**APPENDIX C** HUMAN BONE REPORT
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## 1.0 INTRODUCTION

This report presents the results of human osteological and palaeopatholgical analyses of 177 skeletons and 6,309 disarticulated fragments/bones excavated in Tarbat Old Church, Portmahomack in Scotland by Field Archaeology Specialists Ltd. (FAS), University of York. Most of the data collected were entered into an SPSS database (version 9.0), and are available for future comparative analyses. Scottish assemblages that were compared with Tarbat are presented in Appendix I.

All articulated skeletons represent separate burial events, with the exception of a mother buried with a foetus *in situ* (SK 67 and SK 68). The burials span five phases: Phase 1 represents cist burials thought to be contemporary with the 8th-century monastery, Phase 2 represents 'pillow burials' from the 8th to 11th centuries, Phases 3 and 4 represent a medieval period from the 12th to 16th century and Phase 5 represents the period after the Reformation of 1560. The majority of inhumations were from the medieval period (56%) followed by phase 2 (38%). Very few skeletons belonged to phases 1 or 5 (Table 1.1).

Table 1.1 Tarbat burials by phase

| **Phase** | **N** | **%** |
|---|---|---|
| 1 (cist burials - 8th C) | 4 | 2.3 |
| 2 ('pillow' burials - 8th - 11th C) | 67 | 37.9 |
| 3 & 4 (medieval burials - 12th - 16th C) | 99 | 55.9 |
| 5 (post-medieval burials - post-1560) | 7 | 4.0 |
| **Total** | **177** | **100** |

## 2.0 PRESERVATION

The general state of preservation in a skeletal assemblage can be assessed by examining the completeness of each skeleton and the condition of the bones. Of 177 burials recovered for analysis, the majority (40%) were incomplete (< 40% of the skeleton was represented), although 29% were > 70% complete (Table 2.1). The relatively high percentage of incomplete burials in the Tarbat sample was a result of a high degree of disturbance by subsequent burials over the course of several centuries. A few inhumations were also truncated by the various construction phases of the church, and some were partially beyond the limits of the archaeological excavations.

Thirty-seven percent of the skeletons were in good condition, 35% were in fair condition (some erosion, flaking or fragmentation), and 28% were in poor condition (soft, friable, eroded and/or extensively fragmented) (Table 2.1). In contrast to the findings for completeness, the condition of the bones varied by phase. In Phase 2, the majority of skeletons were in poor to fair condition, whereas in Phases 3 and 4 (the medieval period), most of the skeletons were in fair to good condition (Table 2.3). All of the skeletons from the earliest phase were in poor condition, and five of seven skeletons from Phase 5 were in good condition. Thus, it is apparent that the later burials were generally in better condition than the earlier burials. In some cases, burial conditions were excellent such that hair and other organic material (e.g. a leather shoe) were preserved in association with the skeletons.

In the Tarbat sample, there were no significant differences between the adults and subadults (< 17 years of age) in terms of completeness or bone condition ( $^{2}$ = 1.39 and $^{2}$ = 5.40, df = 2, p = ns, respectively). Similar to the adults, a number of the subadult burials were truncated by later inhumations. These findings suggest that the sample of subadults is not likely to be underrepresented as a result of preservation factors.

Table 2.1 Preservation of the Tarbat skeletons

| | **Completeness** | | | |
|---|---|---|---|---|
| **Condition** | **> 70%** | **40-70%** | **< 40%** | **Total** |
| **good** | 18 | 24 | 24 | 66 (37.3%) |
| **fair** | 24 | 17 | 21 | 62 (35.0%) |
| **poor** | 10 | 14 | 25 | 49 (27.7%) |
| **Total** | **52 (29.4%)** | **55 (31.1%)** | **70 (39.5%)** | **177 (100.0)** |

Table 2.2 Completeness of skeletons by phase

| | **Phase 1** | | **Phase 2** | | **Phases 3 and 4** | | **Phase 5** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| > 70% | | | 17 | 25.4 | 31 | 31.3 | 4 | 57.1 |
| 40-70% | 3 | 75.0 | 21 | 31.3 | 30 | 30.3 | 1 | 14.3 |
| < 40% | 1 | 25.0 | 29 | 43.3 | 38 | 38.4 | 2 | 28.6 |
| **Total** | **4** | **100.0** | **67** | **100.0** | **99** | **100.0** | **7** | **100.0** |

Table 2.3 Bone condition by phase

| | **Phase 1** | | **Phase 2** | | **Phases 3 and 4** | | **Phase 5** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| **good** | | | 12 | 17.9 | 49 | 49.5 | 5 | 71.4 |
| **fair** | | | 30 | 44.8 | 31 | 31.3 | 1 | 14.3 |
| **poor** | 4 | 100.0 | 25 | 37.3 | 19 | 19.2 | 1 | 14.3 |
| **Total** | **4** | **100.00** | **67** | **100.0** | **99** | **100.0** | **7** | **100.0** |

## 3.0 AGE ESTIMATION

### 3.1 ADULTS

Where possible, age-at-death was estimated for each skeleton based on methods recommended by Buikstra and Ubelaker (1994). For adults, this included examining the pubic symphyses (Todd 1921a, 1921b; Suchey and Katz 1986; Brooks and Suchey 1990), auricular surface of the os coxae (Lovejoy *et al.* 1985; Meindl and Lovejoy 1989) and cranial suture closure (Meindl and Lovejoy 1985). In addition, dental attrition was recorded (Brothwell 1981), and sternal rib end morphology (Iscan *et al.* 1984; 1985) was examined when other techniques could not be applied. However, the majority of skeletons (69%) could be aged using the pelvis (alone or with other techniques), and only two skeletons were aged using either dental attrition or sternal end morphology alone. When none of the methods could be applied, skeletons were classified as 'adult' based on size and development (i.e. fused epiphyses).

All of the methods produce age range estimates, and based on an overall assessment, each skeleton was assigned to a standardized age range (Calvin Wells Lab, University of Bradford) to facilitate comparison:

17-25 years - young adult
26-45 years - middle adult
46+ years - old adult

Of 138 adult burials, 14 (10%) were estimated to be young adults, 44 (32%) were middle adults, 57 (41%) were old adults and 23 (17%) were assigned as 'adult'. There was no significant difference in the distribution of age-groups between Phase 2 and the medieval phases (3 and 4) ( $^{2}$ = 4.4, df = 2, p = 0.11).

Table 3.1 Adult age distribution by phase

| | **Phase 1** | | **Phase 2** | | **Phases 3 & 4** | | **Phase 5** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| **adult** | 2 | 50.0 | 11 | 16.7 | 10 | 15.6 | | | **23** | **16.7** |
| **17-25** | | | 5 | 7.6 | 8 | 12.5 | 1 | 25.0 | **14** | **10.1** |
| **26-45** | | | 27 | 40.9 | 16 | 25.0 | 1 | 25.0 | **44** | **31.9** |
| **46+** | 2 | 50.0 | 23 | 34.8 | 30 | 46.9 | 2 | 50.0 | **57** | **41.3** |
| **Total** | **4** | **100** | **66** | **100** | **64** | **100** | **4** | **100** | **138** | **100** |

## 3.2 SUBADULTS (< 17 YEARS OF AGE)

The skeleton and teeth undergo several changes in childhood as it is a period of rapid growth (Johnston and Zimmer 1989). As a result, it is often possible to assign smaller age ranges to subadult skeletons than to adult skeletons. As recommended by Buikstra and Ubelaker (1994), age of subadults was estimated by examining dental formation (Morrees *et al.* 1963a, 1963b) and eruption (Ubelaker 1989) as well as bone fusion of primary ossification centres and union of epiphyses (see Buikstra and Ubelaker 1994). In addition, a selected number of bone measurements were recorded following Buikstra and Ubelaker (1994). Measurements were taken on both sides (where possible) to the nearest 0.1 mm.

Dental development is the preferred method for estimating chronological age as the deciduous dentition may be largely buffered against environmental influences (Konigsberg and Holman, 1999). When dentition are absent, age may be estimated by comparing long bone length to references. In the Tarbat sample, 49% of the subadults did not have dentition. For these individuals, age was determined by comparing diaphyseal lengths to the references from Ubelaker (1989).

In total, 39 children were recovered from Old Tarbat Church (22% of the total sample). Of the subadults, several age groups were almost equally represented, with the exception of the pre-term group (represented by one foetus - 8 1/2 lunar months (Fazekas and Kosa, 1978) - found within the pelvis of an adult female), and one individual in the 14.6 to 17 year age group. However, there was a relatively high percentage of children in the 0.6-2.5 year age group (Table 3.2). As it is unlikely that there was preferential burial of this age group, this finding suggests that there was a relatively high prevalence of deaths after 6 months of age. Breast feeding provides an important source of nutrition and immunological protection to an infant, however, breast milk alone may not be nutritionally sufficient after 4 to 6 months of age (Whitehead and Paul, 1981). Supplementary food is associated with an increased risk of infection. Thus, this age group may be expected to be vulnerable to undernutrition-infection interactions, and high mortality.

Table 3.2 Age distribution of the subadults by phase

| Age Group (years) | Phase 1 | | Phase 2 | | Phases 3 & 4 | | Phase 5 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| pre-term | | | | | 1 | 2.9 | | | **1** | **2.6** |
| newborn -0.5 | | | | | 7 | 20.0 | | | **7** | **17.9** |
| 0.6-2.5 | | | | | 9 | 25.7 | 2 | 66.7 | **11** | **28.2** |
| 2.6-6.5 | | | | | 6 | 17.1 | 1 | 33.3 | **7** | **17.9** |
| 6.6-10.5 | | | | | 6 | 17.1 | | | **6** | **15.4** |
| 10.6-14.5 | | | 1 | 100 | 5 | 14.2 | | | **6** | **15.4** |
| 14.6-17 | | | | | 1 | 2.9 | | | **1** | **2.6** |
| **Total** | **0** | **-** | **1** | **100** | **35** | **100** | **3** | **100** | **39** | **100** |

Almost all the subadults (90%) were from the medieval phases (3 and 4). Only one individual (aged between 10.6 and 14.5 years of age) was recovered from Phase 2, and three subadults were recovered from phase 5 (two 0.6 to 2.5 years of age and one child from 2.6 to 6.5 years of age). As most of the church was excavated, the negligible representation of small children in the 8th to the 11th centuries suggests that there was a change in burial practices *within the church* after that period.

## 3.3 AGE-AT-DEATH AT TARBAT AND OTHER SCOTTISH SITES

While there may be problems examining age-at-death in a sample, a comparison of assemblages can help to identify broad patterns. There are very few Scottish sites available for comparison with the 8th to 11th century phase at Tarbat (Phase 2). In this phase, most of the individuals who were buried in the church were adults (only one young juvenile was represented). This differs from the Isle of May, where 10% of the individuals were subadults, and Hallow Hill, where most of individuals were subadults and young adults (Table 3.3).

There were several sites in Scotland that could be compared to the medieval phase at Tarbat (Table 3.4). Tarbat appears anomalous in having a high percentage of older adults (30%). Most of the other sites, with the exception of Glasgow Cathedral, had very few old adults. Generally, subadults and middle adults had the highest percentage of deaths (although the Isle of May site had a high percentage of young adult deaths). It is noted that in other medieval sites, such as Wharram Percy in England, high percentages (40%) of individuals died in old age (50+) (see Mays 1998).

The medieval assemblage at Tarbat has an age distribution that is roughly U-shaped - that is, there was a much higher risk of dying among the very young and very old. Although the sample is time averaged, this curve is characteristic of most population groups (Chamberlain 1994). Overall, these broad comparisons suggest that the individuals buried within the church at Tarbat during the medieval period are representative of a ‘normal’ age distribution, and were living to older ages in comparison to other population groups, with the exception of Glasgow Cathedral. Burial within churches is likely relatively high-status compared to burial out-side of the church, and it is possible that more privileged individuals lived to older ages. However, this hypothesis cannot be tested without analysing burials from outside of Tarbat church.

Table 3.3 Age-at-death in Scottish sites c.8th - 11th century

| Site | Date | N | Subadults (%) | Young Adults (%) | Middle Adults (%) | Old Adults (%) |
|---|---|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **67** | **1.5** | **7.5** | **40.2** | **34.3** |
| Isle of May | 5th - 12th C | 42 | 9.5 | 16.6 | 33.3 | 26.2 |
| Hallow Hill | 6th - 9th C | 82 | 29.3 | 34.1 | 30.5 | 6.1 |

Table 3.4 Age-at-death in medieval Scottish sites

| Site | Date | N | Subadults (%) | Young Adult (%) | Middle Adults (%) | Old Adults (%) |
|---|---|---|---|---|---|---|
| **Tarbat** | **12th - 15th C** | **99** | **35.4** | **8.1** | **16.1** | **30.3** |
| Glasgow Cathedral | 12th - 15th C | 56 | 19.6 | 1.8 | 25.0 | 25.0 |
| Isle of May | 12th - 17th C | 14 | 7.1 | 35.7 | 35.7 | 7.1 |
| Dundee | 12th - 15th C | 35 | 28.4 | 6.0 | 40.3 | 9.0 |
| Dunbar | medieval | 76 | 48.6 | 1.3 | 31.5 | 9.2 |
| Whithorn | 13th - 15th C | 1605 | 31.9 | 12.5 | 39.7 | 7.1 |
| Aberdeen (C) | 13th - 16th C | 193 | 32.1 | 15.5 | 29.0 | 8.2 |
| Linlithgow | c.13th - 17th C | 201 | 66.2 | 16.9 | 6.5 | 3.5 |

## 4.0 SEX DETERMINATION

The sex of each adult skeleton was determined by examining sexually dimorphic features on the pelvis and skull (as recommended by Buikstra and Ubelaker 1994). In addition, measurements (i.e. articular surfaces and clavicle length) were taken on several bones to help assess dimorphism (after Bass, 1987). In those cases where an individual demonstrated both male and female traits, sex was determined by the predominating number of traits. However, (if present) the pelvis was considered to be the most reliable indicator of sex (Buikstra and Ubelaker 1994). While there are some methods for determining sex in subadults (see Mays 1998 for an overview), these techniques are not generally accepted (Saunders 1992).

Due to incompleteness, several skeletons were assigned as either ''probable female' or 'probable male'. However, for analyses, these skeletons were included in the female and male categories. Overall, the Tarbat assemblage consisted of 24% females (including 11 'probable females') and 71% males (including 26 'probable males'). Sex could not be determined for seven skeletons (5%). It was noted that there was obvious sexual dimorphism in the Tarbat sample.

Table 4.1 demonstrates that there were differences in sex distribution between Phase 2 and the medieval phases (3 and 4) such that there were more men in the earlier phase. This relationship is highly significant ( $^2$= 13.5, $p < 0.001$). In Phase 2, the ratio of females to males was 1:9.2, and in the medieval phases (3 and 4), it was 1:1.6.

Table 4.1 Sex determination of the Tarbat skeletons by phase

| Sex | Phase 1 | | Phase 2 | | Phases 3 & 4 | | Phase 5 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| undetermined | 0 | | 5 | 7.6 | 1 | 1.6 | 1 | 25.0 | **7** | **5.1** |
| female | 2 | 50.0 | 6 | 9.1 | 24 | 37.5 | 1 | 25.0 | **33** | **23.9** |
| male | 2 | 50.0 | 55 | 83.3 | 39 | 60.9 | 2 | 50.0 | 98 | 71.0 |
| Total | 4 | 100 | 66 | 100 | 64 | 100 | 4 | 100 | 138 | 100 |

Table 4.2 presents the Tarbat individuals by sex, age category and phase. To determine if there were differences in the relative proportions of females and males between each age category, chi-square analysis was conducted by phase, however, no significant differences were observed (Phase 2: $^2$ = 0.46, df = 2, p = 0.80, Phases 3 and 4: $^2$ =1.5, df = 2, p = 0.46). There was no association between sex and age-at-death.

Table 4.2 Distribution of females and males by age category and phase

| | adult | | 17-25 | | 26-45 | | 46+ | |
|---|---|---|---|---|---|---|---|---|
| **Phase 1** | **N** | **%** | **N** | **%** | **N** | **%** | **N** | **%** |
| undetermined | | | | | | | | |
| female | 1 | 50.0 | | | | | 1 | 50.0 |
| male | 1 | 50.0 | | | | | 1 | 50.0 |
| **Phase 2** | | | | | | | | |
| undetermined | 4 | 36.4 | | | 1 | 3.7 | | |
| female | 2 | 18.2 | | | 2 | 7.4 | 2 | 8.7 |
| male | 5 | 45.5 | 5 | 100.0 | 24 | 88.9 | 21 | 91.3 |
| **Phases 3 & 4** | | | | | | | | |
| undetermined | 1 | 10.0 | | | | | | |
| female | 3 | 30.0 | 2 | 25.0 | 8 | 50.0 | 11 | 36.7 |
| male | 6 | 60.0 | 6 | 75.0 | 8 | 50.0 | 19 | 63.3 |
| **Phase 5** | | | | | | | | |
| undetermined | | | 1 | 100.0 | | | | |
| female | | | | | | | 1 | 50.0 |
| male | | | | | 1 | 100.0 | 1 | 50.0 |
| **Total Sample** | | | | | | | | |
| undetermined | 5 | 21.7 | 1 | 7.1 | 1 | 2.3 | | |
| female | 6 | 26.1 | 2 | 14.3 | 10 | 22.7 | 15 | 26.3 |
| male | 12 | 52.2 | 11 | 78.6 | 33 | 75.0 | 42 | 73.7 |
| **Total** | **23** | **100** | **14** | **100** | **44** | **100** | **57** | **100** |

## 4.1 SEX DISTRIBUTION AT TARBAT AND OTHER SCOTTISH SITES

When compared with other broadly contemporary sites, the sex distribution of Phase 2 was most similar to the Isle of May, and unlike Hallow Hill (Table 4.4). The sex distribution of the medieval period from Tarbat was very similar to Glasgow Cathedral. At both of these sites, males were more often buried within the church than females. It is not possible to suggest whether this reflects differences in mortality rates between the sexes or whether males were more likely to receive preferential burial within the church. However, several other medieval assemblages also had more males than females, and only Dunbar and Linlithgow had more females than males (Table 4.5).

Table 4.4 Sex distribution in Scottish sites c. $8^{th}$ - $11^{th}$ C

| Site | Date | Females (N) | Males (N) | Ratio |
|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **6** | **55** | **1:9.2** |
| Isle of May | 5th - 12th C | 4 | 32 | 1:8 |
| Hallow Hill | 6th - 9th C | 20 | 17 | 1.2:1 |

Table 4.5 Sex distribution in medieval Scottish sites

| Site | Date | Females (N) | Males (N) | Ratio |
|---|---|---|---|---|
| **Tarbat** | **12th - 15th C** | **24** | **39** | **1:1.6** |
| Glasgow Cathedral | 12th - 15th C | 16 | 27 | 1:1.7 |

| Site | Date | Females (N) | Males (N) | Ratio |
|---|---|---|---|---|
| Isle of May | 12th - 17th C | 3 | 8 | 1:2.7 |
| Dundee | 12th - 15th C | 15 | 16 | 1:1 |
| Dunbar | medieval | 22 | 16 | 1.4:1 |
| Whithorn | 13th - 15th C | 356 | 314 | 1.1:1 |
| Aberdeen (C) | 13th - 16th C | 46 | 60 | 1:1.3 |
| Linlithgow | c.13th - 17th C | 31 | 18 | 1.7:1 |

## 5.0 STATURE

Stature (height) was estimated by taking long bone measurements and applying regression equations suitable for white adult males and females (Trotter,1970). The formulae produces a standard error dependant on the bone measured, and it is likely that this error is greater when applied to different populations and individuals over 30 years of age (Ubelaker 1989). Moreover, stature estimates may differ depending on which bones are used to calculate height (see Waldron 1998). In the Tarbat assemblage, the femur and tibia were most often used to determine height.

Overall, stature could be estimated for 28 females and 86 males (83% of the total sample). When analysed by phase, there was no pattern of increasing height through time. In contrast, the mean stature for females in the medieval period (Phases 3 and 4: 153.8 cm, standard deviation = 4.6) was significantly shorter than in phase 2 (159.7 cm, SD = 3.5) (Table 5.1) (t-test = 2.67, df = 23, $p < 0.05$). In contrast, there was no significant difference between the males from Phase 2 and the medieval period (t = 1.68, df = 81, p = 0.10). There were however, significant differences in height between the males and females in both phase 2 (t = 5.34, df = 5, $p < 0.01$) and the medieval period (t = 9.73, df = 53, $p < 0.001$) - as would be expected, males are consistently taller than the females (Tables 5.1 and 5.2).

Table 5.1 Female stature by phase (cm)

| Phase | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 1 | 2 | 156.8 | 4.3 | 153.7 | 159.8 |
| 2 | 5 | 159.7 | 3.5 | 156.4 | 165.1 |
| 3 & 4 | 20 | 153.8 | 4.6 | 145.9 | 159.8 |
| 5 | 1 | 165.2 | - | 165.2 | 165.2 |
| **Total** | **28** | **155.4** | **5.1** | **145.9** | **165.2** |

Table 5.2 Male stature by phase (cm)

| Phase | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 1 | 1 | 167.7 | - | 167.7 | 167.7 |
| 2 | 48 | 170.1 | 4.2 | 160.7 | 177.3 |
| 3 & 4 | 35 | 168.3 | 5.7 | 156.4 | 180.3 |
| 5 | 2 | 168.4 | 0.8 | 167.9 | 169.0 |
| **Total** | **86** | **169.3** | **4.9** | **156.4** | **180.3** |

### 5.1 STATURE AT TARBAT AND OTHER SCOTTISH SITES

The height data from Tarbat demonstrate some interesting patterns. Firstly, the females from Phase 2 were taller than those from the medieval period (see Tables 5.3 and 5.4). Both groups of women were slightly below the modern average British height of 163cm (Knight, 1984).

In contemporary populations, undernutrition and infection are well-known causes of stunting during childhood. Although these individuals may grow for longer periods of time, they usually achieve less total growth and are shorter as adults (Bogin, 1988). It is possible that the medieval women buried at Tarbat experienced some environmental stress during their growing years. This suggestion may be supported by the observation that the medieval women from Tarbat were also shorter than their Scottish contemporaries. However, when considered in terms of feet and inches, the height of the Tarbat women was not widely different than the average modern British woman (Phase 2: 5'3", medieval period: 5'1", modern: 5' 4"). Thus, while it is possible that the medieval female experienced some environmental stress, it was not likely to have been severe.

