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ARTIFICIAL CRANIAL DEFORMATION AND POROTIC HYPEROSTOSIS AT ANGEL SITE, VANDERBURGH COUNTY, INDIANA

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ABSTRACT: Artificial cranial deformation is the alteration of the natural morphology of the vault by cultural practices. Analysis of a sample of crania from the Late Prehistoric Angel site in southwestern Indiana shows that while the overall degree of deformation is slighter than that in other parts of the New World, it appears to be more prevalent at this site than at other sites studies in the Midwest. Markers of nutritional stress, *porotic hyperostosis* and *cribra orbitalia,* also seem to be correlated with the degree of artificial cranial deformation.

INTRODUCTION

Artificial cranial deformation is the alteration of the natural morphology of the vault by cultural practices. This may be an unintentional side effect of the restraint of an infant on a cradleboard or the result of an intentional effort to change the natural vault morphology to suit aesthetic ideals. According to Steward (1973), eastern North America was one of the three distinct areas of North America where artificial cranial deformation was practiced. Cranial deformation appears in the archaeological record in this area as early as the Adena phase, 200 BC to AD 400, in Kentucky and Ohio (Webb and Snow, 1945). Droessler (1981) provides an excellent summary of the cranial deformation literature and the cultural practices which may be involved in altering the natural vault morphology.

ANGEL SITE AND MATERIALS

A description and analysis of the artificial cranial deformation present in a subset of the burial population from the Angel Site, a Middle Mississippian (ca. AD 1200-1450) center on the lower Ohio River just upstream from the mouth of the Green River in Vanderburgh County, Indiana (Black, 1967) are presented in this paper. Aboriginally, this 40-hectare town was surrounded by a bastioned stockage, and within the stockage were located extensive habitation areas, substructure pyramidal mounds, and a plaza. Large-scale excavations were conducted during the WPA era (1939-1942) within a heavily utilized habitation area in the southeastern corner and on Mound F in the southwestern portion of the site. Much smaller areas were excavated elsewhere during the WPA era and later during a continuing series of Indiana University summer archaeological fieldschools. In all, less than four percent of the total site area has been excavated.

The crania examined were recovered during the large WPA excavations in the southeastern corner of the site and represent the bulk of the relatively complete crania. The 48 skulls listed by Johnson (1957, Tables 13 and 18) from

TABLE 1. Artificial cranial deformation at the Angel site.

Burial Cat. No.	Sex	Flattening Planes Fr[1]	Bf[1]	Lb[1]	Oc[1]	As[2]	Neumann's Classification	CO[3]	PH[3]
X11C/1910	F	—	—	S	—	–	lambdoid	*	M
X11C/1913	M	S	—	M	S	—	fronto-lambdoid	*	P
X11C/1919	F	—	—	M	—	—	lambdoid	*	—
X11C/1932	M	—	—	S	—	L	lambdoid	*	—
X11C/2213	F	—	M	M	S	—	bifronto-occipital	*	—
X11C/2214	M	—	—	—	—	L		—	—
X11B/1779	M	S	M	M	—	L	fronto-/bifronto-verticooccipital	*	—
M11B/3272	F	M	—	M	*	—	fronto-verticooccipital	*	—
X11B/3278	F	—	—	S	S	—	lambdoid/occipital	*	—
X11B/3284	F	—	—	S	—	—	lambdoid	P	—
X11B/3303	M	—	S	M	—	R	bifronto-lambdoid	—	—
W11A/1804	M	S	—	M	M	—	fronto-verticooccipital	*	P
W11A/3237	M	—	M	—	—	L	bifrontal	P	P
W11A/11302	M	M	—	—	M	—	fronto-verticooccipital	—	P
W11A/11857	M	M	M	M	*	—	fronto-/bifronto-verticooccipital	*	P
W11A/12814	M	M	—	M	—	—	fronto-verticooccipital	—	M
W11A/13678	M	M	—	M	M	—	fronto-verticooccipital	*	—
W11B/443	M	—	—	M	M	—	lambdoid/occipital	*	—
W11B/804	F	S	—	M	M	L	fronto-lambdoid	P	—
W11B/805	M	S	—	M	*	—	fronto-lambdoid	—	M
W10D/495	M	S	—	S	M	L	fronto-lambdoid	P	M
W10D/4483	F	S	—	S	M	—	fronto-verticooccipital	*	P
W10D/13132	F	M	—	M	S	—	fronto-verticooccipital	P	P
W10D/13185	F	M	—	M	S	—	fronto-verticooccipital	—	M
W10D/13594	F	—	S	S	—	—	bifronto-occipital	—	—

