OSTEOARTHRITIS OF THE HANDS IN EARLY POPULATIONS

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SUMMARY

A study of the distribution of osteoarthritis of the hands was carried out in a series of 168 skeletons (77 males, 87 females, four unknown sex) from archaeological sites in England. There were substantial differences in the distribution of the disease between the sexes, but the only significant differences between the hands were shown for the second and third metacarpophalangeal joints, which were more often affected on the right side. In the males, the disease was predominantly unifocal (in 45 of the 77 cases), but in the females it was predominantly multifocal (56 of the 87 cases). Where only a single joint was affected, it was most often the first carpometacarpal joint in females, whereas in males, this joint and the first metacarpophalangeal joints were equally likely to be involved. Single-linkage cluster analysis showed that the strongest link in males was between the trapezoscaphoid and trapezoidocapophoid joints; in the females, the strongest links were between the first carpometacarpal, the distal interphalangeal and the first metacarpophalangeal joints.

KEY WORDS: Osteoarthritis, Hands, Skeleton, Medieval, Post-medieval, Eburnation.

OSTEOARTHRITIS (OA) is one of the rather small number of pathological conditions which can be diagnosed unequivocally in the skeleton [1] and it is also by far the most common one seen in human skeletal remains, with the possible exception of dental disease. This combination of factors allows the prevalence and distribution of OA to be studied in early populations, and any changes which are found both between different ancient populations, and between ancient and contemporary populations, may provide some clues to the aetiology of the disease. The results are presented here of an epidemiological study of OA of the hands in skeletal populations drawn from various archaeological sites in England and comments made on some temporal changes.

MATERIAL AND METHODS

The cases were obtained during the study of a large number (3788 in total) of skeletons from archaeological sites in England, including Allington Avenue, Ashstead, Brighton Hill South, Farringdon Street, Great Chesterford, Kelington, Merton Priory, Red Cross Way, Royal Mint, Southgate Street, Spitalfields and Ulwell. The skeletons from the sites were classified into two broad categories, medieval and post-medieval, on the basis of the archaeological evidence. It is difficult to be precise about exactly when the medieval period ended, but for the present purposes, the dividing line was set as the end of the 15th century.

To be entered into the study, cases had to satisfy the criterion that both hands were present and substantially complete, i.e. at least one joint surface of all the joints in the carpus had to be present, with all the metacarpals and at least half the proximal, middle and distal phalanges. Cases were entered into the study consecutively as they presented for examination, but the strict entry requirement meant that very many skeletons which had evidence of OA of the hands could not be included because either only one hand was present, or when both were present, they were so incomplete that not all the joint surfaces were represented. The resultant number of cases was estimated to be approximately a third of the potential total.

OA was diagnosed using the criteria which have been published earlier [1]. It will be obvious that the palaeopathological and clinical diagnoses of OA differ; for the former purposes, the diagnosis is based on finding eburnation on the joint surface and this is pathognomonic of OA in the skeleton. Where eburnation is not present, the diagnosis may be made by finding at least two of the following: marginal osteophyte, new bone on the joint surface, pitting on the joint surface or deformation of the joint contour. In practice, it is unusual to find any of the four minor changes in the joints of the hand in the absence of eburnation and, in the present report, the diagnosis was made only when eburnation was present. Each of the individual bones of the hands was assigned to side and carefully examined for evidence of eburnation. The sex of the skeletons was determined using standard anthropological techniques [2]. Differences in the prevalence of OA for different joints were analysed using the $\chi^2$ statistic.

RESULTS

A total of 168 cases was finally included in the study, a number which, because of the strict entry criterion, took several years to collect. Of these, 77 were male and 87 female; four of the skeletons could not be assigned a sex because the pelvis and skull were missing or were too fragmentary to be useful.

