1992). Thus a consideration of the relevance of both the demographic and palaeopathological findings demands a number of thoughtful deliberations. In particular, there is the need to consider how the skeletal collection does or does not approximate a living counterpart in the society from which it is derived and the need to consider how problems such as incomplete preservation, selective deterioration of age or gender groups and cemetery "sampling" may affect the demographic and pathological conclusions.

Waldron (1991) proposes three main areas to be dealt with in order to comprehend the implications of palaeopathological interpretation of skeletal data. These areas are: 1. determination of the fatal versus non-life-threatening nature of the diseases or conditions present, 2. identification of assumptions against which to test the data, and 3. dealing with missing data (Waldron, 1991:23). The latter two considerations are necessary for any interpretation of the data, either demographic or palaeopathological, while the first area mentioned deals more with the final implications of the data. A fourth area, which should be added in relation to implications of demographic and disease associations, is the fundamental significance of palaeopathological data itself. In the following discussion, assumptions and missing data are the first considerations, followed by a discussion of the significance of palaeopathological data and finally a discussion of the nature of disease in the Helligåndshus collection.

6.1.1 Consideration of Assumptions and Missing Data

The interpretation of osteological data is often hindered by two fundamental problems. The first concerns the tenuous relationship of the data (the study population) to the living population, i.e. the less than absolute correspondence of the dead to the living. The second deals with the accommodation of missing or misleading data. In the latter case, demographic patterns and disease prevalence rates will not be an accurate reflection of vital statistics and disease patterns unless they are made accountable to the missing

data. In the case of the Helligåndshus study population, both of these problems were ever present areas for consideration.

1. Representivity of the Skeletal Collection

Waldron (1991:24) notes that in any attempt to use a burial population to say something about the living, the underlying assumption is "...that the dead population is representative - or at least typical - of the live population." and yet he adds "Given all the non-random events that surround death and burial, not to mention preservation and recovery, this is at best an approximation, and at worst the two (the live and the dead), bear no epidemiological relationship to each other whatsoever." Nevertheless, Waldron (*ibid.*) concedes that if demographic and palaeopathological conclusions are to be drawn, some attempt must be made to establish in what way and to what extent the burial population represents the living population.

The "exceptional" nature of the Helligåndshus study population has been discussed in detail in Chapter 2. To summarise, not only does the G-Series come from just a portion of the cemetery, but it almost certainly derives from a very select portion of the contemporaneous society as a whole. This portion probably included the most poverty stricken members of society. These individuals would likely have been those who could not afford burial in Skt. Peders parish cemetery and many of them may have relied upon the charitable alms and "healthcare" of the Helligåndshus for some time before their death.

As discussed in Chapters 2 and 4, the heterogeneity of age, gender, observable disease associations (see also Fig.1.1), grave orientation, arm placement etc. to provenience throughout the excavation fields is at least suggestive that the G-Series is an unbiased sample, and perhaps even a representative sample, of the entire cemetery. Any conclusions to be drawn from the osteological and palaeopathological data must be made relative, first and foremost, to the special sector of society from which the interred bodies appear to have been derived. For example, instead of viewing the age and gender data as a reflection of the demographic composition of the living society of the time, it would be more appropriate to suggest that these data provide an indication of the demographic make up of the Helligåndshus "clientele".

Outside of the Helligåndshus clientele, the G-Series may only be considered a reflection of the lower class or the "poor', if it is assumed that the users of the facility were "representative" of the lower class in general. It is difficult to say, with any certainty, whether this assumption may be valid. However, considering that charity as offered by the Helligåndshus is thought to have been far reaching, this would not be an unreasonable assumption to make. Not only did charity include the physical shelter of the building, but it is also thought to have included care and assistance, hand-outs of food and attitudes of acceptance and impartiality to all members of society who were in great need. These latter practices would have been in keeping with the mandate of the governing Order of the Holy Spirit and they were very likely practices that assisted many or most of the poverty

stricken members of society, including their needs associated with illness, death and burial.

Nevertheless, it should not be forgotten that for the approximately four hundred years of cemetery use data has been studied for only 328 skeletons. The interpretations to follow must be seen in the context of these considerations. At best the G-Series collection can provide a glimpse of the age and gender structure handled by the Helligåndshus in Næstved as well as an indication of the types of diseases that would have caused morbidity in these people and very likely in the greater society around them.

2. Missing Data

While neither burial patterning nor a biased excavation are thought to have greatly influenced the recovery of age groups, age/gender groups or diseased skeletons, there is a possibility that one or more of these groups are unrepresented due to differential preservation. In particular, the fragile and less calcified skeletons of infants are more likely to deteriorate than the skeletons of the older age groups resulting in an unrepresentation of infants in the demographic profile (Boldsen, 1984). The skeletons of older individuals or those with disease are less likely to deteriorate entirely, unless due to localised soil conditions which was not a concern for this collection. Thus, aside from the possible underrepresentation of the newborn and infant age groups, the problem of missing data primarily concerned the incomplete preservation of various skeletal elements in individuals.

Missing data due to incomplete preservation obviously presents a problem for any interpretation that involves comparison and basic statistical summary calculations. However, it is of particular concern for palaeopathological interpretation. Nevertheless, there are a number of ways of dealing with missing data for disease occurrence investigations. Waldron (1991) suggests figuring missing data (ex. bones) into the calculations by either using a range of probability or by ignoring the missing data altogether. In the former case, the actual proportion of involvement of the missing bones, lies somewhere between minimum and maximum limits which are added to the observed percentage/ proportion affected to try to approximate an actual disease occurrence in the total population (*ibid.*). Whereas, in the latter case, the missing data is ignored so that disease occurrence for the missing bones is assumed to be zero, or the minimum limit, and the observed disease occurrence must be considered to be less than the actual by an unknown factor.

While factoring in missing data as a range of possible involvement is the preferable method, it can be tedious and time consuming, not to mention quite problematic (Waldron, 1991). When many diseases are to be considered and each for not only its own "diagnostic" skeletal distribution, but also its possible interrelationship with other disease entities, the interpretation of what information is potentially missing can be a complex if not misleading endeavour.

Given the time constraints of the osteological investigation, the heterogeneity of which bones were missing for any given skeleton, and the range

of diseases being studied, the most feasible treatment of the missing data was to ignore it. This being the case, it is accepted that all calculated percentages of pathological bone involvement are at the lower limit of an actual potential range.

6.1.2 The Significance of Palaeopathological Data

The issue of the significance of palaeopathological data has been the basis for recent debate; it is a debate that revolves around the validity of perceiving skeletal lesions as indicators of poor health. The "Osteological Paradox" (Wood, et.al.,1992) suggests that "better health makes for worse skeletons". Of course, this is a simplification of a very complex issue for which the authors offer some thought provoking suggestions. In particular, the testing of assumptions and accounting for sources of error are again the primary goals which are advocated when attempting to extract valid conclusions from palaeopathological data.

At the heart of the recent debate is the issue of the meaning of health itself. Standard definitions of "health" are both extremely broad as well as inappropriate for many clinical applications let alone palaeopathological applications. Taber's Cyclopedic Medical Dictionary highlights the practical problems inherent in the definition of "health" (Taber's Cycl. Med. Dict., 1989:784):

> "[AS. *haelth*, wholeness]. A condition in which all functions of the body and mind are normally active. The World Health Organisation defines health as a complete physical, mental and social well-being and not merely the absence of disease or infirmity. This definition is of little usefulness when evaluating an individual; and when one asks who determines well-being, the health professional or the individual. Many persons enjoy a state of well-being even though they might be classed as unhealthy by others."

Larson (1991) has also expressed some reservations with respect to the WHO definition of health. He summarises a number of models which are currently used by a variety of researchers concerned with the definition of health. For practical purposes, Larson (1991) finds that a medical model, which rests on biomedical indices of health such as mortality and morbidity statistics, is the most reliable and most often used model for assessing the health of individuals and populations. This model defines health in terms of the absence of disease and the seriousness of disease in terms of mortality as well as social or physical disability, modified activity and other symptoms of morbidity. Larson (1991) concludes that the best possible measures of health take into account not only the extreme threats to health (fatal diseases), but also the threats to mental and physical well-being (i.e. non-fatal and often chronic diseases). In fact, Larson (1991:95) argues for greater emphasis on morbidity, as opposed to mortality, as an indicator of health:

> "Health is commonly defined as the absence of disease or disability; as physical, mental, and social well-being; and as a state of wellness or being in perfect balance with one's environment. These measurements are more akin to morbidity measures than to mortality measures."

Larson (1991) thus suggests that the best indices for measuring health are the presence of disease and the consideration of the seriousness of those diseases in terms of morbidity, disability and mortality. Taber's Cycl. Med. Dict. (1989) defines a similar assessment of health as "Health risk appraisal". This endeavour, as defined below from Taber's Cylc. Med. Dict. (1989:784), seems a more

appropriate goal for both the clinical and the palaeopathological health investigator:

> "Analysis of all that is known about a person's entire life situation including personal and family medical history, occupation, and social environment in order to estimate his or her risk of disability or death as compared to the national averages. The data used for comparison will vary with age, sex, ethnic background, and income of the patient; and the skill of the evaluator and the sensitivity of the tests used in the evaluation."

