ANCIENT DISEASE IN OHIO: THE EIDEN POPULATION[1]

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Abstract. Skeletal material from a protohistoric (A.D. 1490 ± 55 years) Amerindian population which lived in Lorain County provided information on one of Ohio's early Indian groups. The skeletal material indicated some categories of pathology and skeletal anomalies which were present. The frequency of occurrence of these skeletal lesions were then interpreted from an epidemiological point of view. The analyses showed the presence of the following classes of skeletal lesions: developmental anomalies, infectious diseases, degenerative conditions, neoplastic lesions, fractures, and a possible nutritional disorder. The results suggest that the adults have significantly ($p < .05$) higher frequencies than the subadults for developmental anomalies, infectious diseases, and degenerative conditions. Also, the adult males have significantly higher frequencies than adult females for developmental anomalies and degenerative conditions.

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Archaeological and skeletal material from the Eiden site were analyzed to present a description of the patterning and frequency of occurrence of skeletal lesions. The Eiden site was initially excavated between 1955 and 1964 by Mr. A. A. Bungart, an amateur archaeologist (McKenzie *et al* 1973). Subsequent excavations were carried out by Case Western Reserve University (Scarry 1973). The skeletal and artifactual material is presently owned and housed by the Lorain County Metropolitan Parks Commission at Lorain, Ohio.

Eiden is located within the present town of Sheffield in Lorain County, Ohio and is situated on the high bluffs of the French Creek approximately 0.2 km from the confluence of the creek with the Black River. The site was radiocarbon dated to A.D. 1490 ± 55 years and, on the basis of this chronology, material culture, and ecological adaptation, Eiden was assigned to the Wolf Phase of the Late Woodland (McKenzie *et al* 1973).

The excavation revealed a composite habitation and burial complex which covered an area of 60 by 150 m. The habitation area consisted of refuse pits, midden remains, and post-molds. Burials were located in shallow, rectangular graves which were interspersed throughout the habitation area. McKenzie *et al* (1973) have provided a detailed discussion of the artifactual remains and the ecological adaptations of the Eiden population. These authors suggest that in addition to the surrounding wild flora and fauna, the inhabitants of Eiden included substantial amounts of maize in their diets. The excavation techniques did not permit the recovery of the plant remains. McKenzie and coinvestigators noted that Eiden was located near four major floral complexes that included an elm-ash swamp, a mixed mesophytic forest, a mixed oak forest, and an area of prairie grasslands and that the faunal remains suggested reliance upon Freshwater Drum (*Aplodinotus grunniens*), White-Tailed Deer (*Odocoileus virginianus*), and Elk (*Cervus canadensis*).

METHODS AND MATERIALS

A total of 234 human burials was reported by Bungart in his field notes (McKenzie *et* 1973). From these a sample of 122 individuals was selected. The criteria used in selecting the sample included: a. the burial must be at least 85% anatomically complete so as to insure a reasonable estimate of the patterning and frequency of skeletal lesions; b. the osseous material of the burial must be in a state of preservation which will enable observations of skel-

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etal lesions to be made; and c. each burial must be aged and sexed.

Of the 122 burials in the study 25.4% (31) were identified as subadults (under 15 years of age), and 74.6% (91) as adults (15 years of age or older). In the adult segment of the population 47.3% (43) were classified as males, and 52.7% (48) as females. No attempt was made to sex the subadults. Age determinations for the subadults were based on: their pattern of dental eruption and enamelization (Sundick 1972), epiphyseal closure (Krogman 1962), fusion of the vertebrae (Anderson 1962), and the appearance of centers of ossification (Krogman 1962). The age assignments for the adults were based on: the pattern of dental eruption and enamelization (Sundick 1972), epiphyseal closure (Krogman 1962), changes in the pubic symphysis (McKern and Stewart 1957), and cranial suture closure (Todd and Lyon 1924, 1925).

Sex determinations for the Eiden adults were based on: cranial differences (Ascadi and Nemeskeri 1971), dental measurements (Ditch and Rose 1972), discriminant function analyses of pelvic (Gustav 1972) and femoral measurements (VanGerven 1972). It should be noted that proper caution was exercised when applying metrical measurement analyses which were standarized on populations other than the study population. Of the 91 adults studied 5 had conflicting sex assignments which were resolved to the satisfaction of the investigators.