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There are 29 joints of the hand and carpus (counting the proximal and distal interphalangeal joints as single units) and, with a single exception (the capito-hamate), all were affected by OA in at least one case. However, the disease was not distributed evenly around the hand, but concentrated in a relatively few areas, principally affecting the joints centred on the trapezium, the proximal and distal interphalangeal joints (PIPs and DIPs), and the first three metacarpophalangeal joints (MCPs). The proportion of cases with these joints affected is shown in Table I, where the distribution has also been analysed by sex. There are some substantial differences between the sexes; in general, the joints were affected in a higher proportion of females than males and this is noticeable particularly for the PIPs, DIPs, first carpometacarpal joint (CMC1), MCP2 and trapeziodiscaphoid (TDS) joint, for all of which the differences were significant (P < 0.05).

When the affected joints were analysed by side and by sex, the differences appeared to be reasonably evenly distributed and the only significant differences (P < 0.05) were for MCP2 and MCP3 which, in both sexes, were more often affected in the right than the left hand (see Fig. 1a and b).

Number of joints affected

The total number of joints affected by OA also showed some differences as between males and females. In the males, the disease was predominantly unifocal so that in 45 of the 77 (58.4%) only a single joint was affected. By contrast, in only 31 of the females (35.6%) was OA confined to a single location, the majority of cases having multifocal disease (see Table II).

Differences over time

The period during which the archaeological sites had been used was known from the archaeological evidence and it was possible to group them into two broad divisions: medieval and post-medieval. When this was done, it was found that 42 of the cases were from the medieval period and 126 from the post-medieval period. Of the 42 medieval cases, 25 were male and 16 females (ratio 1.56:1); of the post-medieval cases, 52 were male and 71 female (ratio 0.73:1). Although this suggests a possible change in the sex ratio in the two periods, in fact, the differences were not significant and had most likely arisen by chance. When the data were analysed by period, some differences emerged (Fig. 2). For all the most commonly affected joints, a greater proportion of the post-medieval group was involved with the exceptions of the scaphoidal (SR) joint and MCP3; the differences with respect to the SR was highly significant (P < 0.001). The differences between the proportions of the two groups with involvement of MCP2, CMC1, trapezoidal (TZS) and the triquetroidiscaphoid (TQPI) joint were statistically significant (P < 0.01 for the first two joints, and P < 0.05 for the third and fourth). The differences in distribution over time were analysed using the Mantel–Haenszel ch2 statistic, stratifying by sex, and a highly significant result was obtained: M–H ch2 = 7.20, P = 0.0077.

Finally, there was a difference in the number of sites affected which paralleled the male–female difference shown for the group as a whole (see Fig. 3). In the medieval period, OA of the hands was predominantly unifocal, whereas during the later period, the tendency was for a greater number of joints to be affected. The difference between the two groups for the number of cases with one joint or more than one joint involved, however, did not quite reach the conventional level of statistical significance (P = 0.06), but the consistency of the trend towards greater involvement in the later period is at least suggestive that a change in the character of the disease had taken place.

Patterns of OA in the hands

Single joints. When only a single joint was involved by OA, it was much more likely to be CMC1 than any other in the females (Table III). In males, CMC1 and MCP1 were both equally likely to be affected, with DIP next in rank order. In females, MCP1 was the second most common joint to be solely affected by OA, followed by DIP and PIP. In males, both MCP3 and the SR joint were occasionally the sole site of disease, but never in females.

Multiple joints. There were a number of significant correlations between the prevalence of disease at different joints, and there were some considerable differences between the sexes (Table IV). In the males, there were significant positive correlations between OA of PIP and MCP1, 2 and 3, and a strong correlation between TDS and TQPI; finally, there was a significant negative correlation between DIP and TDS. In the females, by contrast, there were strong correlations between DIP and PIP, MCP1 and 2, but not between PIP and the MCPs. There were also significant correlations between MCP1 and MCP2 and, as in the males, between MCP2 and 3, and between TDS and TDS.