Obviously there will be shortcomings for the palaeopathologist when trying to meet the requirements of this definition. However, the aim toward establishing conclusions with regard to "health risk appraisal", in the individual and in the population, is a more pragmatic and objective goal than trying to establish the elusive condition of "health" or healthfulness from a skeletal population.

Health risk appraisal is essentially an epidemiological endeavour, or a palaeoepidemiological endeavour, as the case may be. It is the consideration and interpretation of possible connections between biological, demographic, environmental and socio-cultural factors and disease occurrence in the individual and in the population. Disease occurrence is commonly expressed as incidence or prevalence rates. However, while these two measurements are appropriate in clinical studies they are either erroneous or misleading when applied to palaeopathological studies. Since studies of disease incidence are prospective investigations that can only be carried out in a living population, it is impossible to investigate disease incidence rates in skeletal populations (Waldron, 1991). Prevalence rates, on the other hand, may be applied to skeletal investigations but since prevalence rates are values which express the proportion of a unit of the

population, usually per 1000, affected by a given disease within a specified period of time, the study population must represent the living population for these rates to have meaning. Neither incidence nor prevalence rates which relate to the general living population are considered appropriate for the interpretation of the rather select population of the Helligåndshus. However, a consideration of the relative prevalence, i.e. the relative proportion expressed as a percentage of the study population which was affected by a condition, was employed to try to better understand disease occurrence within the Helligåndshus population. Therefore, for this study, disease occurrence is not considered to be a rate relative to an average living population over a specified period of time but, rather, a means of illustrating the proportion of the study population affected by the various conditions observed. Prevalence is thus used here as a descriptive term which is not indicative of a rate in the general population.

For the Helligåndshus skeletons, disease occurrence was expressed as a simple percentage of the total study population in each of the disease categories of the previous chapter. Categorical age breakdown and age-gender breakdown supplied in table form for each separate disease process within the disease category, was also presented. These findings may be further scrutinised in order to establish the implications of the different disease processes in relation to goals of health risk appraisal. However, to this end, both a consideration of the nature of the observed disease processes and a consideration of assumptions and missing data must be dealt with.

6.1.3 The Nature of Disease in the Helligåndshus Collection

Whereas the types of disease, i.e diagnostic disease entities, can be generally established directly from the data itself, the interpretation of the nature of disease as a health risk and the prevalence of a given disease in the study population requires some intermediate consideration of sources of error and a testing of assumptions.

The nature of disease refers to the morbid and/or fatal potential of the disease. Diseases with fatal potential (ex. certain infectious or cancerous diseases) contribute an increased probability of death. Non-fatal diseases (ex. arthritis), on the other hand, rarely if ever contribute toward an increased probability of death (Waldron, 1991). The difference between these two disease types becomes significant when the mortality profile of the population is considered. Diseases with fatal potential have the ability to alter the "natural" mortality profile of a population; i.e. individuals with fatal diseases will tend to die before the age of average or maximum life expectancy. Life years are thus lost for these individuals and this in turn lowers the average and maximum life expectancy for the population. The influence of fatal diseases needs to be considered in relation to the overall assessment of mortality risks at different ages, but also in terms of how these "premature" deaths, skew the average longevity toward a lower average age at death for the entire population.

In the case of non-fatal diseases, the probability of death is not altered by the disease in question. Waldron (1991) concludes that the proportion of those

who die with non-fatal diseases should be equal to the portion of those who survive with these diseases. However, non-fatal diseases, although not a direct threat to individual mortality, cannot be excluded from the consideration of health risks. Whereas fatal diseases can alter life expectancy in the individual and for the population as a whole, non-fatal diseases can result in either chronic or acute morbidity, affecting the productivity and survivability of the population as a whole. Disability due to non-fatal diseases must also be viewed as a health risk for individuals and populations (Larson, 1991).

Defining the nature, i.e. the seriousness, of certain disease types is an endeavour which must take into account the time period, the cultural atmosphere and the age of the individual (Larson, 1991). For example, infectious diseases such as tuberculosis were much more serious in terms of mortality potential in the pre-antibiotic era than they are at present. The seriousness or perceived seriousness of certain diseases may vary among cultures according to the implications of the morbid condition. For example, an elderly person with crippling arthritis may experience less morbidity in direct relation to greater levels of tolerance, assistance and care which are available for the infirm in different cultures. Lastly, age may influence the seriousness of disease. For example, many diseases, such as pneumonia and other infectious diseases can often have more serious consequences for the very young and the very old.

In a skeletal population, such as Næstved's Helligåndshus collection, it is difficult to infer the true nature of disease in terms of morbidity and mortality. In

order to try to establish some idea of what kind of health threats certain diseases may have posed, it is necessary to make a number of assumptions. First, it is necessary to assume that a disease entity in the past, as diagnosed from skeletal lesions, was at least as lethal as the natural progression of that disease would be today. The second assumption or set of assumptions suppose that the severity of skeletal lesions is a direct indicator of the chronicity and relative morbidity suffered due to a given disease. On the basis of these assumptions, the diseases suffered by individuals in the G-series were grouped in Table 6.1.2a, below, under three general headings relating to a perceived potential for serious complications leading ultimately to death.

Table 6.1.2a

SEVERITY OF DISEASES IN THE HELLIGÅNDSHUS COLLECTION

I.	II.
HIGH FATAL POTENTIAL	POSSIBLE FATAL COMPLICATIONS
chronic infectious disease	severe neuromechanical conditions
traumatic amputation	avascular necrosis
	malnutrition, severe deficiencies
	chronic severe anaemia
	dental abscess complication

III.
NON-FATAL CONDITIONS
arthritis
most dental conditions
most trauma
mild metabolic conditions:
- dental hypoplasia,
- mild chronic anaemia,
- osteoporosis/osteomalacia
benign disorders of growth
mild congenital and developmental disorders

Beyond the consideration of disease in terms of direct threats to longevity, disease must also be considered in terms of morbidity. Morbidity may include a great range of symptoms but, for a functional definition of health risks, any indications of those symptoms which may be considered threats to normal levels of activity and functioning within society, should be considered as indications of morbidity. Palaeopathological studies based on skeletal evidence are at least as limited, if not more so, for identifying signs of morbidity as they are for identifying the full range of diseases that may have been present in a population. Obviously, neither can the mental stress associated with certain disease states be measured nor can the perception of activity limitations due to pain or physical disability be known for certain. Nevertheless, it is not unreasonable to assume that advanced skeletal lesions or considerable structural alteration of bone are indications of morbidity due to chronic disease.

In evaluating the above listed diseases in terms of mortality, it is likely that a similar grouping of the relative severity of these diseases is appropriate, such that Group I = severe symptoms/ morbidity, Group II = moderately severe symptoms/ morbidity and Group III = moderate, mild or negligent symptoms/ morbidity. However, the non-fatal diseases, aside from symptomless benign tumours and unnoticeable congenital defects, may be more significant in terms of disability or quality of life health risks than in terms of their influence on individual life expectancy. In fact, increased life expectancy may mean more chronic disease, more disability and more morbidity in the population and thus

poorer health, less productivity and a reduced quality of life. From a population perspective, Angel (1969:430) notes that "From the standpoints of survival and physical efficiency of a whole population the average level of health is a critical factor simply because sick people are more of a handicap than a few deaths."

Considering that the Helligåndshus G-series population, was a hospital cemetery for the less fortunate of society, it is likely that the prevalence of morbid conditions was high. Indeed, the presence of skeletal lesions indicating chronic disease in over one third of the population would seem to support this contention. However, an accurate interpretation of the findings requires a consideration of both the sources of error and an understanding of the contextual relationships of the study population. In addition, health risk appraisal should include a consideration of longevity calculations, age and sex mortality profiles, and details and relationships of morbidity in the population.

6.2 Demographic and Palaeopathological Interpretation

Keeping in mind the various assumptions and problems with the data, demographic and palaeopathological interpretations and associations are presented below. The implications of these findings extend only as far as assumptions may prove valid and errors can be accommodated.

Demographic interpretations are especially limited in their scope of applicability since, as mentioned earlier, the Helligåndshus collection is a select population which cannot be considered representative of Næstved society in

general. The age and gender structure and the life expectancy calculations (Tables 6.2.1a and 6.2.1b) presented below apply to the burial population of the Helligåndshus which is just a sample of the entire cemetery and thus only a sample of the clientele of the facility.

Demography also comes into the discussion of pathological associations with respect to age and gender patterns in disease occurrence. At the interpretive stage, these demographic and pathological associations provide some indications of the predilections and relative prevalence of certain diseases in different age and age-gender groups within the Helligåndshus population. Calculated figures for each of these areas of investigation are discussed below. In the following chapter, dealing with palaeopathological implications, these findings are discussed with respect to their significance for health or morbidity in the Helligåndshus population and perhaps the wider population of Næstved.

6.2.1 Demography; Age Patterns, Life Expectancy and Gender

Age Patterns

The age distribution in the Helligåndshus collection has been analysed in age group categories. This data is summarised below in Table 6.2.1a. The data show that almost forty percent of the G-Series were infants, children and adolescents (with only a few gender mature individuals) and the remaining just over 60 percent were adults. Jansen et. al. (1987) suggest that "As was the case over the whole of Europe at this time, the level of child mortality was high and

children and adolescents made up 25% of the material collected." The reason for the apparently higher percentage of childrens' skeletons in the Helligåndshus collection may relate to the atypical nature of the population buried in the cemetery. However, other cemeteries in Denmark report higher than 25 percent childrens' and adolescents' skeletons in their burial populations (Jansen et. al., 1987; Boldsen, 1984).