The skeletal remains provided the material for the analysis of paleopathology. Skeletal lesions were diagnosed by gross macroscopic examination of the external surfaces of a bone, histological sectioning with microscopic analysis, and radiographic techniques. In most cases these procedures permitted a general diagnosis of the skeletal lesions.

DEVELOPMENTAL ANOMALY ANALYSIS

The developmental anomalies identified on the Eiden material have been separated, for the purposes of this analysis, into Class I and Class II anomalies. Class I anomalies included those skeletal variants which were defined as discontinuous biological variations that are primarily genetically determined (Anderson 1968; Berry and Berry 1971). These included: multiple exostoses on the femur and tibia (Anderson 1968); fossa olecrani perforata (Weber 1950); absence of, incomplete, or multiple foramina of the cervical and thoracic vertebrae (Gruneberg 1950); inflexion or absence of the tuberculum anterius of the cervical vertebrae (Gruneberg 1950); variations in the size of the processus spinosus of the vertebrae (Gruneberg 1950); fusion of the sacral vertebrae (Searle 1954); dyssymphysis ischiopubica (Gruneberg 1952); and spina bifida (Anderson 1968).

Class II anomalies represented skeletal variations that may be the end result of biomechanical stresses applied to the skeletal or muscular system. These included: squatting facets on the tibia (Brothwell 1965), Allen's facets on the head of the femur (Brothwell 1965), and the reaction area on the head of the femur (Lallo 1972). The Class I and II anomalies reported in this study were confined to the postcranial skeleton.

RESULTS AND DISCUSSION

Of the 31 subadults studied, 32.3% (10) showed a developmental anomaly and in all cases the anomalies were identified as Class I (table 1). For the 91 adults, 63.7% (58) displayed an anomaly of which 43.1% (25) were assigned to Class I, and 56.9% (33) to Class II. Of the 43 adult males, 88.4% (38) had a developmental anomaly of which 36.8% (14) were identified as Class I, and 63.2% (24) as Class II. For the 48 adult females, 41.7% (20) showed an anomaly of which 55.0% (11) belonged to Class I

TABLE 1

Frequency of occurrence of developmental anomalies in the Eiden population.

Age*	N_1	N_2	%(N_1)*	Class I N_3	Class I %(N_1)*	Class I %(N_2)†	Class II N_4	Class II %(N_1)*	Class II %(N_2)†
0–14.9	31	10	32.3	10	32.3	100.0	0	0.0	0.0
15–59.9 Total	91	58	63.7	25	27.5	43.1	33	36.3	56.9
15–59.9 ♂	43	38	88.4	14	32.6	36.8	24	55.8	63.2
15–59.9 ♀	48	20	41.7	11	22.9	55.0	9	18.8	45.0
0–59.9	122	68	55.7	35	28.7	51.5	33	27.1	48.5

*Age is expressed in developmental years.
N_1 = Number of individuals in each age class.
N_2 = Number of individuals in each age class with a developmental anomaly (combined Class I and II).
N_3 = Number of individuals in each age class with a Class I anomaly.
N_4 = Number of individuals in each age class with a Class II anomaly.
%* = the frequency of individuals in the age class with a particular anomaly derived on the basis of N_1.
%† = the frequency of developmental anomalies of each class out of the total number of developmental anomalies (N_2).

and 45.0% (9) to Class II (table 1). The age specific frequencies of occurrence of anomalies for the subadults, and the adult males and females, are summarized in tables 2 and 3, respectively.

Chi square results showed that the differences observed between subadults and adults for the total frequency of developmental anomalies were statistically significant at the 5% level ($x^2=9.287$). The difference between subadults and adults for the frequency of Class I anomalies was not significant, however, the difference between subadults and

TABLE 2

Age specific frequency of occurrence of skeletal lesions for subadults of the Eiden population.