<table>
<thead>
<tr>
<th>Joint</th>
<th>Male</th>
<th>Female</th>
<th>Total†</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMC1</td>
<td>33.8</td>
<td>50.6*</td>
<td>42.9</td>
</tr>
<tr>
<td>DIP</td>
<td>29.9</td>
<td>47.1*</td>
<td>39.9</td>
</tr>
<tr>
<td>MCP1</td>
<td>37.7</td>
<td>34.5</td>
<td>35.7</td>
</tr>
<tr>
<td>PIP</td>
<td>9.1</td>
<td>12.6**</td>
<td>19.6</td>
</tr>
<tr>
<td>TDS</td>
<td>10.4</td>
<td>23.0*</td>
<td>17.3</td>
</tr>
<tr>
<td>TZS</td>
<td>10.4</td>
<td>20.7</td>
<td>16.1</td>
</tr>
<tr>
<td>MCP2</td>
<td>7.8</td>
<td>20.7*</td>
<td>14.3</td>
</tr>
<tr>
<td>MCP3</td>
<td>13.0</td>
<td>12.6</td>
<td>13.1</td>
</tr>
<tr>
<td>TQPI</td>
<td>6.5</td>
<td>9.2</td>
<td>8.3</td>
</tr>
<tr>
<td>SR</td>
<td>10.4</td>
<td>3.4</td>
<td>7.1</td>
</tr>
</tbody>
</table>

CMC1, first carpometacarpal; DIP, distal interphalangeal; MCP1, first metacarpophalangeal; PIP, proximal interphalangeal; TDS, trapeziodiscaphoid; TZS, trapezoidiscaphoid; MCP2, second metacarpophalangeal; MCP3, third metacarpophalangeal; TQPI, triquetroidiscaphoid; SR, scaphoidal.

†Only joints affected in ≥ 5% of cases included. The full table is available from the author on request.

*P < 0.05.

**P < 0.01.
Thus, there seemed to be different patterns of joint involvement between the sexes and this was borne out by single-linkage cluster analysis (SLCA) [3]. This is a qualitative technique whereby associations between characteristics can be investigated. The scale of association runs from 0 to 1, and the higher the score, the higher the degree of association. The linkage between the characteristics being examined can be shown visually by means of computer-generated dendrograms (Fig. 4). The dendrograms obtained by SLCA in this case show that for the males the strongest link is between TZS and TDS; there is a weaker link between MCP2 and MCP3, and weaker links still between CMC1, DIP and MCP1, and MCP3 and PIP.
In the females, the strongest links are between CMC1, DIP and MCP1, with less strong links between PIP and MCP1, and TDS and TZS.

DISCUSSION

This study has indicated that past populations were affected by OA of the hands in some ways which are similar to those experienced in the present day. Thus, in the fingers, the disease is centrifugal with the DIPs being much more commonly affected than the PIPs [4–7]; and, as in modern populations [8–12], in the past the disease was much more common on the radial side of the hands and the first ray (including the trapezium) was very frequently affected. There is, in addition, a trend for the MCPs to be affected in decreasing frequency as one progresses from the second to the fifth fingers, which corresponds to modern experience [13, 14] (see Table I).

In modern populations, OA of the hands is more common in females than in males [15, 16] and here there were more females than males in the sample, and although this difference was not significant, the trend was at least in the expected direction.

The dominant hand is more often affected by OA than the non-dominant in contemporary populations [13], with the possible exception of the thumb [15]. In the skeletons, the differences between left and right hands were more or less evenly spread (Fig. 1), and the only two significant differences ($P < 0.05$) were for MCP2 and 3; in each case, the right hand was more often affected than the left. Assuming that the right hand was the dominant hand in the historical populations—and there is no reason to suppose otherwise [17]—then the difference between the historical and the modern populations may reflect different types of activity, although other possibilities should be considered, as discussed below.

