

The Incidence of the Perforation of the Coronoid-olecranon Septum in the Middle Mississippian Population of Dickson Mounds, Fulton County, Illinois

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Abstract

The humeral septum is a thin plate of bone between the coronoid and olecranon fossae at the distal end of the humerus. Into these fossae fit the coronoid and olecranon processes of the ulna and together they form the hinge joint of the elbow. Occasionally the septum dividing the fossae is perforated.

During the summer of 1968 the authors conducted a quantitative and qualitative study of the perforation of the coronoid-olecranon septum in a prehistoric Middle Mississippian American Indian population at Dickson Mounds, Fulton County, Illinois. Included in the study were determination of the incidence of bilateral and unilateral perforation, the relationship of the perforation with age and sex, and the possible relationship of the size of the perforation with age and sex.

It was found that the perforation of the coronoid-olecranon septum is positively correlated with sex, occurring more commonly in females. The perforation seems to be absent in infants and children. The size of the perforation does not seem to increase with age.

Introduction

At the distal end of the humerus is a thin plate of compact bone which separates the coronoid fossa and the olecranon fossa. The bone between the two fossae is termed the humeral, or coronoid-olecranon, septum. Into these fossae fit the coronoid and olecranon processes, respectively, of the ulna. These hook-like processes of the ulna together with the rounded trochlea and fossae of the humerus form the hinge joint of the elbow. Extension of the arm is limited by contact between the olecranon process and posterior surface of the septum. Flexion at the elbow is restricted by contact between the coronoid process and the anterior surface of the septum and the intervening soft tissue on the anterior aspect of the upper and lower arm.

Occasionally the coronoid-olecranon septum is perforated (Figure 1). Apertures in the septum may be bilateral, that is, occurring in both humeri of one individual, or it may be unilateral, occurring on either the right or left side. Hrdlička noted the occurrence of bilaterally and unilaterally perforated septa in a variety of mammalian species, thus demonstrating that the presence of the aperture is not species-specific (6). Among human populations the frequency of the perforation varies from close to zero to almost 60% (1). In most human groups observed to date, perforated septa are more common among females than males, and when present are predominantly bilateral. The incidence of perforated septa is greater in the left than right humerus.

Various theories have been put forth to explain the causes of the variability within and between human populations. Both genetic and

environmental determinants have been invoked, but it remains unclear as to what degree the various factors contribute to the formation of the aperture. The mechanical hypothesis contends that the perforation is a result of activity which wears a hole in the septum. The aperture may be formed by certain types of activity or activities of long duration and thus might be culturally determined.

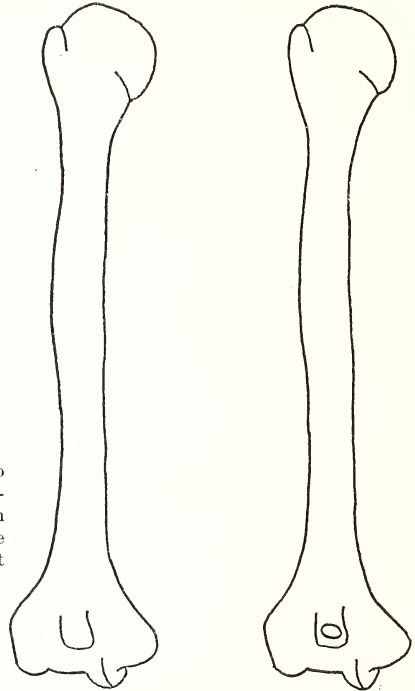


Figure 1. Anterior view of two right humeri. The coronoid-olecranon septum of the humerus on the left is unperforated while the septum of the humerus on the right is perforated.

In a qualitative study conducted in 1932, Hrdlička posited a phylogenetic origin for perforation of the coronoid-olecranon septum, suggesting that the potential for the perforation is inherited as one of a number of generalized mammalian traits (6). As evidence, he cites comparative data which demonstrates similar frequencies of incidence and comparable sexual variability in a variety of infrahuman mammals. Hrdlička also pointed out that the differences in the frequency of the perforation among human populations sharing similar physique and mode of life and activity suggest that presence of the aperture is common to all human groups. Hrdlička further suggests that the realization of this genetic potential is determined by the degree of robusticity of the humerus. The greater the muscularity of an individual, the greater the bone formation and consequently the less likely that incomplete ossification will result in the absence of bone at the septum. Thus lack of bone resorption may result in the perforated coronoid-olecranon septum. This theory would explain the higher incidence of the perforation on the weaker left arm of right-handed individuals, and the greater

frequency of the perforation among females who are generally less robust than males.