The height of the males did not significantly differ between the phases, but was greater than the females. Generally, the stature of women averages between 88 and 95 per cent of the stature of males (see Bogin, 1988) - a finding also observed in the Tarbat assemblage.

Both the females and males from Phase 2 demonstrated remarkably similar statures to other sites in Scotland from roughly the same time period (Table 5.3). It is noted, however, that the sample sizes were small, especially for the women.

The medieval males were, on average, shorter than other medieval males from Scotland, although by only 1 to 6cm (Table 5.4). The average male stature from Phase 2 (5'7") and the medieval period (5'6") revealed that the males, particularly from the medieval period, were probably not as healthy and well nourished during childhood as the average modern British man, who has an average height of 5'10" (177cm) (Knight, 1984). However, as with the women, the differences in height were not large.

Table 5.3 Statures from Scottish sites c. 8th - 11th C (cm)

| Site | Date | N | Females | N | Males |
|---|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **5** | **159.7** | **48** | **170.1** |
| Isle of May | 5th - 12th C | 2 | 159.1 | 29 | 170.4 |
| Hallow Hill* | 6th - 9th C | 17 | 160.2 | 11 | 169.7 |

* the researcher used the method of Dupertuis and Hadden (1951)

Table 5.4 Statures from medieval Scottish sites (cm)

| Site | Date | N | Females | N | Males |
|---|---|---|---|---|---|
| **Tarbat** | **12th - 15th C** | **20** | **153.8** | **35** | **168.3** |
| Glasgow Cathedral | 12th - 15th C | 14 | 156.5 | 22 | 174.1 |
| Isle of May | 12th - 17th C | 3 | 161.2 | 8 | 173.7 |
| Dundee | 12th - 15th C | 27 | 157.8 | 30 | 170.8 |
| Dunbar | Medieval | 18 | 159.8 | 13 | 170.4 |
| Whithorn | 13th - 15th C | 140 | 155 | 128 | 169 |
| Aberdeen (A) | c.13th - 17th C | | 160 | | 168 |
| Aberdeen (B) | 13th -16th C | 28 | 158 | 47 | 170 |
| Linlithgow | c.13th - 17th C | | 156 | | 170 |

## 6.0 LOWER LIMB SHAPE

It has been observed that the proximal part of the tibia and femoral shafts sometimes show differences in shape between populations. The degree of antero-posterior flattening of the femur was calculated using the meric index, and the degree of medio-lateral flattening of the tibial shaft was calculated using the cnemic index (Brothwell 1981; Bass 1987). Indices were calculated using bones from the left side of the skeleton, unless they were missing.

In total, measurements were taken on 96 femora (from 21 females, 72 males and 3 undetermined) and 75 tibiae (from 17 females, 57 males and 1 undetermined). The majority of the Tarbat individuals had femora that were platymeric (i.e. an index below 84.9) (see Tables 6.1 and 6.2). That is, the individuals had flattening of the femoral shaft as opposed to rounded femoral shafts. The average meric index, and the percentages of individuals with platymeria and eurymeria was similar between Phase 2 and the medieval period (Phases 3 and 4). In both phases, the majority of individuals were platymeric (90% in Phase 2 and 88% in the medieval period).

Table 6.1 Meric index by phase

| Phase | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 1 | 2 | 73.4 | 5.2 | 69.7 | 77.1 |
| 2 | 40 | 76.8 | 7.1 | 58.8 | 95.0 |
| 3 & 4 | 50 | 75.2 | 8.0 | 60.2 | 94.3 |
| 5 | 4 | 80.2 | 3.5 | 75.3 | 82.9 |
| **Total** | **96** | **76.0** | **7.5** | **58.8** | **95.0** |

Table 6.2 Meric index by percentage and phase

| Phase | N | % Platymeric | % Eurymeric |
|---|---|---|---|
| 1 | 2 | 100.0 | |
| 2 | 40 | 90.0 | 10.0 |
| 3 & 4 | 50 | 88.0 | 12.0 |
| 5 | 4 | 100.0 | |
| **Total** | **96** | **89.6** | **10.4** |

Platymeric - index below 84.9
Eurymeric - index of 85 to 99.9

The Tarbat tibiae were largely eurycnemic (broad with an index above 70.0), followed closely by mesocnemic tibiae (moderate degree of flattening - index between 63 and 69.9) (Tables 6.3 and 6.4). Individuals with playtcnemia have tibiae that are flattened medio-laterally. There was no significant difference between the proportions of tibiae in each class between Phase 2 and the medieval period (Phases 3 and 4) ( $^{2}$= 2.66, df = 2, p = n.s). In Phase 2, 43% of the individuals were eurycnemic, and 34% were mesocnemic. Similarly, 45% of the medieval tibiae were eurycnemic and 31% were mesocnemic.

Table 6.3 Cnemic index by phase

| Phase | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 1 | 1 | 71.3 | - | | |
| 2 | 28 | 69.5 | 5.9 | 60.2 | 85.2 |

| Phase | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| 3 & 4 | 42 | 69.4 | 7.6 | 56.3 | 87.4 |
| 5 | 4 | 63.3 | 16.6 | 38.8 | 73.9 |
| **Total** | **75** | **69.1** | **7.6** | **38.8** | **87.4** |

Table 6.4 Cnemic index by percentage and phase

| Phase | N | % Platycnemic | % Mesocnemic | % Eurycnemic |
|---|---|---|---|---|
| 1 | 1 | | | 100.0 |
| 2 | 28 | 10.7 | 34.2 | 42.9 |
| 3 & 4 | 42 | 23.8 | 31.0 | 45.2 |
| 5 | 4 | 25.0 | 25.0 | 50.0 |
| **Total** | **75** | **18.9** | **35.1** | **46.0** |

Platycnemic - index below 62.9
Mesocnemic - index of 63 to 69.9
Eurycnemic - index above 70.0

## 6.1 LOWER LIMB SHAPE AT TARBAT AND OTHER SCOTTISH SITES

The meric indices were very similar between the Isle of May (5th to 11th C phase) and Phase 2 at Tarbat (Table 6.5)(no other sites could be compared). In addition, all of the medieval sites in Scotland, including Tarbat, demonstrate a high percentage of individuals with platymeria (i.e. anterior-posterior flattening of the femoral shaft)(Table 6.6). This finding suggests that the biomechanical stresses applied to the proximal femora were similar for all these Scottish groups.

The cnemic indices were also very similar between individuals buried at the Isle of May (5th to 12th C) and individuals buried at Tarbat (Phase 2)(Table 6.7). Platycnemic indices tend to be lower in more mechanically stressed populations than in less mechanically stressed populations (Larsen 1997). Thus, given that most of the individuals at Tarbat had high indices, it is unlikely that that they were a mechanically stressed population group - a finding that is consistent with all Scottish assemblages (Table 6.8).

Table 6.5 Meric indices from Scottish sites c.8th - 11th C

| Site | Date | N | % Platymeric | % Eurymeric |
|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **40** | **90.0** | **10.0** |
| Isle of May | 5th - 12th C | 21 | 85.7 | 14.3 |

Table 6.6 Meric indices from medieval Scottish sites

| Site | Date | N | % Platymeric | % Eurymeric |
|---|---|---|---|---|
| **Tarbat** | **12th -15th C** | **40** | **88.0** | **12.0** |
| Isle of May | 12th - 17th C | 6 | 66.6 | 33.3 |
| Dundee | 12th - 15th C | 36 | 94.4 | 5.6 |
| Dunbar | medieval | 29 | 100.0 | - |
| Whithorn | 13th - 15th C | 343 | 90.0 | 10.0 |
| Aberdeen (C) | 13th -16th C | 100 | 86.0 | 46.0 |

| Site | Date | N | % Platymeric | % Eurymeric |
|---|---|---|---|---|
| Linlithgow | c.13th - 17th C | 98 | 69.0 | 31 |

Table 6.7 Cnemic indices from Scottish sites c. 8th - 11th C

| Site | Date | N | % Platycnemic | % Mesocnemic | % Eurycnemic |
|---|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **28** | **10.7** | **34.2** | **42.9** |
| Isle of May | 5th - 12th C | 19 | 10.5 | 42.1 | 47.4 |

Table 6.8 Cnemic indices from medieval Scottish sites

| Site | Date | N | % Platycnemic | % Mesocnemic | % Eurycnemic |
|---|---|---|---|---|---|
| **Tarbat** | **12th -15th C** | **42** | **23.8** | **31.0** | **45.2** |
| Isle of May | 12th -17th C | 9 | 11.1 | 55.6 | 33.3 |
| Dundee | 12th - 15th C | 35 | 5.7 | 28.6 | 65.7 |
| Dunbar | medieval | 18 | 27.8 (38.8) | 33.3 (44.4) | 27.8 |
| Whithorn | 13th -15th C | 411 | 15.0 | 45.0 | 40.0 |
| Aberdeen (C) | 13th -16th C | 157 | 7.0 | 34.0 | 39.0 |
| Linlithgow | c.13th-17thC | 98 | 6.0 | 33.0 | 61.0 |

## 7.0 CRANIAL INDICES

A selected number of cranial measurements were taken on the adult skulls following Buikstra and Ubekaler (1994). These measures were summarised using indices which express the ratio of width to length of a feature (Bass 1987) and are used to describe the physical characteristics of the sample. Heritability studies have demonstrated that genes largely influence cranial shape, and as a result, it has been assumed that it may be possible to demonstrate that groups with similar craniofacial morphology are more closely related than groups that differ in skull size and shape (Buikstra and Ubelaker 1994).

There were 30 males and 6 females with crania that could be measured, at least partly (Tables 7.1 and 7.2). Generally, the males from all phases had similar cranial shape. T-tests revealed no differences in craniofacial morphology between the males from Phase 2 and the medieval period (sample sizes were too small to compare the females). On average, these men had medium shaped crania (as opposed to long or broad headed), low skull height, narrow faces and nasal apertures, medium sized eye orbits and broad palates (Appendix II presents data for all males and females). Two women from the medieval period had broader faces and nasal apertures, and narrower orbits than the men, however, there were no statistically significant differences between the males and females (for the medieval period or for the total sample).

Table 7.1 Female cranial indices by phase (mm)

| | Phase 1 | | | Phase 2 | | | Phases 3 & 4 | | | Phase 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Index** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** |
| cranial | 1 | 73.2 | - | 1 | 77.5 | - | 3 | 79.0 | 5.0 | 1 | 79.7 | - |
| mean height | 1 | 80.6 | - | 1 | 83.0 | - | 2 | 79.9 | 0.9 | 1 | 77.4 | - |
| fronto-parietal | 1 | 67.9 | - | 1 | 68.1 | - | 2 | 67.8 | 4.7 | 1 | 68.1 | - |
| upper facial | | | | | | | 2 | 49.1 | 6.6 | 1 | 58.5 | - |
| nasal | | | | | | | 2 | 53.0 | 10.3 | 1 | 46.2 | - |

| | Phase 1 | | | Phase 2 | | | Phases 3 & 4 | | | Phase 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Index** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** |
| orbital | 1 | 83.4 | - | | | | 2 | 94.7 | 5.0 | 1 | 85.2 | |
| maxilloalveolar | | | | | | | 2 | 125.7 | 14.4 | | | |

Table 7.2 Male cranial indices by phase (mm)

| | Phase 1 | | | Phase 2 | | | Phases 3 and 4 | | | Phase 5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Index** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** | **N** | **Mean** | **SD** |
| cranial | 1 | 75.3 | - | 15 | 75.6 | 4.3 | 13 | 78.7 | 4.3 | 1 | 77.1 | - |
| mean height | 1 | 80.0 | - | 11 | 79.5 | 4.2 | 11 | 77.0 | 9.5 | 1 | 76.5 | - |
| fronto-parietal | 1 | 67.1 | - | 12 | 68.8 | 4.2 | 10 | 66.4 | 10.1 | 1 | 68.8 | - |
| upper facial | | | | 1 | 74.6 | - | 4 | 57.6 | 13.5 | | | |
| nasal | | | | 6 | 44.9 | 4.8 | 13 | 46.4 | 3.4 | 1 | 51.7 | - |
| orbital | | | | 5 | 85.4 | 3.1 | 11 | 87.2 | 6.2 | 1 | 81.4 | - |
| maxilloalveolar | | | | 3 | 123.1 | 9.5 | 7 | 120.6 | 6.4 | 1 | 122.1 | - |

The cranial index is calculated as maximum cranial breath x 100 / maximum cranial length (Bass, 1987). As presented in the tables above, the average skull shape in the Tarbat assemblage was average or medium shaped (mesocrany). When examined by percentages in each class, however, it appeared that a large percentage of individuals also had narrow or long heads (dolichocrany), except in the medieval period where a third of the individuals also had broad or round heads (brachycrany) (Table 7.3). Chi-square analysis revealed no significant difference in the proportions of individuals in each class between phase 2 and the medieval period (Phases 3 and 4) ( $^{2}$ = 2.1, df =2, p = ns).

Table 7.3 The cranial index by percentage and phase

| Phase | N | % Dolichocrany | % Mesocrany | % Brachycrany |
|---|---|---|---|---|
| 1 | 2 | 50 | 50.0 | |
| 2 | 16 | 43.8 | 43.8 | 12.5 |
| 3 & 4 | 16 | 25.0 | 43.8 | 31.3 |
| 5 | 2 | | 100.0 | |
| **Total** | **36** | **33.3** | **47.2** | **19.5** |

Dolichocrany - below 74.99 (narrow or long headed)
Mesocrany - 75.00 to 79.99 (average or medium)
Brachycrany - above 80.00 (broad or round headed)

## 7.2 TARBAT CRANIAL INDEX AND OTHER SCOTTISH SITES

A number of skeletal reports did not calculate the cranial index, or the sample sizes were too small to be included in this comparison. The only sites comparable with Tarbat were medieval. In most of these sites, the majority of skulls were either medium or broad in size (except at Whithorn). It is apparent from this overview that the Tarbat assemblage is broadly similar to other Scottish medieval groups.

Table 7.4 Cranial indices from medieval Scottish sites

| Site | Date | N | % Dolichocrany | % Mesocrany | % Brachycrany |
|---|---|---|---|---|---|
| **Tarbat** | **12th -15th C** | **16** | **25.0** | **43.8** | **31.3** |
| Glasgow | 12th -15th C | 17 | 5.8 | 35.3 | 58.8 |
| Whithorn | 13th -15th C | 18 | 39.0 | 61.0 | |
| Aberdeen (C) | 13th -16th C | 52 | 9.6 | 40.4 | 50.0 |
| Linlithgow | c.13th-17thC | 22 | 9.1 | 59.1 | 31.9 |

## 8.0 NON-METRIC TRAITS

A selected number of cranial and post-cranial non-metric traits were recorded (following Berry and Berry 1967 and Finnegan 1978 in Buikstra and Ubelaker 1994). These are skeletal variants on the skeleton which are recorded as present or absent and may be used for broad comparisons between archaeological assemblages.

In the Tarbat sample, certain cranial non-metric traits were frequently observed in both Phase 2 and the medieval period - including supraobital notches, zygomatico-facial foramen, and mastoid foramen (data for the total sample is presented in Appendix III). Approximately half of the individuals from Phase 2 and the medieval period also had supraorbital foramen, parietal foramen and condylar canals (Table 8.1).

The most frequently observed traits in Phase 2 and the medieval period were lateral tibial squatting facets and double anterior calcaneal facets (Table 8.2). It is likely that the cranial non-metric traits observed at Tarbat were a result of genetic factors, although it is noted that nutrition could be correlated with some foramina and ossicles on the skull (see Mays 1998). Squatting facets in the ankle region, however, are more likely to be activity related, as the name suggests (Mays 1998).

Chi-square tests were conducted to determine if there were differences in the prevalence of non-metric traits between Phase 2 and the medieval phases (3 and 4). Only two significant relationships were observed: individuals with mandibular tori, and third trochanters were more likely to be from Phase 2 than from the medieval period ( $^{2} = 6.65$, $p < 0.05$, $^{2} = 8.8$, $p < 0.005$ respectively). A third trochanter is a prominent bony process at the superior end of the gluteal (hypertrochanteric) crest and mandibular tori are bony ridges on the lingual surface of the mandible. Although the causes of these traits are not known, they may suggest minor biological differences between the phases.

Table 8.1 Prevalence of cranial non-metric traits

| | Phase 1 | | Phase 2 | | Phases 3 & 4 | | Phase 5 | |
|---|---|---|---|---|---|---|---|---|
| **Trait** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** |
| Metopic suture | 2 | 0 | 26 | 2 (8) | 23 | 3 (13) | 4 | 2 (50) |
| Supraorbital notches | 2 | 2 (100) | **23** | **18 (78)** | **21** | **17 (81)** | 4 | 3 (75) |
| Supraorbital foramen | 2 | 0 | **24** | **12 (50)** | **21** | **11 (52)** | 4 | 1 (25) |
| Multiple infraorbital foramen | 1 | 0 | 13 | 3 (23) | 17 | 1 (6) | 2 | 1 (50) |
| Zygomatico-facial foramen | 1 | 1 (100) | **18** | **16 (89)** | **18** | **15 (83)** | 3 | 2 (67) |
| Parietal foramen | 2 | 1 (50) | **22** | **12 (55)** | **19** | **11 (58)** | 4 | 2 (50) |
| Epipteric bone present | 2 | 0 | 20 | 1 (5) | 19 | 5 (26) | 2 | 0 |
| Fronto-temporal articulation | 2 | 0 | 20 | 0 | 19 | 1 (5) | 2 | 0 |
| Ossicles in coronal | 2 | 1 (50) | 23 | 0 | 19 | 1 (5) | 3 | 0 |
| Ossicle at bregma | 2 | 0 | 23 | 0 | 19 | 0 | 3 | 0 |
| Sagittal ossicles present | 2 | 0 | 25 | 1 (2) | 19 | 0 | 4 | 0 |
| Apical bone present | 2 | 0 | 26 | 4 (15) | 20 | 3 (15) | 4 | 0 |

| | Phase 1 | | Phase 2 | | Phases 3 & 4 | | Phase 5 | |
|---|---|---|---|---|---|---|---|---|
| **Trait** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** |
| Ossicles in lambdoid | 2 | 1 (50) | 27 | 17 (63) | 19 | 7 (37) | 4 | 3 (75) |
| Asterionic bone present | 2 | 1 (50) | 25 | 6 (24) | 20 | 2 (10) | 3 | 0 |
| Ossicle in occipito-mastoid | 2 | 0 | 25 | 0 | 20 | 0 | 3 | 1 (33) |
| Ossicle at parietal notch | 2 | 0 | 25 | 2 (8) | 21 | 5 (24) | 3 | 1 (33) |
| Inca bone present | 2 | 0 | 27 | 0 | 21 | 0 | 4 | 0 |
| Condylar canal present | 2 | 1 (50) | **22** | **11 (50)** | **14** | **7 (50)** | 2 | 2 (67) |
| Divided hypoglossal canal | 2 | 1 (50) | 22 | 5 (23) | 16 | 4 (25) | 3 | 0 |
| Foramen ovale incomplete | 2 | 0 | 17 | 0 | 15 | 1 (7) | 3 | 0 |
| Foramen spinosum incomplete | 2 | 2 (100) | 17 | 6 (35) | 14 | 4 (4) | 3 | 0 |
| Double condylar facet | 2 | 0 | 21 | 4 (19) | 14 | 1 (7) | 3 | 0 |
| Auditory exostosis | 2 | 0 | 28 | 0 | 22 | 0 | 3 | 0 |
| Mastoid foramen | 2 | 1 (50) | **27** | **20 (74)** | **21** | **17 (81)** | 4 | 1 (25) |
| Mandibular torus | 2 | 1 (50) | 30 | 10 (33) | 23 | 1 (4) | 4 | 1 (25) |
| Mylohyoid bridge | 1 | 0 | 28 | 2 (7) | 21 | 1 (5) | 3 | 0 |

N = number of individuals observed

P = number of individuals exhibiting trait on either or both sides

Table 8.2 Prevalence of post-cranial non-metric traits

| | Phase 1 | | Phase 2 | | Phases 3 and 4 | | Phase 5 | |
|---|---|---|---|---|---|---|---|---|
| **Trait** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** | **N** | **P (%)** |
| Atlas bridging | 1 | 1 (100) | 24 | 6 (25) | 11 | 3 (27) | 2 | 0 |
| Accessory transverse foramen | 1 | 0 | 27 | 14 (52) | 19 | 6 (32) | 3 | 0 |
| Suprascapular foramen | 0 | | 18 | 1 (6) | 19 | 2 (11) | 4 | 0 |
| Circumflex sulcus | 1 | 1 (100) | 34 | 11 (32) | 32 | 5 (16) | 4 | 0 |
| Acromial articular facet | 1 | 0 | 21 | 1 (5) | 27 | 2 (7) | 4 | 0 |
| Sternal foramen | 0 | | 58 | 1 (2) | 28 | 0 | 2 | 0 |
| Septal aperture | 2 | 0 | 39 | 2 (5) | 39 | 4 (10) | 4 | 0 |
| Supracondyloid process | 3 | 0 | 39 | 0 | 38 | 1 (3) | 3 | 0 |
| Allen's fossa | 2 | 0 | 34 | 1 (3) | 50 | 2 (4) | 3 | 1 (33) |
| Poirer's facet | 2 | 0 | 31 | 2 (7) | 49 | 11 (22) | 3 | 0 |
| Vastus notch | 2 | 0 | 25 | 5 (20) | 35 | 6 (17) | 3 | 0 |
| Third trochanter | 2 | 0 | 43 | 7 (16) | 50 | 0 | 3 | 1 (33) |
| Medial tibial squatting facet | 2 | 0 | 27 | 4 (15) | 40 | 1 (3) | 3 | 0 |
| Lateral tibial squatting facet | 2 | 2 (100) | **28** | **20 (71)** | **41** | **24 (59)** | 3 | 2 (67) |
| Double inf-ant talar facet | 2 | 1 (50) | 28 | 14 (50) | 35 | 11 (31) | 2 | 1 (50) |
| Double anterior calcaneal facet | 2 | 1 (50) | **30** | **16 (53)** | **35** | **16 (46)** | 2 | 1 (50) |

N = number of individuals observed

P = number of individuals exhibiting trait on either or both sides

## 8.1 NON-METRIC TRAITS AT TARBAT AND OTHER SCOTTISH SITES

It is difficult to compare non-metric traits between sites as the type of traits recorded often differ. Moreover, there may be problems of intra-observer error. Taking these problems into consideration, different distributions of non-metric traits were observed in the Tarbat, Isle of May and Glasgow Cathedral samples. However, some cranial non-metric traits were present at all three sites with a frequency greater than 20%: the presence of supraorbital, parietal and mastoid foramina, ossicles in the lambdoid suture, and the presence of a condylar canal.