Table 6.2.1a

Age-Gender Breakdown of the Helligåndshus G-series

Age Category: yrs	Total # Individ.	Males Total; %	Indeterminate (I) or prepubescent (p) Total ;percent %	Females Total; %
Nbn: 0 +/-2 mns.	12		12(p) ; 3.7	
Inf: 2mon.- 1 yr.	2		2(p) ; 0.6	
Ch1: 1 - 6 yrs	35		35(p) ; 10.6	
Ch2: 6 - 12 yrs	44		44(p) ; 13.4	
Jv: 12 - 21 yrs	31	5 ; 1.5	19(p) ; 5.8 2(I) ; 0.6	5 ; 1.5
FG: ≥ 15-21	35	9 ; 2.7	23(I) ; 7.0	3 ; 0.9
Ad?: ≥ 21-...?	17	4 ; 1.2	2(I) ; 0.6	11 ; 3.4
Ad1: 21 - 39.5 yrs	103	42 ; 12.8	5(I) ; 1.5	56 ; 17.1
AdM: 39.5 - 57 yrs	46	17 ; 5.2	3(I) ; 0.9	26 ; 7.9
AdS: 57 - 79 yrs	3	1 ; 0.3	0	2 ; 0.6
Total all ages	328	78 ; 23.7% (or 43% of the 216 gender determined skeletons)	112 (p), 35 (I) = 147 no gender determined	103; 31.3% (or 57% of the 216 gender determined skeletons)

The age breakdown may be another factor; if the "Jv" individuals 12-21 years of age are excluded, childrens' skeletons make up approximately 30% of the

G-Series population. The most comparable known cemetery population to the Helligåndshus collection would be that of a similar charitable hospital, the Helgeandsholmen collection from Sweden. In this collection, although the age breakdown is somewhat different, childrens' skeletons aged less than 14 years make up approximately 16% of the population and including the 10 to 24 year olds the percentage is as high as 35% (Jacobzen and Sjögren, 1983). The reason for the great number of children and adolescents in these collections may be less related to actual mortality rates than it is to the possible bias in young clientele. The Houses of the Holy Spirit are known to have functioned as orphanages as well as infirmaries and senior's homes (Hug, 1980; Jacobzen and Sjögren, 1983). Therefore, instead of indicating very high childhood mortality, the high percentage of children's skeletons may be at least partially a reflection of an age bias in cleintele over hundreds of years of cemetery use.

Of the adult skeletons, the majority of skeletons were young adults aged 21 to 39.5 years. This appears to contradict the expected mortality profile for this age group as Boldsen (1984:112) suggests that "Under normal conditions people aged 15-30 years have the lowest mortality rate in a population." However, looking at the age ranges individually, only 46 of the young adults were aged less than 30. Added to the 25 adolescents aged over 15, those estimated between 15 and 30 years of age make up 22% of the G-series. This percentage is probably somewhat low since the number of full grown, "FG", and adults of unknown age, "Ad1", who are between 15 and 30 years of age is not known.

The explanation for the high percentage of young adults in the G-Series may include the possibility that the clientele were skewed toward this age range for it may be that a great number of those in need of charity were young adults. However, Boldsen (1984) offers two other possible explanations for the prevalence of young adults in a skeletal population where neither cemetery bias nor violent death (such as in war) can explain the pattern. These explanations, immigration and endemic disease, are both commonly urban phenomenon. In a trading town such as Næstved, it is quite possible that immigration could have contributed to the seemingly high representation of this age group, especially since any homeless and destitute immigrants would likely have sought the resources of the Helligåndshus. The second possiblity, that of endemic diseases which may or may not leave traces on the skeleton, tends to lead to a higher mortality rate among children and young people in towns (Boldsen, 1984). This may have contributed to the high percentage of individuals in these age groups in the G-Series.

In any case, the high percentage of young adults in the G-Series can be partially explained by a lower life expectancy during the time period. Life expectancy for adults (FG to AdS) has been calculated at 32.5 years for the G-Series (see Table 6.2.1b, below). Although this appears to be somewhat lower than the Helgeandsholmen collection this may be due to a greater number of elderly clientele served by that facility (Jacobzen and Sjögren, 1983). Life expectancy reported for a number of different Scandinavian collections is in the range of 18 to 36 years, at least during the medieaval period (Jacobzen and Sjögren, 1983; Bennike, 1985).

The life table, 6.2.1b summarises the age breakdown and presents the total number of years lived by each age group and age-gender group. Life expectancy is calculated in the right hand column, based on the total number of years lived by the total number of individuals surviving in each successive age category. Gender-specific life expectancy for the full grown and adult portion of the population is presented in Table 6.2.1c. It should be re-emphasized that the data presented in tables 6.2.1b and 6.2.1c is relative to the G-Series only. Since the Helligåndshus population, and therefore the G-Series, is considered a "special" population in which there may be biases in the demographic profile on the basis of age and/or gender, the life tables will be similarly biased.

Life Expectancy

Life expectancy calculations include average estimated life expectancy and life expectancy in relation to age and gender groups. Crude average life expectancy without correction for the age-specific mortality structure for the 7552.25 years lived by 328 individuals equals 23.0 years (i.e. life expectancy at birth). However, as to be expected, the average life expectancy increases for the survivors of each age group and the calculation can be erroneous when infants and children are included (Angel, 1969; Bennike, 1985). Thus the following age-specific life expectancy figures are presented for each successive age group in Table 6.2.1b, below. The life expectancy figure calculated for adults (at age FG) is considered the most accurate average estimate.

Table 6.2.1b

Life Table of the Næstved Helligåndshus G-Series

Age Category	Number of individuals	Years/ Gender ♀	I	♂	p	Total years lived per age	Total years remaining	Life Expectancy in years
Newborn	12					0	7552.25	23.0
Infant	2				0.5	0.5	7552.25	23.9
Child-1	35				105.25	105.25	7551.75	24.1
Child-2	44				323.00	323.00	7446.50	26.7
Adolescent	31	88	30	85	286.00	489.00	7123.50	30.3
Full Grown	35	53	432	161.5		646.50	6634.50	32.5*
Adult?	17	308	45	94		447.00	5988.00	35.4*
Adult-1	103	1715	166	1331		3212.00	5541.00	36.5
Adult-M	46	1213	143	792		2148.00	2329.00	47.5
Adult-S	3	121	0	60		181.00	181.00	60.3
Totals:	328	3498	816	2523.5	714.75	7552.25 years		

Years lived by gender are broken down as follows:
♀ / I /♂/p = female/indeterminate/male/prepubescent

* these age groups are problematic and introduce error into the life expectancy calculations for adults. Because age estimations for individuals only have a minimum age, they lower the total number of years lived and reduce the life expectancy figures by an unknown factor. See discussion below.

Another, perhaps lesser, source of error may be in the possible under representation of infants in this collection. Under representation of infants has the opposite effect on life expectancy calculated at birth, increasing the life expectancy figure by an unknown factor.

Gender

Two patterns were observed in relation to gender in the Helligåndshus G-Series. These patterns emerge as a greater percentage of females, 57%, in relation to males, 43%, in the burial population and a gender difference in life expectancy at different ages.

Life expectancy in relation to gender can be calculated from the information in Table 6.2.1b by dividing the total years lived by the gender group by the total

number of individuals in that gender group. The adolescents (Jv) are excluded from the calculation since gender could only be estimated for a few individuals in this age group. Life expectancy by gender is assessed only for the adults. Individuals of indeterminate gender can be accommodated in the calculation by assuming that these individuals have a 50/50 chance of belonging to one gender or the other. Thus the total years and the total individuals in the indeterminate group can be divided evenly between males and females (Table 6.1.2c).

Table 6.2.1c

Average Life Expectancy by Gender

Gender	Years Lived by Gender & Age		Indeterminate Gender Years ½ ♀ , ½ ♂		Total # Individ. for Adult Ages (+½ "I" gender)	Average Life Expectancy by Gender
Female:						
FG	308.0		22.5		3 (+11.5)	
Ad?	53.0		216.0		11 (+ 1)	
Ad1	1798.0		83.0		56 (+ 2.5)	
AdM	1213.0		71.5		26 (+ 1.5)	
AdS	121.0		0		2 (+ 0)	
summary calculation:	(3,410.0 ♀	+	393.0 I)	÷	114.5 individ.=	33.2 years
Male:						
FG	94.0		22.5		9 (+11.5)	
Ad?	161.5		216.0		4 (+ 1)	
Ad1	1414.0		83.0		42 (+ 2.5)	
AdM	863.5		71.5		17 (+ 1.5)	
AdS	70.0		0		1 (+ 0)	
summary calculation	(2,438.5 ♂	+	393.0 I)	÷	89.5 individ.=	31.6 years

The average life expectancy is somewhat higher for females than for males, but if these calculations are broken down into the three adult age groups, Ad1, AdM and AdS, a slightly different pattern emerges. In a preliminary look at age group variations, excluding the FG and Ad? individuals, female life expectancy calculates to 30.7 years for the Ad1 group, whereas male life expectancy is slightly higher at 31.7 years. In the AdM group the pattern reverses and female life expectancy is higher at 48.5 years versus 46.7 years for males. Finally the AdS category, with only three individuals, illustrates a slightly higher advantage for females; i.e. 60.5 years for females versus 60.0 years for males.