Age*	N_1	Devel. Anomalies Class I		Infectious Disease: Periostitis		Infectious Disease: Osteomyelitis		Nutritional Disorders		Trauma	
		N_2	%	N_2	%	N_2	%	N_2	%	N_2	%
0– 1.9	5	0	0.0	0	0.0	1	20.0	2	40.0	0	0.0
2– 4.9	8	2	25.0	1	12.5	1	12.5	4	50.0	0	0.0
5– 9.9	11	3	27.3	5	45.4	2	18.2	7	63.6	2	18.2
10–14.9	7	5	71.4	3	42.9	2	28.6	3	42.9	0	0.0
Total	31	10	32.3	9	29.0	6	19.4	16	51.6	2	64.5

*Age is expressed in developmental years. Note: Because no cases of Class II anomalies, degenerative conditions, or tumors were noted for the subadults, these lesions were omitted from the table.

N_1=number of subadults in each age class.

N_2=number of subadults in each age class with the specified lesion or disease.

TABLE 3

Age specific frequency of occurrence of skeletal lesions for males and females in the Eiden population.

Age*	Sex	N_1	Class I		Class II		Periostitis		Osteo-myelitis		Degenerative Pathology		Nutritional Disorder		Tumors		Trauma	
			N_2	%	N_2	%	N_2	%	N_2	%	N_2	%	N_2	%	N_2	%	N_2	%
15–19.9	♂	5	2	40.0	2	40.0	2	40.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	♀	3	0	0.0	1	33.3	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
20–24.9	♂	4	1	25.0	3	75.0	2	50.0	0	0.0	1	25.0	0	0.0	0	0.0	0	0.0
	♀	4	2	50.0	1	25.0	2	50.0	0	0.0	0	0.0	0	0.0	0	0.0	1	25.0
25–29.9	♂	7	2	28.6	5	71.4	5	71.4	2	28.6	4	57.1	0	0.0	0	0.0	2	28.6
	♀	12	2	16.7	2	16.7	7	58.3	0	0.0	0	0.0	0	0.0	1	8.3	0	0.0
30–34.9	♂	8	3	37.5	4	50.0	6	75.0	2	25.0	6	75.0	0	0.0	1	12.5	0	0.0
	♀	10	2	20.0	2	20.0	5	50.0	0	0.0	5	50.0	0	0.0	1	10.0	2	20.0
35–39.9	♂	4	1	25.0	3	75.0	2	50.0	1	25.0	3	75.0	0	0.0	1	0.0	0	0.0
	♀	3	0	0.0	1	33.3	1	33.3	2	66.7	2	66.7	0	0.0	0	0.0	0	0.0
40–44.9	♂	5	3	60.0	2	40.0	3	60.0	1	20.0	4	80.0	0	0.0	0	0.0	0	0.0
	♀	9	2	22.2	1	11.1	7	77.8	2	22.2	5	55.6	0	0.0	1	11.1	0	0.0
45–49.9	♂	7	2	28.6	4	57.1	4	57.1	2	28.6	6	85.7	1	14.4	1	14.4	1	0.0
	♀	3	2	66.7	1	33.3	2	66.7	1	33.3	2	66.7	3	100.0	0	0.0	0	0.0
50–54.9	♂	2	0	0.0	1	50.0	2	100.0	0	0.0	2	100.0	0	0.0	0	0.0	0	0.0
	♀	2	1	50.0	0	0.0	2	100.0	0	0.0	1	50.0	1	50.0	0	0.0	0	0.0
55–59.9	♂	1	0	0.0	0	0.0	1	100.0	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0
	♀	2	0	0.0	0	0.0	2	0.0	0	0.0	2	100.0	0	0.0	1	50.0	0	0.0
Total ♂		43	14	32.6	24	55.8	27	62.8	8	18.6	27	62.8	1	2.2	2	4.7	2	4.7
Total ♀		48	11	22.9	9	18.8	29	60.4	5	10.4	17	35.4	4	8.3	4	8.3	3	6.3
Grand Total		91	25	27.5	33	36.3	56	61.5	13	14.3	44	48.4	5	5.5	6	6.6	5	5.5

*Age is expressed in developmental years.

N_1=Number of individuals studied.

N_2=Frequency of different types of lesions or disease.

adults for Class II anomalies was significant at the 5% level ($x^2 = 13.627$). The difference observed between adult males and females for the total frequency of developmental anomalies was significant ($x^2 = 21.406$). The difference between adult males and females for Class I anomalies was not significant, however, the difference between the sexes for Class II anomalies was significant at the 5% level ($x^2 = 13.481$).