Recent studies have tended to ignore Hrdlička's phylogenetic theory and have concentrated on the interpretation that the degree of robusticity is fundamental in determining the presence or absence of the perforation. Benfer and McKern found a positive correlation between the size of the humerus and the presence of perforation of the humeral septum (1). Using minimum middle diameter of the humerus as a quantitative assessment of robusticity, the authors noted that the aperture was more likely to be present in humeri of smaller diameter. Glanville, in 1967, published evidence suggesting a positive correlation between the presence of the perforation and longer coronoid and olecranon processes and increased angles of flexion and extension (5). If robusticity is positively correlated with the length of the ulnar processes, then Glanville's findings lend support to the robusticity theory.

Sample

During the summer of 1968, while analyzing the skeletal material excavated at Dickson Mounds, the authors conducted a qualitative and quantitative study of the perforation of the coronoid-olecranon septum. Dickson Mounds (F^o34) is one of over fourteen hundred prehistoric American Indian sites in Fulton County, Illinois. The semilunar-shaped mound is located on a bluff overlooking the west floodplain of the Illinois River approximately thirty-five miles southwest of the present Peoria, Illinois. The artifact assemblage associated with the burials indicates that the site was used as a burial cemetery by a Middle Mississippian population (4), although recent evidence suggests that a few of the burials represent a Late Woodland people (3). Radiocarbon dates for the Eveland site, a Middle Mississippian site adjacent to Dickson Mounds, range from 950 to 1350 A.D. (communication from E. J. Blasingham).

To date, the number of burials recovered at Dickson Mounds approximates 1050. The majority of the burials are in an excellent state of preservation due to the alkalinity of the loess deposits of which the mound is constructed. The sample includes those burials removed during the 1966, 1967, and 1968 summer excavations as well as those left exposed in situ in the enclosed museum for display purposes.

In the present study of the perforation of the humeral septum the authors examined only those skeletons for which age and sex had been previously determined (2). In addition, all Late Woodland burials were omitted from the analysis because it was felt that to include them in the study might invalidate the findings. The Late Woodland people may have been subjected to different cultural and physical factors than the Middle Mississippian population, and these factors may have contributed to the formation of the perforation as the mechanical theory suggests.

The sample size was further reduced by selecting out for analysis only those burials for which at least the distal portion of both humeri

were available. The purpose in doing so was to eliminate sampling error which would skew the relative percentages of the incidence of perforation among males and females and the frequencies of right, left, and bilaterally perforated septa. As a result, the sample was pared down to 147 burials of which thirty-two were infants and children of indeterminant sex. These burials were excluded from the analysis so that an accurate sex ratio could be ascertained. Therefore 115 burials were utilized in the study.

Methods

Perforation of the coronoid-olecranon septum has usually been treated as a qualitative trait, whose presence or absence has been correlated with various properties of the humerus. The present study is both qualitative and quantitative in the sense that, in addition to observation of the occurrence and nonoccurrence of the perforation, osteometric measurements of the aperture were taken.

First each individual was examined for presence or absence of the perforation. Bilateral and unilateral perforations were noted. The frequency of unperforated septa and bilaterally and unilaterally right and left perforated septa were then separated out according to sex and graphed in Figure 2 to illustrate the sex differential. From these frequencies it was possible to derive percentages which demonstrate the incidence of the perforation in relation to the total sample (N) and male (N_1) and female (N_2) samples (Fig. 3). The chi-square test,

$$\chi^2 = \sum \left[\frac{d^2}{e} \right]$$

was applied to determine the significance of the following variations: 1) distribution of the perforation by sex, 2) distribution of bilateral perforation by sex, 3) distribution of unilateral right perforation by sex, and 4) distribution of unilateral left perforation by sex. Chi-square values and significance, or level of confidence, (p) are given in Figure 3. In all cases the 0.05 level of significance was required.

