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Osteological Evidence for Smallpox: A Possible Case From Seventeenth Century Ontario

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ABSTRACT Identification of possible osteomyelitis variolosa in a Neutral Indian cemetery dated to just before A.D. 1650 provides the first recognition of smallpox in an archaeological context. The radiological literature is reviewed to support the identification. The ethnohistorical literature is at odds with the evidence presented and the historical background is briefly discussed, together with the ambiguities and contradictions in both primary and secondary sources.

In spite of debates on the effect of epidemic diseases on American Indian populations in the seventeenth, eighteenth, and nineteenth centuries, there is no doubt that many diseases were exported from Europe and hit very hard those populations as yet unexposed to them. In a number of cases we know what these diseases were and how they were introduced (e.g., smallpox in Mexico in 1520, and New England in 1633), but in other cases (e.g., Huronia in 1634) the historical records are open to several interpretations. We must also assume that epidemics of introduced diseases went unrecorded. For example, the depopulation of the eastern coast of Canada, as reported to the Jesuits (Thwaites, 1898:3:105), may well have been the result of introduced diseases.

When epidemics are unrecorded or described ambiguously, direct evidence of disease can be our only source of information as, for example, with the skeletal changes resulting from syphilis. Viral diseases, e.g., measles, smallpox, and influenza, had severe effects on "virgin soil populations" in the Pacific, Australia, and the Americas, but in the palaeopathological literature there is almost no reference to skeletal changes as a consequence of viral infections (although see Ortner and Putschar, 1981:227). However, in the radiological literature (Edeiken, 1981:801–803; Resnick and Niwayama, 1981:2220–2223), it is well recognized that very specific bone changes (osteomyelitis variolosa) result from smallpox in up to 20% of cases (Davidson and Palmer, 1963). The fact that smallpox has an effect on bones has been recognized since at least 1568 (by Paré; see Creighton, 1965:469).

OSTEOMYELITIS VARIOLOSA

The skeletal changes resulting from smallpox appear from the literature to be remarkably consistent. In 80% of cases the elbows are involved with all three bones at the joint showing disruption. The wrists, hands, ankles, and feet are the next most common sites of osteomyelitis variolosa. Although several sites are affected in most cases, the major clue to a diagnosis of osteomyelitis following smallpox is a bilateral involvement of the elbows (Cockshott, 1965; Cockshott and MacGregor, 1958; Eeckels et al., 1964).

The severity of the smallpox has no bearing on the extent of skeletal change, but the final effect of age at onset is not known. Very few recorded cases are known for individuals over 15. In Davidson and Palmer's (1963) large sample none were over 15 years and 93% were under 10 years of age.

Osteomyelitis variolosa is characterized by a disruption of the area around the metaphysis which may lead to the detachment or destruction of the epiphysis. Longitudinal bone growth is then reduced or ceases. In the two cases reported in the recent literature of adults who had smallpox as young children (Lentz and Noyes, 1979; Nathan and Nguyen, 1974), the discernible reduction in growth of long bones was limited to the metacarpals and metatarsals. This had led to irregular shortening and deviation of some fingers and, in one case, toes. The individual whose metatarsals were normal had, however, a destruction of the talus which led to a limp.

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Changes to the elbow as a consequence of osteomyelitis variolosa are described in terms of flail joints or of a limitation of mobility (this seems to be more common) and eventual ankylosis. The changes are known only from radiographs and in the humerus apparently consist of destruction of the trochlea and capitulum with elongation of the lateral and medial epicondyles.

So far as I can determine, the present paper reports on the first case of possible osteomyelitis variolosa based on osteological evidence.

THE GRIMSBY CEMETERY

In the winter of 1976–1977, the Royal Ontario Museum, under the direction of Dr. W. Kenyon, carried out the salvage excavation of a Neutral Indian cemetery at Grimsby, Lincoln County, southern Ontario. I have studied the human remains (Jackes, in preparation) and the archaeology has been published recently (Kenyon, 1982). The cemetery is dated between A.D. 1640 and 1650 on the basis of historic records and trade goods which accompanied the burials. It thus marks the end of the Neutral Nation which had occupied the land west of Lake Ontario until the final Iroquois incursions (White, 1972).