If the Class I anomalies were primarily genetically determined, then the results suggest that there was little genetic difference between the subadults and the adults and between the adult males and females. This indicates a relatively homogenous and continuous genetic population at Eiden. Alternative interpretations include: Class I anomalies may be influenced by variables other than genetic, or that the study sample may be biased. Since Class II anomalies were primarily stress related (effects of wear and tear), it is suggested that males at Eiden were subjected to greater physical stress or were more susceptible to the effects produced by such stress. At Eiden, differential role behavior (e.g., horticultural activity, hunting, or warfare) may account for the higher frequency of Class II anomalies among the males.

INFECTIOUS DISEASES

The infectious diseases which were tentatively diagnosed for the Eiden population include periostitis and osteomyelitis. Both of these are bacterial infections have their most frequent expression on the long bones. In the diagnosis of periostitis, we relied upon macroscopic and radiographic examination. Macroscopic analysis noted both destructive and regenerative changes which occurred on the periosteal surface. Radiographically, the destructive and regenerative changes were confined to the periosteal region and did not extend into the cortex or the medullary canal. Osteomyelitis caused a much more severe destruction of the osseous material and the infection penetrated the endosteum and entered the haversian and lacunar systems. Macroscopically, we noted large areas of sclerosis in the metaphyseal area of the tibia and the femur, both of which also had sinus tracts which were clearly visible. On several of the subadult specimens the sequestrum and the involucrum were identified.

The causative agents responsible for these bacterial infections are difficult to define. Robbins (1974) pointed out that some form of streptococci or staphylococci is most commonly responsible and reaches the bone through hematogenous seeding, direct extension from a neighboring focus of infection, or as a consequence of trauma which exposes the bone to bacterial contamination. For the Eiden population all three pathways were potential sources of the infections.

On a populational level (ages 0 through 59.9 years), 68.9% (84) of the inhabitants of Eiden had some form of infectious disease (table 4). Of these 84 cases, 77.4% (65) were tentatively classified as periostitis, and 22.6% (19) as osteomyelitis. For the subadults, 48.4% (15) had some form of infection while 75.8% (69) of the adults manifested a lesion. Of the 15 cases of infection among the subadults, 60.0% (9) were periostitis, and 40.0% (6) were osteomyelitis. For the adults, 81.2% (56) of the cases were diagnosed as periostitis, and 18.8% (13) as osteomyelitis. Among the adult males, 81.4% (35) had bony infections of which 77.1% (27) were identified as periostitis, and 22.9% 22.9% (8) as osteomyelitis. For the adult females, 70.8% (34) had infections of which 85.3% (29) were periostitis, and 14.7% (5) were osteomyelitis (table 4). The age specific frequencies of infectious disease for the subadults, and the adult males and females, were presented in tables 2 and 3, respectively.

On a populational level periostitis had a significantly higher ($p < .05$) frequency of occurrence than osteomyelitis ($x^2 = 13.481$). The adults had a significantly higher ($p < .05$) frequency of total infectious diseases than did the subadults ($x^2 = 8.117$). In addition, the adults had a significantly higher frequency of periostitis than the subadults ($x^2 = 9.814$). The subadults had a higher frequency of osteomyelitis but the difference observed between subadults and adults was not significant. Within the subadult segment of the Eiden population, periostitis

TABLE 4
Frequency of occurrence of infectious disease in the Eiden population.

Age*	N_1	N_2	$\%(N_1)$*	Periostitis			Osteomyelitis		
				N_3	$\%(N_1)$*	$\%(N_2)$†	N_4	$\%(N_1)$*	$\%(N_2)$†
0–14.9	31	15	48.4	9	29.0	60.0	6	19.4	40.0
15–59.9 Total	91	69	75.8	56	61.5	81.2	13	14.3	18.8
15–59.9 ♂	43	35	81.4	27	62.8	77.1	8	18.6	22.9
15–59.9 ♀	48	34	70.8	29	60.4	85.3	5	10.4	14.7
0–59.9	122	84	68.8	65	53.3	77.4	19	15.6	22.6