Alternatively, the FG and the Ad? categories may be "spread" over the young, mature and senior adult categories to get a better idea of life expectancy in relation to age group and age-gender group, without excluding these 52 individuals. Considering that the number of individuals determined as falling into the latter categories, Ad1, AdM and AdS, was 103, 46 and 3, respectively, a ratio of approximately 35 Ad1 for every 16 AdM and every 1 AdS is indicated. In accordance with this ratio the total number of FG and Ad? individuals were relegated to the Ad1, AdM and AdS groups. The total number of years lived by FG and Ad?, although less precise, were similarly relegated to Ad1, AdM and AdS. For these augmented Ad1, AdM and AdS group figures, the age-gender life expectancy pattern is similar, though the actual numbers are somewhat different. For the Ad1 group the female average is 28.9 years compared to a male average of 29.3 years. In the AdM group, the female average is 41.7 years compared to

39.7 years for males and in the AdS group, the female average is 53.1 years compared to 47.9 years for males.

While it is apparent that all life expectancy figures are lower when FG and Ad? years are added, this is expected since the lower end of these groups are definite but the upper end could not be determined. Thus it is known that these two age groups underestimate the years lived by these individuals. However, it is interesting and encouraging that the age-gender pattern corresponds to the previous set of calculations. Without undue speculation, it may be posited that the relative female "disadvantage" in the Ad1 category could relate to greater health risks for females of child bearing age. Such health risks may be directly related, indirectly related or perhaps unrelated to pregnancy and birth. However, the risks of greater nutritional demands and physical demands in relation to pregnancy, childbirth, and child rearing, including lactation have been often noted and should hardly be entirely dismissed as unrelated to female health, especially in a population sample derived from the lower class of society. On the other hand, Wells (1975b) suggests that higher female mortality in the past was related to a heavy workload and an unequal share of nutrient and protein rich food in comparison to males. Higher female mortality may thus be related to reduced health as a result of poor nutrition and greater stress and yet its correlation with childbearing years is probably not unrelated to the demands of childbearing as this would only serve to compound the state of poor health in women of child bearing age (Högberg et. al., 1987).

These age and age-gender patterns notwithstanding, there remains a greater overall percentage of females in the G-Series. The reason for the surplus of females over males is not clear but a number of factors may be responsible. The possiblity of inaccurate gender estimation with a bias towards female estimations could be partly or wholly responsible. However, it is felt that other factors such as a greater need for charity among females or perhaps a greater number of females over males migrating to urban centres such as Næstved may also be part of the explanation for a surplus of females in the Helligåndshus burial population.

6.2.2 The Presence of Disease: Age and Gender Associations

Table 6.2.2a (pp. 319 and 320 below) is a summary of the age and gender associations in the age/gender tables presented in Chapter 5 for each separate disease category. This summary table provides a convenient means of comparing the demographic data for the total G-Series (top row of the table) with the age and gender associations observed for each disease category. The table can be read such that the upper row is total number of individuals for each gender and age category in the G-Series, and each row below gives the total number of individuals exhibiting skeletal indications for each of the pathological conditions in these gender and age categories. As an example, the total number of individuals in the G-Series, "T", equals 328 while in the row below, the total number of individuals exhibiting signs of one or more metabolic condition, "T", equals 38; therefore, signs of metabolic disease are indicated for 38 out of 328

Table 6.2.1d
The Presence of Disease in Relation to Gender and Age Category

	# Individuals by Gender T: ♂/ I/ ♀/ p	#of Individuals in Each Age Category Nbn	Inf	Ch1	Ch2	Jv	FG	Ad?	Ad1	AdM	AdS
TOTALS FOR G-SERIES	**328:78/35/103/112**	**12**	**2**	**35**	**44**	**31**	**30**	**22**	**102**	**47**	**3**
Pathology:											
METABOLIC CONDITIONS	38: 7/ 0/ 23/ 8	-	-	4	2	6	1	1	13	10	1
Rickets/post-rachitic deformity	7: 3/ 0/ 3/ 1	-	-	1	-	-	1	-	1	4	-
Osteoporosis/osteomalacia	7: 0/ 0/ 7/ 0	-	-	-	-	-	-	1	2	4	-
Dental Hypoplasia	25: 4/ 0/14/7	-	-	3	2	6	-	-	10	3	1
Scurvy	2: 1/ 0/ 1/ 0	-	-	-	-	-	-	-	1	1	-
VASCULAR DISORDERS	31: 4/ 0/ 9/ 18	-	-	-	4	10	7	-	1	6	3
Cribra Orbitalia	24: 3/ 0/ 4/17	-	-	4	10	6	-	-	3	1	-
Localised circulatory	7: 1/ 0/ 5/ 1	-	-	-	-	1	-	1	3	2	-
INFECTIOUS CONDITIONS	45: 9/ 3/ 23/ 10	3	1	-	4	6	4	1	17	9	-
Non-specific	30: 8/ 2/15/ 5	3	-	-	1	4	4	1	10	7	-
Specific: syphilis	8: 1/ 0/ 6/ 1	-	1	-	-	1	-	-	5	1	-
tuberculosis	4: 0/ 1/ 2/ 1	-	-	-	-	1	-	-	2	1	-
actinomycosis	3: 0/ 0/ 0/ 3	-	-	-	3	-	-	-	-	-	-
TRAUMA	19: 7/ 2/ 10/ 0	-	-	-	-	-	1	1	8	9	-
Fractures	15: 7/ 2/ 6/ 0	-	-	-	-	-	1	1	6	7	-
Pathological fractures	3: 0/ 0/ 3/ 0	-	-	-	-	-	-	-	1	2	-
Amputation	1: 0/ 0/ 1/ 0	-	-	-	-	-	-	-	1	-	-

*See note on reading the table on the bottom of the following page.

Pathology continued...	# Individuals by Gender T: ♂/ I/ ♀/ p	#of Individuals in Each Age Category Nbn	Inf	Ch1	Ch2	Jv	FG	Ad?	Ad1	AdM	AdS
GROWTH DISORDERS	4: 1/ 0/ 2/ 1	-	-	-	-	2	-	-	-	2	-
Benign neoplasm	4: 1/ 0/ 2/ 1	-	-	-	-	2	-	-	-	2	-
CONGENITAL DISORDERS	4: 2/ 0/ 0/ 2	-	-	-	1	1	-	-	1	1	-
Dysplasia	1: 0/ 0/ 0/ 1	-	-	-	1	-	-	-	-	-	-
Localised defects/complications	3: 2/ 0/ 0/ 1	-	-	-	-	1	-	-	1	1	-
NEUROMECHANICAL	77:24/ 9/ 43/ 1	-	-	-	-	1	2	12	29	30	3
Arthritis: Vertebral	40:15/ 6/19/0	-	-	-	-	-	-	7	18	14	1
Vertebral/General	16: 4/ 0/12/0	-	-	-	-	-	-	1	1	1	2
Localised	21: 8/ 3/12/1	-	-	-	-	1	2	4	10	4	-
Deformities: Spinal Curvatures	6: 2/ 0/ 4/ 0	-	-	-	-	-	-	-	1	5	-
Localised	1: 0/ 0/ 1/ 0	-	-	-	-	-	-	-	-	1	-
DENTAL CONDITIONS	57:15/ 1/ 35/ 6	-	-	2	4	3	-	3	23	21	1
Caries	39:12/ 0/22/5	-	-	2	3	3	-	2	17	11	1
Abscess	20: 3/ 0/15/2	-	-	-	1	1	-	2	10	6	-
Wear	17: 7/ 1/ 7/ 2	-	-	-	2	-	-	-	5	10	-
Loss	37:10/1/26/ 0	-	-	-	-	-	-	2	13	21	1
Alveolar Disease	40: 9/ 1/29/1	-	-	-	1	-	-	3	16	20	1

Reading the Table:
DOWN: Each sub-category records the number of individuals affected by the specific disease in relation to the total number of individuals in the disease category. For example, 39 out of 57 individuals showing signs of dental disease have dental caries.
ACROSS: In the gender column the Total number of individuals is broken down into the total number belonging to each age gender determination where ♂/I/♀/p = male/indeterminate gender/female/pre-pubescent. Note that not all "subadults" were determined to be prepubescent. Some adolescents (Jv) did exhibit features which enabled the estimation of their gender. Therefore when reading further across to the age breakdown, some designated as Jv age may be included in the male or female gender total for that pathology.
The Age category columns are simply a further breakdown of the initial total number of individuals in the category row. Reading across age category figures are the total number of individuals broken down into the total number belonging to each age group.

individuals or 11.6% of the G-Series. Similarly, reading the table for gender associations indicates that metabolic disease was diagnosed in 7 out of 78 males (9.0% of all males) and in 23 out of 103 females (22.3% of all females). Associations to age category follow the same convention, for example, the number of young children, Ch1, diagnosed with a metabolic disease is 4 out of a total of 35 Ch1 children in the G-Series.

