Palaeopathology of spinal osteophytosis, vertebral ankylosis, ankylosing spondylitis, and vertebral hyperostosis

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SUMMARY Five hundred and sixty intact skeletons and several thousand disarticulated vertebrae have been examined with special reference to spinal fusion. In period they ranged from a 21st dynasty Egyptian mummy to a mid-19th century skeleton. Osteophytes were found in about half of the specimens, as reported previously. Fifteen skeletons with extensive blocks of spinal fusion were also identified. Sacroiliitis was present in two, but the asymmetrical spinal disease and peripheral joint changes suggested Reiter's disease or psoriatic spondylitis rather than ankylosing spondylitis. The remaining 13 had typical features of Forrester's disease, and extraspinal findings indicative of diffuse idiopathic skeletal hyperostosis (DISH) were also common. A review of the available literature suggests that many palaeopathological specimens previously reported as ankylosing spondylitis are examples of DISH or other seronegative spondylarthropathies. The antiquity and palaeopathology of AS needs reappraisal.

Ankylosing spondylitis is said to be an ancient disease which occurred in animals and man in prehistory.¹⁻⁵ However, it can be difficult to differentiate the osteophytes of spondylosis, vertebral hyperostosis (Forrester's disease), and ankylosing spondylitis (AS). Zorab⁶ and Bourke⁷ have suggested that descriptions of AS in Egyptian material may have been due to the misdiagnosis of severe osteophytosis.

During recent examinations of skeletal material from this country severe vertebral osteophytosis as well as several cases of probable diffuse idiopathic skeletal hyperostosis (DISH) have been seen, but AS has been absent.⁸⁻¹⁰ We therefore decided to review evidence of spinal osteophytosis (spondylosis), AS, and DISH in a larger selection of palaeopathological material and to review the literature on the antiquity of AS and spinal fusion.

Materials and methods

A total of 560 adult skeletons with at least part of the vertebral column intact and thousands of disarticulated vertebrae from other skeletons have been

examined. They include one 21st dynasty Egyptian mummy and bones from seven Saxon bishops from Wells Cathedral. Apart from the mummy the earliest is Romano-British and the latest from the mid-nineteenth century, and all were from recently excavated sites in England. These include St Peter's Church, Barton-on-Humber; St Oswald's Priory, Gloucester; Wells Cathedral; and a cemetery in Ilchester in Somerset. Table 1 shows the number of intact skeletons from each period.

After excavation the bones were submitted for anthropological, demographic, palaeopathological (Rogers), radiological (Watt), and rheumatological (Dieppe) assessment. During examination of the vertebral column posterior joints were assessed separately from the changes which occurred at the bony margins. Osteophytes were scored according

Table 1 *Numbers of skeletons*

<i>Period</i>	<i>Numbers of skeletons</i>
Egyptian mummy 21st Dynasty	1
Romano-British 1-500 AD	81
Saxon 700-1100	121
Mediaeval 1100-1500	303
Post-mediaeval 1500-1850	54
Total	560

Accepted for publication 5 September 1984.

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Table 2 Osteophytosis of the spine

Period	% Skeletons affected
Romano-British	46
Saxon	69
Mediaeval	37

to the standards laid down in the *Atlas of Standard Radiographs of Arthritis*.¹¹ If ankylosis was present between two or more adjacent vertebrae note was made of the distribution of the ankylosed bone on the vertebral body. The number of vertebrae fused, involvement of the posterior joints, involvement of the sacroiliac joints (where possible), and the presence and extent of hyperostosis or arthritis in other parts of the skeleton, including changes at tendon insertions, were also noted.

Results

INTACT SKELETONS

As in other recent studies of skeletal material⁸⁻¹⁰ osteophytosis was found to be common, nearly half the skeletons examined having some degree of spinal osteophytosis, often of a massive and exuberant nature (Table 2, Figs. 1, 2). Fusion of osteophytes was seen in only one case. Fifteen other spines with exuberant new bone formation and extensive ankylosis were seen.

Two of these may have been due to a seronegative

Fig. 1 Superior view of a disarticulated cervical vertebra showing large osteophytes on the margin of the body and extensive osteoarthritis of the right apophyseal joint.

Fig. 2 Radiograph of a section of the lumbar spine from an intact Romano-British skeleton showing typical large, horizontal osteophytes originating from the margins of the vertebral bodies.

spondylarthritis. Both cases were associated with an erosive peripheral arthritis in which proliferative erosions, 'cup-and-pencil' deformities, and fusion of intertarsal joints were seen. In one the changes in the sacroiliac joints and spine were asymmetrical and in both the vertebral long bridges were more exuberant than expected in ankylosing spondylitis.