The cemetery contained 373 individuals of whom 42.7% were under 20 years of age, 28.5% were adult males, 27.2% were adult females, and 2% were adults that could not be sexed. The burial pattern is of interest for several reasons. The skeletons were distributed among 55 features which contained from one to 103 individuals. Some of the larger features contained a careful and symmetrical arrangement of bundle burials, but the extent to which complete individuals could be identified varied from feature to feature. In Huron ossuaries individuals can almost never be identified, but Neutral burial practices were, it seems, unlike those of the Huron. The burial pattern at Grimsby does not appear to support the characterization of Neutral burial practices as ossuary burial (cf. Noble, 1968:79).

The human bones could be neither marked nor cleaned and they could not be removed from the town of Grimsby. They were studied either on the site or nearby and reburied close to the original site almost immediately after excavation and study. Thus, analysis of any abnormalities observed must rely on notes, photographs, and some x-rays, and the difficulties of diagnosis in the case of pathological specimens are compounded.

Feature 1, burial 33

Among the pathological specimens were the fragmentary remains of an adult male (Fe 1/33) which, according to the excavators' notes, consisted of "mixed bones—no articulations." Included were some elements of a child of about 6 years and the badly preserved bones of more than one adult (there were three right patellae, two left tali, and two sacra). The following bones appeared to belong to one individual: scapulae, atlas, axis, a sternum with the manubrium fused, a sacrum with S.1 and S.2 fused, innominates that were probably male, and fragments of a humerus, of radii, ulnae, femora, and tibiae. The pubic symphyses were not preserved, but all the bones gave an impression of porosity. This together with the sacral and sternal fusion suggested an advanced age.

Fe 1/33 had abnormalities of the hip, femora, and elbows. The acetabula appeared to be shallow, but only the right side could be measured. The width/depth ratio of 3.8 (width = 46 mm; depth = 12 mm) is just outside the population mean plus two standard deviations.

Unfortunately, both femora were broken. A reconstruction of the proximal portions appears in Figure 1. The right femur was the more complete. Its neck was in valgus (neck/shaft angle = 138°) and the head was flattened. The head extended well beyond the greater trochanter, which in fact appeared to be hypotrophied. The right shaft seemed slightly atrophied in comparison with the left, and this is confirmed by the platymeric indices which differed greatly (Table 1). The narrow neck of the right femur was well below the population mean of 29 mm.

Both elbows were abnormal (Fig. 2) but only the left was well enough preserved to be described. On the left ulna the whole area of the semilunar notch was grossly deformed with the coronoid process extended cranially. It appears certain that the right proximal ulna had a similar deformity. The deformity of the semilunar notch of the left ulna was clearly related to the complete abnormality of the articular region of the left humerus. The interarticular area was quite simply nonexistent and the whole of the joint area had been transformed to articulate with the ulna. In other words, there was no apparent capitulum. It is unfortunate that both radial heads were missing since the proximal radii must also have been markedly abnormal. The left radial neck was

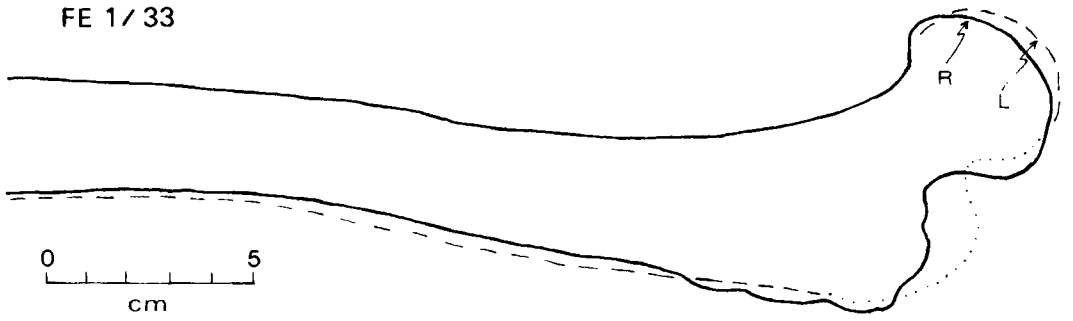

Fig. 1. Proximal femora of Fe 1/33 showing asymmetry.

TABLE 1. Metrical characteristics of the femora of Fe 1/33

	Proximal A/P Diameter	Transverse Diameter	Index	Neck Diameter	Neck/Shaft Angle
Right	24.0	30.0	80.0	23.0	138.0°
Left	22.0	33.0	66.7	—	± 140.0°
Normal male					
Right	24.6	32.2	76.4	29.1	127.3°
Left	24.6	32.3	77.3	28.9	

elongated and it seems certain, at least for the left arm, that there was disuse atrophy of all three bones.