All perforations were then measured. (In four incidences, post-mortem damage rendered the aperture immeasurable.) The width and height of the perforation were measured on the anterior aspect of the bone using sliding calipers accurate to 0.1 mm. Width was taken as the maximum distance across the aperture on a line perpendicular to the central axis of the shaft, or diaphysis, of the humerus. The height was taken as the maximum distance across the aperture on a line parallel to the central axis of the diaphysis of the humerus. As a measure of the relative size of the perforation the two dimensions were summed. The purpose of this quantitative procedure was to provide data which might indicate sex and age variations in the size of the perforation. To this end, the mean ($\bar{X}$) values of the width and height of the perforations of both the right and left humerus were derived for males and females independently (Fig. 4). To indicate the individual variability in size, standard deviation,

$$\text{s.d.} = \sqrt{\frac{\sum (fd^2)}{N}}$$

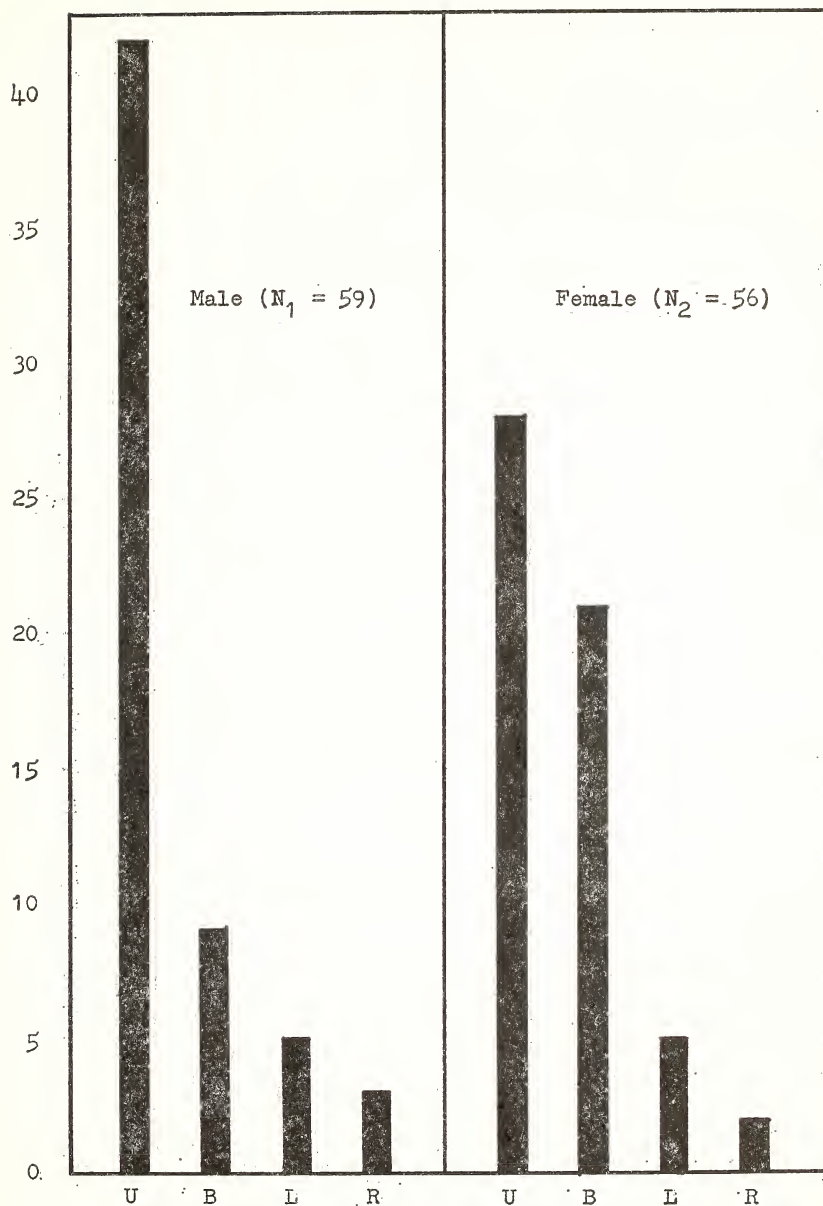


Figure 2. Frequencies (vertical axis) of unperforated septa (U), bilaterally perforated septa (B), and unilaterally perforated septa: left (L) and right (R).

are also listed. In addition, mean values and standard deviations for the total sample are given. To determine the significance of the size difference between the sexes, the chi-square test was employed and the results

are presented in Fig. 4. The 0.05 level of significance was again required. Not shown is a table in which the size of the perforation is plotted against the age gradient of the total sample of individuals with apertures ($n=45$), males displaying perforation ($n=17$) and females displaying perforation ($n=28$). The results are discussed below.