Table 3 Prevalence of ankylosing hyperostosis of spine (Forrester spine) and diffuse idiopathic skeletal hyperostosis (DISH) in different skeletal material

Period	No. of skeletons	Forrester spine		DISH	
		No.	%	No.	%
Egyptian	1	1	100	1	100
Romano-British	81	0	0	0	0
Saxon	121	2	2	2	100
Mediaeval	303	8	2.6	5	62
Post-mediaeval	54	2	3.7	2	100
Total	560	13	2.3	8	61.5

Fig. 3 Photograph of the bones of the forefoot from case 1. Note the fusion of mid-tarsal joints and 'cup-and-pencil' erosion of the interphalangeal joint of the great toe. Other joints in this skeleton showed similar erosive changes, clearly *antemortem* in origin.

These findings suggest psoriatic arthropathy, or possibly Reiter's disease, rather than AS.¹²⁻¹⁴

The 13 remaining examples of spinal fusion corresponded to the classical descriptions of Forrester's disease,^{15 16} and many of them also had the extraspinous manifestations as described by Resnick *et al.*¹⁷ Table 3 indicates the distribution of Forrester type spines within the various populations and the percentage of these that also had extraspinous manifestations.

A description of the two possible seronegative spondylarthritides and of four typical examples of DISH is given to demonstrate the features seen in archaeological skeletal material.

Case 1 (Fig. 3).

A 13th century male from Barton-on-Humber, probably over 40 years old. The spine showed marginal lipping of most vertebral bodies with florid spurring and anterior fusion of three blocks, C5-7, T8-12, and L3-5. Peripheral joint changes included ankylosis of the tarsus and carpus and some interphalangeal joints, with pencil and cup erosions of terminal interphalangeal joints in the hand. Other joints affected included the temporomandibular joints, shoulders, and right sacroiliac joints, all of which showed an erosive arthropathy. The left sacroiliac joint appeared normal.

Case 2 (Figs. 4, 5)

Mediaeval adult male skeleton from Bath Abbey. Axial changes included bilateral ankylosis of the sacroiliac joints and ankylosis of the segment between T7 and L1. There was proliferative new bone formation round many segments of the spine, and fusion of the posterior joints from T7 to L5. Spinal syndesmophytes were asymmetrical and predominantly anterior lateral. Peripheral joint changes included moderate osteoarthritic findings of both hips and a proliferative erosive arthropathy of the metacarpophalangeal joint of the left second finger and the carpometacarpal joint of the left thumb.

Case 3 (Fig. 6)

21st Dynasty mummy from Bristol City Museum. Male aged over 50. Combined assessment of spinal radiographs and of the joints (which are still covered in resin-hardened soft tissue) suggested right-sided fusion of T5-7, T8-10, and T10-12, + L4-5. There was definite posterior and inferior calcaneal spurring and a small olecranon spur on the right ulnar.

Case 4

The Saxon Bishop Giso of Wells Cathedral, died in 1087. A complete male skeleton aged at least 50. The vertebral column was complete. Fusion occurred between C3 and 4, T3 and 4, and T5-12 inclusive. The ankylosis had the appearance of flowing 'candle wax' down the right hand side. Ossification of costal and thyroid cartilage had also occurred, and there was exostotic spurring at the sacroiliac joints and the iliac crests, ischial tuberosities, and linea aspera, and many of the peripheral joints were surrounded by large osteophytes.

Case 5

A mediaeval dean from Lichfield Cathedral. Right-sided ankylosis between C7-T1, T7-9, and T9-11. Hyperostotic spurring was found at the ulna, hum-

Fig. 4 The pelvis from case 2. The sacroiliac joints are completely fused, and the pelvis broke away from the sacrum only during excavation of the specimen.

erus, iliac crests, ischial tuberosity, trochanters, linea aspera, tibial tubercles, patella, and calcaneum. Ossification had also taken place in the costal cartilages, and fragments of calcified blood vessels were found with this skeleton.

Case 6 (Fig. 7)

A 79-year-old woman, early 19th century. Widespread and marked osteophytosis of most joints as well as new bone formation at all the sites mentioned in the previous skeleton. Fusion, again right-sided, had occurred from T4 to L2. L3, although bearing a large bulbous excrescence of bone on the superior right margin, had not yet fused.