The only post-cranial non-metric trait observed at all three sites (during the medieval period) with a frequency greater than 20% was a double anterior calcaneal facet. For Phase 2 at Tarbat and the early phase at the Isle of May (5th to 12th C), the double anterior calcaneal *and* talar facets were frequently observed (greater than 35%) as well as a circumflex sulcus on the scapula (25% at Isle of May, and 32% at Tarbat).

It is difficult to interpret these observations at present, but they may be useful for future comparative studies of non-metric traits in Scotland.

## 9.0 HEALTH AND DISEASE

Pathological lesions on the skeleton provide an important source of information on health and disease in the past. By analysing frequencies and types of pathologies, including those that reflect diet and/or nutrition, population density, and activity patterns, health and disease can be inferred. In addition, examining groups of skeletons can provide important information on biological variation, cultural behaviour and environmental conditions.

While there are a number of diseases that can affect bone (e.g. syphilis, leprosy, rickets, neoplasms (cancers) and osteoarthritis), many do not. Thus, a palaeopathological reconstruction cannot represent the whole picture of health and disease in the past. For diseases that affect bone, an individual may not survive long enough for bony changes to occur. Incomplete skeletal remains may hinder a diagnosis, or may result in the underestimation of disease prevalence in a sample (see Roberts and Manchester, 1995). As many skeletons were incomplete in the Tarbat assemblage, the prevalence of pathological conditions is probably underestimated.

Nevertheless, some interesting patterns emerge from the palaeopathological analysis of the Tarbat assemblage. Dental disease, joint diseases, fractures, infection, anaemia, osteoporosis and cancer were some of the conditions present. Detailed analysis of these conditions are presented in the following sections. Diachronic comparisons were restricted to Phase 2 and the medieval period (Phases 3 and 4).

## 10.0 DENTAL DISEASE

The teeth and corresponding alveolar bone were examined for ante-mortem tooth loss, calculus, dental enamel hypoplasia, caries, abscess and periodontal disease (following Brothwell 1981 and Buikstra and Ubelaker 1994). While many of the dentition were only partially present, teeth from 73 individuals including three subadults (SK 4, 110 and 119) had at least one type of dental disease. Three individuals suffered from all of the above conditions (SK17, 66 and 113). Table 10.1 presents the number of individuals from each phase with dentition and dental disease. In total, 1,249 teeth were present from these 73 individuals, and of those teeth, only 17% were not affected by dental disease. The number of observable teeth (by tooth type) for the entire sample, for Phase 2 and for the medieval period (Phases 3 and 4) are presented in Appendix IV.

Table 10.1 Number of individuals with dentition by phase

| | |
|---|---|
| Phase 1 | 2 |
| Phase 2 | 36 |

| | |
|---|---|
| Phases 3 and 4 | 31 |
| Phase 5 | 4 |
| **Total** | **73** |

## 10.1 CALCULUS

Calculus is mineralized plaque on the surfaces of the teeth. During life, this plaque is formed by a build up of bacteria embedded within a matrix - the matrix being manufactured by the bacteria themselves and proteins in the saliva (Hillson, 1986). There are a number of complex factors that affect the rate and extent of dental calculus formation, although diet is involved (see Lieverse, 1999). It is commonly observed on the lower incisors (towards the tongue) and on the upper molars (towards the cheek) where the main salivary glands are situated.

In the Tarbat sample, calculus was the most frequently observed dental condition, such that 95% of individuals with teeth had calculus (100% of individuals from Phase 1, 92% from Phase 2, 97% from Phases 3 and 4, and 100% from Phase 5). It was present on 76% of the teeth, and ranged in degree from flecks to considerable build-up.

Table 10.2 presents the prevalence of teeth with calculus by phase. There was a significant difference between Phase 2 and the medieval period (Phases 3 and 4) - teeth were more likely to have calculus from Phase 2 ( $^2 = 11.1$, $p < 0.001$). There was no significant difference between the sexes for the medieval period (49 out of 65 female teeth had calculus (75%) and 335 out of 458 male teeth (73%) had calculus) ( $^2 = 0.07$, p = ns). There were only 11 female teeth in phase 2, 8 of which had calculus. In contrast, 433 out of 546 male teeth had calculus in Phase 2.

Table 10.2 Percentage of teeth with calculus by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 16 | 9 | 56.3 |
| Phase 2 | 557 | 441 | 79.2 |
| Phases 3 and 4 | 581 | 410 | 70.6 |
| Phase 5 | 95 | 93 | 97.9 |
| **Total** | **1,249** | **953** | **76.3** |

N = number of observable teeth
n = number of teeth with calculus

Tables 10.3 and 10.4 present the prevalence of calculus by tooth and phase (the total sample is presented in Appendix V). Generally, the lower teeth had more calculus than the upper teeth. The high percentages of teeth with calculus in all areas suggests that there was a lack of attention to remove plaque during life.

Table 10.3 Prevalence of calculus by tooth (Phase 2)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 10 | 12 | 8 | 11 | 14 | 12 | 6 | 5 | 7 | 6 | 10 | 14 | 12 | 12 | 10 | 9 |
| % | **67** | **80** | **67** | **69** | **78** | **67** | **60** | **56** | **54** | **43** | **67** | **74** | **75** | **86** | **77** | **69** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 19 | 22 | 21 | 18 | 18 | 19 | 19 | 14 | 11 | 17 | 18 | 21 | 17 | 16 | 19 | 14 |
| **%** | **95** | **85** | **88** | **86** | **86** | **79** | **86** | **93** | **92** | **94** | **82** | **88** | **84** | **80** | **86** | **82** |

n = number of teeth with calculus

Table 10.4 Prevalence of calculus by tooth (Phases 3 and 4)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 1 | 8 | 7 | 12 | 15 | 18 | 17 | 15 | 13 | 13 | 17 | 14 | 11 | 12 | 9 | 5 |
| **%** | **11** | **53** | **50** | **52** | **65** | **82** | **85** | **84** | **93** | **65** | **81** | **70** | **55** | **71** | **60** | **56** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 10 | 14 | 15 | 13 | 15 | 14 | 19 | 15 | 14 | 18 | 20 | 17 | 17 | 9 | 7 | 6 |
| **%** | **83** | **70** | **79** | **62** | **71** | **70** | **95** | **79** | **78** | **90** | **77** | **74** | **77** | **56** | **44** | **75** |

n = number of teeth with calculus

## 10.2 DENTAL CARIES

Bacteria in dental plaque ferment carbohydrate (especially sucrose) from the diet producing an acidic (low pH) waste product. These conditions cause demineralization of the dental tissues, resulting in caries. The lesions may occur anywhere on the tooth were plaque is formed, especially in protected traps or crevices. Caries in the early stages appear as white opaque spots. A cavity observed macroscopically represents a late stage in the disease process (Hillson 1986).

These cavities, or carious lesions were present in 43% of the individuals with dentition (from all phases) (Table 10.5). More individuals were affected by caries in the medieval period (55%) than in Phase 2 (28%).

Table 10.5 Percentage of individuals with caries by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 2 | 0 | |
| Phase 2 | 36 | 10 | 27.8 |
| Phases 3 and 4 | 31 | 17 | 54.8 |
| Phase 5 | 4 | 4 | 100.0 |
| **Total** | **73** | **31** | **42.5** |

N = number of individuals with dentition
n = number of individuals with caries

Out of a total of 1,249 teeth, 5% had caries. Table 10.6 presents the percentage of teeth with caries by age category and phase. In phase 2, 4% of the teeth were affected by caries. In contrast, a significantly higher number of teeth had caries in the medieval period (phases 3 and 4) ( $^2$ = 4.13, p < 0.05). Caries was observed to be age-related in both phase 2 and medieval period, such that younger adults had less teeth affected the middle or older adults.

Medieval females were more likely to have carious lesions than the males ( $^2$ = 7.53, p = < 0.01). Out of 65 observable female teeth, 9 (14%) had caries. In contrast, only 26 out of 458 male teeth (6%) had caries. None of the female teeth from phase 2 had caries (N = 11), whereas 23 out of 546 male teeth (4%) had caries from Phase 2.

Table 10.6 Prevalence of caries by age category and phase

| | **17-25 years** | | **26-45 years** | | **46+ years** | | **Total*** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| Phase 1 | | | | | 14 | 0 | **16** | **0** |
| Phase 2 | 88 | 0 | 272 | 14 (5) | 197 | 9 (5) | **557** | **23 (4)** |
| Phases 3 & 4 | 78 | 1 (1) | 197 | 12 (6) | 209 | 18 (9) | **581** | **40 (7)** |
| Phase 5 | 25 | 1 (4) | 29 | 1 (3) | 41 | 3 (7) | **95** | **5 (5)** |
| **Total** | **191** | **2 (1)** | **498** | **27 (5)** | **461** | **30 (7)** | **1,249** | **68 (5)** |

* includes 'adult' category
N = number of observable teeth
n = number of teeth with caries

Generally, the molars were the most frequently affected teeth (64% of the teeth with caries were molars). This finding is consistent with observations of caries in both archaeological and modern dentition (Lunt, 1974; Hillson, 1986). The following tables present the number of caries by tooth for Phase 2 and the medieval period (Phases 3 and 4)(caries by tooth for the total sample is presented in Appendix VI).

Table 10.7 Prevalence of caries by tooth (Phase 2)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 3 | 1 | 2 |
| **%** | **7** | **7** | **8** | **6** | - | - | - | **11** | **8** | - | - | - | **6** | **21** | **8** | **15** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 |
| **%** | - | **12** | **8** | - | - | - | - | - | - | - | - | **4** | - | **5** | **9** | **6** |

n = number of teeth with caries

Table 10.8 Prevalence of caries by tooth (Phases 3 and 4)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 2 | 1 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| **%** | **22** | **7** | **21** | **13** | **13** | - | - | - | - | - | **5** | - | **5** | **6** | - | **11** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 3 | 3 | 3 | 3 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 3 | 0 | 1 |
| **%** | **25** | **15** | **16** | **14** | - | **5** | **5** | **5** | **6** | **10** | **8** | - | - | **19** | - | **13** |

n = number of teeth with caries

## 10.3 DENTAL ENAMEL HYPOPLASIA

Dental defects consisting of horizontal lines, grooves or pits on the enamel surface are indicative of dental enamel hypoplasia (DEH) (Hillson 1986). They are caused by temporary halts in enamel matrix production while teeth are developing, but remain on teeth throughout life (Goodman 1991). Thus, they represent a permanent record of a childhood environmental stresses, including nutritional deficiencies and illness (Hillson 1986; Roberts and Manchester 1995). The number of teeth with DEH in the Tarbat assemblage may be underestimated, as DEH could not be observed when teeth were heavily covered with calculus.

Overall, 34% of the individuals buried in the church had DEH. Table 10.9 shows that a higher percentage of individuals were affected by DEH in the medieval period (52%) than in Phase 2 (19%).

Table 10.9 Percentage of individuals with DEH by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 2 | 1 | 50 |
| Phase 2 | 36 | 7 | 19.4 |
| Phases 3 and 4 | 31 | 16 | 51.6 |
| Phase 5 | 4 | 1 | 25 |
| **Total** | **73** | **25** | **34.2** |

N = number of individuals with dentition
n = number of individuals with DEH

Nine percent of the teeth from Tarbat had grooves or lines on the teeth. Table 10.10 demonstrates that a relatively high percentage of teeth from the medieval period had DEH. As with caries, there was a highly significant relationship, such that teeth with DEH were more likely to be from the medieval period (Phases 3 and 4) than from Phase 2 ( $^{2}$ = 37.2, $p < 0.001$). There was also a significant difference between the sexes in the medieval period. Female teeth were more likely to have DEH (15 out of 65 - 23%) than male teeth (58 out of 458 - 13%) ( $^{2}$ = 5.29, $p < 0.05$). No female teeth had DEH from phase 2 (N = 11), although 22 out of 546 male teeth had DEH (4%) from this phase.

Table 10.10 Prevalence of DEH by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 16 | 1 | 6.3 |
| Phase 2 | 557 | 22 | 3.9 |
| Phases 3 and 4 | 581 | 84 | 14.5 |
| Phase 5 | 95 | 1 | 1.0 |
| **Total** | **1,249** | **108** | **8.6** |

N = number of observable teeth
n = number of teeth with DEH

Tables 10.11and 10.12 present the prevalence of DEH for each tooth type (for the total sample, see Appendix VII). From these tables, it is apparent that the most frequently affected teeth were the maxillary and mandibular incisors and canines. Particularly, the lower canines were often affected. The crown of canines develop until four years of age (Moorrees *et al.*

1963b), suggesting that a number of individuals experienced stress at some time during early childhood.

Table 10.11 Prevalence of DEH by tooth (Phase 2)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| **%** | - | - | **8** | - | **6** | **6** | - | - | **8** | **7** | **7** | **5** | - | - | - | - |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 0 | 0 | 0 |
| **%** | - | - | - | - | **10** | **8** | **9** | **7** | **17** | **6** | **9** | **4** | **11** | - | - | - |

n = number of teeth with DEH

Table 10.12 Prevalence of DEH by tooth (Phases 3 and 4)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 2 | 0 | 0 | 2 | 6 | 5 | 3 | 4 | 5 | 7 | 1 | 0 | 0 | 2 | 0 |
| **%** | - | **13** | - | - | **9** | **27** | **25** | **17** | **29** | **25** | **33** | **5** | - | - | **13** | - |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 0 | 1 | 4 | 11 | 4 | 4 | 4 | 3 | 12 | 4 | 0 | 0 | 0 | 0 |
| **%** | - | - | - | **5** | **19** | **55** | **20** | **21** | **22** | **15** | **46** | **17** | - | - | - | - |

n = number of teeth with DEH

## 10.4 DENTAL ABSCESS

The soft tissues inside the pulp chamber of a tooth can be exposed to infection from mouth bacteria when a carious cavity, severe dental wear, periodontal infection or a traumatic fracture to the crown occurs. Inflammation and pus may develop which eventually kill the pulp. The infection may then continue down to the root canal and into the bone. As pus accumulates, pressure increases and causes a hole (sinus) to develop on the surface of the bone in order to allow pus to escape (Hillson 1986; Roberts and Manchester 1995). In skeletons, these lesions are often observed as round perforations in the bone at the apex (or base) of the tooth root.

Of those individuals with dentition, 29% had at least one abscess (Table 10.13). More individuals had abscesses from Phase 2 (31%) than from the medieval period (23%).

Table 10.13 Percentage of individuals with abscesses by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 2 | 1 | 50.0 |
| Phase 2 | 36 | 11 | 30.6 |
| Phases 3 and 4 | 31 | 7 | 22.6 |

| | | | |
|---|---|---|---|
| Phase 5 | 4 | 2 | 50.0 |
| **Total** | **73** | **21** | **28.8** |

N = number of individuals with dentition

n = number of individuals with at least one abscess

Out of a total of 1,596 tooth positions from the entire sample, 3% had abscesses. In Phase 2, 4% of observable tooth positions had abscesses, whereas in the medieval period only 2% had abscesses (Table 10.14). This observation was found to be significant ( $^{2}$ = 7.32, $p < 0.01$). When examined by age category, teeth from older individuals were more likely to have abscesses than teeth from middle adults from Phase 2 (no teeth from young adults had abscesses) ( $^{2}$= 4.66, $p < 0.05$), but not in the medieval period (see table below).

When examined by sex, no significant differences were observed. In the medieval period, only 1 abscess out of 111 (1%) observable tooth positions was observed on the female dentition, and 10 out of 520 tooth positions (2%) had abscesses on the male dentition. No females from Phase 2 had abscesses (N = 22), while 33 out of 751 (4%) male tooth positions had abscesses from this phase.

Table 10.14 Prevalence of abscess by age category and phase

| | **17-25 years** | | **26-45 years** | | **46+ years** | | **Total*** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| Phase 1 | | | | | 22 | 1 (5) | **24** | **1 (4)** |
| Phase 2 | 88 | 0 | 378 | 12 (3) | 307 | 21 (7) | **773** | **33 (4)** |
| Phases 3 & 4 | 78 | 1 (1) | 198 | 4 (2) | 313 | 5 (2) | **689** | **13 (2)** |
| Phase 5 | 26 | 0 | 30 | 1 (3) | 55 | 2 (4) | **110** | **3 (3)** |
| **Total** | **192** | **1 (1)** | **606** | **17 (3)** | **697** | **29 (4)** | **1,596** | **50 (3)** |

* includes ‘adult’ category

N = number of observable tooth positions

n = number of tooth positions with an abscess

Tables 10.15 and 10.16 present the prevalence of dental abscess by tooth and phase (the total sample is presented in Appendix IX). When examined by tooth type, abscesses were frequently observed at the roots of molar teeth, particularly M1.

Table 10.15 Prevalence of dental abscess by tooth position (Phase 2)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 1 | 2 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 0 | 0 | 4 | 2 | 0 |
| **%** | **4** | **8** | **7** | **4** | **4** | **5** | **-** | **-** | **5** | **9** | **9** | **-** | **-** | **15** | **8** | **-** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 1 | 0 |
| **%** | **-** | **9** | **10** | **4** | **-** | **4** | **-** | **-** | **-** | **4** | **-** | **-** | **-** | **14** | **3** | **-** |

n = number of teeth dental abscesses

Table 10.16 Prevalence of dental abscess by tooth position (Phases 3 and 4, n = 13)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 |
| % | **-** | **-** | **5** | **4** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | | **5** | **5** | **-** | **8** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 0 |
| % | **-** | **-** | **-** | **-** | **4** | **5** | **-** | **4** | **5** | **-** | **-** | | **4** | **9** | **5** | **-** |

n = number of teeth with dental abscesses

## 10.5 ANTEMORTEM TOOTH LOSS

Ante-mortem tooth loss (AMTL) is a result of periodontal disease (see below) and caries (Brothwell 1981). In the Tarbat sample, approximately half of the individuals with dentition had some AMTL. In Phase 2, 50% had AMTL, and 39% of the dentition from the medieval phase had AMTL (Table 10.17).

Table 10.17 Percentage of individuals with AMTL by phase

| | **N** | **n** | **%** |
|---|---|---|---|
| Phase 1 | 2 | 2 | 100.0 |
| Phase 2 | 36 | 18 | 50.0 |
| Phases 3 and 4 | 31 | 12 | 38.7 |
| Phase 5 | 4 | 3 | 75.0 |
| **Total** | **73** | **35** | **47.9** |

N = number of individuals with dentition

n = number of individuals with ante-mortem tooth loss

In total, 22% of the teeth were lost ante-mortem. There appeared to be a trend of decreasing ante-mortem tooth loss with time (Table 10.18). Chi-square analyses revealed that this relationship was significant between Phase 2 and the medieval period ( $^{2} = 25.1$, $p < 0.001$). However, there was a highly significant difference between the males and females from the medieval period. Women were more likely to have AMTL than the men ( $^{2} = 56.2$, $p < 0.001$). Out of 111 female tooth positions, 46 (41%) had AMTL, whereas 62 out of 520 (12%) male tooth positions demonstrated AMTL. In Phase 2, half of the 22 female tooth positions had AMTL, and 205 out of 751 (27%) had AMTL.

In addition to these findings, there was a pattern of increasing AMTL from the middle to older age groups for both Phase 2 ( $^{2} = 4.55$, $p < 0.05$), and the medieval period ( $^{2} = 80.1$, $p < 0.001$). This result was not surprising, as dental disease is more likely to occur the longer a person lives (Roberts and Manchester 1995).

Table 10.18 Prevalence of AMTL by age group and phase

| | **17-25 years** | | **26-45 years** | | **46+ years** | | **Total*** | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Phase 1 | | | | | 22 | 0 | **24** | **8 (33)** |
| Phase 2 | 88 | 0 | 378 | 106 (28) | 307 | 110 (36) | **773** | **216 (28)** |
| Phases 3 & 4 | 78 | 0 | 198 | 1 (1) | 313 | 104 (33) | **689** | **108 (16)** |
| Phase 5 | 26 | 0 | 30 | 1 (3) | 55 | 14 (25) | **110** | **15 (14)** |
| **Total** | **192** | **0** | **606** | **108 (18)** | **697** | **228 (33)** | **1,596** | **347 (22)** |

* includes 'adult' category

N = number of observable tooth positions

n = number of tooth positions with an abscess

When examined by tooth type, AMTL occured most frequently in the molar region. Tables 10.19 and 10.20 demonstrate the prevalence of AMTL by tooth for Phase 2 and the medieval period (the total sample is presented in Appendix X).

Table 10.19 Prevalence of AMTL by tooth position (Phase 2)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 9 | 9 | 16 | 9 | 7 | 3 | 8 | 8 | 7 | 8 | 7 | 5 | 6 | 13 | 12 | 10 |
| **%** | **38** | **38** | **57** | **36** | **28** | **14** | **44** | **47** | **35** | **36** | **32** | **21** | **27** | **48** | **48** | **43** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 7 | 6 | 7 | 6 | 5 | 1 | 2 | 2 | 3 | 5 | 4 | 2 | 6 | 8 | 7 | 8 |
| **%** | **26** | **19** | **23** | **22** | **19** | **4** | **8** | **12** | **20** | **22** | **15** | **8** | **24** | **29** | **24** | **32** |

n = number of teeth lost ante-mortem

Table 10.20 Prevalence of AMTL by tooth position (phases 3 and 4)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 3 | 4 | 7 | 2 | 1 | 1 | 1 | 3 | 2 | 2 | 2 | 3 | 2 | 5 | 4 | 3 |
| **%** | **25** | **21** | **33** | **8** | **4** | **4** | **5** | **14** | **13** | **9** | **9** | **13** | **9** | **23** | **21** | **25** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 6 | 6 | 7 | 4 | 2 | 1 | 2 | 4 | 2 | 2 | 1 | 2 | 5 | 7 | 6 | 6 |
| **%** | **33** | **23** | **27** | **16** | **9** | **5** | **9** | **17** | **10** | **9** | **4** | **8** | **19** | **30** | **27** | **43** |

n = number of teeth lost ante-mortem

## 10.6 ALVEOLAR RESORPTION/PERIODONTAL DISEASE

When calculus accumulates between the tooth (and jaw) and soft tissues, periodontal pockets may form. These are associated with alveolar bone loss, and ultimately, may lead to loosening and loss of the teeth (Hillson, 1986). Predisposing factors of periodontal disease include poor oral hygiene, a soft, carbohydrate rich and/or sugar rich diet, although other factors may also be involved (e.g. crowding, malocclusion) (Hillson, 1986). There is however, some concern for identifying periodontal disease in skeletal material. As well as problems of standardized recording, it has been suggested that severe attrition may result in continued eruption of teeth, giving the appearance of periodontal disease (Roberts and Manchester

1995).