*Age is expressed in developmental years.
N_1 = number of individuals in each age class.
N_2 = number of individuals in each age class with an infectious disease (combined frequency of Periostitis and Osteomyelitis).
N_3 = number of individuals in each age class with Periostitis.
N_4 = number of individuals in each age class with Osteomyelitis.
%* = the frequency of individuals in each age class with an infectious disease derived from the totals in column N_1.
%† = the frequency of each type of infectious disease out of the total number of cases of infectious disease for each age class in N_2.

had a slightly higher frequency than osteomyelitis but the difference was not statistically significant. For the adult segment, periostitis had a higher frequency of occurrence than osteomyelitis and the observed difference was significant at the 5% level ($x^2 = 9.242$). There was no significant difference between adult males and females for the frequency of occurrence of infectious diseases. The adult males had slightly higher frequencies for both periostitis and osteomyelitis but the differences were not statistically significant.

Using contemporary clinical pathology and cultural anthropology concepts, it may be possible to speculate on the cultural-ecological context within which the infectious diseases at Eiden may have begun. For example, Robbins (1974) suggested that the bacterium *Staphylococcus aureus* is the agent most commonly responsible for periostitis and osteomyelitis. It can be suggested that any variable within the environment of the Eiden population which brought it into contact with this bacterium, or one similar to it, may be an important agent in the etiology of the bony infections. May (1960) suggested a model in which culture functioned as a variable in the environment of a human population and also played an important role in the disease experiences of that population. In this model, culture can serve a dual role. It can function either as a wall or a link between human populations and the diseases or disease agents which exist in the environment. Application of May's model to the Eiden population, suggests that any aspect of culture (e.g., technology, social organization, or ideology) which had brought the population into contact with bacterium could result in an increase in the frequency of the bony infections. Likewise, any aspect of culture which functioned to keep the people of Eiden out of contact with bacterium would result in a reduction of the frequency of the bony infections. It must be emphasized that this is only a speculative suggestion but it does provide a model which can be tested by additional archaeological research at Eiden.

It should be noted that for the Eiden population the discussion of infectious disease has focused upon periostitis and osteomyelitis. There are other classes of infectious diseases which may have occurred among the inhabitants of Eiden but infections confined to soft tissues or organ systems do not leave their imprint on the skeletal material. An analysis of paleopathology which is confined to bony material can only identify lesions which leave their imprint on bone. As a result, there are numerous classes of diseases and anomalies for which data cannot be collected and our analyses probably tend to underestimate the actual frequency of diseases and anomalies in the Eiden population.

DEGENERATIVE PATHOLOGY

The degenerative pathology tentatively identified on the Eiden skeletal material was limited to probable osteoarthritis. The distribution at Eiden was, in order of decreasing frequency: the acetabulum and the head of the femur, the distal femur and the proximal tibia, the spinal column (cervical, lumbar, and thoracic), the proximal humerus, the distal humerus, the proximal ulna, and the radius. Surface erosion made it difficult to observe the small bones of the hands and feet. As a result, these observations were omitted from the report.

On a populational level, 36.1% (44) of the inhabitants of Eiden manifested osteoarthritis and none were among the subadults (table 3). Out of 43 adult males, 62.8% (27) showed the lesion; whereas, only 35.4% (17) of the adult females displayed osteoarthritis. The findings suggested that the adult segment of the population had a higher frequency of occurrence of osteoarthritis than the subadults and that the adult males had a higher frequency than the females. The difference observed between the subadults and adults was significant at the 5% level ($x^2 = 21.394$), and the difference between the males and females was also significant ($x^2 = 6.806$).

Robbins (1974) suggested that osteoarthritis was most commonly the result of age and/or repeated trauma acting independently or in conjunction. At Eiden, osteoarthritis was confined to the adult segment of the population. This finding strongly suggests that the lesion was age related. As a probable cause of osteoarthritis, the role of repeated trauma may account for the difference observed between adult males and females. For example, differential cultural role behavior such as horticultural activity (e.g., the breaking of new ground) and hunting may have contributed to the occurrence of osteoarthritis among the adult males. For the adult males, the lesion had its most frequent expression in the acetabulum and head of the femur. These were followed in frequency by the distal and proximal tibia, the proximal humerus, and the spinal column. This pattern of distribution involved the major weight bearing complexes of the body and may reflect the strains of male oriented activities. The adult females however, had low frequencies of involvement for these weight bearing complexes but higher frequencies in the distal tibia and fibula. Since the pattern of role behavior cannot be known for certain, these interpretations should be made with caution.