In spines 3–6 there was no apparent involvement of the apophyseal joints nor any erosive disease of the sacroiliac joints. In some of the sacroiliac joints of skeletons showing Forrester's disease there was some ankylosis, but in the superior part only, and it had the appearance of smooth exuberant bone growth as seen on the vertebrae.

DISARTICULATED VERTEBRAE

During archaeological excavations many separate disarticulated bones are recovered without knowledge of their skeletal origin. Thousands of such vertebrae and several pelvic bones have been seen. Typical osteophytes were very common on these samples (Figs. 1, 2), but in a few of them vertical ossification originating from the body of the vertebra was seen, suggesting the early lesion of DISH described by Fournasier *et al.*¹⁷ One fused pair of vertebrae was seen in which the visual and radio-

graphic evidence of old erosive changes suggested old tuberculosis (Fig. 8). No lesions suggesting AS have been observed.

Discussion

Analysis of skeletal material from archaeological excavation presents a unique opportunity to examine the complete spectrum of bony change in the skeleton. Obviously the skeletons examined depended on availability and may not be representative, but a large number (560) of skeletons as well as thousands of disarticulated bones have been looked at critically, and the observations on vertebral ankylosis seem worthy of discussion.

The main problem encountered is that of diagnostic criteria: for example, when does severe osteophytosis which becomes ankylosed cease to be spondylosis and become ankylosing vertebral hyperostosis?^{14 18 19} For the purpose of this study we took a vertebral osteophyte to be a bony protrusion from the cortex of the vertebra appearing at the junction of the vertebral body and the intervertebral disc. This new bone pointed sideways and was unlike the vertical ossification of Forrester's disease, which had a 'dripping wax' appearance, was predominantly on the right anterolateral part of the vertebra, and arose from the body, well away from the disc junction.

Vertebral osteophytes, typical of the type seen in disc disease and spondylosis, were by far the commonest finding in our study. This was also the case in other recent surveys of archaeological specimens.^{8–10} Osteophytes are found in skeletal material from all historical periods²⁰ and from many

different geographical sites.⁷ Vertebral osteophytes are well known to palaeopathologists and have been used to age skeletons²¹ or to aid interpretation of the possible habits of our ancestors.⁹

Fig. 5 Part of the thoracolumbar spine from case 2. Note the asymmetrical bony fusion and exuberant calcification. The lower lumbar sections were not affected ('skip lesions') and the overall picture, including hypertrophic peripheral joint erosions, suggests the spondylitis of Reiter's disease or psoriatic arthropathy.

Fig. 6 Chest radiograph of case 3: The Bristol mummy. Note the right sided exuberant osteophytes with fusion, suggesting Forrester's disease. Typical spurs were seen in other parts of the skeleton.

In 13 of our skeletons and many separate vertebrae the large flowing osteophytes found in the absence of posterior joint changes or erosions of the sacroiliac joints were thought to be typical of Forrester's disease.¹⁴⁻¹⁸ This was supported by the finding of extraspinal new bone formation in many cases, and the fusion of blocks of at least four vertebrae in the complete skeletons.

We found DISH in 2.3% of the adult skeletons examined, varying from 2% to 3.7% according to period. This is similar to the rate of 3.8% for males and 2.6% for females found by Julkunen *et al.*²² in a contemporary study in Finland. In considering the incidence of DISH in earlier populations it must be noted that contemporary Forrester's disease has not been found in persons under the age of 40. The number of people surviving to that age was considerably less in earlier populations than now, so the fact that the incidence is similar was surprising. Although we do not know the origin of all the skeletons with DISH, many of them are definitely from higher social backgrounds—for example, the Egyptian mummy (a priest), a Saxon bishop, and a mediaeval dean. Their standard of living and nutrition was probably better than that of the general

population, and they probably lived longer. Obesity and diabetes have been noted in association with DISH^{23 24} and may also have been present in these people.

The high incidence of severe osteophytosis and DISH in this and other recent surveys of archaeological material,⁸⁻¹⁰ without there being any examples of ankylosing spondylitis, must raise doubts about

Fig. 7 A section of thoracolumbar spine from case 6. The typical exuberant, right-sided anteriolateral, 'dripping wax' (osteophytes of Forrester's disease (DISH) have caused fusion of this large segment.

previous reports of frequent AS in skeletal material. DISH has been recognised only relatively recently and is not mentioned in contemporary palaeopathological texts.^{19 25} It can cause fusion of the upper third of the sacroiliac joints²⁶ and causes confusion with AS in medicine today.²⁷ We have therefore examined previous reports of AS in the palaeopathological literature.