Results

Of the 115 individuals represented in the sample, forty-five, or 39.1%, possessed either bilateral or unilateral perforations of the corono-olecranon septum. Although the sample includes more males than females (59:56), apertures occur more frequently in females, twenty-eight to seventeen (Fig. 2). Perhaps more revealing is the fact that 50.0% of the female population manifests bilateral or unilateral perforations, whereas occurrence is limited to 28.8% among males. The chi-square test was applied to determine the significance of the differential incidence by sex, and although it proved insignificant at the 0.05 level of confidence (Fig. 3), the disparity should not be overlooked.

Of the 115 burials, 26.1% represent individuals with bilateral perforations. In both sexes bilaterally perforated septa were more common than unilateral perforations, occurring in thirty of the forty-five cases in which perforations were observed. However, bilateral perforation of the humeral septum is present in 37.5%, represented by twenty-one individuals, of the female sample (N_2), while it occurs in only 15.3% (nine burials) in the male population (N_1). The difference proved to be significant at the 0.05 level, p equalling 0.03 (Fig. 3).

It is of interest to note that the findings are consistent with the data presented in previous studies and lends strong support to the robusticity theory. The fact that the aperture is more common among females suggest that the lack of robusticity observed in females is positively correlated with presence of the aperture.

Unilaterally perforated septa were few, occurring in 13.0% of the total sample. Of the fifteen unilateral perforations, ten were noted on the left humerus. There is little sexual variation; both males and females manifesting five apertures on the left humerus and three and two perforated septa, respectively, on the right humerus. The 2:1 ratio observed between left and right septa may reflect a lack of robusticity of the left humerus in right-handed individuals; however this conclusion is questionable since the sample size is small and whether this population was indeed predominantly right-handed remains unknown. The fact that there are twice as many bilateral perforations as unilateral perforations probably indicates that the differences in robusticity between individuals is far greater than that between the two humeri of the same individual.

When all burials were listed in order of ascending age at the time of death, it was noted that the width and height of the aperture of both the left and right humerus did not increase with age. If the perforation is related to activity as suggested by the mechanical theory, one might expect the aperture to enlarge with age, at least until the

Sample (N) = 115

Male (N_1) = 59, or 51.3% of N

Female (N_2) = 56, or 48.7% of N

Incidence of perforation = 45, or 39.1% of N

Male perforation = 17, or 28.8% of N_1

Female perforation = 28, or 50.0% of N_2

Chi-square test of significance of distribution of perforation by sex: $X^2 = 2.68$, $p > 0.05$ and $= 0.10$

Incidence of bilateral perforation = 30, or 26.1% of N

Male bilateral perforation = 9, or 15.3% of N_1

Female bilateral perforation = 21, or 37.5% of N_2

Chi-square test of significance of distribution of bilateral perforation by sex: $X^2 = 4.80$, $p < 0.05$ and $= 0.03$

Incidence of unilateral perforation = 15, or 13.0% of N

Left perforation = 10, or 8.7% of N

Male left perforation = 5, or 8.5% of N_1

Female left perforation = 5, or 8.9% of N_2

Chi-square test of significance of distribution of left perforation by sex: $X^2 = 0.0$, $p = 1.0$

Right perforation = 5, or 4.3% of N

Male right perforation = 3, or 5.1% of N_1

Female right perforation = 2, or 3.6% of N_2

Chi-square test of significance of distribution of right perforation by sex: $X^2 = 0.20$, $p = 0.65$

Figure 3. Frequencies and percentages of total perforations, bilateral perforations, and left and right unilateral perforations of the caronoid-olecranon septum indicating the distribution by sex and the significance of that distribution.