A POSSIBLE NUTRITIONAL DISORDER

Porotic hyperostosis is a general term for a variety of bone disorders characterized by rarification. Terms such as symmetrical osteoporosis, cribra orbitalia, cribra cranii, and hyperostosis spongiosa have been used in place of porotic hyperostosis. Armelagos (1967) suggested the use of 3 specific terms which describe specific lesions and reference their location. These terms are: osteoporotic pitting, spongy hyperostosis, and cribra orbitalia. Osteoporotic pitting refers to lesions which consist of small pits on the external table of the cranium and correspond to the "porotic type" of Nathan and Haas (1966). Spongy hyperostosis or hyperostosis spongiosa is characterized by the appearance of osteophytes which form a network of trabecula-like bone on the external table of the cranium (Putschar 1966). The term cribra orbitalia was first employed by Welcker (1888) and refers to a lesion located on the superior wall of the ocular orbit. It exhibits close ties, both radiographically and physiologically to osteoporotic pitting and spongy hyperostosis. The lesion can be characterized by tiny porous openings in the roof of an orbit (either unilaterally or bilaterally), or as an extension of cribrous bone into the area of the orbit. Although these terms are used to specifically reference the location of the lesions, all 3 of the cranial lesions are an expression of a general marrow hyperplasia. Recently several investigators suggested that the lesions were the result of a general dietary iron deficiency anemia (Carlson *et al* 1974; El-Najjar *et al* 1975).

On a populational level, 16.4% (20) of the inhabitants of Eiden showed some form of porotic hyperostosis. In all 20 specimens the lesion was identified as cribra orbitalia. In addition to the cribra orbitalia, 60.0% (12) of the cases also displayed a postorbital involvement. That is, 20.0% (4) of the cases of cribra orbitalia also had osteoporotic pitting; 15.0% (3) also had spongy hyperostosis; and 25.0% (5) had both osteoporotic pitting and spongy hyperostosis along with the cribra orbitalia. In 40.0% (8) of the cases of porotic hyperostosis, cribra orbitalia occurred as an isolated lesion but none of the examples of the post-orbital involvement occurred without the presence of cribra orbitalia.

Of the 31 subadults in the sample, 51.6% (16) manifested porotic hyperostosis whereas only 5.5% (5) of the 91 adults showed the lesion (tables 2 and 3). For the 43 adult males at Eiden the frequency of the lesion (table 3) was 2.2% (1), while for females it was 8.3% (4). None of the adults showed any evidence of postorbital involvement but 75.0% (12) of the subadults displayed the post-orbital lesion. The difference observed between subadults and adults was significant at the 5% level ($x^2 = 12.476$) but the difference observed between males and females was not significant.

NEOPLASTIC LESIONS

The analysis of the Eiden skeletal material revealed that 6.6% (6) of the adults had some form of neoplastic lesion (table 3) but none were found in the subadults. Of the 43 adult males, 4.7% (2) had a tumor, while 8.3% (4) of the adult females showed the lesion. Four of the tumors were classified as benign osteomas (button tumors) and 2 as benign hemangiomas. The osteomas were located on the parietals of four of the adult females. One of the hemangiomas was located in the bicipital groove of the left humerus of an adult male, while the other was on the right ilium of an adult male. The differences observed between the subadults and adults, and between adult males and females were not statistically significant.

FRACTURES

On a populational level, 5.7% (7) of the inhabitants of Eiden showed a well healed traumatic lesion. Since all of the observed fractures were healed, it was assumed that they occurred long before death. Of the 7 fractures, 5 had healed without misalignment or excessive callus formation. It was difficult to determine if the 5 aligned fractures were artifically set or manipulated. Of the 31 subadults in the sample, 6.5% (2) had fractures and in both cases the lesions were located on the femur (table 2). Of the 91 adults, 5.5% (5) had fractures, 4.7% (2) in males, and 6.3% (3) in females (table 3). For adult males, the 2 fractures were located on the fibula and for the females, 2 of the 3 fractures were located on the ulna. None of the observed differences were statistically significant.

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