Many Egyptian skeletons, ranging in date from 3000 BC to the beginning of the Christian era, were examined by Ruffer and Rietti and others.¹⁻⁴ They described 'ankylosing spondylitis' or 'spondylitis deformans' in many cases, but the terms are not clearly defined. Sacroiliac changes were often ignored or absent, and the spinal changes described included asymmetrical fusion with 'roughness of bones' elsewhere. Nubian skeletons examined by Smith and Wood Jones were also said to show frequent spinal fusion.²⁸ Salib describes frequent 'spondylitis' and spinal 'arthritis deformans' in Egyptian material²⁹ and Shore states³⁰ that spinal fusion was seen in 7 of 274 vertebral columns from Ancient Egypt, although he concluded that infection was the most likely cause. Bourke also looked at Egyptian and Nubian material and reported some possible cases of ankylosing spondylitis.⁷ However, only one case is convincing, and in others the asymmetrical changes with large paravertebral osteophytosis suggest possible DISH. Zorab⁶ was unable to find convincing evidence of AS in Egyptian material and thought that the previous authors had misdiagnosed osteophytosis. It is of interest, therefore, that the only mummy we have been able to look at had clear evidence of mild DISH.

There are surprisingly few convincing descriptions of AS in other palaeopathological literature. A possible French case from the neolithic period was described by Snorrason;³¹ Morse³² and Kidd³³ have both examined suspected cases from ancient Midwestern skeletons; Zivanovic records a case of mediaeval Anglo-Saxon origin with probable AS³⁴ (although he diagnosed rheumatoid arthritis); and Kramar gave a detailed description of a very convincing case from mediaeval Geneva.³⁵ Calvin Wells describes many examples of spinal fusion from Anglo-Saxon skeletons; in many of these cases DISH seems the likely diagnosis.^{20 36} In an excellent recent monograph Steinbock suggests that about 30 cases of possible AS can be found in the palaeopathology literature, and adds two examples of his own.³⁷ One of these has widespread ankylosis of peripheral as well as spinal joints. It is apparent from examining this literature that most authors, with the notable exception of Kramar³⁵ were not aware of DISH or of other possible causes of spinal fusion such as fluorosis or psoriatic spondylitis.

Fig. 8 Part of two disarticulated but fused vertebrae found during excavation. The vertebrae are viewed from the front and show an area of extensive antemortem erosion around the fusion, affecting both bones. It is possible that these changes were caused by tuberculosis.

Most authorities credit Bernard Connor (1691) with the first good pathological description of AS.³⁸ Several good descriptions followed, and, as O'Connell points out, the eponymous work of Bechterew (1892–9), Marie (1898) and Strumpell (1897) came much later.³⁹ In view of the striking nature of the disease it is perhaps surprising that there are no good medical descriptions before Connor's work.⁴⁰

The subtle differentiation between AS and the spondylitis of psoriasis or Reiter's syndrome is not mentioned in previous palaeopathological literature. Although it is difficult to be certain on the evidence of old skeletons alone, our two cases with evidence of a seronegative spondylarthritis seem much more compatible with a diagnosis of psoriatic arthropathy or Reiter's disease than simple AS.^{12–14} It is impossible to discover whether other skeletons described in the palaeopathology literature had these diseases because of the poor quality of the descriptions and illustrations. However, psoriasis was probably common in our ancestors, and we have seen other skeletons with peripheral joint changes indicating psoriatic arthropathy (Rogers *J et al.*, in preparation). It is certainly surprising that a condition with a prevalence today of nearly 1%⁴¹ has not been seen in large surveys of skeletal material which have the discrimination to pick up cases of DISH, spinal TB, and possible psoriatic arthropathy.

CONCLUSIONS

The very high incidence of AS previously reported in early skeletal populations was not found in our study. DISH was certainly as common in our

ancestors as it is now, and may have been mistaken for AS by other palaeopathologists. The presumed antiquity of AS requires critical reappraisal. It is possible that AS, like rheumatoid arthritis, might be of recent origin,⁴² although there are a few convincing cases of some type of seronegative spondylarthritis in ancient skeletons. Bywaters dismisses palaeopathological data on disease history as unreliable.⁴⁰ We would argue that critical appraisal of the findings may help establish the antiquity of many bone and joint diseases; in the case of AS, however, the previous descriptions of a high frequency in many ancient skeletons do indeed seem unreliable.

We are grateful to the Arthritis and Rheumatism Council, the Science and Engineering Research Council, and A H Robins Co. Ltd, for financial support.

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