In the Tarbat sample, a very high percentage of individuals (87%) had alveolar resorption, and overall, 72% of observable jaw quadrants had alveolar resorption. As ante-mortem tooth loss was more frequently observed in Phase 2, it was expected that the severity of this disease would also be greater in this phase. However, only a slightly higher percentage of jaw quadrants had considerable alveolar resorption in Phase 2 than in the medieval period (phases 3 and 4) (Table 10.21).

Table 10.21 Prevalence of alveolar resorption by severity and phase

| | N | **Slight** n (%) | **Medium** n (%) | **Considerable** n (%) | **Total** n (%) |
|---|---|---|---|---|---|
| Phase 1 | 8 | 1 (13) | 0 | 4 (50) | **5 (63)** |
| Phase 2 | 136 | 23 (17) | 19 (14) | 59 (43) | **101 (74)** |
| Phases 3 and 4 | 102 | 14 (14) | 17 (17) | 38 (37) | **69 (68)** |
| Phase 5 | 16 | 4 (25) | 4 (25) | 6 (38) | **14 (88)** |
| **Total** | **262** | **42 (16)** | **40 (15)** | **107 (41)** | **189 (72)** |

N = number of half maxillas and mandibles
n = number of half maxillas and mandibles with alveolar resorption
(degree of resorption is based on the descriptions of Brothwell, 1981)

When the number of medieval female and male quadrants with periodontal disease were examined, no significant difference was observed ( $^{2}$ = 0.2, p = ns). Out of 28 female quadrants, 14 (50%) had medium or considerable alveolar resorption, and out of 74 male quadrants, 41 (55%) had medium or considerable alveolar resorption. In Phase 2, 2 of 4 female quadrants were affected, and 76 of 132 (58%) male quadrants were affected (by medium or considerable alveolar resorption).

## 10.7 DENTAL WEAR

Dental wear (attrition) occurs when the teeth are ground together during mastication. Although it is not a dental disease *per se*, it may aid the development of caries and abscesses if the pulp chamber becomes exposed (Lukacs, 1989). A major factor affecting the degree of wear is diet type. For example, using a stone mortar introduces tiny particles of stone into the grain and the food produced from it (Roberts and Manchester 1995).

In the Tarbat assemblage, 18 male skeletons with dentition had very heavy wear on the teeth. Of these individuals, the majority were from Phase 2 (68%). Most of these individuals were middle or older adults (with the exception of one subadult - SK 2) which would be expected given that dental wear increases with age. In most of these cases the teeth were worn down to the roots, and in some instances, the roots were also affected. It was also noted that the wear was often uneven (i.e. occlusal surface was not flat). As heavy dental wear was more frequently observed in adults from Phase 2 (particularly in the older age group), it is possible that the medieval diet may have been softer and easier to chew (Table 10.22). A list of the skeletons with heavy dental wear is presented in Appendix XI.

Table 10.22 Percentage of individuals with heavy dental wear by age group and phase

| | **26-45 years** | | **46+ years** | | **Total** | |
|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| Phase 1 | 0 | 0 | 2 | 1 (50) | **2** | **1 (50)** |
| Phase 2 | 17 | 3 (18) | 14 | 9 (64) | **31** | **12 (39)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Phases 3 and 4 | 9 | 2 (22) | 14 | 2 (14) | **23** | **4 (17)** |
| Phase 5 | 1 | 0 | 2 | 1 (50) | **3** | **1 (33)** |
| **Total** | **27** | **5 (19)** | **32** | **13 (41)** | **59** | **18 (31)** |

N = number of individuals with dentition

n = number of individuals with heavy dental wear

## 10.8 UNERUPTED THIRD MOLARS

Eleven of the adult individuals from the Tarbat assemblage did not have one or more erupted third molars (see Appendix XII). At Hallow Hill, a number of 3rd molars were also absent (Lunt, 1996). The significance of this observation cannot be determined until more sites are available for comparison.

## 10.9 DENTAL DISEASE AT TARBAT AND OTHER SCOTTISH SITES

Overall, there were differences in the prevalences of dental disease between Phase 2 and the medieval period (Phases 3 and 4). In Phase 2, calculus, dental abscesses, ante-mortem tooth loss and dental wear were more frequent, whereas in the medieval period, caries and dental enamel hypoplasia were more frequent. These differences may represent differences in diet and oral hygiene (see above and below). It is likely that the heavy dental wear observed on individuals from phase 2 resulted in exposure of the pulp cavities, causing dental abscesses. It is also possible that caries prevalence could be underestimated given the high percentage of ante-mortem tooth loss in Phase 2.

In the medieval period, the teeth from women had caries, dental enamel hypoplasia and ante-mortem tooth loss more frequently than the males. These findings suggest that there may have been differences in diet and oral hygiene between some of the medieval women and men buried in the church. Two out of seven medieval women had dental enamel hypoplasia, suggesting that both these women suffered from environmental stress during childhood.

A number of specialists have reported on the prevalence of caries in permanent teeth, allowing for comparisons of this dental disease to be made with the Tarbat material. It was noted however, that Hallow Hill was the only site that could be compared to Tarbat Phase 2. Both these sites had a low prevalence rate of caries relative to medieval teeth (with the exception of Dundee and Dunbar) (Tables 10.23 and 10.24). It has been reported that caries prevalence was low in Dark Age (4.3%) and Viking Scotland (2.9%) (Lunt, 1974). Although it is possible that a more recent overview of Dark Age Scottish teeth may reveal different rates, a relatively recent overview of Viking teeth from the North Atlantic demonstrated almost no, or a very low prevalence of, carious lesions (Scott *et al.*, 1992).

The percentage of medieval teeth with caries from Tarbat roughly corresponds with most other Scottish sites. Based on information compiled by Lunt (1993), 6.2% of Scottish teeth from this period had caries. Generally, there appears to be an increase in the prevalence of caries through time in British populations (Roberts and Manchester, 1995). It was not until the 12th century that cane sugar was imported into Britain, although it was generally unavailable to the majority of the population. During the Anglo-Saxon or early medieval period (5th to 10th centuries), honey was probably the main sweetening agent, and bread was the main source of carbohydrate (Hardwick, 1960; Roberts and Manchester, 1995).

Table 10.23 Caries prevalence in Scottish sites c. 8th - 11th century

| **Site** | **Date** | **N** | **% Caries** |
|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **557** | **4.1** |
| Hallow Hill | 6th -9th C | 1162 | 3.3 |

N = number of teeth present

Table 10.24 Caries prevalence in medieval Scottish sites

| Site | Date | N | % Caries |
|---|---|---|---|
| **Tarbat** | **$12^{th}$ -$15^{th}$ C** | **581** | **6.9** |
| Glasgow Cathedral | $12^{th}$ -$15^{th}$ C | 585 | 5.6 |
| Dundee | $12^{th}$ - $15^{th}$ C | 767 | 3.7 |
| Dunbar | medieval | 892 | 3.0 |
| Whithorn | $13^{th}$ - $15^{th}$ C | 11,200 | 6.7 |
| Aberdeen (A) | c.$13^{th}$ - $17^{th}$ C | * | 5.0 |
| Aberdeen (B) | $13^{th}$ -$16^{th}$ C | 741 | 6.7 |
| Linlithgow | c.$13^{th}$ - $17^{th}$ C | 1,869 | 7.4 |
| Kirkhill | medieval | 2,864 | 6.8 |

* data not presented in report

N = number of teeth present

Other dental diseases could not be compared to the Tarbat assemblage with the exception of Glasgow Cathedral (12th to 15th century phase). The percentages of dental abscesses was almost identical (1.8% for Tarbat and 1.9% for Glasgow Cathedral). In contrast, the medieval dentition at Tarbat had almost twice as much ante-mortem tooth loss as the Glasgow Cathedral individuals (15.7% vs 8.7%). In addition, 14.5% of the teeth had dental enamel hypoplasia at Tarbat, whereas only 5.3% of the teeth from Glasgow Cathedral had dental enamel hypoplasia.

## 11.0 JOINT DISEASE

Any changes to the joint surfaces which involved lipping (osteophytes), pitting (subchondral porosity), eburnation (polishing of bone surface) and changes to the joint shape were described following the recommendations of Buikstra and Ubelaker (1994). However, for the purposes of analysis, osteoarthritis was only diagnosed if there was presence of eburnation, or when at least two of the following conditions were present: marginal osteophyte and/or new bone on the joint surface, pitting on the joint surface, or alteration in the bony contour of the joint (Rogers and Waldron, 1995). Based on the recommendations of Rogers and Waldron (1995), the severity of osteoarthritis was not considered in the analysis (with the exception of bony fusion in spinal joint disease).

### 11.1 OSTEOARTHRITIS

Osteoarthritis (OA) is a common disease in antiquity and in modern populations. It affects synovial joints and is characterised by a loss of articular cartilage and subchondral bone changes. Current understanding of OA is that it is a normal remodelling or repair process in response to joint failure as a result of alterations in joint mechanics. These may occur partly through injury and activity, although other factors such as age, and the systemic and genetic predisposition of an individual are also important. The mechanical element may determine which joints are involved in people predisposed to OA (Rogers and Waldron 1995).

Out of 130 adult skeletons with joints to observe (excluding the spinal column), 41% had at least one joint affected by OA (as defined above). It is noted, however, that the incompleteness of many of the Tarbat skeletons may have resulted in an underestimate of this percentage. In modern populations, the prevalence of OA increases with age (Rogers and Waldron 1995). Despite the incomplete nature of the sample, this finding was also observed in the Tarbat assemblage ( $^{2}$ = 7.85, df

= 2, $p < 0.05$) (Table 11.1).

Table 11.1 Percentage of individuals with OA by age category and phase

| | Adult | | 17-25 years | | 26-45 years | | 46+ years | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| Phase 1 | 2 | 0 | | | | | 2 | 2 (100) | **4** | **2 (50)** |
| Phase 2 | 8 | 1 (13) | 5 | 0 | 26 | 10 (38) | 22 | 11 (50) | **61** | **22 (36)** |
| Phases 3 & 4 | 7 | 4 (57) | 8 | 2 (25) | 16 | 6 (38) | 30 | 16 (53) | **61** | **28 (46)** |
| Phase 5 | | | 1 | 0 | 1 | 0 | 2 | 1 (50) | **4** | **1 (25)** |
| **Total** | **17** | **5 (29)** | **14** | **2 (14)** | **43** | **16 (37)** | **56** | **30 (54)** | **130** | **53 (41)** |

N = number of individuals
n = number of individuals with OA

The prevalence of OA was examined by joint. In order to facilitate this analysis, the number of observable joints was recorded. Overall, 1,120 joints were examined and 10% were found to have OA. Table 11.1 presents the number of affected joints by age category and phase. No significant difference was observed in the number of joints affected in Phase 2 compared to the medieval period ( $^{2}$ = 1.47, p = ns). As might be expected, there was a clear increase in the percentage of affected joints with age in phase 2, whereas in the medieval period, a slightly higher percentage of joints were affected in middle adults (18%) compared to old adults (15%). In the medieval period, male and female joints were equally affected by OA (12% for both - females: 19 out of 159 joints, and males: 43 out of 368 joints). No female joints had OA in Phase 2 (N = 31), although 10% of male joints were affected (48 out of 476 joints) from this phase.

Table 11.1 Prevalence of joints with OA by age category and phase

| | Adult | | 17-25 years | | 26-45 years | | 46+ years | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Phase** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| 1 | 9 | 0 | | | | | 21 | 3 (14) | **30** | **3 (10)** |
| 2 | 36 | 1 (3) | 57 | 0 | 241 | 19 (8) | 178 | 28 (16) | **512** | **48 (9)** |
| 3 & 4 | 40 | 10 (25) | 63 | 2 (3) | 173 | 13 (18) | 251 | 37 (15) | **527** | **62 (12)** |
| 5 | 0 | | 11 | 0 | 14 | 0 | 26 | 2 (8) | **51** | **2 (4)** |
| **Total** | **85** | **11 (13)** | **131** | **2 (2)** | **428** | **32 (8)** | **476** | **70 (15)** | **1,120** | **115 (10)** |

N = number of joints
n = number of joints with OA

Tables 11.3 to 11.6 present the prevalence of joint disease by age category for each phase. From these tables, it is apparent that the most frequently affected joints in Phase 2 were the right toes (27%), right and left hips (22 and 18%), and the right fingers (16%). In the medieval period (Phases 3 and 4), the right toes were also frequently affected (20%) as well as the right wrist (20%), followed by the left toes (19%), right fingers (17%), right shoulder and left hip (16% for both). Data for the total sample is presented in Appendix XIII. Twenty-two individuals also had OA on the ribs, but this was not included in the analyses as the prevalence could not be calculated.

Today, commonly observed sites of OA include the hands, acromioclavicular joint, first metatarsophalangeal joint (foot), hip and knee (Rogers and Waldron 1995). Certainly, the results from the Tarbat assemblage correspond well with these observations. The lack of unusual patterns of OA suggests that prevalence and distribution of OA is what might be expected in a population group of mainly middle and older adults.

Figure 11.1 Osteoarthritis of the right hip (SK 42)

There were no significant differences in joint involvement between Phase 2 and the medieval period (Phases 3 and 4), with the exception of the right knee ( $^{2}$ = 4.6, $p < 0.05$) - no right knee joints were affected by OA in Phase 2. There were also no significant differences in joint involvement by age in Phase 2, or in the medieval period (statistics not shown). In addition, no significant differences were found in male and female joint involvement, with one exception. Females in the medieval period were more likely to have joint disease in the left toe than males ( $^{2}$ = 7.14, $p < 0.05$) from this period.

Table 11.3 Prevalence of OA by joint and age category (Phase 1)

| | **Adult** | | **17-25** | | **26-45** | | **46+** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| R shoulder | | | | | | | 2 | 0 | **2** | **0** |
| L shoulder | 1 | 0 | | | | | 2 | 0 | **3** | **0** |
| R elbow | | | | | | | 2 | 0 | **2** | **0** |
| L elbow | 1 | 0 | | | | | 2 | 1 (50) | **3** | **1 (33)** |
| R wrist | | | | | | | 1 | 0 | **1** | **0** |
| L wrist | | | | | | | 1 | 0 | **1** | **0** |
| R fingers | | | | | | | 1 | 1 (100) | **1** | **1 (100)** |
| L fingers | | | | | | | 1 | 0 | **1** | **0** |
| R hip | 1 | 0 | | | | | 2 | 0 | **3** | **0** |
| L hip | 1 | 0 | | | | | 2 | 0 | **3** | **0** |
| R knee | 1 | 0 | | | | | 1 | 0 | **2** | **0** |
| L knee | 1 | 0 | | | | | 1 | 1 (100) | **2** | **1 (50)** |
| R ankle | 1 | 0 | | | | | 1 | 0 | **2** | **0** |
| L ankle | 1 | 0 | | | | | 1 | 0 | **2** | **0** |
| R toes | | | | | | | | | | |
| L toes | 1 | 0 | | | | | 1 | 0 | **2** | **0** |
| **Total** | **9** | **0** | | | | | **21** | **3 (14)** | **30** | **3 (10)** |

N = number of joints observed
n = number of joints with OA

Table 11.4 Prevalence of OA by joint and age category (Phase 2)

| | **Adult** | | **17-25** | | **26-45** | | **46+** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| R shoulder | | | 5 | 0 | 16 | 1 (6) | 10 | 2 (20) | **31** | **3 (10)** |
| L shoulder | | | 5 | 0 | 17 | 2 (12) | 11 | 1 (9) | **33** | **3 (9)** |
| R elbow | 1 | 0 | 5 | 0 | 19 | 0 | 16 | 1 (6) | **41** | **1 (2)** |
| L elbow | | | 3 | 0 | 19 | 0 | 17 | 1 (6) | **39** | **1 (3)** |
| R wrist | | | 4 | 0 | 16 | 2 (13) | 12 | 2 (17) | **32** | **4 (13)** |
| L wrist | 1 | 0 | 4 | 0 | 16 | 0 | 12 | 3 (25) | **33** | **3 (9)** |
| R fingers | **1** | **1 (100)** | **3** | **0** | **11** | **3 (27)** | **10** | **0** | **25** | **4 (16)** |

| | **Adult** | | **17-25** | | **26-45** | | **46+** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| L fingers | 1 | 0 | 3 | 0 | 14 | 0 | 11 | 1 (9) | **29** | **1 (3)** |
| R hip | **3** | **0** | **5** | **0** | **18** | **3 (17)** | **15** | **6 (40)** | **41** | **9 (22)** |
| L hip | **4** | **0** | **4** | **0** | **22** | **4 (18)** | **19** | **5 (26)** | **49** | **9 (18)** |
| R knee | 6 | 0 | 4 | 0 | 16 | 0 | 9 | 0 | **35** | **0** |
| L knee | 5 | 0 | 3 | 0 | 18 | 0 | 13 | 1 (8) | **39** | **1 (3)** |
| R ankle | 5 | 0 | 3 | 0 | 11 | 0 | 7 | 2 (29) | **26** | **2(8)** |
| L ankle | 4 | 0 | 2 | 0 | 14 | 0 | 8 | 1 (13) | **28** | **1 (4)** |
| R toes | **2** | **0** | **2** | **0** | **7** | **2 (29)** | **4** | **2 (50)** | **15** | **4 (27)** |
| L toes | 3 | 0 | 2 | 0 | 7 | 2 (29) | 4 | 0 | **16** | **2 (13)** |
| **Total** | **36** | **1 (3)** | **57** | **0** | **241** | **19 (8)** | **178** | **28 (16)** | **512** | **48 (9)** |

N = number of joints observed

n = number of joints with OA

Table 11.5 Prevalence of OA by joint and age category (Phase 3 and 4)

| | **Adult** | | **17-25** | | **26-45** | | **46+** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| R shoulder | | | **3** | **0** | **12** | **0** | **16** | **5 (31)** | **31** | **5 (16)** |
| L shoulder | 1 | 0 | 3 | 0 | 12 | 0 | 6 | 1 (17) | **22** | **1 (5)** |
| R elbow | 1 | 1 (100) | 3 | 0 | 13 | 1 (8) | 19 | 2 (11) | **36** | **4 (11)** |
| L elbow | | | 4 | 0 | 12 | 0 | 15 | 2 (13) | **31** | **2 (7)** |
| R wrist | **3** | **2 (67)** | **3** | **0** | **11** | **1 (9)** | **18** | **4 (22)** | **35** | **7 (20)** |
| L wrist | 1 | 0 | 4 | 0 | 12 | 1 (8) | 12 | 2 (17) | **29** | **3 (10)** |
| R fingers | **2** | **1 (50)** | **2** | **1 (50)** | **11** | **0** | **14** | **3 (21)** | **29** | **5 (17)** |
| L fingers | 1 | 1 (100) | 2 | 0 | 10 | 0 | 8 | 1 (13) | **21** | **2 (10)** |
| R hip | **3** | **0** | **4** | **0** | **14** | **4 (29)** | **24** | **3 (13)** | **45** | **7 (16)** |
| L hip | 3 | 0 | 4 | 0 | 15 | 2 (13) | 21 | 2 (10) | **43** | **4 (9)** |
| R knee | 5 | 2 (40) | 6 | 0 | 14 | 1 (7) | 24 | 3 (13) | **49** | **6 (12)** |
| L knee | 5 | 2 (40) | 6 | 0 | 13 | 2 (15) | 21 | 2 (10) | **45** | **6 (13)** |
| R ankle | 4 | 0 | 6 | 0 | 7 | 0 | 18 | 1 (6) | **35** | **1 (3)** |
| L ankle | 5 | 0 | 6 | 0 | 7 | 1 (14) | 17 | 0 | **35** | **1 (3)** |
| R toes | **3** | **1 (33)** | **4** | **0** | **5** | **0** | **8** | **3 (38)** | **20** | **4 (20)** |
| L toes | **3** | **0** | **3** | **1 (33)** | **5** | **0** | **10** | **3 (30)** | **21** | **4 (19)** |
| **Total** | **40** | **10 (25)** | **63** | **2 (3)** | **173** | **13 (8)** | **251** | **37 (15)** | **527** | **62 (12)** |

N = number of joints observed

n = number of joints with OA

Table 11.6 Prevalence of OA by joint and age category (Phase 5)

| | **Adult** | | **17-25** | | **26-45** | | **46+** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| R shoulder | | | | | 1 | 0 | 2 | 0 | **3** | **0** |

| | Adult | | 17-25 | | 26-45 | | 46+ | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | n (%) | N | n (%) | N | n (%) | N | n (%) | N | n (%) |
| L shoulder | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| R elbow | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| L elbow | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| R wrist | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| L wrist | | | 1 | 0 | 1 | 0 | 2 | 1 (50) | **4** | **1 (20)** |
| R fingers | | | | | | | 1 | 0 | **1** | **0** |
| L fingers | | | | | | | 1 | 1 (100) | **1** | **1 (100)** |
| R hip | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| L hip | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| R knee | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| L knee | | | 1 | 0 | 1 | 0 | 2 | 0 | **4** | **0** |
| R ankle | | | 1 | 0 | 1 | 0 | 1 | 0 | **3** | **0** |
| L ankle | | | 1 | 0 | 1 | 0 | 1 | 0 | **3** | **0** |
| R toes | | | | | 1 | 0 | 1 | 0 | **2** | **0** |
| L toes | | | | | 1 | 0 | 1 | 0 | **2** | **0** |
| **Total** | **0** | | **11** | **0** | **14** | **0** | **26** | **2 (8)** | **51** | **2 (4)** |

N = number of joints observed
n = number of joints with OA

## 11.2 SPINAL JOINT DISEASE

Spinal joint disease (SJD) is characterised by OA of the vertebral body, posterior apophyseal joints and transverse joints, but may also be identified by Schmorl's nodes or degenerative disc disease Schmorl's nodes are depressions in the vertebral body as a result of herniation of the disc contents, possibly from trauma (Roberts and Manchester 1995). Degenerative disc disease (DDD) consists of course pitting, sometimes associated with new bone growth, on the superior and inferior surfaces of the vertebral bodies and is presumed to reflect degeneration of the intervertebral disc (Rogers and Waldron 1995).