Male Sample = 17	Left Humerus		Right Humerus	
	Width (mm)	Height (mm)	Width (mm)	Height (mm)
$\bar{X}$	5.33	3.76	4.76	3.76
s.d.	± 3.26	± 1.41	± 2.22	± 1.94

Female Sample = 28	Left Humerus		Right Humerus	
	Width (mm)	Height (mm)	Width (mm)	Height (mm)
$\bar{X}$	6.25	4.39	4.77	3.82
s.d.	± 2.99	± 1.91	± 2.14	± 1.26

Male + Female Sample = 45	Left Humerus		Right Humerus	
	Width (mm)	Height (mm)	Width (mm)	Height (mm)
$\bar{X}$	5.94	4.18	4.76	3.79
s.d.	± 2.76	± 1.78	± 2.18	± 1.55

Chi-square test of significance of size differential by sex			
Chi-square	Left Humerus	Right Humerus	Both Humeri
X^2	3.41	5.23	4.32
	> 0.05	< 0.05	< 0.05
p	$= 0.06$	$= 0.02$	$= 0.04$

Figure 4. Mean values of the width and height of the perforation of the coronoid-olecranon septum in both humeri. Males are given at the top, followed by females. The third chart combines male and female values. Standard deviations are listed for each mean value. At the bottom are chi square values which indicate the significance of the difference in size (width + height) between males and females.

third decade when a decline in activity is inevitable. The data suggests that the duration of the activity is not involved in the formation or development of the perforation. It should, however, be noted that only the size of the perforation at the time of death is known and not what the size might have been five, ten, or twenty years before death. The

assumption has thus been made that the age gradient for the entire population is an accurate reflection of the size at different ages.

The age of the onset of the performance seems to be during the second decade when development of musculature is at a maximum and bone formation is approaching completion. Of the thirty-four individuals observed under age twelve years, only two evidenced perforation of either humerus. The two exceptions, seven and eight year old females, possessed large perforations which may reflect early maturation or genetic variability.

The mean dimension of the width and height of perforations of both the right and left humerus are, in each case, larger in females than males (Fig. 4). When the chi-square test is employed to determine the significance of the difference in size between males and females, it is observed that the disparity is significant to the 0.05 level of confidence. This quantitative finding, coupled with the greater incidence of perforations among females, lends credence to the robusticity theory. It should also be noted that the mean width and height of the aperture of the left humerus is greater than that of the right (Fig. 4). This fact, too, supports the robusticity theory.

Conclusions

In summary, on the basis of the present study of the perforation of the coronoid-olecranon septum, the following conclusions can be stated:

- 1) The incidence of perforation is greater in females than males.
- 2) The incidence of bilaterally perforated septa is significantly greater among females.
- 3) The size of the perforation in both humeri is significantly larger in females.
- 4) Bilateral perforations are twice as common as unilateral perforations.
- 5) Perforations of the left humerus occur twice as often as perforations of the right humerus.
- 6) The size of the aperture of the left humerus is uniformly larger than the left.
- 7) The size of the perforation does not increase with age.

The current study provides data which may refute the mechanical theory. If the perforation is indeed produced by wear, one would expect the size of the perforation to increase with the accumulating duration of activity. Because the size of the perforation of the humeral septum does not increase with age, the authors reject the mechanical theory as untenable in light of the present findings.

Both the qualitative and quantitative data collected during the study lend support to the robusticity theory. The authors accept Hrdlicka's contention that the presence of the perforation is positively correlated with the lack of robusticity due to incomplete bone formation

of the humeral septum (6). As evidence it is possible to cite the greater incidence of perforation (and bilateral perforations) among females who are less robust than males. Quantitatively, the mean dimensions of both humeri are absolutely larger in females than males, suggesting a lesser degree of bone resorption among females. The greater frequency and larger size of the perforation of the left humerus also tend to substantiate the robusticity theory, if indeed the majority of the sample was right-handed.

The authors have no basis for either accepting or refuting Hrdlička's proposed phylogenetic origin of the perforation of the coronoid-olecranon septum. However, it is suggested that perhaps it is not the potential for the perforation that is inherited, but rather that the potential for degrees of robusticity are inherited and conditioned by environmental factors, the result of which is the presence or absence of the humeral septum.

It seems probable that the perforation of the coronoid-olecranon septum is a result of more than one or two interrelated factors. Before it is possible to understand this complex problem, more data will be required. More extensive studies as well as more intensive analyses of existing data are necessary before the questions touched upon here can be fully answered.

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