The distribution of numbers in the table suggests some preferences for specific ages or for gender in relation to certain diseases. The interpretation of these associations requires a testing of assumptions in order for the true implications of the data to be understood. Disease associations on the basis of age predilections are generally easier to understand because there are fewer factors involved. Degenerative arthritis, for example, is well known as a disease of adults which predominantly affects those past the third decade of life. When this assumption is tested on the Helligåndshus G-Series, the data is in accordance. The results of the investigation support the contention that osteoarthritis is a disease of the aged, affecting the greatest proportion of individuals in the older age groups. The proportion of those exhibiting signs of arthritis shows an association with increasing age; the disease affects less than 1% of those under 21 years old, 28.2% of those 21 to 39.5 years old, 65.2% of those 39.5 to 57 years old and 100% of those aged 57 years and older.

Predilections on the basis of gender can be much more difficult to explain. In terms of the aetiology of disease, gender can subsume a number of factors, in

addition to the biological factors, which contribute to the likelihood of disease. Some of these factors may include social, dietary and occupational differences that are attributed to one gender or the other. Once again using arthritis as an example, differences in the type, frequency and intensity of occupational activities can result in a higher proportion of one gender being affected as opposed to those of the opposite gender. In most skeletal series, a slightly greater proportion of males are affected by arthritis (Steinbock, 1976; Ortner and Putschar, 1985).

The data from the Helligåndshus G-Series suggests that arthritis was more common in female skeletons in the collection, occurring in 11% more females than males. However, the implications of this finding are not clear; arthritis may not have been more common in females in general. It may be that this finding is just an artefact of the select group of persons that used the resources of the Helligåndshus. It may be more accurate to suggest that the average female who sought the charity of the Helligåndshus had engaged in more frequent activities which predisposed to arthritis than her male counterpart. In any event, the age and gender associations which appear in the data are best scrutinised in terms of how they measure up to the conventional assumptions for these diseases. It may be that more questions are generated from this exercise than questions are answered, and yet both results may be enlightening. Each of the categories is summarized with respect age and gender associations in the data and how they correlate with common assumptions.

Statistical treatment of the data has been avoided because of the preliminary scope of the investigation and the problematic quality of the original data. Therefore, the occurrence of disease has been reported only as the percentage or proportion of the total G-series population exhibiting indications of the given condition.

The major limitations of the data, which have been discussed previously, have presented problems both for interpretation as well as for statistical analysis. These problems included the small sample size of age and age-gender subsets for each disease occurrence as well as the possibility of selective skeletal deterioration (missing data) on the basis of gender and/or age groups. Also complicating interpretation are the multiplicity of factors which may affect the influence of perceived associations, on the basis of gender, age or other variables. The latter problem is compounded by the ca. 400 year time span of the cemetery and the select nature of the burial population, both factors which could affect the validity of any derived associations (preliminary or statistical). Therefore, statistical treatment of the data will require a full scale consideration of the quality of the data as well as a consideration of the most appropriate method of testing the data in light of the problems and inherent biases of the data.

It is hoped that the demographic and palaeopathological associations suggested by the preliminary interpretation of the data will highlight a few of the key areas where further investigations are indicated.

Metabolic Conditions

Skeletal and/or dental signs of metabolic conditions were observed for most age groups, excepting only the newborn and infant age groups. The exclusion of these ages may be due to lack of preservation or recovery of a representative sample for these age groups, non-recognition of metabolic disease or an actual lack of the observed metabolic diseases in these age groups. In the latter case, it may be that nutrients supplied by breast-feeding were sufficient to protect infants, from metabolic deficiencies at any rate.

Rickets, including post-rachitic deformities, and dental hypoplasia are conditions which manifest on the growing skeleton and teeth of young children. Both of these conditions, if sufficiently severe and chronic, will leave traces that remain on the skeleton/ teeth throughout the lifetime of the affected individual. Therefore, it is expected that these conditions will be found at any age from young childhood through old adulthood. The data from the Helligåndshus G-Series supports this expectation. The gender association for these diseases is approximately equal for the occurrence of rickets but, for dental hypoplasia, 7.5% more females were affected than males. On the surface this may mean that females were less well nourished than males; a consideration of all gender differences in disease occurrence may lend credence to this assertion.

The metabolic conditions which were seen only on adult skeletons included possible scurvy and osteoporosis and/or osteomalacia. The latter two conditions are usually associated with adult skeletons. Osteomalacia, the adult counterpart

of rickets, is by definition, a deficiency condition which occurs in mature bone. Osteoporosis, a condition of reduced bone tissue per total bone mass, often accompanies osteomalacia and is a condition occurring primarily in aged adults (Steinbock, 1976; Ortner and Putschar, 1985). Scurvy, on the other hand is a deficiency condition which may affect any individual from infancy through adulthood. However, since there are only two possible cases in the entire G-Series, i.e. the condition affects less than one percent of the study population, epidemiological conclusions would be presumptive.

Vascular (Circulatory) Conditions

Vascular conditions included manifestations of systemic anaemia and various bone changes due to localised circulatory disruption. Neither of these disorders are age or gender specific; however, predilections on the basis of age and gender have been noted for both anaemic and localised circulatory disorders. The anaemic conditions, for example, are more common during infancy and puberty when the demands for iron during rapid growth are greatest (Mensforth et.al 1978; Wharton, 1989). Furthermore, skeletal changes, including cribra orbitalia are thought to be a phenomenon which may only occur in the growing bones of children; the richly vascularised marrow space of children is already "filled to capacity" and thus it is the most vulnerable to structural alterations from increased marrow hyperplasia (Stuart-Macadam, 1991:38). Thus cribra orbitalia, the skeletal manifestation of anaemia, can be expected to be more common on the skeletal

remains of the young (infancy through adolescence). In the older age groups, remodelling of bone changes from childhood and a lack of bone changes in adult cases should translate as less traces or less severe evidence of the disease occurring in adulthood. The age distribution for the occurrence of cribra orbitalia in the Helligåndshus G-Series agrees with this assumption. Although not apparent on any infant skeletons, the condition was identified in 18.2% of skeletons aged less than 21 years compared to only 2.7% of adult skeletons.

Localised circulatory conditions including osteochondritis dissecans and ischaemic necrosis were identified in only 2.1% of the G-Series. The former condition occurs between the ages of 8 and 14 and traces remain throughout the life, while the latter can occur at any age but is more common in the older age groups as a result of the compounding affects of years of mechanical stress and weight bearing (Ortner and Putschar, 1985). Again the occurrence of these conditions in the G-Series is in accordance with the expected age predilection. However, in most series both conditions are more common in males, whereas in the G-Series, more females were affected by localised ischaemic necrosis. This may be an artefact of the low overall occurrence of the condition in the collection, a reflection of error in gender determination or an actual reflection of greater prevalence in females.

Inflammatory and Infectious Conditions

Inflammatory bone changes are difficult to ascertain in terms of an infectious aetiology but it is likely that most or all of the inflammatory conditions have some infectious component. Therefore inflammation has been treated together with infectious conditions in this investigation. Skeletal indications due to inflammation and/or infection were identified in individuals from peri-natal age into mature adulthood. Only young children between the ages of 1 and 6 years appear to have been spared. The reason for the lack of infection in this age group is uncertain but it may be no more than an artefact of possible incomplete representivity of this age group.

Of all the age groups the newborn and infant ages exhibited the highest proportion of individuals with bone changes due to infectious conditions. Four out of fourteen individuals or 28.6% exhibited infectious lesions. The proportion of individuals affected then seems to drop off during early childhood with no indications of infectious disease for 1-6 year olds. Although the reason for the apparent sparing of young children is unclear, it may be that occasion for exposure, length of exposure and incubation of chronic disease is less than sufficient for either the development of these diseases or the skeletal lesions that confirm their presence. Almost 10% of 6-12 year olds and approximately 15% of adults aged 21-57 exhibit signs of infectious disease. The age distribution for infectious disease is not particularly surprising except for the rather high proportion of infants affected. One infant of about 3 months old was diagnosed

with congenital syphilis and the three other infants of newborn age were diagnosed with non-specific infection which may have been congenital syphilis as well. Considering that syphilis was observed in six females in the G-Series, even four infants deaths for this number of infected females is not unlikely. Thus since venereal syphilis was present in the population and it would have posed a particular threat to infant survival, the predilection for infants in not surprising. The seemingly high prevalence of venereal syphilis (or other peri-natal infection) in infants is likely a reflection of the particularly fatal nature of the disease(s) in infants.

The proportion of those with infectious conditions in relation to gender is once again biased towards females. The proportion of females affected is 4.3% higher for non-specific inflammation and infection; 4.5% higher for treponemal infection and 1.9% higher for tuberculosis infection. For actinomycosis, the third specific infection identified, all individuals were subadults and, therefore, no gender differential could be determined. While these figures can not be projected onto the general population for explanation, the bias towards females could mean that the female "clientele" of the Helligåndshus were at greater risk for contracting these communicable diseases or that females with these conditions were more likely to seek the charity of the Helligåndshus.

Traumatic Conditions

Trauma included primary and pathological fractures and one amputation. In all cases signs of trauma occurred in adults between 21 and 57 years of age. The proportion of males affected was slightly higher for primary fractures as is often the finding in the general population (Steinbock, 1976). Pathological fracture, on the other hand was only seen in females. This may be a result of female bone being generally less robust and thus more prone to fracture secondary to pathology or it simply may be a result of the fact that the pathologies which seriously undermine the structural integrity of bone, syphilis and osteoporosis, were by far more common in females than in males.