Ninety-eight individuals had vertebrae to analyse (Table 11.7). Of these individuals, 79% had spinal joint disease and 5% had osteophytes, revealing that 84% of the individuals had some vertebral changes. As might be expected, the highest percentages of individuals with SJD were middle and older adults.

Table 11.7 Percentage of individuals with SJD by age category and phase

| | Adult | | 17-25 years | | 26-45 years | | 46+ years | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Phase** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| 1 | | | | | | | 2 | 2 (100) | **2** | **2 (100)** |
| 2 | 2 | 1 (50) | 5 | 2 (40) | 24 | 22 (97) | 20 | 19 (95) | **51** | **44 (86)** |
| 3 & 4 | 1 | 0 | 4 | 1 (25) | 15 | 10 (67) | 22 | 19 (86) | **42** | **30 (71)** |
| 5 | | | 1 | 0 | | | 2 | 1 (50) | **3** | **1 (33)** |
| **Total** | **3** | **1 (33)** | **10** | **3 (30)** | **39** | **32 (82)** | **46** | **41 (89)** | **98** | **77 (79)** |

N = number of individuals
n = number of individuals with SJD

There were 1,453 vertebrae present, of which 47% were affected by SJD (Table 11.8). In Phase 2, 52% of the vertebrae were affected by SJD, whereas less vertebrae (39%) were affected in the medieval period ( $^2$ = 25.7, $p < 0.001$). In both Phase 2, and the medieval period, there were clear increases in the percentage of affected vertebrae with increasing age. It was noted however, that a larger percentage of young adults had SJD in Phase 2 than in the medieval period (30% vs. 3%). It is hypothesised from this observation that the young adults from the earlier phase experienced more activity or injury related stresses to the back.

In Phase 2, there was a significant difference between the males and females, such that males were more likely to have SJD ( $^2$ = 17.25, $p < 0.001$) (9 of 42 female vertebrae were affected, and 379 out of 714 male vertebrae were affected). In the medieval period, 39% of female vertebrae were affected (74 out of 189) and similarly, 40% (167 out of 410) male vertebrae were affected by SJD.

Table 11.8 Prevalence of SJD by age category and phase

| | **Adult** | | **17-25 years** | | **26-45 years** | | **46+ years** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Phase** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| 1 | | | | | | | 25 | 20 (80) | **25** | **20 (80)** |
| 2 | 29 | 7 (24) | 91 | 27 (30) | 356 | 192 (54) | 304 | 183 (60) | **780** | **409 (52)** |
| 3 & 4 | 12 | 0 | 88 | 3 (3) | 223 | 61 (27) | 296 | 177 (60) | **619** | **241 (39)** |
| 5 | | | 7 | 0 | 2 | 0 | 20 | 6 (30) | **29** | **6 (21)** |
| **Total** | **41** | **7 (17)** | **186** | **30 (16)** | **581** | **253 (44)** | **645** | **386 (60)** | **1,453** | **676 (47)** |

N = number of vertebrae

n = number of vertebrae with SJD

Every vertebra was found to be affected by SJD - the least affected being C1 (Table 11.9). Overall, the most frequently affected vertebrae were C5/C6 and T8 to T12. As a result of spinal curvature, certain vertebrae are more commonly affected by SJD than others, including C5 and C6, T7 and T8, and L3 and L4 (Manchester 1983). The findings from the Tarbat assemblage were consistent with this, with the exception of the lower lumbar vertebrae, which were relatively less affected by SJD than other areas of the spine.

There were very few differences in the prevalence of affected vertebrae between Phase 2 and the medieval period (Phases 3 and 4) with the exception of T10, L1 and L2 - a significantly higher percentage of these vertebrae were affected in Phase 2 than in the medieval period ( $^2$ = 5.19, $^2$ = 6.25, $^2$ = 5.38, all $p < 0.05$). A number of vertebrae were also observed to increase in prevalence with age. In Phase 2, this involved C6, and in the medieval period, this involved C4 to C7, T1, T11 and T12 (statistics not shown). Finally, there were no differences between the females and males, except for T3. In the medieval period, this vertebra was most likely to be affected in females ( $^2$ = 6.66, $p < 0.05$).

Table 11.9 Prevalence of SJD by vertebrae and phase

| | **Phase 1** | | **Phase 2** | | **Phases 3 & 4** | | **Phase 5** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| C1 | 2 | 1 (50) | 27 | 6 (22) | 13 | 1 (8) | 2 | 0 | **44** | **8 (18)** |
| C2 | 1 | 1 (100) | 29 | 11 (38) | 15 | 4 (27) | 2 | 0 | **47** | **16 (34)** |
| C3 | 1 | 1 (100) | 28 | 16 (57) | 14 | 6 (42) | 2 | 0 | **45** | **23 (51)** |
| C4 | 1 | 1 (100) | 30 | 16 (53) | 17 | 9 (53) | 2 | 1 (50) | **50** | **27 (54)** |

| | **Phase 1** | | **Phase 2** | | **Phases 3 & 4** | | **Phase 5** | | **Total** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** | **N** | **n (%)** |
| C5 | 1 | 1 (100) | 31 | 18 (58) | 17 | 8 (47) | 2 | 1 (50) | **51** | **28 (55)** |
| C6 | 1 | 1 (100) | 31 | 20 (65) | 19 | 10 (53) | 2 | 1 (50) | **53** | **32 (60)** |
| C7 | 1 | 1 (100) | 34 | 16 (47) | 19 | 6 (32) | 1 | 1 (100) | **55** | **24 (44)** |
| T1 | 1 | 1 (100) | 33 | 12 (36) | 21 | 5 (24) | 0 | | **55** | **18 (33)** |
| T2 | 1 | 1 (100) | 35 | 8 (23) | 22 | 4 (18) | 0 | | **58** | **13 (22)** |
| T3 | 1 | 1 (100) | 37 | 12 (32) | 23 | 9 (39) | 1 | 0 | **62** | **22 (36)** |
| T4 | 1 | 1 (100) | 36 | 16 (44) | 26 | 9 (35) | 1 | 0 | **64** | **26 (41)** |
| T5 | 1 | 1 (100) | 34 | 19 (56) | 26 | 12 (46) | 1 | 0 | **62** | **32 (52)** |
| T6 | 1 | 1 (100) | 36 | 20 (56) | 27 | 12 (44) | 1 | 0 | **65** | **33 (51)** |
| T7 | 0 | | 34 | 22 (65) | 29 | 12 (41) | 1 | 0 | **64** | **34 (53)** |
| T8 | 1 | 1 (100) | 35 | 22 (63) | 31 | 16 (52) | 1 | 0 | **68** | **39 (57)** |
| T9 | 1 | 1 (100) | 33 | 21 (64) | 31 | 16 (52) | 1 | 0 | **66** | **38 (58)** |
| T10 | 1 | 1 (100) | **32** | **23 (72)** | **32** | **14 (44)** | 1 | 0 | **66** | **38 (58)** |
| T11 | 1 | 1 (100) | 32 | 23 (72) | 32 | 17 (53) | 1 | 0 | **66** | **41 (62)** |
| T12 | 1 | 1 (100) | 31 | 21 (68) | 30 | 14 (47) | 0 | | **62** | **36 (58)** |
| L1 | 1 | 0 | **32** | **21 (66)** | **32** | **11 (34)** | 0 | | **65** | **32 (49)** |
| L2 | 1 | 0 | **33** | **21 (64)** | **34** | **12 (35)** | 1 | 0 | **69** | **33 (48)** |
| L3 | 1 | 0 | 33 | 16 (48) | 35 | 16 (46) | 2 | 0 | **71** | **32 (45)** |
| L4 | 1 | 1 (100) | 34 | 15 (44) | 37 | 10 (27) | 2 | 1 (50) | **74** | **27 (37)** |
| L5 | 2 | 2 (100) | 30 | 13 (43) | 37 | 8 (22) | 2 | 1 (50) | **71** | **24 (34)** |
| **Total** | **25** | **21 (84)** | **780** | **408 (52)** | **619** | **241 (39)** | **29** | **6 (21)** | **1,453** | **676 (47)** |

N = number of vertebrae

n = number of vertebrae with SJD (OA and/or SN and/or DDD)

A relatively high percentage of individuals had Schmorl's nodes in the Tarbat sample (41%). Five individuals (5%) had degenerative disc disease (DDD) in addition to DJD. Table 11.10 demonstrates the prevalence of osteoarthritis (OA), Schmorl's nodes (SN), degenerative disc disease (DDD) and osteophytes (O) for each vertebra *for the total sample*. It is evident from this table that OA and osteophytes affected all vertebrae, while Schmorl's nodes were most prevalent between T7 and L2. Similarly, DDD was observed on the lower thoracic and lumbar vertebrae.

Table 11.10 Prevalence of spinal joint disease (total sample)

| | | **OA** | **SN** | **DDD** | **O** |
|---|---|---|---|---|---|
| | **N** | **n (%)** | **n (%)** | **n (%)** | **n (%)** |
| C1 | 44 | 8 (18) | 0 | 0 | 4 (9) |
| C2 | 47 | 16 (35) | 0 | 0 | 5 (11) |
| C3 | 45 | 23 (51) | 0 | 0 | 1 (2) |
| C4 | 50 | 27 (54) | 0 | 0 | 1 (2) |
| C5 | 51 | 28 (55) | 0 | 0 | 2 (4) |
| C6 | 53 | 32 (60) | 0 | 0 | 2 (4) |
| C7 | 55 | 24 (44) | 0 | 0 | 2 (4) |
| T1 | 55 | 18 (33) | 0 | 0 | 3 (5) |

| | N | OA n (%) | SN n (%) | DDD n (%) | O n (%) |
|---|---|---|---|---|---|
| T2 | 58 | 13 (22) | 0 | 0 | 7 (12) |
| T3 | 62 | 22 (35) | 1 (2) | 0 | 9 (15) |
| T4 | 64 | 24 (38) | 5 (8) | 0 | 12 (19) |
| T5 | 62 | 24 (39) | 13 (21) | 0 | 12 (19) |
| T6 | 65 | 22 (34) | 19 (29) | 1 (2) | 15 (23) |
| T7 | 64 | 18 (28) | 25 (39) | 1 (2) | 19 (30) |
| T8 | 68 | 20 (29) | 29 (43) | 0 | 21 (31) |
| T9 | 66 | 18 (27) | 28 (42) | 1 (2) | 22 (33) |
| T10 | 66 | 21 (32) | 28 (42) | 2 (3) | 19 (29) |
| T11 | 66 | 22 (33) | 31 (47) | 2 (3) | 17 (26) |
| T12 | 62 | 12 (19) | 26 (42) | 3 (5) | 19 (31) |
| L1 | 65 | 10 (15) | 24 (37) | 3 (5) | 20 (31) |
| L2 | 69 | 11 (16) | 25 (36) | 2 (3) | 27 (39) |
| L3 | 71 | 18 (25) | 17 (24) | 3 (4) | 20 (28) |
| L4 | 74 | 19 (26) | 10 (14) | 1 (1) | 24 (32) |
| L5 | 71 | 20 (28) | 7 (10) | 1 (1) | 20 (28) |
| **Total** | **1,453** | **470 (32)** | **288 (20)** | **20 (2)** | **303 (21)** |

## 11.3 VERTEBRAL FUSION

There were two individuals who had several fused vertebrae, but the fusion did not demonstrate the classical characteristics of either ankylosing spondylitis (an inflammatory disease of unknown etiology) or diffuse idiopathic hyperostosis (see below). An old adult ?male from phase 2 (SK 128) had a fused sacro-iliac joint on the right side (the left side was missing), as well as fusion between T3 and T4 and the 4$^{th}$ ribs (with no joint space left between the vertebrae) and fusion between C5 to C7 (T5 to L1 were missing). The osteophytes on the cervical vertebral bodies were square and 'bamboo' like in appearance, with fusion also occurring between the lamina and transverse processes. In addition, the atlas was fused to the occipital in such a way that this individual's head would have been slightly raised and tilted to the right side.

An old adult male from phase 4 (SK 90) demonstrated fusion of the bodies (square), apophyseal joints and laminae between T4 and T5 (all vertebrae were present). In addition, T4 was slightly collapsed on the right side resulting in scoliosis. Ossification of ligaments was also present on a number of lumbar vertebrae, but only L4 and L5 were fused. In this case, the fusion was large and bulbous in appearance. It was also noted that this individual had an area of ossification on the base of the skull (lateral to the left occipital condyle), resulting in limited mobility to raise the head, and causing the head to be permanently faced slightly to the left side. No sacral-iliac fusion was present.

## 11.4 DIFFUSE IDIOPATHIC SKELETAL HYPEROSTOSIS

Diffuse idiopathic skeletal hyperostosis (DISH) has an unknown etiology, but has been associated with diabetes and obesity. It is slightly more common in males than females, and the age of onset is usually over 50 years. The disease is characterised by gradual and complete fusion of the spine with a 'candlewax' appearance of the osteophytes, particularly on the right side of the vertebrae, while the spaces between vertebral bodies and apophyseal joints are maintained. Ossified cartilage may also be present in other areas of the skeleton as people affected with DISH are often 'bone formers'. Symptoms of this disease include pain, aching and stiffness (Roberts and Manchester 1995; Rogers and Waldron 1995).

In the Tarbat assemblage, there was only one old adult male (from Phase 4) who demonstrated changes characteristic of DISH (SK 64). This individual had 'candle wax' spinal osteophytosis on the right side of vertebral bodies of T12 to L4 (although not all were fused), without affecting the apophyseal joints. In addition, there was ligamentous fusion of both sacro-iliac joints without affecting the joint spaces. This individual also had enthesopathies (ossification) on the distal ends of the tibiae and fibulae.

### 11.5 DEFECTS OF THE ARTICULAR SURFACE

At least two skeletons had round lytic lesions of unknown etiology on the joint surfaces. Both SK 167 (adult ?male from phase 2) and SK 129 (young adult ?male from Phase 2) had a large lytic lesion with rounded edges on the proximal articular surface of the 1st proximal phalanx of the foot.

### 11.6 JOINT DISEASE AT TARBAT AND OTHER SCOTTISH SITES

Some interesting patterns emerged when joint disease was examined in the Tarbat assemblage. While there was no difference in the prevalence of joints affected by osteoarthritis (OA) between Phase 2 and the medieval period, there was a difference in the prevalence of spinal joint disease (SJD). More vertebrae were affected by SJD in Phase 2, and more younger individuals had SJD than in the medieval period. These findings suggest that the individuals from Phase 2 were likely experiencing different stresses on the back, particularly, the lower back - perhaps as a result of some physical activity.

Joint diseases are very difficult to compare between sites because of the different methodologies used to diagnose OA and SJD, and because of the differing age distributions. The prevalence rate of OA may be artificially increased or decreased depending on the proportion of older individuals (Waldron 1994). Table 11.11 and 11.12 present the prevalence rates from various Scottish sites. While they cannot be used for direct comparison, they demonstrate that both OA and SJD were frequently observed in Scottish assemblages.

Table 11.11 Prevalence of joint disease in Scottish sites *c*.8th - 11th century

| Site | Date | N | % OA | N | % SJD |
|---|---|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **512** | **9.4** | **780** | **52.4** |
| Isle of May | 5th - 12th C | 492 | 21.5 | 476 | 62.8 |

N = number of joints/vertebrae

Table 11.12 Prevalence of joint disease in medieval Scottish sites

| Site | Date | N | % OA | N | % SJD |
|---|---|---|---|---|---|
| **Tarbat** | **12th -15th C** | **527** | **11.7** | **619** | **38.9** |
| Glasgow Cathedral | 12th -19th C | * | * | 548 | 47.3 |
| Isle of May | 12th - 17th C | 168 | 10.1 | 178 | 43.3 |
| Dundee | 12th - 15th C | 219 | 7.3 | 270 | 30.7 |
| Dunbar | Medieval | * | * | 553 | 69.1 |

* data not presented in report
N = number of joints/vertebrae

## 12.0 TRAUMA

In skeletal remains, trauma may be observed as fractures, weapon wounds, dental trauma, dislocations, scalping and surgery (trephination and amputation) (Merbs, 1989). In the Tarbat sample, 21% of the adults demonstrated traumatic injuries to the bones (no subadults had evidence of trauma on their bones), most of which were healed fractures. Overall, a higher percentage of individuals had traumatic injury in Phase 2 (32%) compared to the medieval period (12%). In the medieval period, 13% of the women and 11% of the men had fractures (Table 12.1).

Table 12.1 Percentage of individuals with traumatic injury by phase

| | **Females** | | **Males** | | **Total*** | |
|---|---|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **N (%)** | **N** | **N (%)** |
| Phase 1 | 1 | 0 | 2 | 0 | 3 | 0 |
| Phase 2 | 5 | 0 | 55 | 20 (36) | 62 | 20 (32) |
| Phases 3 and 4 | 23 | 3 (13) | 38 | 4 (11) | 61 | 7 (12) |
| Phase 5 | 1 | 0 | 2 | 0 | 4 | 0 |
| **Total** | **30** | **3 (10)** | **97** | **24 (25)** | **130** | **27 (21)** |

* includes undetermined sex category
N = number of individuals
n = number of individuals with traumatic injuries

## 12.1 FRACTURES

The fibula was fractured more than any other bone at Tarbat, with 10% being affected from Phase 2, and 4% being affected from the medieval period (Table 12.2). Several individuals also had fractures to the ribs, hands or feet (see below), but the prevalences could not be calculated. A description of all the fractures are presented in Table 12.3.

Table 12.2 Prevalence of fractures by bone element

| | **Phase 2** | | | **Phases 3 & 4** | | |
|---|---|---|---|---|---|---|
| | **N** | **n** | **%** | **N** | **n** | **%** |
| Clavicle | 67 | 3 | 4.5 | 53 | 0 | - |
| Radius | 48 | 1 | 2.1 | 61 | 0 | - |
| Tibia | 51 | 1 | 2.0 | 77 | 0 | - |
| Fibula | 39 | 4 | 10.3 | 70 | 3 | 4.3 |

N = number of complete bone elements
n = number of bone elements with fractures

Table 12.3 Fractures observed on the Tarbat individuals

| **Skeleton** | **Phase** | **Age** | **Sex** | **Bone** | **Side** | **Description** |
|---|---|---|---|---|---|---|
| 145 | 2 | middle adult | M | clavicle | L | Non-united fracture approximately mid-shaft, with healed irregular new bone formation on both sides which articulated with one another. The ends of the bones are displaced such that the medial portion of the clavicle overlaid the lateral portion (anteriorly). |

| Skeleton | Phase | Age | Sex | Bone | Side | Description |
|---|---|---|---|---|---|---|
| 176 | 2 | middle adult | M | clavicle | L | Non-united fracture approximately 25-30 mm from the acromial end. One side is flared, and the other is rounded, forming a pseudo-joint. |
| | | | | ribs | | Five healed middle ribs. |
| 170 | 2 | middle adult | M | clavicle | L | Well-healed fracture near the conoid tubercle - slightly displaced, so that the lateral end is slightly inferior to the rest of the shaft. |
| 39 | 2 | adult | M | fibula | R | Proximal end - well healed (with callus formation), complete, oblique fracture. |
| 122 | 2 | old adult | M | fibula | R | Proximal end - well healed (with callus formation), complete, oblique fracture. |
| 141 | 2 | middle adult | M | fibula | R | Proximal end - well healed (with callus formation), complete, oblique fracture. |
| 113 | 3 & 4 | old adult | M | fibula | L | Proximal end - well healed (with callus formation), complete, oblique fracture. |
| | | | | 1st metacarpal & hamate | R | Well-healed complete fractures. A proximal and middle phalanx from the left hand is fused at the joint with little new bone formation. - trauma? |
| | | | | ribs | L | Well-healed fracture to four middle ribs. Weapon wound to the cranium also (see below). |
| 64 | 3 & 4 | old adult | M | fibula | L | Incomplete fracture on distal end (appears like a crack in the articular surface) with evidence of healing. |
| 105 | 3 & 4 | old adult | F | fibula | R | Well-healed incomplete fracture on distal end. |
| 125 | 2 | old adult | M | tibia fibula | L | Both are well-healed, complete, oblique fractures on the distal ends, but the tibia also has gaps and cloacae present along the fracture line. The ends of the fracture overlap by approximately 35 mm and as a result, the L tibia is shorter than the right. In addition, the proximal end of the fibula shaft is angled slightly medially and the fracture ends overlap by approximately 22 mm. This individual also has OA of the left hip (secondary?), and probably walked with a limp. |
| 123 | 2 | old adult | M | 5th proximal phalanx | R | Well-healed, complete, straight fracture across the shaft. |
| 74 | 3 & 4 | old adult | M | 3rd metacarpal | L | Fracture of the styloid process. |
| 142 | 2 | old adult | ?M | 5th metacarpal | R | Fusion at an angle with the proximal phalanx - trauma? |
| | | | | 5th metatarsal | | Non-united fracture at the base (tuberosity). |
| 51 | 2 | middle adult | M | 5th metatarsal | | Non-united fracture at the base (tuberosity). |
| 62 | 3 & 4 | old adult | M | 5th metatarsal | | Non-united fracture at the base (tuberosity). |
| 5 | 3 & 4 | old adult | F | rib | | Healed fracture of a middle rib. |
| 151 | 2 | old adult | M | rib | | Healed fracture of a middle rib. |
| 42 | 2 | adult | M | rib | | Healed fracture with new bone formation which has developed into a facet for articulation with a middle rib. |

| Skeleton | Phase | Age | Sex | Bone | Side | Description |
|---|---|---|---|---|---|---|
| 158 | 2 | old adult | M | ribs | | Mid-shaft fractures on four middle ribs. One rib also has a lytic lesion (oval with rounded edges - approximately 4.4 x 2.8 mm in size) approximately 20 mm away from fracture, possibly indicative of infection. This individual also had evidence of trauma to the skull (see below). |
| 164 | 2 | middle adult | M | rib | | Rib fracture as well as a trauma or infection to the pelvis (see below). |

### 12.1.1 Compression Fractures of the Vertebrae

Trauma to the vertebrae can result from compression fractures caused by a vertical force induced by a hyperflexion injury, or secondary to osteoporosis (Roberts and Manchester 1995). One example of the latter may be observed on SK 95, an old adult female from the medieval period. The bones of this individual were light and it is likely that one of her thoracic vertebral bodies collapsed as a result of osteoporosis.