At first, Fe 1/33 was thought to be a case of Perthès's disease, which had an unusually high incidence in this population (Jackes, 1981). However, the features of the femora are not consistent with the diagnosis nor with other common disorders of the hip. Thus I began to look for an explanation for the abnormalities of the elbow joints. These cannot have been caused by trauma because the left elbow shows no misalignment and the abnormality is clearly bilateral.

The descriptions of osteomyelitis variolosa as given in the literature cited previously are so reminiscent of Fe 1/33 that the diagnosis of smallpox is hard to avoid. This impression is confirmed by W.P. Cockshott (*in litt.*, 17 January 1982) who, after examining photographs and my description of the bones, stated, "I believe that there is a high probability—let's say 80%+—of this being variola."

The date of feature 1

There are a minimum of 17 individuals in Feature 1, on the basis of the innominates, but although the excavators described "discrete bundles" all individuals were probably incomplete. Two lacked skulls, including Fe 1/33, and there were several bundles containing extra arms or legs, as well as a good deal of "stray" bone. It is not surprising that feet and hands are lacking. They were missing even in some of the single extended burials at the site, probably because of the Neutral practice of delayed primary burial (Thwaites, 1898:21:199). Nevertheless, the individuals in Feature 1 are generally more incomplete and mixed than elsewhere in the cemetery. This suggests to me that burial was delayed longer than usual and that interment was a hurried affair without the normal care and ceremony.

The last few years of Neutral society were disrupted by famine, disease, war against the Fire Nation to the west, and finally, annihi-