Growth Disorders

Benign disorders of growth were diagnosed in just over one percent of the population. These conditions would not have been life threatening and they were likely asymptomatic. The discussion of these conditions was included for the sake of completeness but with such a small proportion of the population affected no epidemiological conclusions would be valid. Furthermore, neither the number of those affected nor the nature of the conditions would have contributed to morbidity in the population and thus their discussion in relation to health risks is not warranted.

Congenital Disorders

A number of mild congenital/developmental defects were recognised but only two of these defects were considered to have progressed into symptomatic conditions, perhaps due to exacerbation by growth and mechanical strain. Both of these defect conditions occur in adults; however, it is posited that the exacerbation of such defects would not develop into recognisable pathological conditions without the action of growth and mechanical that are commensurate with aging into adulthood.

Aside from the rather mild defect conditions, there were two serious disorders for which a congenital aetiology was posited. These conditions, a metaphyseal dysplasia and a congenital hip malformation, are isolated conditions for which no epidemiological conclusions are warranted.

Neuromechanical Conditions

Neuromechanical conditions, which were briefly discussed above by way of example, were the most prevalent type of pathology observed in the Helligåndshus G-Series. The proportion of those affected was seen to increase in direct relation to increasing age. The proportion of females affected was as much as 10.9% higher than the proportion of males affected. While the age distribution is in accordance with the norm or the expected age association for arthritis and neuromechanical/structural deformities, the gender distribution is opposite to the expected pattern.

Gender differences in the pattern or arthritis and neuromechanical deformities could be the result of one or both the following possibilities: females with neuromechanical pathology were more likely to seek the services of the Helligåndshus and/or females of the Helligåndshus clientele population, the "poorest of the poor" in Næstved, engaged in more activities which predisposed to neuromechanical pathology.

Dental Conditions

Dental conditions were the second most prevalent type of pathology observed in the Helligåndshus G-Series. Those affected ranged in age from approximately 2 years of age (Ch1) to over 60 years of age (AdS). Both the wide distribution in ages affected and the types of conditions most prevalent in the respective age groups were in accordance with general assumptions for the occurrence of dental disease. Dental caries affect the very young to the very old and both dental caries and abscessing reach a peak in young adulthood after which tooth wear, tooth loss and alveolar conditions become more common.

Once again while the age distribution for the occurrence of disease is not considered unusual, a female gender bias was noted in the study collection. The proportion of females affected is 6.0% higher for dental caries, 10.8% higher for dental abscess, 12.4% higher for tooth loss and 16.7% higher for alveolar disease. The implications of this gender bias are much the same as those mentioned for other types of pathology. Either, on average, more females with pathology sought

the services of the Helligåndshus or the female "poor" suffered from more pathology or were more prone to pathology than were their male counterparts.

It is equally possible that differences in nutrition could explain poorer dental health in females. Other osteological studies have indicated that this is indeed the case and that starting in childhood females suffered more from malnutrition than did males (Wells, 1975b; Högberg et. al., 1987). The higher percentage of females with dental hypoplasia in the Helligåndshus collection supports the idea of more prevalent malnutrition in females and it is concievable that the poorer dental health in females began with substandard enamel development and progressed with caries and related dental complications throughout their lives.

In the following chapter, the analysis of these demographic and palaeopathological observations and interpretations are taken a step further to consider the implications of the age and age-gender composition of the Helligåndshus population with respect to the health risks affecting the overall level of health experienced by these groups and how these health risks may have related to or impacted upon the wider society of Næstved.

CHAPTER 7: CONCLUSION

7.1 Demography and Disease: Associations and Implications

At its most basic level, the presence of disease is an indication of a stress endured. There has been recent debate with regard to the significance of skeletal indications for disease and their implications for the state of 'health' in the individual (Ortner, 1991; Stuart-Macadam, 1991; Wood et.al., 1992). It is questioned whether skeletal traces of disease are in fact indications of an individual's 'healthfulness' or adaptedness. Skeletal indications of chronic disease have been interpreted as indications of the body's ability to overcome the early fatal threat of certain diseases. Lesions are said to represent the strength of the body's immune response since the very presence of skeletal lesions indicates a long term immune response to infective agents or disease states (Stuart-Macadam, 1991).

This discussion of palaeopathological "health" is problematic in that it suggests that individuals may be considered "healthy" despite evidence of disease; indeed, the presence of pathological (healed) lesions is being cited as an indicator of "health". This is in direct contrast to the functional "medical model" used to define health in modern populations (Larson, 1991). However, the difference in the two concepts is the notion of health itself. The palaeopathological concept suggests that individuals and populations who are able to survive in spite of

chronic disease are better adapted to their environments, more suited for survival (immune strength) and thus more "healthy" or less "frail" in an evolutionary sense than those who die in the acute phase of disease and thereby manifest no skeletal signs of the disease. The medical model on the other hand, views the presence of disease as an indicator of poor health. The presence of clinical disease is not seen as a positive adaptation, it is seen as a cause of morbidity, a hinderance to optimal functioning and a risk to survival.

The ultimate difference in the two concepts of health lies in the comparison of the healthy to the unhealthy in each definition. In clinical medicine, disease is much more identifiable. Persons who die in the acute phase of a disease may be identified and differentiated from those who survive into the various stages of the chronic phase. More importantly, those who are not affected by a given disease may be differentiated from those who die in the acute phase of that disease. The latter differentiation is not possible for skeletal series. The cemetery is a mix of superimposed generations, changing biological and social circumstances, and variations in causes and rates of death in different age and gender groups (Angel, 1969). Therefore all of the so called 'unhealthy', lesion-free skeletons are a mix of ages, gender and unidentifiable causes of death that cannot be compared to any of the case groups for a given disease. Yet the question remains whether, in any age group or any whole series, those skeletons exhibiting healed lesions can be considered more healthy than those without lesions who, Wilkinson (1992:364) points out, "...by virtue of their inclusion in our samples, are equally dead."

Comparing the health status of those diagnosed with a certain disease to the health status of those who died for unknown reasons has little merit.

Longevity, and fertility when it can be calculated, provide the ultimate indices of successful adaptation and survival in a population (Stuart-Macadam, 1991). Yet for an understanding of the threats to survival and functional quality of life, the appraisal of health in terms of "health risks" provides a descriptive and qualitative understanding of disease stress and threats to adaptation and survival in palaeopathological contexts. Individuals exhibiting signs of disease serve as indicators of the presence of health risks in the population and morbidity and perhaps disability in the individual.

The presence of disease has been established for the Helligåndshus G-Series. Almost half of the population, 154 individuals, exhibited evidence for one or more pathological condition. Infection was probably the greatest threat to survival, affecting 45 individuals of all ages and both genders and likely posing a very serious health threat to perhaps 20 or 30 of these individuals. Two other conditions which may have had fatal potential include one amputation and possibly two cases of scurvy.

A number of other conditions that are not normally considered to have fatal consequences may have resulted in complications that contributed toward death. Serious dental conditions such as numerous caries, chronic dental abscess and tooth loss, that can interfere with proper nutrition or can cause acute systemic infection spread from the dental focus, may result in or contribute toward death.

Deficiency diseases such as dental hypoplasia, rickets, osteomalacia, osteoporosis and iron deficiency anaemia are the end result of dietary insufficiencies (or other disease stress) that indicate ill health in the individual. These conditions may have very little influence on the direct cause of death in an individual but they do suggest morbidity which may have interfered with optimal levels of activity and functioning as well as contributed toward an overall state of poor health in the persons afflicted.

In the Helligåndshus G-Series arthritis, dental disease and infection were the most commonly occurring palaeopathological conditions. These conditions are not uncommonly the most frequent pathologies observed in skeletal populations. However, the proportion of the population affected by these conditions appears to have been greater in the Helligåndshus G-series than for other populations. This is very likely a reflection of the fact that the collection is that of a "hospital cemetery" as opposed to an average cross section of society. A comparable population from a Swedish House of the Holy Spirit, *Helgeandsholmen* in Stockholm, seems to have suffered from similar types of disease but the prevalence of these conditions may have been somewhat lower (Jacobzon and Sjögren, 1983).

The demographic distribution of the palaeopathological conditions was as to be expected in relation to age. Infection was the only type of pathology identified in the newborn and infant categories. Diseases of childhood, such as dental hypoplasia, cribra orbitalia, and rickets were prevalent amongst the Ch1

and Ch2 age categories (1-12 years of age), while the lingering traces of these diseases were identified in adolescents and adults. In addition to these childhood diseases, other less age specific diseases such as dental disease and infectious disease suffered during childhood may all have contributed to poor health that was carried over into adulthood. The diseases of childhood should thus be considered as being at least contributory to the overall health problems augmenting in adulthood.

In the Helligåndshus population, adult health problems included osteomalacia and or osteoporosis, scurvy, non-specific and specific infectious disease, trauma, arthritis, dental disease and a few isolated conditions of various aetiologies. The types and patterns of these health problems correspond with that which is expected for older individuals. Osteomalacia, osteoporosis and arthritis are diseases which affect mature adults. Dental disease in the adult population consists of more abscessing, tooth loss and alveolar conditions as opposed to the predominantly carious conditions of childhood. Infection may occur at any age but in the older adolescent and adult groups there are several cases of chronic venereal syphilis which are neither seen nor expected in the children's skeletons.