Three middle adult males from Phase 2 also had collapsed vertebrae. SK 153 had T6 to T8 flattened on the left side of the body, and T9 flattened on the right side of the body, resulting in scoliosis. In contrast, the anterior surface of the first lumbar vertebrae of SK 121 was wedge shaped, resulting in kyphosis. SK 176 also had kyphosis as a result of three wedge-shaped vertebrae (T12, L1 and L3). In this case, the vertebrae appear to have collapsed as a result of large lesions on the inferior surfaces of the body (with the exception of L3). It is possible that these individuals sustained these fractures as a result of a vertical force injury.

## 12.2 SPONDYLOLYSIS

Spondylolysis is a condition were a lumbar vertebra separates into two parts (between the upper and lower joint surfaces on the neural arch), possibly as a result of congenital weakness. It has also been suggested that recurrent stresses and strains as a result of bending and lifting in an upright posture create a gradual series of small fractures in this area of weakness (Roberts and Manchester, 1995).

This condition was observed in the skeletal remains of three middle adult males - all from Phase 2. As well as suffering from collapsed vertebrae, SK 121 had spondylolysis of L5. Skeleton 141 also had spondylolysis of the 5$^{th}$ lumbar vertebra, while uncommonly, SK 171 had spondylylosis of both L3 and L4.

## 12.3 WEAPON WOUNDS

Four of the skeletons had wounds inflicted with weapons - three of which were from Phase 2. The first case was a young adult male (SK 117) from phase 2 who had three sharp edged cut marks on the skeleton. One was present on the left parietal (near the occipital), and extended 53 mm in length. It was slightly angled, so that it sheared the outer table of the skull, and only partially extended into the internal table. The second cut was on the proximal end of the posterior surface of the left femur, and was 33 mm in length. Another was found on the proximal end of the right femur (posterior-lateral surface). This cut was approximately 4 mm deep, but only the cortex was affected. There was no evidence of healing suggesting that the individual died at the time the cuts were made. The placement of the cuts - and the type of cuts suggested a violent attack from behind, with a sharp weapon such as a sword.

Figure 12.1 Cut mark on the posterior surface of the left femur (SK 117)

A middle adult male (SK 152) from Phase 2 had three sharp cut marks to the skull. One was approximately 72 mm in length and extended across both parietals with radiating fractures extending from both ends (one curved into the right side of the frontal bone and the other curved along the left parietal). The cut was angled such that one side was sharp and the other was broken post-mortem, but it did not extend into the endocranial surface (although there was a fracture line along the wound). The second wound bisected the lamboid suture on the left side. It was 41 mm in length, and was slightly angled and did not penetrate the inner table. The last fracture was on the right side of the occipital, however, much of the area was broken post-mortem and the extent of the wound was difficult to assess. A radiating fracture extended from this cut towards the cranial base. There was no evidence of healing suggesting this individual did not survive after the wounds were inflicted. As two of the cuts were on the back of the head, it is likely that the assailant attacked from behind. Given that one of the fractures was on the crown of the head, the individual may have been below the assailant at one point (e.g. kneeling). As injuries with larger weapons are more likely to produce terminal fractures (Wenham 1987), it is possible that a weapon such as a large sword may have been used to produce these fractures.

Figure 12.2 Cut marks on the cranium of SK 152

An old adult male from Phase 2 (SK 158) had two well healed fractures on the left parietal. They were smooth parallel depressions extending from the coronal suture approximately 46 and 30 mm posteriorly, and 12 and 10 mm wide, but did not extend into the internal table. Given the linear nature of the injuries, it is possible that a large blade was used to inflict these injuries, probably in a 'face-to-face' position.

Only one individual from the medieval period had evidence of violent trauma (SK 113). This old adult male had a healed wound to the right parietal bone (near the occipital), possibly as a result of a sharp blade. The wound was oval - approximately 45mm by 35 mm - with definite edges associated with a flat surface, suggesting that the bone was sheared. Within the oval, the bone surface was very slightly irregular, but did not affect the inner table of the skull. The interpretation of a healed bade injury may be supported by the number and type of other fractures present on the skeleton. Together, these injuries suggest that this individual likely experienced violent conflict earlier in his life.

## 12.4 OSTEOCHONDRITIS DISSECANS

Osteochondritis dissecans can be identified by well-defined, porous, and often circular defects in the subchondral bone of a joint surface (see Roberts and Manchester 1995). It occurs as a result of fragmentation and probable disruption of the articular cartilage after trauma (Rogers and Waldron 1995).

There was one possible case of osteochondritis dissecans in the Tarbat sample (not included in the prevalence figures above). A middle adult male from phase 2 (SK 171) had a depression on the superior portion of the articular surface of both acetabulae (approximately 10 mm in size, but triangular in shape). In addition, the femoral heads had plaques of new bone formation (associated with porosities) near the fovea capitis.

## 12. TRAUMA AT TARBAT AND OTHER SCOTTISH SITES

While the number of fractures was small, some types of fractures were consistently observed on the Phase 2 males, such as fractured left clavicles, right proximal fibulae, ribs, compression fractures of the vertebrae and spondylolysis. Most fractures are caused by sudden and excessive force from direct violence (e.g. blow) or indirect violence (e.g. bending or twisting of the bone) (Apley and Solomon, 1988). Rib fractures may occur as a result of a fall or from crushing, or from a direct blow (Roberts and Manchester, 1995). While it was not possible to determine what type of violence was inflicted (except for the cranial injuries), the pattern of fractures may be *suggestive* of shared activity patterns resulting in ?accidental trauma. The weapon wounds were obvious indicators of interpersonal violence.

While there is some difficulty with comparing the percentage of individuals with fractures between sites, it is apparent that there were higher percentages of fractures in the earlier Scottish assemblages compared to the medieval ones (Tables 12.4 and 12.5). A broad overview of all these sites reveals that fractures to the clavicles, vertebrae (compression), ribs, hands, fibulae, 5th metatarsals and cut marks were common to all periods, with males being more affected than females.

Table 12.4 Percentage of individuals with fractures in Scottish sites *c*.8th - 11th century

| Site | Date | N | % Fractures |
|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **62*** | **32.3** |
| Isle of May | 5th - 12th C | 42 | 23.8 |
| Hallow Hill | 6th - 9th C | 37* | 24.3 |

N = number of individuals
* adults only

Table 12.5 Percentage of individuals with in fractures in medieval Scottish sites

| Site | Date | N | % Fractures |
|---|---|---|---|
| **Tarbat** | **12th -15th C** | **61*** | **11.5** |
| Glasgow Cathedral | 12th -19th C | 62* | 14.5 |
| Isle of May | 12th - 17th C | 14 | 14.3 |
| Dundee | 12th - 15th C | 35 | 8.6 |
| Dunbar | Medieval | 76 | 9.2 |
| Whithorn | 13th - 17th C | 926* | 7.0 |
| Aberdeen (C) | 13th - 16th C | 108* | 15.7 |

N = number of individuals
* adults only

## 13.0 INFECTION

Infection was evident on a few of the Tarbat skeletons in the form of periostitis. Periostitis can be identified as fine pitting, longitudinal striation and plaque-like new bone formation on the original cortex surface of the bone as a result of surface inflammation during life (Roberts and Manchester, 1995). In the Tarbat cases, the infections were non-specific - that is, not a result of a specific disease. As well as being a result of infection, periostitis could also result from trauma to the soft tissues (Ortner and Putschar 1985).

Of 130 adult skeletons, 12 (9.2%) had infectious lesions (two children also had infective lesions - see below). Five of these individuals were from phase 2 (8.1%) and seven were from the medieval period (11.5 %). While most of these lesions occurred on the long bones, one individual had spicules of new bone and thickening in the sinuses (SK 176 - a middle adult male from phase 2). This condition is referred to as maxillary sinusitis - a condition caused by the spread of dental infection through the sinus, or as a result of air pollution (such as smoke) or allergies irritating the sinus (Lewis *et al*., 1995). It is likely that its occurrence was underestimated in the Tarbat sample, as sinuses could only be observed when skulls were fragmented. Another individual had fine, porous, grey new bone formation surrounding a dental abscess (SK 35 - a young adult male from the medieval period). Finally, a middle adult male from the medieval period (SK 93) had fine, porous, grey new bone formation on the left side of the mandible (internal and external surfaces) extending from the coronoid process to the gonial angle on the external surface. This individual also had ?neoplastic disease which affected the jaw (see below).

Table 13.1 summarises the infectious lesions observed on the long bones. From this table, it is apparent that the tibia was the most frequently affected bone (with a prevalence rate of 7.8% for both phase 2 and the medieval period), followed by the femur (phase 2: 4.8%, medieval: 0%) and the fibula (phase 2: 2.5%, medieval: 1.4%). No other types of long bones had infective lesions.

Table 13.1 Individuals with infection

| Skeleton | Phase | Age | Sex | Bone | Side | Description |
|---|---|---|---|---|---|---|
| 143 | 2 | old adult | M | tibia | R | Focal area (oval shape, approx. 42 by 14 mm) of well-healed, smooth lamellar bone on the proximal, posterior surface of the shaft. |
| 154 | 2 | middle adult | M | tibia | R | Smooth (well-healed lamellar) new bone formation on the anterior surface at the mid-shaft, extending approx. 80 mm. |
| 148 | 2 | old adult | M | femur | L | Focal area of raised (by approx. 2 mm), well-healed, smooth lamellar bone on the proximal half of shaft. Anterior/lateral surface is thickened in an area extending approx. 41 by 11 mm. |
| 150 | 2 | adult | M | femur | R & L | Striated (rough) new bone formation on distal ends (anterior surface) extending approx. 54 by 10 mm (both femora). |
| | | | | tibia | R & L | Well-healed lamellar bone that is slightly porous and striated (but thickened) (anterior and medial surfaces of distal ends of tibiae are affected - and lateral surface at midshaft). |
| | | | | fibula | L | Striated, but thickened area of new bone at the distal end of the fibula (approx. midshaft). |
| 92 | 3 & 4 | middle adult | F | fibula | R | Well-healed lamellar bone and fine porous, striated grey bone on the distal half of the shaft (medial and posterior surface). |
| 104 | 3 & 4 | adult | ?M | tibia | L | Focal area (oval shape, approx. 40 by 19m) of striated, well-healed lamellar bone at the mid-shaft (medial surface). |
| 107 | 3 & 4 | young adult | M | tibia | R & L | Well-healed lamellar bone (more striated on right side) on proximal, medial surfaces (extends approx. 90 mm +). |
| 108 | 3 & 4 | middle adult | M | tibia | L | Small plaque of well-healed bone (approx. 8 by 16 mm) on the medial side, just above the mid-shaft. |
| 134 | 3 & 4 | young adult | ?M | tibia | R & L | Striated, raised, plaque-like and sclerotic bone on the medial and lateral surfaces of the tibiae (almost entire lengths of shafts are affected). |
| | | | | fibula | R & L | All surfaces affected - bone is more sclerotic on distal end, and striated, plaque-like bone at the proximal end (left fibula). Right fibula is fragmented, but not as extensively affected. |

## 13.1 INFECTION AT TARBAT AND OTHER SCOTTISH SITES

Comparing the percentages of individuals with infection between assemblages was also difficult, as some authors reported percentages for all infectious diseases, whereas others reported percentages for non-specific and specific infections separately. Tables 13.2 and 13.3 present comparable information. In all these assemblages, with the exception of Glasgow Cathedral (which included one case of leprosy), the reported infections were entirely non-specific.

Overall, the percentages of individuals with infectious lesions were low at Tarbat compared to all other assemblages (for both phase 2 and the medieval period), with the exception of Glasgow Cathedral. Generally, the lower limbs are most often affected by infectious lesions in all sites presented below.

Table 13.2 Percentage of individuals with infections in Scottish sites c. 8th - 11th century

| Site | Date | N | % Infections |
|---|---|---|---|
| **Tarbat** | **8th - 11th C** | **62** | **8.1** |
| Isle of May | 5th - 12thC | 42 | 35.7 |

N = number of individuals

Table 12.5 Percentage of individuals with infections in medieval Scottish sites

| Site | Date | N | % Infections |
|---|---|---|---|
| **Tarbat** | **12th -15th C** | **97** | **9.3** |
| Glasgow Cathedral | 12th -19th C | 77 | 5.2 |
| Isle of May | 12th - 17th C | 14 | 28.6 |
| Dundee | 12th - 15th C | 35 | 45.7 |
| Dunbar | Medieval | 76 | 44.8 |

N = number of individuals

## 14.0 METABOLIC DISEASE

Metabolic diseases may be loosely considered as conditions resulting from deficiencies or excesses in diet, or in hormones (Roberts and Manchester, 1995). Three type of conditions were observed in the Tarbat assemblage: anaemia, rickets and osteoporosis (rickets is discussed below in the palaeopathology of subadults - section 19.1).

### 14.1 ANAEMIA

Anaemia occurs when there is a deficiency in the haemoglobin content in red blood cells, or in the number of circulating red blood cells per unit volume of blood. Iron is needed for the development of haemoglobin, but when depleted in the body, the bone marrow is stimulated to increase red cell production. In skeletal material, this process can be macroscopically observed as porous lesions in the external surfaces of the cranial vault (porotic hyperostosis) and orbital roofs (cribra orbitalia), which are a result of hyperplasia of the underlying marrow (see references in Lovell, 1997). It is believed that these lesions are a result of chronic anaemia during childhood (Stuart-Macadam 1985). Causes of anaemia include an iron-deficient diet, excessive blood loss through injury, chronic disease and parasitic infection of the gut (Roberts and Manchester 1995).

Cribra orbitalia was scored using the categories of Buikstra and Ubelaker (1994). Only three adults had cribra orbitalia (1 subadult also had cribra orbitalia - see below), all of which were classified as ‘barely discernable’. These individuals were an old adult male from phase 1 (SK 149), an old adult ?male from Phase 2 (SK 139) and a middle adult male from Phase 2 (SK 176). The individuals from Phase 2 represented 14% of the sample. No cases of porotic hyperostosis were observed on the articulated skeletons.

### 14.2 OSTEOPOROSIS

Osteoporosis is characterised by a reduction in total bone volume, and is correlated with age, although a number of other factors such as diet, sex and exercise are also important (Roberts and Manchester 1995). The diagnosis of osteoporosis in skeletal material can be problematic, however, it is possible that at least two individuals had osteoporosis, both old adult females (SK 155 from Phase 2 and SK 95 from the medieval period). In both cases, the bones were very light, and in one case, a vertebrae had collapsed (SK 95). Scanning electron microscopy of sections of bones may be useful in assessing osteoporosis, and could confirm these diagnoses (Roberts and Manchester, 1995).

### 14.3 METABOLIC DISEASE AT TARBAT AND OTHER SCOTTISH SITES

There was very little evidence of metabolic disease on the articulated burials. However, only 47 adults and 5 subadults had frontal bones that could be observed for cribra orbitalia, and osteoporosis may have been underestimated due to the lack of macroscopic diagnostic techniques.

In Phase 2, 2 out of 22 individuals (9%) with eye orbits had cribra orbitalia and in the medieval period, 1 out of 26 adults and subadults (4%) had this condition. At the Isle of May, 27% of the individuals from the early phase, and 30% from the 12th to 17th century phase, had cribra orbitalia. At Glasgow Cathedral (12th to 15th century), 4% had cribra orbitalia and 16% had it at Aberdeen (13th to16th century). At Whithorn (13th to 15th century), 30% of the individuals had cribra orbitalia, and osteoporosis was observed in 38 skeletons. At Dunbar (medieval), 9% of the individuals had cribra orbitalia, and osteoporosis was observed in two individuals. Finally, 24% of the individuals had cribra orbitalia at Dundee (12th to 15th century) and one skeleton from this site had osteoporosis.

The results from the disarticulated remains suggests that cribra orbitalia may have relatively low at Tarbat compared to other Scottish sites, with the exception of Glasgow Cathedral. However, a high percentage of orbits with cribra orbitalia from the disarticulated material, suggests that the prevalence may be underestimated. The presence of osteoporosis suggests that this condition was observed in Scottish groups in the past, although the prevalence rate is not known.

## 15.0 NEOPLASTIC DISEASE

Neoplastic disease refers to uncontrolled growth of tissue cells which may be either benign or malignant. Malignant neoplasms are characterised by the spread of primary growth into local organs, and into distant organs of the body (metastases) (Roberts and Manchester 1995). Given that malignant neoplasms are uncommon in palaeopathology (Ortner and Putchar 1985), two possible cases of malignant neoplasms at Tarbat is of some significance.

An old adult male from Phase 2 (SK 38) had signs of neoplastic disease on the right pelvis, left pubis and right femoral head. The right pelvis was largely fragmented (the bone was fragile as a result of pathological changes), however, all fragments had new bone formation. Some fragments appeared thickened in size as a result of increased trabecular bone. On other fragments, the cortical bone appeared porous and slightly scalloped in some areas, while in other areas, it was sclerotic or thickened with disorganised new bone formation (woven or spiculed). Similarly, the trabecular bone was thickened in some areas, and destroyed in others. Two lytic lesions with sharp edges (9 x 6 mm and 12 x 10 mm) that exposed underlying trabeculae were present on the left pubis. In addition, the right femoral head demonstrated abnormal bone loss in a focal area near the fovea capitis. This area was slightly scalloped in appearance with irregular, but remodeled edges. This skeleton was greater than 80% complete, and no other lesions were found. An x-ray revealed no additional lesions on the pelvis, although further x-rays need to be conducted.

The pelvis observed at Tarbat was very similar to one described by Waldron (1997). His case is an old adult male from 19th-century London who demonstrated widespread periosteal new bone formation through the skeleton, including the vertebrae. He attributed these changes to prostatic carcinoma. Another similar case, with osteoblastic lesions on the pelvis was presented by Ortner and Putschar (1985). The authors also attributed these changes to metastatic carcinoma of the prostate. The case of Tarbat may also represent a skeletal metastases of a primary tumour - *perhaps* secondary to cancer of the prostate.

The second possible case of neoplastic disease was observed in a middle adult male from the medieval period (SK 93). He had a number of lytic lesions on the skeleton, particularly on the cranium and mandible. There was abnormal bone loss (affecting the external table and diploe) on the frontal bone in the region of the glabella and the left supra-orbital margin, extending approximately 66 by 32 mm. The bone loss appeared like a series of scalloped lesions, although it was rough with some slight spicules. The right side of the mandible was also affected with large (approximately 4 mm deep) overlapping circular lytic lesions. Unlike the cranium, the bone within these lesions was smooth, and the edges were sharp. Alveolar resorption was present around the tooth roots, with subsequent loss of all teeth on the right side of the mandible.

In addition to these changes, several lytic lesions were present on the skeleton, including the left scapula (posterior to the glenoid fossa), left pelvis, rib shafts (four) and the body of L3. Although they varied in size from 8 by 10 mm to 15 by 12mm, all had sharp edges and affected both the cortical and trabecular bone. It appeared that the trabecular bone was affected first, thinning the cortical bone until a hole was produced. Some of the lesions had very fine, porous new bone formation surrounding them, suggesting an inflammatory response. Four lesions were present on the left pelvis: two on the ilium (one which extended from the anterior to the posterior surface), one on the ischium which extended into the acetabulum, and one on the inferior surface of the pubis. The right pelvis did not appear to be affected (by macroscopic examination).

A similar case to the one observed at Tarbat was reported by Greig (1931) of a old adult male with basal cell carcinoma of the frontal sinus. In this case, there was destruction of the frontal bone with no new bone formation and sharp edges (although no lesions were described elsewhere on the skeleton). The presence of lesions on the Tarbat skeleton other than on the cranium was suggestive of metastases (osteolytic metastatic carcinoma), perhaps secondary to the tumour on the face.

No other neoplasms of these types were observed in any other Scottish assemblages. In contrast, common neoplasms were button osteomas (benign small, smooth, round dense bone) observed at the Isle of May (Roberts and Battley 1998), Glasgow Cathedral (King 1994), Dundee (Roberts 1999) and Aberdeen (A) (Cross and Bruce 1989). Two cases of osteochondroma have also been tentatively diagnosed from Aberdeen and Linlithgow (Cross and Bruce 1989).

Figure 15.1 ?Metastatic carcinoma of the right pelvis (SK 38)
Figure 15.2 ?Carcinoma of the face (SK 93)

## 16.0 OTHER

Other miscellaneous pathological conditions were observed at Tarbat, including spina bifida occulta (a congenital condition), and a possible case of kidney stones.

### 16.1 SPINA BIFIDA OCCULTA

Spina bifida occulta is a genetic and congenital defect of the spine (it is not the severe form - spina bifida cystica). It is an asymptomatic condition involving incomplete fusion of the sacrum. This condition was observed in one old adult male (SK 42) from Phase 2. This normal variant has also been observed at Isle of May (5th to 12th century phase)(Roberts and Battley 1998), Glasgow Cathedral (King 1994), Whithorn (Cardy 1997), and Aberdeen (Cardy forthcoming).

### 16.3 POSSIBLE KIDNEY STONES

Three calcified masses were recovered with the right hand (which was placed on the pelvis at burial) of an old adult ?female from the medieval period (SK 97). They measured approximately 15.5 mm by 13.mm, 16.3 by 11.5 and one was broken. The surface of the masses had an appearance of tiny flecks of bone fused together. In some areas the surface was smooth.

## 17.0 UNDIAGNOSED LESIONS

There are often lesions in a skeletal assemblage that cannot be diagnosed either because they are not characteristic of the 'normal' expression of a disease, they are not well-documented in the palaeopathological literature, or the skeleton is incomplete. Two skeletons at Tarbat had lesions on the pelvis which were uncharacteristic of commonly observed pathological conditions.

A middle adult male from Phase 2 (SK 164) had a large lytic lesion (approximately 36 by 28 mm) on the right pelvis in an area superior to the acetabulum, on the posterior surface. The lesion appeared scalloped with very little new bone formation (although there were some spicules and lipping around the acetabulum), and the edges were sharp and irregular. It is possible that this lesion may be a result of infection, although an alternative diagnoses could be neoplastic disease.