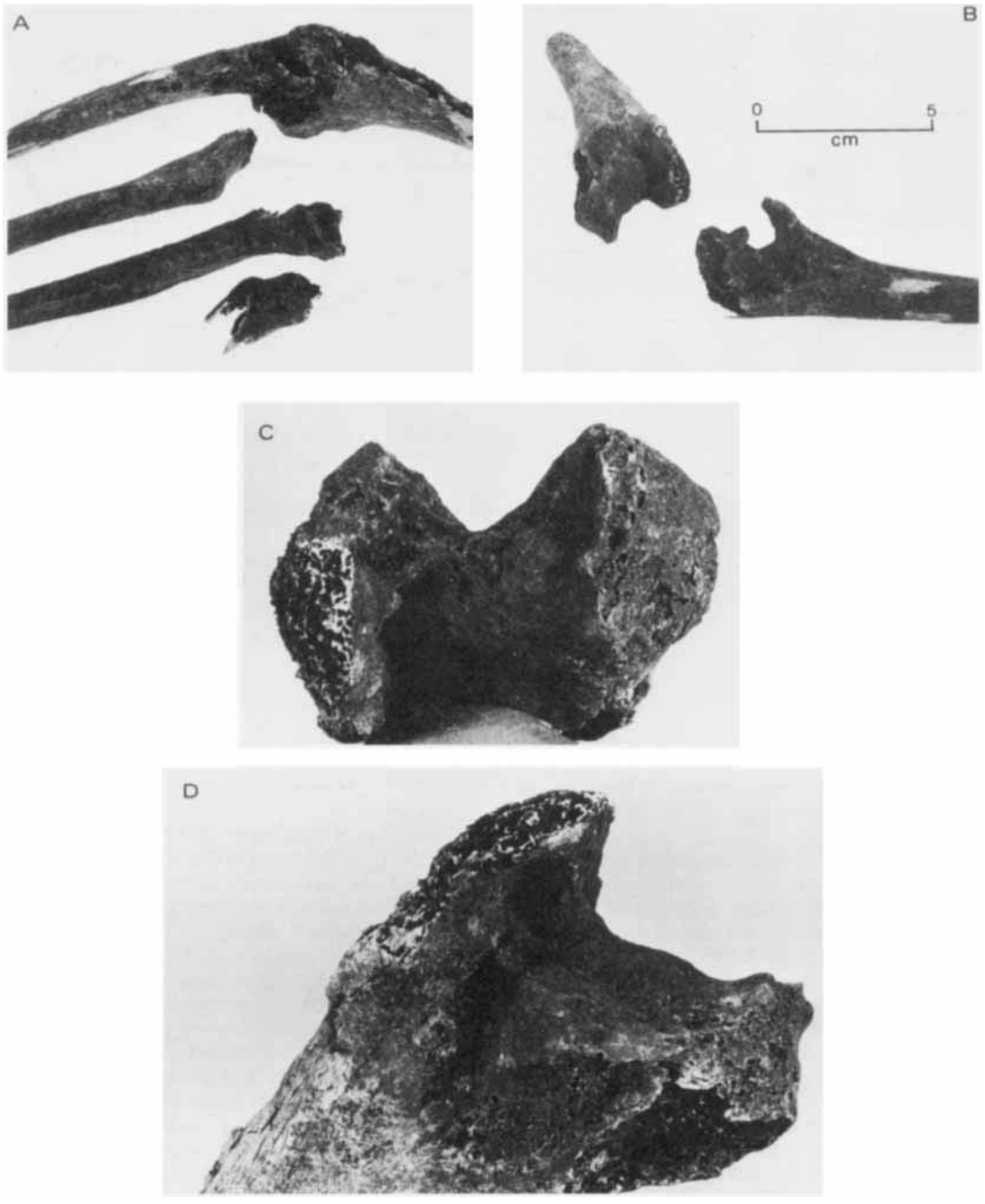

Fig. 2. Elbow joints of Fe 1/33 showing osteomyelitis variolosa. A) Anterior view of left humerus and ulna, lateral view of right ulna, posterior view of radial fragments. B) Left elbow with posterior view of humerus and medial view of ulna. C) Enlargement of caudad view of left distal humerus. D) Enlargement of left humerus, posterior aspect of distal articular surface. Area of periosteal reaction can be seen proximal to what was, in all probability, an elongated medial epicondyle.

lating war launched from the south. At the same time, the disruption of the Huron Nation to the north by the combined effects of the fur trade, the French presence, disease, famine, and war, must have led to disruption also of Neutral life. It would come as no surprise to learn that the later features at the site were not pristine examples of Neutral burial practices. Rather, they were perhaps the unceremonious burial of an increasing number of dead by a decreasing number of survivors. Feature 1 is thus interpreted as a late burial, dating from 1649 to 1650.

The age of feature 1/33

Osteomyelitis variolosa has a peak incidence between 1.5 and 6 years of age (Cockshott, *in litt.*, 17 January 1982) in populations with a long history of exposure to smallpox. Nevertheless, there are cases reported in the literature of individuals having ages of onset of up to 21 years (cited in Cockshott and MacGregor, 1958). The study by Davidson and Palmer (1963) of an epidemic with an extremely high incidence of osteomyelitis variolosa provides information on the age distribution of bone involvement. Of the 82 cases of osteomyelitis, 80% were under 6 years of age and none was over 14.

It seems unlikely that the severe changes seen in Fe 1/33 could have been the result of contracting variola after puberty. Although it is impossible to estimate accurately the age of Fe 1/33 since both the skull and the pubic symphyses are missing, there are several indications of fairly advanced age at death. The osteoporosis, at least of the arms, could have been a consequence of disuse rather than age. However, fusion of the manubrium to the sternum and the fused sacrum suggest an age of at least 30 and probably considerably more.

Since Feature 1 was most likely to be one of the later burials in the Grimsby cemetery, Fe 1/33 probably died in 1649 or 1650 and could have been born as early as 1600. The disease which caused the damage to his elbows probably occurred well before fusion of the distal humeral articular epiphysis—i.e., before age 15. This is especially true if his limp was the result of epiphyseal destruction or premature fusion of the metatarsals, and we may assume that destruction of the tarsals was not the cause in that, of the two calcanei and three tali present, none showed *obvious* abnormalities. We must then look for possible outbreaks of disease from 1600 to 1640 (which is the last possible date if we give Fe 1/33 the latest possible burial [1650], a late age of onset [15 years], and the youngest possible age [25 years]). The Huron and Neutral are well known to have suffered a smallpox epidemic in 1639 (Trigger, 1976:588), but an earlier epidemic would accord much better with the evidence afforded by Fe 1/33.