It is interesting to note the relative frequency with which OA of the second and third MCP joints was encountered, in the right hand especially. OA at this site is uncommon in modern populations and when it is found may be associated with other conditions, such as haemachromatosis, where MCP2 and MCP3 are particularly often involved [18], or it may seem to have an occupational cause [19]. There is no means of diagnosing haemachromatosis from the skeleton, but it seems reasonable to suppose that the aetiology is much more likely to be a reflection of the high level of manual labour undertaken in the past than of an unusually high prevalence of a rare disease.

When OA affected only a single joint, this was most likely to be CMC1 (although in the males, MCP1 was equally likely to be affected). Thereafter, single-joint involvement differed substantially between the sexes (Table III). Thus, the PIPs were almost never solely affected in males, nor were MCP3 or SR in females, although they were in a relatively small number of males. Considering associations between the disease in different joints, there were also clear differences between the sexes (Fig. 4) and I am not aware that this
difference in pattern of joint involvement has been noted previously; it certainly has not been reported in palaeopathological material before. Dickson and Morrison [9] studied the involvement of other joints in a series of 21 patients who had been admitted for surgery to the thumb base. They found that MCP3 was the joint most likely also to be involved, although four other joints were also diseased in at least half of their patients. The results of a similar analysis carried out on the skeletal population do not agree with those of Dickson and Morrison at all (see Table V). Among the skeletons, the DIPs are most frequently involved when CMC1 is affected and the rank order of other affected joints shows almost no correspondence with the modern patients. This is not altogether surprising since the samples are not strictly comparable—their vital status notwithstanding. In particular, there is no means of knowing the severity of the disease in the palaeopathological population, and they are rather more typical of a general population sample, which is known to differ in many respects from a hospital-based one as studied by Dickson and Morrison. This highlights the difficulties which may exist when attempting to compare the results of the study of skeletal material with those of contemporary epidemiology.

**Changes over time**

The results of this study give some indication that OA of the hands has changed in character over time. When the population was divided into medieval and post-medieval groups, it was found that not only was the sex distribution different with the male/female ratio exceeding unity in the medieval period, but there was much less likelihood for the females to have multifocal disease than in the post-medieval period. In the medieval period, half of the females had multifocal disease, whereas in the post-medieval period, more

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**TABLE III**

Proportion of cases with a single joint affected

<table>
<thead>
<tr>
<th>Joint affected*</th>
<th>Male (n = 45)</th>
<th>Female (n = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIP</td>
<td>20.0</td>
<td>12.9</td>
</tr>
<tr>
<td>PIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP1</td>
<td>22.2</td>
<td>16.1</td>
</tr>
<tr>
<td>MCP3</td>
<td>6.7</td>
<td></td>
</tr>
<tr>
<td>CMC1</td>
<td>22.2</td>
<td>38.7</td>
</tr>
<tr>
<td>SR</td>
<td>6.7</td>
<td></td>
</tr>
</tbody>
</table>

*Only joints affected in >5% of cases are included. The complete list is available from the author on request.

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**TABLE IV**

Correlation matrices, r (P), for OA of the hands, by sex

<table>
<thead>
<tr>
<th></th>
<th>PIP</th>
<th>MCP1</th>
<th>MCP2</th>
<th>MCP3</th>
<th>TDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DIP</td>
<td>0.293 (0.01)</td>
<td>0.332 (0.00)</td>
<td>0.314 (0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP1</td>
<td></td>
<td>0.226 (0.03)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCP2</td>
<td></td>
<td></td>
<td>0.318 (0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDS</td>
<td></td>
<td></td>
<td></td>
<td>0.395 (0.00)</td>
<td></td>
</tr>
</tbody>
</table>

|       |       |       |       |       |       |
| **Males** |       |       |       |       |       |
| DIP   |       |       |       | -0.222 (0.05) |       |
| PIP   | 0.314 (0.01) | 0.245 (0.03) | 0.281 (0.01) |       |       |
| MCP2  |       |       | 0.320 (0.00) |       |       |
| TDS   |       |       |       | 0.721 (0.00) |       |
FIG. 4.—Dendrograms obtained by single-linkage cluster analysis, by sex. Note that the horizontal and vertical scales differ in the two dendrograms. The horizontal scale shows the degree of association between OA in the joints; the higher the number, the higher the degree of association.