A young adult male from Phase 3 (SK 41) had a first sacral vertebrae that was angled upwards on the anterior portion of the body. Ossified ligaments were also present on the right side of the body. L5 was also slightly wedge shaped with some new bone formation (rough and irregular) on the anterior surface of the body. There was also a small facet on the spinous process of L5 with a corresponding facet on the inferior surface of L4 spinous process. The anterior surface of the bodies of L3 and L4 also had small bony nodules. These changes to the bone resulted in a angle between the sacrum and lumbar vertebrae which likely produced a significant kyphosis of the spine.

## 18.0 ANOMALIES OF THE SKELETON

The most common skeletal anomaly was six sacral segments, instead of the ususal five. This anomaly was observed on four skeletons: SK124, SK 140, SK 157 and SK141. Skeleton 141 also had only four lumbar vertebrae. It is noted that all of these individuals were from Phase 2. The only other skeletal anomaly was a left rib with two sternal ends (SK 103). A similar type of rib has also been identified at the Isle of May (5th to 12th century)(Roberts and Battley 1998).

## 19.0 PALAEOPATHOLOGY OF THE SUBADULTS

Only five children had pathological conditions on the skeleton - all from the medieval period. Two children had infective lesions, one which was less than 6 months of age (SK 22). Two rib fragments from the infant skeleton had small areas of raised, porous, new bone formation on the internal surfaces. The second child was older (in the 10.6 to 14.5 year age group - SK 110) and had fine, porous new bone formation on the distal end (anterior surface) of the right femur, extending approximately 23 by 13 mm. The left radius was also thicker in size than the right radius.

Cribra orbitalia was observed in one subadult aged from 6.6 to 10.5 years (SK 86), but was only barely discernable (Buikstra and Ubelaker, 1994). Finally, the femora were slightly bowed anteriorly in a child aged from 2.6 to 6.5 years (SK 63). In addition, the femora and tibiae were slightly bowed anteriorly in a child aged from 0.6 to 2.5 years of age (SK 6). These changes were characteristic of rickets - a condition caused by vitamin D deficiency which results in 'softening' of the bones. When a child begins to walk, the weight-bearing boned become bowed (Roberts and Manchester, 1995). Sources of vitamin D come from fish oil, animal fat and sunlight. The presence of rickets suggests that these children may have been swaddled or kept indoors during the first year of life and ate foods which lacked vitamin D.

There was no evidence of rickets at Aberdeen (Cross and Bruce 1989; Cardy forthcoming), Linlithgow (Cross and Bruce

1989) or Whithorn (Cardy 1997) although there was a possible case of rickets at the Isle of May (Roberts and Battley 1998). Thus, the cases of rickets at Tarbat may be anomalous.

## 20.0 THE DISARTICULATED REMAINS

The following sections present a brief analysis of 3,827 fragments and 2,482 bones collected from the soil between the articulated burials. As there was no phasing for these bones, the results were presented together. In addition to these disarticulated remains, Prof. Don Brothwell examined a 'charnel' deposit beneath the flagstone floor of the nave which represented a single context. Prof. Brothwell's detailed recording forms are available from FAS at the University of York. Where possible, some of the results of his analyses will be incorporated into the present overview. For the disarticulated remains examined below, detailed cranial measurements, non-metric traits, and dental disease were recorded for future reference. All other information, including that presented below, is available on a SPSS database (version 9.0).

### 20.1 MINIMUM NUMBER OF INDIVIDUALS

Tables 20.1 and 20.2 present an overview of the disarticulated fragments and bones by element and age (subadult vs. adult). Based on the number of complete left femora, the minimum number of subadults was 22, and based on the number of complete left tibiae, the adult MNI was 31, giving a total MNI of 53. For the 'charnel' deposit, an "MNI of a little over a 100" was estimated using the mandibles and sacra (Roe and Brothwell 1997). In this deposit, there were 51 left subadult femora and 69 left adult tibiae - giving an overall MNI of 173.

Table 20.1 Incomplete fragments (N = 3,827)

| | **Subadult** | **Adult** |
|---|---|---|
| Skull | 663 | 296 |
| Maxilla | 9 | 18 |
| Mandible | 14 | 29 |
| Teeth | 41 | 149 |
| Vertebrae | 339 | 149 |
| Sacrum | 26 | 25 |
| Pelvis | 48 | 118 |
| Sternum | 15 | 11 |
| Ribs | 298 | 612 |
| Clavicle | 14 | 16 |
| Scapula | 23 | 85 |
| Humerus | 12 | 71 |
| Radius | 18 | 48 |
| Ulna | 13 | 48 |
| Carpals | | 1 |
| Metacarpals | 5 | 21 |
| Phalanges (hand) | | 7 |
| Femur | 29 | 62 |
| Patella | | 1 |
| Tibia | 32 | 70 |
| Fibula | 21 | 99 |

| | Subadult | Adult |
|---|---|---|
| Tarsals | 1 | 25 |
| Metatarsals | 1 | 40 |
| Phalanges (foot) | 1 | 8 |
| Epiphyses | 88 | |
| Unidentified | 15 | 92 |
| **Total** | **1,726** | **2,101** |

Table 20.2 Complete bones (N = 2,482)

| | Subadult | | | Adult | | |
|---|---|---|---|---|---|---|
| | U | R | L | U | R | L |
| Skull | 2 | | | 24 | | |
| Maxilla | 2 | 10 | 8 | 11 | 1 | |
| Mandible | 8 | 7 | 4 | 12 | 1 | |
| Vertebrae | 73 | | | 255 | | |
| Sacrum | | | | 13 | | |
| Pelvis | | 5 | 4 | | 11 | 9 |
| Ilium | | 15 | 8 | | | |
| Ischium | | 8 | 9 | | | |
| Pubis | | 7 | 7 | | | |
| Sternum | 1 | | | 3 | | |
| Ribs | 2 | 86 | 84 | | 54 | 55 |
| Clavicle | | 10 | 11 | | 12 | 10 |
| Scapula | | 8 | 12 | | 10 | 9 |
| Humerus | | 18 | 21 | | 13 | 14 |
| Radius | | 8 | 10 | | 17 | 10 |
| Ulna | | 12 | 10 | | 8 | 17 |
| Carpals | 2 | | | 136 | | |
| Metacarpals | 52 | | | 169 | | |
| Phalanges (hand) | 72 | | | 246 | | |
| Femur | | 19 | 22 | | 21 | 21 |
| Patella | | | | | 18 | 9 |
| Tibia | | 22 | 18 | | 17 | 31 |
| Fibula | 18 | | | | 6 | 13 |
| Tarsals | 13 | 9 | 5 | 119 | 42 | 44 |
| Metatarsals | 63 | | | 212 | | |
| Phalanges (foot) | 5 | | | 35 | | |
| Total | 313 | 228 | 233 | 1,235 | 231 | 242 |

## 20.2 AGE ESTIMATION

When the pelvis was present, adult age was determined based on the pubic symphysis and auricular surface (see section 3.1.1). However, age could only be determined on eleven right pelves: one young adult, six middle adults and four old adults. The significance of these findings were limited, other than to suggest that all adult age groups were represented in the disarticulated remains. Similarly, in the ‘charnel’ deposit, three young adults, twenty-four middle adults and ten old adults were identified.

For twenty-two subadults, age could be determined by comparing the left femoral lengths to the references of Ubelaker (1989). These comparisons revealed that two were foetal, seven were probably less than 6 months of age, six were between 0.6 and 2.5 years, two were between 2.6 and 6.5 years, two were between 6.6 and 10.5 years, and three were probably between 10.6 and 18.5 years (the reference data were not adequate for the teenage years to divide into smaller age groups). While there are some problems with this ageing technique, these finding suggest that subadults of all ages were represented in the disarticulated material, particularly children below 2.5 years of age. In the analyses of the ‘charnel’ deposit, Brothwell found that the majority of subadults (94%) were less than 6.5 years of age (based on dental eruption/development of teeth from the left or whole mandible).

## 20.3 SEX DETERMINATION

Based on an examination of the right pelves, five females and six males were identified. Again, these findings suggest that both sexes were represented in the disarticulated material. Similarly, Brothwell identified both females and males in the 'charnel' deposit.

## 20.4 STATURE

Stature was estimated from seven female and four male left femora using the equations of Trotter (1970). These females ranged in stature from 149.7 cm to 160.8 cm (with an average of 154.9 cm) and the males ranged in stature from 168.5 cm to 171.6 cm (with an average of 170.7 cm). Although the sample sizes were small, these estimates were found to fall within the ranges observed for the total sample of articulated burials (section 5.1). The average height of the males from the ‘charnel’ deposit was 167.7 cm.

## 20.5 LOWER LIMB SHAPE

Eighteen left femora could be measured to determine the meric index and all were found to be platymeric (i.e. an index below 8.9 suggesting flattened femoral shafts). This corresponded well with the femora from the articulated burials where the majority were also found to be platymeric.

Twenty-six left tibiae could be measured and 19% were found to be platycnemic, 42% were mesocnemic and 39% were eurycnemic. These percentages were broadly similar to those observed from the articulated burials, although more tibiae were eurycnemic than mesocnemic in the articulated burials (see section 6.1).

## 20.6 CRANIAL INDEX

The cranial index was calculated for 24 disarticulated skulls (see section 7.1). They ranged from 73.6 to 83.5 mm, with an average of 78.2 mm (SD = 2.48). When examined as percentages in each class, 8% were found to be dolichocranic (narrow or long heads), 58% were mesocranic (average or medium shaped) and 33% were brachycranic (broad or round headed). In the 'charnel' deposit, the mean cranial index was 77.8 mm (SD = 3.1) with a range from 71.7 to 86.6 mm (N = 45). The majority of these skulls were also mesocranic (56%), while 24% were brachycranic and 20% were dolichocranic. Overall, there is considerable evidence to suggest that the majority of individuals recovered from Old Tarbat church had average or medium shaped heads.

## 20.7 NON-METRIC TRAITS

Cranial and post-cranial non-metric traits were recorded when possible on the disarticulated remains. A selected list of traits is presented in Table 20.3. For the post-cranial traits, only bones from the left side of the skeleton were included in the table. Similar to the articulated remains (total sample), supraorbital notches, parietal foramen and ossicles in the lambdoid were commonly observed on the disarticulated bones. A higher percentage of crania had epipteric bones in the disarticulated material than in the articulated material (32% vs. 14% for the total sample). The percentages of post-cranial traits differed between the articulated and disarticulated material, although both demonstrated that the lateral tibial squatting facet was the most frequently observed trait, followed by the double anterior calcaneal facet.

In the ‘charnel’ deposit, ten out of seventy-six (13%) of the crania demonstrated metopism. This figure is similar to that observed on the disarticulated ( 11%) and the articulated material (13% for the total sample). Other cranial non-metric traits were recorded by Prof. D. Brothwell, but were not included in this analysis.

Table 20.3 Cranial and post-cranial traits observed on the disarticulated remains

| **Trait** | **N** | **P (%)** |
|---|---|---|
| Metopic suture | 35 | 4 (11) |
| Supraorbital notches | 31 | 23 (74) |
| Supraorbital foramen | 30 | 13 (43) |
| Parietal foramen | 31 | 17 (55) |
| Epipteric bone present | 25 | 8 (32) |
| Ossicles in lambdoid | 32 | 18 (56) |
| Septal aperture | 17* | 0 |
| Allen's fossa | 21* | 4 (19) |
| Poirer's facet | 21* | 4 (19) |
| Vastus notch | 12* | 1 (8) |
| Medial tibial squatting facet | 29* | 3 (10) |
| Lateral tibial squatting facet | 29* | 21 (72) |
| Double inf-ant talar facet | 17* | 9 (53) |
| Double anterior calcaneal facet | 18* | 10 (56) |

N = number of bones observed (* left side)
P = number exhibiting trait

## 20.8 HEALTH AND DISEASE

Dental disease, osteoarthritis, spinal joint disease, a fracture, weapon wounds, osteochondritis dissecans, non-specific infection, cribra orbitalia and rickets were observed on the disarticulated remains. These conditions were also observed on the articulated skeletons, and on the skeletons from the ‘charnel’ deposit. Overall, these diseases were ubiquitous at Tarbat.

### 20.8.1 Dental Disease

The teeth and alveolar bone from 24 maxillae and 18 mandibles were examined, and all except one individual (represented by a mandible) had at least one type of dental disease. As might be expected, calculus was the most frequently observed disease, although caries, dental enamel hypoplasia, dental abscess, ante-mortem tooth loss and alveolar resorption (periodontal disease) were also observed. A detailed record of these dental diseases exists for future analyses.

20.8.2 Joint Disease

There were 138 fragments/bones with joint changes (including osteophytes). Table 20.4 presents the percentage of complete bones with OA (as defined in section 11.1) out the total number of observable bones. The right clavicle and scapula were frequently affected by OA.

Table 20.4 Disarticulated bones (complete) with OA

| | **N** | **n (%)** |
|---|---|---|
| Carpals | 136 | 3 (4) |
| Metacarpals | 169 | 3 (2) |
| Phalanges (hand) | 246 | 1 (0.4) |
| Metatarsals | 212 | 3 (1) |
| R clavicle | 12 | 3 (25) |
| L clavicle | 10 | 1 (10) |
| R scapula | 10 | 2 (20) |
| R radius | 17 | 2 (12) |
| R pelvis | 11 | 1 (9) |
| R femur | 21 | 1 (5) |

20.8.3 Spinal Joint Disease

There were 127 vertebral fragments/bones with osteophytes, Schmorl's nodes, and/or osteoarthritis. Of the complete vertebrae, 45 had spinal joint disease (10 had Schmorl's nodes and 35 had OA). Overall, 18% of those vertebrae were affected by SJD. This percentage is less than that observed for the articulated burials (47%).

20.8.4 Trauma

Only one fracture was observed on the disarticulated bones - a phalanx from the hand of an adult. However, there were three vertebral compression fractures, one case of spondylolysis (adult), two cases of osteochondritis dissecans (one on the distal end of an adult humerus fragment, and one on an adult talus), two enthesopathies (one on the right femur of an adult male and one on a right adult fibula) and four weapon wound cases.

The first weapon wound case was on a maxilla of a middle adult of unknown sex (17/1229). A sharp edged weapon had sliced the whole maxilla roughly horizontally. The second case was present on a middle adult male (17/1132). The sharp edged blade wound extended approximately 84 mm in a sagittal plane from the left frontal to the left parietal. The blade appeared to have acted like a wedge and displaced a large, square piece of bone (the edges were rough on all three other sides of the wound). Another adult male had a sharp horizontal blade wound on the inferior surface of the right zygomatic (17/1211). There was also a shearing wound on the left frontal bone, just above the zygomatic. It appears that the maxilla would have been separated from the rest of the face. It is noted however, that the maxilla described above did not belong to this skeleton.

Finally, a large cranial fragment had a round perforation (approximately 9mm in diameter) on the left parietal near the coronal and sagittal sutures which extended into the internal table (20/1204). The wound was slightly beveled so that the internal surface was slightly larger than the external surface. A radiating fracture extended from this lesion. There were also two cuts on this skull - one on the right parietal (approximately 26mm) which was very shallow and did not penetrate the internal table, and one (approximately 23 mm) on the right side of the frontal. In all of the above cases, no healing was observed.

Figure 20.1 Weapon wounds observed on the disarticulated crania

### 20.8.5 INFECTION

There were 41 cases of non-specific infection observed on the disarticulated fragments/bones. Nine cases of new bone formation were observed on the endocranial surface of subadult skull fragments. Conditions that could cause inflammation or haemorrhage of the meningeal vessels include meningitis, epidural haematomas, birth trauma, scurvy and tuberculosis (Kreutz *et al*., 1995; Schultz, 1993). While the cause of these lesions on the Tarbat material is not known, they are indicators of serious childhood illness.

Grey, porous, raised new bone formation was also present on a subadult tibia fragment, right tibia and fibula. Table 20.5 presents the fragments/bones with infectious lesions on the adult material. Similar to the articulated material, most of the infectious lesions were observed on the lower limbs. In addition to these lesions, there were three cases of maxillary sinusitis (one subadult (6.6 to 10.5 years of age) and two adults).

Table 20.5 Infectious lesions on the adult disarticulated fragments/bones (n = 26)

| | **Grey/ Porous** | **Lamellar** | **Woven and Lamellar** |
|---|---|---|---|
| Metatarsals (fragments) | 1 | | |
| Metatarsals (complete) | 2 | | |
| Radius (fragments) | | | 1 |
| L ulna (complete) | 1 | | |
| R femur (complete) | 2 | 1 | 1 |
| Tibia (fragments | 3 | | |
| R tibia (complete) | 1 | 1 | |
| L tibia (complete) | 2 | | |
| Fibula (fragments) | 3 | 6 | 1 |

### 20.8.6 METABOLIC DISEASE

Cribra orbitalia (porosites and/or coalescing porosities) was observed on 19 skull fragments/crania. Eleven skull fragments were from children and two were from adults. Six complete skulls had cribra orbitalia (1 young adult female, 2 adult females, 2 adult males and 1 middle adult male), two of which also had healed porotic hyperostosis. Table 20.6 presents the number of right and left orbits examined, and the percentage with cribra orbitalia. These figures were relatively high compared to the articulated remains (see section 14.3).

Table 20.6 Cribra orbitalia

| | **Right Orbit** | | **Left Orbit** | |
|---|---|---|---|---|
| | **N** | **n (%)** | **N** | **n (%)** |

| | | | | |
|---|---|---|---|---|
| Subadults | 13 | 7 (54) | 15 | 6 (40) |
| Adults | 22 | 8 (36) | 20 | 6 (30) |
| **Total** | **35** | **15 (43)** | **35** | **12 (34)** |

N = number of orbits observed

n = number of orbits with cribra orbitalia

There were four possible cases of rickets observed in the disarticulated material. One right radius, one left radius and two right femora were bowed. All were subadults - 3 which were probably between 0.6 and 2.5 years of age, and one which was 2.6 to 6.5 years of age. No cases of osteoporosis were identified in the disarticulated material.

20.8.7 POSSIBLE NEOPLASTIC DISEASE

There was one possible case of neoplastic disease on an adult proximal humerus fragment (also demonstrating osteoporosis). The articular surface appeared as a slightly expanded thin shell of bone with no underlying trabeculae. There was also a bony projection of bone just below the 'articular' surface on the lateral side (due to trauma?). This new bone formation may an osteoclastoma (giant cell tumor). This is a border-line benign neoplasm that is commonly observed in the proximal and distal ends of long bones (Ortner and Putschar 1985; Aufderheide and Rodríguez-Martín 1998). Two other cases of neoplastic disease have also been identified in the 'charnel' deposit by Prof. Brothwell.

Figure 20.2 ?Neoplastic disease on a proximal humerus fragment

20.8.8 OTHER

There was only one case of spina bifida occulta observed on an adult sacrum. One adult axis also demonstrated non-fusion of the lamina.

20.8.9 ANOMALIES OF THE SKELETON

One adult ?male had six sacral segments instead of five. No other skeletal anomalies were observed.

**21.0 SUMMARY AND DISCUSSION**

Most of the skeletons from Tarbat were from an 8th to 11th century phase (Phase 2) (N = 67) or a 12th to 16th century medieval period (Phases 3 and 4) (N = 99). In Phase 2, the individuals were mostly males who lived until middle or old age, whereas the medieval period was represented by individuals of all ages. In this later period, there was a more equal representation of females to males, with a ratio of 1:1.6, whereas in Phase 2 the ratio of females to males was 1:9.2. Overall, these differences suggest that there was a change in burial practice within the church through time.

The majority of phase 2 Tarbat individuals died at older ages compared to the Isle of May (6th to 9th century phase) and Hallow Hill (6th to 9th century). However, similar to Tarbat, very few females were buried at the Isle of May during the monastic phase. The majority of individuals from the medieval period at Tarbat also lived to relatively older ages in comparison to other medieval Scottish assemblages, with the exception of Glasgow Cathedral (12th to 15th century phase). At that site, most individuals died as middle or old adults. There was also an almost identical ratio of females to males at Tarbat (Phases 3 and 4) and Glasgow Cathedral.

The stature of the females and males from Phase 2 (5'3" and 5'7" respectively) was comparable to the Isle of May and

Hallow Hill. The stature of the medieval individuals from Tarbat was slightly less than their Scottish contemporaries. In addition, the medieval females were, on average, less tall than the females from Phase 2. Overall, however, the average medieval female height of 5'1" and the average male height of 5'6" were not largely different than the average modern Scot (females: 5'4" and males: 5'10", Knight, 1984).

In terms of physical features, the Tarbat Phase 2 individuals had a similar lower limb shape to the individuals buried at Isle of May (5th to 12th century phase) - that is, the majority of individuals had anterior-posterior flattening of the femoral shaft, and broad tibiae. The lower limb shape of the Phase 2 individuals was also similar to those from the medieval period at Tarbat. Medieval Scottish assemblages generally demonstrate a pattern on anterior-posterior flattening of the femora, whereas tibiae were either broad or moderately flattened - depending on the site.

There were no differences in cranial morphological features through time at Tarbat (when examined as averages). Overall, the males and females had medium shaped crania, low skull height, narrow faces and nasal apertures, medium sized eye orbits and broad palates. However, when examined as proportions, an equal number of individuals from Phase 2 had narrow heads or medium shaped heads. In the medieval period, most individuals had medium shaped heads, although a third also had broad heads. Most of the individuals from other Scottish medieval assemblages had medium or broad shaped heads. Overall, the physical features of the Tarbat individuals were not unlike to those observed on individuals from other Scottish sites.

The Tarbat individuals suffered from a number of diseases - the most frequently observed being dental disease. Calculus, abscesses, ante-mortem tooth loss and dental wear were more frequently observed in Phase 2 than in the medieval period. However, medieval teeth were more likely to have caries and dental enamel hypoplasia. In addition, female teeth from the medieval period were more likely to have caries, dental enamel hypoplasia, calculus and ante-mortem tooth loss than the male teeth. Overall, the prevalence of caries in Phase 2 and in the medieval period was similar to other contemporary Scottish sites. In the medieval phase at Tarbat, however, there was more ante-mortem tooth loss and dental enamel hypoplasia than in the Glasgow Cathedral dentitions.

These findings suggested that there were differences in diet and oral hygiene between the two phases, between the females and males from the medieval period, and between the Tarbat and Glasgow Cathedral individuals. In Phase 2, the diet may have been more coarse than during the medieval period at Tarbat. Indeed, a small particle of stone was embedded in the pulp cavity of one of the well worn teeth from Phase 2. The heavy wear may have also resulted in exposure of the pulp cavities, causing dental abscesses. The presence of heavy calculus may be associated with diet type and/or the lack of oral hygiene to remove plaque build-up.