DISCUSSION

An epidemic of smallpox began in London, England, in 1628 (Creighton, 1965:435). By 1633 it had reached New England (Cook, 1973:491; Duffy, 1953:43; Stearn and Stearn, 1945:2) and then spread, reaching the Mohawk in 1634 (Jameson, 1909:141). In that same year, 1634, an epidemic raged among the Huron. The Jesuit accounts describe it as beginning "with violent fever, which was followed by a sort of measles or smallpox, different, however, from that common in France, accompanied in several cases by blindness for some days, or by dimness of sight, and terminated at length by diarrhea which has carried off many and is still bringing some to the grave" (Thwaites, 1898 8:89). Most authors (e.g., Trigger, 1976:500) seem to accept that this epidemic was measles. Duffy (1953:165) called it a "mild" outbreak of measles although in an earlier publication (Duffy, 1951) he said it was smallpox. Stearn and Stearn (1945:25) used a misreading of the *Jesuit Relations* (Thwaites, 1898 7:287) to prove the disease to be smallpox. Heidenreich (1971:92) said that whether it was measles or smallpox it was more virulent than the forms known in France.

The English occupied Quebec from 1629 to 1633, and most of the French (certainly the literate ones) were sent back to France (Trudel, 1973:177). The St. Lawrence was closed to the French during this period. Thus, it is possible that smallpox was introduced into Huronia from England between 1629 and 1633 (just as it was into New England), or that it arrived from New England via the Mohawk in 1634. In 1633 and 1634, there was a great deal of contact between the Mohawk and the Montagnais (Trigger, 1976:485–486) and there is no doubt that it was from the latter that the Huron in early July contracted the disease which led to the epidemic of 1634 (Thwaites, 1898:8:73, 87). Furthermore, there was contact in the spring of 1634 between the Huron and the most western of the Five Nations of the Iroquois. The Huron sent a large war party to attack a Seneca village and 100 of them were taken prisoner, several of whom managed to escape back to Huronia through Neutral ter-

ritory (Thwaites, 1898:7:213,215; Trigger, 1976:489). There were thus two routes of contact in the years 1633 and 1634 along which smallpox could have reached the Huron.

But was it smallpox? The descriptions provided in two places by the Jesuits (Thwaites, 1898:7:221; 8:87,89) of the epidemic which struck the Huron in 1634 are vague. The French appear not to have caught the disease (but see Thwaites, 1898:7:221) but nearly every Indian seems to have become ill, and the Huron were described as "dying in great numbers" (Thwaites, 1898:7:221). LeJeune and Brébeuf's descriptions could apply almost equally to measles to smallpox (no other diseases need be considered). Both measles and smallpox can cause impairment of the vision. The Jesuits made no reference to the coughing which is a common symptom of measles, and bronchial pneumonia is the usual complication of measles (Christie 1974:390), rather than diarrhea. Nevertheless, diarrhea *can* be the major consequence of measles (Morley, 1980:123 and see discussion in Black et al., 1977:131), especially when individuals are malnourished.

Diarrhea can also be a direct consequence of malnutrition and there is no doubt that both on the trip from Trois Rivières to Huronia (Thwaites, 1898:8:77) and at home in Huronia (Thwaites, 1898:8:97) the Indians were suffering from hunger and famine. Once they became ill they had little to eat (Thwaites, 1898:8:129, 149) and no doubt conditions of hygiene deteriorated as the epidemic took hold. The diarrhea may thus have had an indirect relation to the disease.

Those who choose to interpret the Jesuits's descriptions as measles probably do so because of the implication that the Huron did not die directly from the disease but rather from the complications of it (as in the Fijian epidemic of 1875 [Morley, 1980:117], and the Yanomamo epidemic of 1968 [Neel, 1977:162], but cf. Black et al., 1977:120). This is a reasonable point of view but one that ignores the fact that there are a number of types of smallpox (Koplan and Foster, 1979:440) with mortality rates ranging from less than 1% to almost 100%. It also ignores the real possibility that smallpox has had a "natural history" obscured by vaccination (Christie, 1974:204; Gale, 1959:59) and that the early seventeenth century form was one with a low mortality rate (Cartwright, 1977:77,78).

The history of smallpox and the study of the historical sources relating to the period 1628–1634 are more properly dealt with in detail elsewhere. For the moment we can say that there is no good reason to state that the Jesuits' descriptions of the 1634 epidemic in eastern Canada prove the disease to have been measles or to have been smallpox. We can say only that there was contact with those who are known to have had smallpox in 1634. Either way, the fact remains that a man who died in Neutral country, perhaps in the late 1640s, had probably had smallpox, almost certainly before 1639 and perhaps even before 1634.

The identification in an archaeological context of skeletal changes resulting from smallpox is of interest to palaeopathologists and osteologists, but it may also be the first step in a new understanding of an old problem, the depopulation of North America prior to direct contact with large numbers of Europeans.

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