The net result of nutritional/ metabolic and infectious health risks suffered during childhood and the stresses of health risks encountered with advancing age may provide another explanation for the large number of deaths which occurred during young adulthood. Adult life expectancy was on average only about 32 years. While this is not considerably different than the life expectancy for other

"normal" populations around the same time period, such a low life expectancy suggests that health risks must certainly have been high for the average adult in the Helligåndshus population.

One of the most interesting patterns which was observed for the Helligåndshus G-Series was both a surplus of females over males in the gender mature (late adolescent to adult) portion of the population and a predilection for females with respect to the occurrence of most diseases. This gender differential may indicate that females were in greater need of charity from the Helligåndshus. It may be that a greater number of females were without alternate resources for subsistence, "medical care" and ultimately for burial. It is interesting to speculate on the possible reasons for greater need in females; this is one area of research that may have potential for further social/historical investigation. At this point there is little known about the economy of the poor in Næstved and how it may have differed between the sexes.

Graus (1988) summarises the poor as including wage workers, farm girls and peasants with insufficient land to sustain a living as well as thieves, cripples, prostitutes and vagrants living "outside of society", mainly in the urban centres. The lot of women in these capacities was worse than that of her male counterpart. Females had a lower labour status and were often paid less for the same work (Gies and Gies, 1978; Howell, 1986). Gies and Gies (1978:181) note that "Discrimination in pay and status forced many women to eke out their income by prostitution or thievery...". While married women may have been able to sustain

a viable subsistence by her own household production (Howell, 1986), many peasant women did not marry and thus had few resources (Gies and Gies, 1978).

In terms of the effects of lower labour status on women's health, Wells (1975b) asserts that lower longevity and greater morbidity in females is a result of chronic malnutrition due to a diet inferior to that of males and inadequate to meeting the metabolic needs of an extremely demanding lifestyle. The possibilities of malnutrition leading to greater susceptibility to infection and other diseases as well as the occurrence of unwanted pregnancy inevitably left women in greater need of charity than their male counterparts.

The skeletal evidence from the Helligåndshus, if we can assume those buried in the cemetery represent the "poorest" in Næstved society, suggests that those in greatest need included individuals of both sexes and of all ages from infancy to old adulthood. However, it appears that females may have had greater health risks, probably due to a poorer level of subsistence, and perhaps particularly due to poorer nutrition. Dental hypoplasia, osteomalacia and/or osteoporosis, infection, dental disease and arthritis were between 6.8% and 14.8% more prevalent in the female population than the male population. Dental hypoplasia, which was 7.5 percent more prevalent in females than in males, suggests that malnutrition and/or other disease stress was more prevalent among female children than among male children. Osteomalacia and osteoporosis were only identified in females, suggesting that malnutrition and/or metabolic dysfunction were also a problem for females in adulthood.

The primary health risks for the users of the Helligåndshus, presumably the lower class of society in Næstved, included diseases resulting from malnutrition and/or metabolic dysfunction, diseases related to aging and mechanical stress on the skeleton, dental pathologies and diseases of an infectious and/or communicable nature. Although there were a few cases of trauma and congenital defects, these conditions seem not to have been a considerable health problem for the population as a whole.

In terms of the wider population of Næstved, palaeopathological data from the Helligåndshus G-Series confirms the presence of syphilis and tuberculosis, although the earliest date of their presence in the town is not known. These two communicable infectious diseases were not likely confined to only the lower class. The upper classes may not have suffered to any great extent from the diseases of malnutrition and hard labour but they were undoubtedly exposed to tuberculosis and syphilis. The Helligåndshus population provides an indication of the demography of the 'poor' in Næstved and the health risks associated with age and gender in the poor, but the population also gives an indication of the diseases that were present in the community at large. The Helligåndshus population may not serve as a template for the "average" population of Næstved, but it does provide some illumination on a section of the population and society. As sure as syphilis and tuberculosis were present in the wider community of Næstved, the poverty stricken were present and their needs as described by their age, gender and disease made their impression on the wider community of Næstved by virtue of the particular demands which were placed on charitable resources.

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APPENDICES

APPENDIX I - A

AGE DETERMINATION RECORD

AGE DETERMINATION RECORD

Project no.:..... Date:.....
Institute inventory no.:.....
Condition of skeleton:.....
.....
.....
Age; general category: ...young ...middle age ...old age
specific : ...+/-...years

JUSTIFICATION:MACROSCOPIC OBSERVATIONS

EPIPHYSIAL FUSION:.....age est.:.....
1.Pelvis:
a.acetabulum:(ilium, ischium, pubis):.....
b.obturator foramen (ilium and pubis):.....
c.ischial tuberosity and ramus:.....
2.Scapula:.acromion...../coracoid process...../glenoid cavity.....
.inferior angle...../vertebral border...../neck.....
3.Clavicle:.attachment of medial epiphysial cap.....
4.Ribs:.head and tubercle; early:1-3,10-12...../ late 4-9.....

PELVIC DATA:
1.Pubic symphysial face:.....age est.:.....
a.surface topography:.billowed...../smooth...../eroded.....
b.ventral border:.margin(?).....
c.dorsal border:.degree of dev.:.....
d.superior extremity:.defined(?).....
e.inferior extremity:.defined(?).....
2.Auricular surface:.(grain,density,porosity).....age est.:.....
a.superior demi-face:.....
.billows/striae(?).....
.smooth/irreg.(?).....
b.inferior demi-face:.....
.billows/striae.....
.smooth/irreg.(?).....
c.retro-articular area:.smooth.....rough/irreg.:.....
d.articular apex area:.smooth.....rough/irreg.:.....

STERNAL RIB ENDS:.....age est.:.....
a.shape:."V"shape...../infilled...../"U"shape.....
b.surface:.billowed...../smooth...../deep,porous.....
c.margin:.smooth,round...../scalloped...../sharp,irreg.....
d.pit floor:.projections/accretions(?).....
e.wall wdth:.thick...../intermed...../thin.....
f.bone qual:.firm,solid...../intermed...../brittle.....

SUBJECTIVE OBSERVATIONS:.....age est.:.....
1.cranial sutures:.....
.....
2.dental wear:.....
.....
3.arthritis:.....
.....

APPENDIX I - B

GENDER DETERMINATION RECORD

GENDER DETERMINATION RECORD

Project no.:..... Date:.....
Institute inventory no.:.....
Condition of skeleton:.....
.....
.....
Gender:.....Male(M).....Female(F).....Indeterminate (I)

JUSTIFICATION:MACROSCOPIC OBSERVATIONS

PELVIC OBSERVATIONS:.....gender est.:.....

	MALE	FEMALE
1.subpubic concavity:	V"shape >.....	U"shape >.....
2.ischiopubic ramus :	no ridge.....	ridge .....
3.Ventral arc :	absent.....	present.....
4.Pubic bone shape :	narrow.....	wide;rectangular.....
5.Dorsal pitting :	absent.....	present.....
6.Sciatic notch > :	sm,acute >; deep.....	wide;shallow.....
7.Auricular surface :	not raised.....	raised margin.....
8.Pre-auric. sulcus :	absent.....	lrg.circ.depression....
9.Ilium shape :	high; vert.trend.....	lat.divergent.....
10.Pelvic inlet :	heart shaped.....	elliptical.....
11.True Pelvis :	rel.small.....	rel.wide;shallow.....
12.Obturator foram. :	large; ovoid.....	sm;triangular.....
13.Acetabulum :	lrg; lat.directed....	sm;ant-lat directed....
14.Sacrum shape :	long; narrow.....	short;broad.....
15.No. sacral segs. :	five or more.....	five.....
16.Sacral curve(lat):	even,gentle curve....	sharp S1-S2;S3-S5.....
17.Posterior view :	S-I joints vis.....	S-Ijnts not vis.inf....
18.Muscle marking :	marked,rugged.....	faint,smooth.....

CRANIAL OBSERVATIONS:.....gender est.:....

	MALE	FEMALE
1.Rel.size;build :	lrg;rugged.....	sm;smooth.....
2.Forehead :	steep,vert.....	full;rounded.....
3.Frontal eminences :	small.....	large.....
4.Sup-orbital tori :	med-large.....	small-med.....
5.Orbits & margins :	low;sq & sm;rnd.....	high;rnd;lrg & shp.....
6.Nasal ap. & margin:	high;nrw & sharp.....	low;wide & sharp.....
7.Nasal bones :	lrg;shrp>midline.....	sm;wide> at junct.....
8.Zygomatic bones :	hvy:lat.arch;muscled.	gracile;compressed;smth post.past E.A.M..... post.end pre-E.A.M.....
9.Parietal eminences:	small.....	large.....
10.Mastoid processes:	med-large.....	small-med.....
11.Occipital area :	prom.musc.lines.....	protub.not marked.....
12.Occipital condyls:	large.....	small.....
13.Palate shape :	lrg;broad;"U".....	sm;parabolic.....
14.Rel.tooth size :	lrg;5 cusped M1.....	rel.smaller.....
15.Mandible size :	lrg;high symphysis;..	sm;lower corp.& ramus-broad ascend.ramus...dimensions.....
16.Gonial angle :	<125 ,flaring.....	>125 ,no flare.....
17.Chin form :	square.....	rounded.....