than two-thirds did; in both periods, by contrast, unifocal disease is the norm in the males, although the proportion with multifocal disease is greater in the post-medieval than the medieval period. The distribution of OA within the hand differs between the two periods (Fig. 3) so that in the post-medieval period there is a tendency for a greater proportion of joints to be affected, the differences being significant ($P < 0.05$) for MCP2, CMC1, TZS and SR. Possible reasons for these differences are considered below.

Potential sources of bias

The entry criterion for this study was stringent and many skeletons which had OA of the hands were excluded because the hands were incomplete and thus did not allow for a complete inventory of the joints to be made. It is possible that this introduced some selection bias into the study, although there seems no a priori reason to suppose that any particular pattern of OA is more likely than another to reduce the chances of bones surviving, nor that the hands of one sex rather than the other would survive. Selection bias, therefore, seems an unlikely explanation for any of the present findings.

A more serious exception to palaeoepidemiological studies is that the samples with which palaeopathologists have to deal are seldom random, but the nature of a burial assemblage is such that there is almost nothing which can be done to correct this deficiency [20].

There is no likelihood of diagnostic bias in the study since it was based solely on the presence of eburnation, which is unmistakable in the skeleton and is pathognomonic of OA. The palaeopathological diagnosis of OA is based on different criteria than the clinical or radiological diagnoses, and hence the prevalence rates in modern and ancient populations are not strictly comparable. The male–female prevalence ratio and the distribution of OA in the hands—and in other joints also—ought to be qualitatively similar, and comparisons between an ancient and a modern population in these respects ought to be valid.

### Aetiology of changes over time

A difference in the pattern of OA in the medieval and post-medieval periods has been shown here, and has also been found for OA of the knee. Both Rogers and Dieppe [21] and I [22] have found OA of the hip to be more common than that of the knee during the medieval period, whereas the converse is true in post-medieval skeletons. Whether the change in the
relationship between OA of these two sites is due to the prevalence of OA of the hips declining or that of the knee increasing is not clear, but there seems little doubt that the modern pattern of OA of the knee is of relatively recent origin and the data presented here suggest that the same may be true in some respects for OA of the hands.

Exactly what has brought about these changes in the pattern of OA is by no means clear. There are a number of determinants of OA, including age, genetic predisposition and activity [23]. There is also an association between OA of the hands and obesity [24, 25], and nutritional factors have been found to be related to the incidence of OA in animals [26]. One possible explanation for the differences found may relate to diet and this is something which ought to be amenable to study in the historical record.

Although the interval of time during which the archaeological sites were occupied covered several hundred years, this remains far too short to permit any significant change in genetic predisposition to have occurred. Age is also unlikely to have been a factor as the age distribution between the medieval and post-medieval skeletons was similar, with the majority aged at least 45 yr at the time of death. The attribution of age to a skeleton is fraught with difficulty, but the fact that the ageing of the skeletons was performed by the same person makes it likely that such bias as there was in the method was at least consistent and there is no reason to suppose that the error was greater for skeletons from one period than the other. Of course, OA was never used as an ageing criterion in these studies.

With the model in Dieppe’s paper in mind [23], the most plausible explanation for the temporal variations found in this study is that the activities of the populations represented by these skeletons varied in some material way; there is certainly evidence to support the view that activity is an important determinant in the pattern of OA in the hands of industrial workers [27]. This is probably also the explanation for the change in the relative frequency of OA of the hip and knee, which seems to have reversed at about the same time as changes in OA of the hand were taking place. What these changes in activity were remains to be determined if, indeed, they are susceptible to precise identification.

References