Similarly, the high frequency of dental disease in medieval females may be indicative of a difference in diet (and oral hygiene) between the sexes. It is possible that women may have been eating more high carbohydrate foods (or more sugary foods) than the males. It has been suggested that the consumption of animal protein may be associated with better dental health (Larsen, 1997).

The high prevalence of dental enamel hypoplasia at Tarbat in comparison to Glasgow Cathedral suggests that environmental stress during childhood may have been experienced more often (or more severely) by the Tarbat individuals, particularly by the females.

Osteoarthritis was also frequently observed in both phases (and sexes) at Tarbat - the pattern of joint involvement reflected what might be expected in groups of mainly middle and older adults, rather than reflecting any unusual stresses of the joints. There were however, differences in the pattern of spinal joint disease, with more vertebrae being affected in phase 2 (52%) than in the medieval period (39%). Particularly, T10, L1 and L2 were more affected by spinal joint disease in Phase 2.

These observations, along with three cases of spondylolysis (a condition which may occur as a result of bending and lifting in an upright posture) and three cases of compression fractures of the vertebrae (possibly as a result of a vertical force injury) suggested that the Phase 2 individuals may have participated in activities resulting in lower back stress more frequently than the medieval individuals. There is also evidence to suggest that this stress began at younger ages in Phase 2 than in the medieval period.

There were also differences in the number of individuals with traumatic injuries between the phases, with more Phase 2 individuals suffering from fractures (32%) than the medieval individuals (12%). In addition, similar types of fractures were consistently observed on the Phase 2 skeletons, including three fractures of the left clavicle and three of the right proximal fibula. It is possible that these individuals experienced similar accidents. There was also evidence of interpersonal conflict at Tarbat - sharp edged weapon wounds were present on three skeletons from Phase 2, and one from the medieval period (as well as four cases in the disarticulated remains). Weapon wounds have been observed in other Scottish sites spanning all time periods. Overall, a higher percentage of fractures were observed in earlier Scottish assemblages compared to the medieval assemblages.

In contrast to other Scottish assemblages (with the exception of Glasgow Cathedral), the Tarbat individuals did not have very many infectious lesions on their bones (phase 2 = 8.1% and the medieval period = 9.3%). In all assemblages, including Tarbat, the majority of the lesions were on the lower limbs.

Analysis of the articulated burials suggested that metabolic disease was low at Tarbat, with very few individuals showing signs of cribra orbitalia (9% in phase 2 and 3.8% in the medieval period). A similarly low percentage was also observed at Glasgow Cathedral (4.2%), whereas in other assemblages, higher percentages of individuals were affected. It is noted however, when the disarticulated remains were analysed, several orbits were affected by cribra orbitalia, suggesting that the prevalence of anaemia may have been underestimated in the articulated sample from Tarbat.

Unlike other Scottish assemblages, there were several cases of rickets observed in the Tarbat articulated and disarticulated remains. These children may have been swaddled or kept indoors (out of the sun) and/or ate foods which lacked vitamin D.

Tarbat also differed from other Scottish assemblages by having five possible cases of neoplastic disease (two from articulated burials, one from the disarticulated material and two from the ‘charnel’ deposit). One case was a possible metastatic carcinoma, perhaps secondary to prostate cancer. Another was a possible primary tumour to the face (basal cell carcinoma?) with secondary changes (metasteses) to the scapula, pelvis, ribs and a lumbar vertebra. The changes on the disarticulated bone remains undiagnosed, although osteoclastoma may be a possibility.

## 21.1 CONCLUSIONS

The demographic pattern in Tarbat Phase 2 was most similar to the Isle of May, suggesting that this phase may represent a monastic community. In contrast, the medieval period at Tarbat was more representative of a family community - consisting of children, women and men. The age and sex profile of the medieval phase was most similar to that observed at Glasgow Cathedral. As the burials were recovered within the parish church at Tarbat and Glasgow Cathedral, they might be expected to be of a higher status than those buried outside of the church. As both of these sites have relatively higher percentages of older individuals in their medieval phases, it is conceivable that Scottish people of relatively high status sometimes lived to older ages, or that old adults were often given more prestigious burials.

Although the Tarbat individuals died at relatively older ages in comparison to most other Scottish groups, there was evidence that the medieval men, and particularly the women, suffered from some environmental stress. They were slightly shorter in stature than their contemporaries, and the high prevalence of dental enamel hypoplasia suggests that they likely suffered from nutrition-infection interactions during childhood. The number of medieval children with rickets (and perhaps also anaemia) at Tarbat is suggestive of nutritional deficiencies, although anaemia may also result from other conditions including chronic disease or parasitic infection (Roberts and Manchester 1995). There was also evidence of non-specific infection on the crania of several subadult skull fragments from the disarticulated remains. Thus, while the adults who survived childhood lived to relatively old ages, childhood morbidity and mortality were prevalent at medieval Tarbat. Those individuals who did survive to adulthood suffered from age related diseases including osteoarthritis, spinal joint disease and osteoporosis.

The low percentage of individuals with infectious lesions at Tarbat, and the lack of specific diseases such as tuberculosis and leprosy may suggest that the population was not dense enough for these diseases to become prevalent (see Larsen 1997). The presence of infectious lesions on the skeleton is indicative of long-term responses to pathogens. Thus, while acute diseases may have been present, there is evidence to suggest that some individuals survived long enough to elicit a skeletal response, and therefore, may have had relatively healthy immune systems (Ortner 1991).

Overall, the body build and head shape of the Tarbat individuals (from Phase 2 and the medieval period) was similar to their Scottish contemporaries. As discussed above, there was paleopathological evidence to suggest that the individuals from Phase 2 differed from the medieval period in terms of diet and perhaps, activity patterns. Moreover, there is evidence to suggest that although the medieval individuals suffered from childhood illnesses, they may have been healthier in older ages than other contemporary Scottish population groups, with the exception of Glasgow Cathedral.

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## Appendix I Sites Used for Comparison

**Isle of May** (5th to 12th and 12th to 17th C phases):

Roberts, J.A. and N. Battley (1998) Skeletal Remains from the Isle of May Excavations 1995-1997. Unpublished GUARD report (incorporating data from King, S.E. (1995) Human remains from the Isle of May. Unpublished GUARD report).

**Hallow Hill, St. Andrews** (6th to 9th C):

Young. A. (1996) The skeletal material. In E. Proudfoot: Excavations at the long cist cemetery on the Hallow Hill, St. Andrews, Fife, 1975-7. *Proceedings of the Society of Antiquaries of Scotland* 126:429-431.

Lunt, D. (1996) The dentitions. In E. Proudfoot: Excavations at the long cist cemetery on the Hallow Hill, St. Andrews, Fife, 1975-7. *Proceedings of the Society of Antiquaries of Scotland* 126:424-429.

**Glasgow Cathedral** (12th to 15th C):

King, S.E. (1994) The human skeletal remains from Glasgow Cathedral Excavations 1992-93. Unpublished GUARD report.

**Dundee** (12th to 15th C):

Roberts, J. (1999) Skeletal Remains from City Churches, Dundee. Unpublished GUARD report.

**Dunbar** (medieval):

Roberts, J. (1999) Skeletal Remains from Dunbar. Unpublished GUARD report.

**Whithorn (13th to 15th C):**

Cardy, A. (1997) The human bones. In P. Hill: *Whithorn and St. Ninian: The Excavation of a Monastic Town, 1984-91*. Stroud: Sutton Publishing Ltd. pp. 519-562.

Lunt, D.A and M.E. Watt (1997) The human dentitions. In P. Hill: *Whithorn and St. Ninian: The Excavation of a Monastic Town, 1984-91*. Stroud: Sutton Publishing Ltd. pp. 562-592.

**Aberdeen A*** (c.13th to 17th C):

Cross, J.F. and M.F. Bruce (1989) The skeletal remains. In J.A. Stones (ed.): *Three Scottish Carmelite Friaries: Aberdeen, Linlithgow and Perth*. Edinburgh: Society of Antiquaries of Scotland Monograph Series Number 6. pp.119-141.

**Aberdeen B* and C* (13th to 16th C):**

Cardy, A. (forthcoming) The human remains. In A.S. Cameron and J.A. Stones: *Aberdeen Carmelite Friary Revisited*. Internet Archaeology.

*Initial analysis of Aberdeen was conducted by Cross and Bruce, refered to as 'A'. Additional skeletons from this site were later analysed by Cardy (B) and her report included some data for the combined sample (C). Data from the combined sample was used in the present report whenever possible.

**Linlithgow** (c. 13th to 17th C):

Cross, J.F. and M.F. Bruce (1989) The skeletal remains. In J.A. Stones (ed.): *Three Scottish Carmelite Friaries: Aberdeen, Linlithgow and Perth*. Edinburgh: Society of Antiquaries of Scotland Monograph Series Number 6.

pp.119-141.

Kerr, N.W., Bruce, M.F. and J.F. Cross (1990) Caries experience in Medieval Scots. *American Journal of Physical Anthropology* 83: 69-76.

**Kirkhill** (medieval):

Lunt, D.A. (1996) Mediaeval dentitions from St. Andrews. In: E. Cruwys and R.A. Foley (eds.) *Teeth and Anthropology*. Oxford: Bar International Series 291.

**Appendix II Cranial Indices of the Females and Males**

Cranial indices of the Tarbat females (all phases)

| | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| cranial index | 6 | 77.9 | 4.0 | 73.2 | 84.4 |
| mean height index | 5 | 80.1 | 2.1 | 77.4 | 83.0 |
| fronto-parietal index | 5 | 67.9 | 2.3 | 64.5 | 71.1 |
| upper facial index | 3 | 52.2 | 7.2 | 44.4 | 58.5 |
| nasal index | 3 | 50.7 | 8.2 | 45.7 | 60.2 |
| orbital index | 4 | 89.5 | 6.7 | 83.4 | 98.2 |
| maxilloalveolar index | 3 | 124.5 | 10.3 | 115.5 | 135.8 |

Cranial indices of the Tarbat males (all phases)

| | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| cranial index | 30 | 76.9 | 4.3 | 65.7 | 88.3 |
| mean height index | 24 | 78.2 | 7.0 | 49.2 | 88.9 |
| fronto-parietal index | 24 | 67.7 | 7.0 | 38.4 | 79.3 |
| upper facial index | 5 | 61.0 | 14.0 | 45.8 | 77.6 |
| nasal index | 20 | 46.2 | 3.9 | 40.3 | 52.8 |
| orbital index | 17 | 86.3 | 5.4 | 76.9 | 100.0 |
| maxilloalveolar index | 11 | 112.5 | 6.6 | 112.5 | 130.7 |

**Appendix III Non-Metric Traits (Total Sample)**

Prevalence of cranial non-metric traits (total sample)

| Trait | N | P | % |
|---|---|---|---|
| Metopic suture | 55 | 7 | 12.7 |
| Supraorbital notches | 50 | 40 | 80.0 |
| Supraorbital foramen | 51 | 24 | 47.1 |
| Multiple infraorbital foramen | 33 | 5 | 15.2 |
| Zygomatico-facial foramen | 40 | 34 | 85.0 |
| Parietal foramen | 47 | 26 | 55.3 |
| Epipteric bone present | 43 | 6 | 14.0 |
| Fronto-temporal articulation | 43 | 1 | 2.3 |
| Ossicles in coronal | 47 | 2 | 4.3 |
| Ossicle at bregma | 47 | 0 | - |
| Sagittal ossicles present | 50 | 1 | 2.0 |
| Apical bone present | 52 | 7 | 13.5 |
| Ossicles in lambdoid | 52 | 28 | 53.8 |
| Asterionic bone present | 50 | 9 | 18.0 |
| Ossicle in occipito-mastoid | 50 | 1 | 2.0 |
| Ossicle at parietal notch | 51 | 8 | 15.7 |
| Inca bone present | 54 | 0 | - |
| Condylar canal present | 41 | 21 | 51.2 |
| Divided hypoglossal canal | 43 | 10 | 23.3 |
| Foramen ovale incomplete | 37 | 1 | 2.7 |
| Foramen spinosum incomplete | 36 | 12 | 33.3 |
| Double condylar facet | 40 | 5 | 12.5 |
| Auditory exostosis | 55 | 0 | - |
| Mastoid foramen | 54 | 39 | 72.2 |
| Two mental foramen | 58 | 1 | 1.7 |
| Mandibular torus | 59 | 13 | 22.0 |
| Mylohyoid bridge | 53 | 3 | 5.7 |

N = number of individuals observed

P = number of individuals exhibiting trait on either or both sides

Prevalence of post-cranial non-metric traits (total sample)

| Trait | N | P | % |
|---|---|---|---|
| Atlas bridging | 38 | 10 | 26.3 |
| Accessory transverse foramen | 50 | 20 | 40.0 |
| Suprascapular foramen | 41 | 3 | 7.3 |
| Circumflex sulcus | 71 | 17 | 23.9 |
| Acromial articular facet | 53 | 3 | 5.7 |
| Sternal foramen | 38 | 0 | - |
| Septal aperture | 84 | 6 | 4.3 |
| Supracondyloid process | 83 | 1 | 1.2 |
| Allen's fossa | 89 | 4 | 4.5 |
| Poirer's facet | 85 | 13 | 15.3 |
| Vastus notch | 65 | 11 | 16.9 |
| Third trochanter | 98 | 8 | 8.2 |
| Medial tibial squatting facet | 72 | 5 | 6.9 |
| Lateral tibial squatting facet | 74 | 48 | 64.9 |
| Double inferior-anterior talar facet | 67 | 27 | 40.3 |
| Double anterior calcaneal facet | 69 | 34 | 49.3 |

N = number of individuals observed

P = number of individuals exhibiting trait on either or both sides

**Appendix IV Number of Observable Teeth**

Number of observable teeth (total sample, N = 1,249)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 26 | 34 | 30 | 42 | 44 | 43 | 31 | 29 | 30 | 37 | 38 | 42 | 41 | 35 | 32 | 25 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 36 | 51 | 46 | 46 | 47 | 49 | 46 | 37 | 34 | 41 | 53 | 51 | 44 | 39 | 41 | 29 |

Number of observable teeth (phase 2, N = 557)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 15 | 15 | 12 | 16 | 18 | 18 | 10 | 9 | 13 | 14 | 15 | 19 | 16 | 14 | 13 | 13 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 20 | 26 | 24 | 21 | 21 | 24 | 22 | 15 | 12 | 18 | 22 | 24 | 19 | 20 | 22 | 17 |

Number of observable teeth (phases 3 and 4, N = 581)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 9 | 15 | 14 | 23 | 23 | 22 | 20 | 18 | 14 | 20 | 21 | 20 | 20 | 17 | 15 | 9 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 12 | 20 | 19 | 21 | 21 | 20 | 20 | 19 | 18 | 20 | 26 | 23 | 22 | 16 | 16 | 8 |

**Appendix V** **Prevalence of Calculus by Tooth (Total Sample, n = 953)**

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 13 | 22 | 18 | 25 | 31 | 32 | 24 | 22 | 23 | 22 | 29 | 31 | 27 | 27 | 23 | 17 |
| **%** | **50** | **65** | **60** | **60** | **71** | **74** | **77** | **76** | **77** | **59** | **76** | **74** | **66** | **77** | **72** | **68** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 33 | 41 | 39 | 35 | 38 | 38 | 42 | 32 | 29 | 38 | 43 | 42 | 37 | 28 | 29 | 23 |
| **%** | **92** | **80** | **85** | **76** | **81** | **78** | **91** | **85** | **85** | **93** | **81** | **82** | **84** | **72** | **71** | **79** |

n = number of teeth with calculus

**Appendix VI** **Prevalence of Caries by Tooth (Total Sample, n = 68)**

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 3 | 2 | 4 | 4 | 3 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 2 | 6 | 2 | 3 |
| **%** | **12** | **6** | **13** | **10** | **7** | **-** | **-** | **3** | **3** | **-** | **3** | **-** | **5** | **17** | **7** | **12** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 3 | 6 | 6 | 3 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 4 | 3 | 2 |
| **%** | **8** | **12** | **13** | **7** | **-** | **2** | **2** | **3** | **3** | **5** | **4** | **2** | **-** | **10** | **7** | **7** |

n = number of teeth with caries

**Appendix VII** **Prevalence of DEH by Tooth (Total Sample, n = 108)**

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 2 | 1 | 0 | 3 | 7 | 5 | 4 | 5 | 6 | 8 | 2 | 0 | 0 | 2 | 0 |
| **%** | **-** | **6** | **3** | **-** | **7** | **16** | **16** | **14** | **17** | **16** | **21** | **5** | **-** | **-** | **6** | **-** |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 0 | 0 | 1 | 6 | 13 | 6 | 5 | 6 | 4 | 15 | 5 | 2 | 0 | 0 | 0 |
| **%** | **-** | **-** | **-** | **2** | **13** | **27** | **13** | **14** | **18** | **10** | **28** | **10** | **5** | **-** | **-** | **-** |

n = number of teeth with DEH

**Appendix VIII Number of Observable Tooth Positions**

Number of observable tooth positions (total sample, N = 1,596)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 39 | 48 | 54 | 55 | 53 | 47 | 41 | 41 | 41 | 48 | 48 | 51 | 50 | 54 | 49 | 39 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 49 | 63 | 61 | 57 | 54 | 51 | 50 | 44 | 39 | 48 | 58 | 55 | 56 | 55 | 55 | 43 |

Number of observable tooth positions (phase 2, N = 773)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 24 | 24 | 28 | 25 | 25 | 21 | 18 | 17 | 20 | 22 | 22 | 24 | 22 | 27 | 25 | 23 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 27 | 32 | 31 | 27 | 26 | 25 | 24 | 17 | 15 | 23 | 26 | 26 | 25 | 28 | 29 | 25 |

Number of observable tooth positions (phases 3 and 4, N = 689)

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 12 | 19 | 21 | 25 | 24 | 23 | 21 | 21 | 16 | 22 | 23 | 23 | 22 | 22 | 19 | 12 |
| | Right mandible | | | | | | | | Left mandible | | | | | | | |
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| N | 18 | 26 | 26 | 25 | 23 | 21 | 22 | 23 | 20 | 22 | 27 | 25 | 27 | 23 | 22 | 14 |

**Appendix IX** **Prevalence of Dental Abscess by Tooth Position (Total Sample, n = 50)**

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 1 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 2 | 2 | 0 | 1 | 7 | 2 | 1 |
| **%** | **3** | **6** | **6** | **4** | **2** | **1** | **-** | **-** | **2** | **4** | **4** | **-** | **2** | **13** | **4** | **3** |

| | Right mandible | | | | | | | | Left mandible | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 0 | 3 | 3 | 1 | 1 | 2 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 6 | 2 | 1 |
| **%** | **-** | **5** | **5** | **2** | **2** | **4** | **-** | **2** | **3** | **2** | **-** | **-** | **2** | **11** | **4** | **2** |

n = number of teeth with dental abscesses

**Appendix X** **Prevalence of AMTL by Tooth Position (Total Sample, n = 347)**

| | Right maxilla | | | | | | | | Left maxilla | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 13 | 14 | 24 | 13 | 9 | 4 | 10 | 12 | 11 | 11 | 10 | 9 | 9 | 19 | 17 | 14 |
| **%** | **33** | **29** | **44** | **24** | **17** | **9** | **24** | **29** | **27** | **23** | **21** | **18** | **18** | **35** | **35** | **36** |

| | Right mandible | | | | | | | | Left mandible | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M3 | M2 | M1 | P2 | P1 | C | I2 | I1 | I1 | I2 | C | P1 | P2 | M1 | M2 | M3 |
| n | 13 | 12 | 15 | 11 | 7 | 2 | 4 | 7 | 5 | 7 | 5 | 4 | 12 | 16 | 14 | 14 |
| **%** | **27** | **19** | **25** | **19** | **13** | **4** | **8** | **16** | **13** | **15** | **9** | **7** | **21** | **29** | **25** | **33** |

n = number of teeth lost ante-mortem

**Appendix XI** **Skeletons with Heavy Dental Wear**

| **SK number** | **Phase** | **Age** |
|---|---|---|
| 149 | 1 | 46+ |
| 2 | 2 | subadult |
| 44 | 2 | 46+ |
| 45 | 2 | 46+ |
| 53 | 2 | 46+ |
| 126 | 2 | 46+ |
| 130 | 2 | 26-45 |
| 139 | 2 | 46+ |
| 144 | 2 | 46+ |
| 151 | 2 | 46+ |
| 153 | 2 | 26-45 |
| 157 | 2 | 26-45 |
| 158 | 2 | 46+ |
| 173 | 2 | 46+ |
| 31 | 3 & 4 | 46+ |
| 36 | 3 & 4 | 46+ |
| 66 | 3 & 4 | 26-45 |
| 161 | 3 & 4 | 26-45 |
| 56 | 5 | 46+ |

**Appendix XII** **Skeletons with at Least One Unerupted 3rd Molar**

| **SK number** | **Phase** |
|---|---|
| 172 | 1 |

| | |
|---|---|
| 40 | 2 |
| 47 | 2 |
| 145 | 2 |
| 157 | 2 |
| 35 | 3 & 4 |
| 43 | 3 & 4 |
| 88 | 3 & 4 |
| 91 | 3 & 4 |
| 100 | 3 & 4 |
| 56 | 5 |

**Appendix XIII Prevalence of OA by Joint Type (Total Sample)**

| | **N** | **n** | **%** |
|---|---|---|---|
| R shoulder | 67 | 8 | 11.9 |
| L shoulder | 62 | 4 | 6.5 |
| R elbow | 83 | 5 | 6.0 |
| L elbow | 77 | 4 | 5.2 |
| R wrist | 72 | 11 | 15.3 |
| L wrist | 67 | 7 | 10.4 |
| R fingers | 56 | 10 | 17.9 |
| L fingers | 52 | 4 | 7.7 |
| R hip | 93 | 16 | 17.2 |
| L hip | 99 | 13 | 13.1 |
| R knee | 90 | 6 | 6.7 |
| L knee | 90 | 8 | 8.9 |
| R ankle | 66 | 3 | 4.5 |
| L ankle | 68 | 2 | 2.9 |
| R toes | 37 | 8 | 21.6 |
| L toes | 41 | 6 | 14.6 |
| **Total** | **1,120** | **115** | **10.3** |

N = number of joints

n = number of joints with OA