APPENDIX II

DATABASE CODE DESCRIPTIONS FOR PATHOLOGY TABLES

Description of Codes Used in Chapter 5 Pathology Tables

Numerical, alphabetic and symbol codes were developed for the dBASE IV cataloguing and processing of demographic and pathological information. The tables generated from the database catalogue are presented and modified in each major section of chapter 5. The code descriptions below apply to these tables and can be used as a reference dictionary.

Some codes are general and used in all tables to indicate age, gender and disease occurrence and/or associations (see "General Codes used in all Tables"). Other codes are used as specific descriptors of the types and expression of pathology relative to each major disease category (see "Disease Codes by Disease Category").

The sample entry code, below, for a given individual with neuromechanical and degenerative disease illustrates the combined use of codes to describe more than one condition, complication of a condition or more than one location of pathological changes.

> **Aahvg ;**
> Combinations of the above codes describe the condition of arthritis in the individual. In this case, "**A**": arthritis, involves ankylosis "a" at the hip, "**h**"; vertebral osteoarthritis, "**v**" and a generalized "**g**" condition, i.e. involving other joints of the skeleton. See the case description for the individual for further notes on specific locations and details of complications etc.

General Codes Used in all Tables:

Code	Description
GRAVE	Number of the G-Series grave/skeleton.
METAB	Metabolic disease occurrence, see disease codes section below for code descriptions.
VASCL	Vascular/circulatory disease occurrence, see disease codes section below for code descriptions.
INFLAMM	Inflammatory and/or Infectious disease occurrence, see disease codes section below for code descriptions.
TRMA	Traumatic disease occurrence, see disease codes section below for code descriptions.
GROWTH	Growth disorder occurrence, see disease codes section below for code descriptions.

Code	Description
CONGEN	Congenital or developmental disorder occurrence, see disease codes section below for code descriptions.
NEUROMEC	Neuromechanical disorder (arthritis and neuromechanical deformities) occurrence, see disease codes section below for code descriptions.
DENTAL	Dental disease occurrence, see disease codes section below for code descriptions.
SEX	Estimated gender of the individual.
AGE	Estimated age category of the individual (see chapter 4 for descriptions of age categories and equivalent range in years).
YEARS	Estimated age in years derived from the summary of all age determination criteria for the individual.
----	Disease Association; indicates a posited relationship between arthritis and other observed conditions. Specifically, it is suspected that these conditions may have contributed to, or resulted as complications of, the specified arthritic condition.
_I_	Excluding this condition. In this case, infection (I) is not thought to be related to the other conditions suffered by this individual.
*	Indicates that a certain pathological condition may be considered to have more than one pathogenic component or the aetiology is ambiguous; see asterisks for corresponding categories.
--?--	Possible or questionable association between diseases connected by the dashed line.
? (pathology)	Questionable presence or questionable significance of a condition. Always *precedes* the condition in question.
? (age or sex)	Age in years or gender estimation is questioned.
Dh	The condition which is double underlined are those which have been counted as the second condition within a disease category in the age and gender breakdown tables ("b" tables in each major disease section of Chapter 5). See the disease category for code descriptions of the disease type.
~	Minor trace or expression of a condition. Significance is questionable.

Disease Codes by Disease Category:

METAB; Metabolic Disorders

Code	Description
Dh	Dental Hypoplasia
B	Brittle Deformation. Reduced bone quality was observed. The predominantly brittle quality of the bone indicates osteoporosis.
P-pr	Post-rachitic Plastic Deformation. Reduced bone quality where the predominant features are bending deformities due to plastic deformation. In children and in adults where the condition appears to be inactive and healed the disease is referred to as post-rachitic deformity.
P	Plastic Deformation. Reduced bone quality where the predominant features are bending deformities due to plastic deformation. Osteomalacia is indicated in adults
PB	Plastic and Brittle Deformation. Reduced bone quality where the both plastic and brittle deformation are observed together. Osteomalacia and/or Osteoporosis are suspected.
S	Scurvy indicated by dental and/or post-cranial lesions.

VASCL; Vascular and Circulatory Disorders

Code	Description
C	Cribra Orbitalia. This is further characterized as an active lesion type or a fine porous, healing type (see case description for details).
Ct	Trace Cribra Orbitalia; Indicates very fine porosity of a healed condition.
Ph	Porotic Hyperostosis; Indicates hyperostosis of the cranial vault.
oschr	Osteochondritis Dissecans (localised vascular disruption). See case notes for the skeletal location of the condition.
necr	Ischaemic Necrosis (localised vascular disruption). See case notes for the nature and skeletal location of the lesion.

INFLAMM; Inflammatory and/or Infectious Conditions

Code	Description
Im	Inflammation (Non-specific). Pathological bone changes is predominantly periostitis due to a non-specific pathogen.
I	Infection (Non-specific). Osteomyelitis is indicated and may or may not be accompanied by periostitis. A non-specific pathogen is suspected.

Specific Infections: I or Im describe the involvement of the cortex and marrow cavity (bone infection) or the periosteum (inflammation) or both (inflammation and infection).

Isy	Syphilis (Treponemal Infection). See case notes for diagnosis of the specific treponemal disease/syndrome.
Itb	Tuberculosis.
ItbRib	Rib lesions are a notable location of infectious bone changes. important for differential diagnosis.
ImIRib	Inflammation and infection involving the ribs; suspected Actinomycosis. See case description for differential diagnosis.

TRMA; Traumatic Conditions

Code	Description
F	Fracture. Location of fracture is coded ex. Fcl = fractured clavicle.
PF	Pathological Fracture. Fracture occurring as a complication of a pre-existing pathology such as infection. See related disease types and case description for details.
sp	Spondylolysis; fracture of the vertebral neural arch.
Amp	Amputation

Skeletal location of trauma:

cl	Clavicle
rib	Rib fracture(s)
rd	Radius
ul	Ulna
L5	5th lumbar vertebra.
pv	Pelvis; fracture of the innominate.
fib	Fibula
ank	Ankle
fn	Femoral neck

GROWTH; Disorders of Growth

Code	Description
exost	exostosis; see case description for skeletal location.
osteom	osteoid osteoma; see case description for skeletal location.
ostchd	osteochondroma; see case description for skeletal location.

CONGEN; Congenital and/or Developmental Disorders

Code	Description
dypls	Skeletal dysplasia; See case description for skeletal location.
scr	Sacralisation of a lumbar vertebra, where **L6=** of the 6th Lumbar vertebra; or **L5=** of the 5th lumbar vertebra.
clf	Cleft defect of a vertebra, where **L5=** of the 5th lumbar vertebra.
acetab	Acetabulum; indicates a localised congenital malformation of this joint.

NEUROMEC; Neuromechanical and Degenerative Disorders

Code	Description
A	Arthritis:
v	Vertebral osteophytosis and/or Degenerative Joint Disease of the dorsal facets.
-c	Cervical localisation of vertebral arthritis (Av-c).
-t	Thoracic localisation of vertebral arthritis (Av-t).
-l	Lumbar localisation of vertebral arthritis (Av-l).
Sm	Schmorl's nodes accompany the condition.
†	Vertebral column was incomplete; localisation of arthritis is an artefact of preservation.
g	Generalised Degenerative Joint Disease (diffuse peripheral joint involvement).

Neuromechanical and degenerative conditions continued...

Code	Description
loc	Localised Degenerative Joint Disease (singular joint involvement). Refer to the list of skeletal location codes below for specific location of the degenerative joint disease. See case notes for description of all elements involved. An underlying precursor to arthritic development, such as trauma or developmental defects, may be indicated.

Skeletal location of Degenerative Joint Disease:

Tmj	Temporo-mandibular joint
sh	shoulder
h	hip
f	feet
e	elbow
k	knee
wr	wrist
uplim	upper limb
cl	clavicle
r	rib
r/v	costo-vertebral joints
s-i	sacro-iliac joint(s)
L5	5th lumbar vertebra

Neuromechanical and Degenerative Complications:

Code	Description
!H	Severe hip pathology with ankylosis and/or contracture.
Ns	Neuromechanical deformity of the spine (scoliosis and/or kyphosis)
a	Arthritis complicated by ankylosis. This most often refers to a condition of the spine or hip where bony ankylosis has occurred or soft tissue ankylosis is suspected.
!HNp	Special case; i.e. localised severe hip degeneration with neuromechanical complications, see detailed discussion.

DENTAL; Dental pathology

Code	Description
n/a	Not applicable. No dental remains recovered for the individual.
D	Dental condition indicated.
a	Dental abscess; see case description for location and details.
c	Caries (**o**; occlusal, **g**; gumline).
l	Tooth loss. Notable pre-mortem tooth loss is indicated by absence of the tooth (or teeth) and the corresponding reduction of the tooth socket, indicative of intravital bone resorption. See case description description for notes on extent of tooth loss, alveolar resorption, age and etiological indications.
w	Wear (Attrition). Noted for cases of "anomalously" excessive wear for the estimated age of the individual.
r	Resorption; generalised condition affecting the entire tooth row(s).
~	Generalised mild resorption has occurred.
e	Generalised extreme resorption has occurred.
I	Alveolar infection. Refers to changes in the alveolar bone where resorption or porosity may indicate periodontal or gingival infection. Scurvy may also be indicated when this code is used, refer to metabolic disease codes for these individuals.
Im	Alveolar inflammation.