[1] Coding for flattening planes: **F**rontal to **O**ccipital.
— absent
S slight
M marked
* bone too fragmentary

[2] Coding for flattening planes: **As**terion.
— absent
L present on left side
R present on right side

[3] Coding for **C**ribra **O**rbitalia and **P**orotic **H**yperostosis.
— absent
P present
M marginally present
* orbital surface of frontal not preserved

Subdivisions X-11-C, X-11-B, X-10-C, W-11-A, W-11-B, and W-10-D provided a maximum list of potential specimens. Of these, three could not be located in the curated collections. Twenty were sufficiently fragmentary and/or distorted post-mortem so that extensive reconstruction would be necessary, resulting in a greater chance of falsely identifying deformation. The final sample studied consisted of 25 crania, 14 male and 11 female.

CRANIAL DEFORMATION

The scoring of deformation used for the Angel series was adapted from that of Judith Droessler (1981), which was in turn modified from the classificatory scheme of Georg Neumann (1942). Of the seven types of artificial cranial deformation described by Neumann, four are relevant to the study of the Angel cranial deformation (Figure 1).

According to Neumann (1942, pp. 308), *lambdoid deformation* (Figure 1A) "occurs only in a mild form as an occasional individual variation in crania with simple occipital deformation in series from the southeastern states. In skulls from the Chaco Canyon region of New Mexico, . . . the plane of flattening is inclined at an angle of 50 to 60 degrees to the eye-ear plane [Frankfurt horizontal]." Neumann distinguishes this from natural lambdoid flattening; the latter is centered on the sagittal suture between the centers of artificial obelionic and lambdoid deformation.

Occipital deformation (Figure 1C) is "at right angles to the eye-ear plane, is probably unintentional, often markedly asymmetrical, and generally does not involve the frontal bone" (1942, pp. 308). This type of flattening is sometimes referred to as *cradleboard deformity* (Droessler, 1981); the flattening is thought to have been the result of the weight of the infant's head on a hard cradleboard (Tennessee State Museum, 1985). This may be the reason Neumann characterized it as probably unintentional.

Bifronto-occipital deformation (Figure 1B) "consists of bilateral flattening that produces a very narrow frontal bone associated with a moderate degree of vertical occipital flattening" (Neumann, 1942, pp. 308). *Fronto-verticooccipital deformation* (Figure 1D) "is characterized by flattening of the frontal, probably by means of a board, in conjunction with the simple vertical occipital deformation produced by tying the head of the infant to a flat surface" (Neumann 1942, pp. 309). Since Neumann considered lambdoid deformation a variation of occipital deformation, his compound categories of bifronto-occipital and fronto-verticooccipital deformation could and probably did include *bifronto-lambdoid* and *fronto-lambdoid deformation*, respectively.

Because anterior flattening was not clearly associated with posterior flattening in the Illinois Late Woodland and Mississippian cranial series examined by Droessler (1981), she did not use Neumann's types but derived from them four planes of cranial flattening: *frontal*, *bifrontal*, *lambdoid* (centered at *lambdoid*, the point at which the two parietal and the occipital bones meet), and *occipital* (centered at *inion*, the point at the base of the external occipital protuberance in the midline of the skull). These four planes of cranial flattening could be independently scored.

The flattening in the Angel sample was scored with reference to the skulls Droessler considered typical of the deformation classes she created (Droessler,

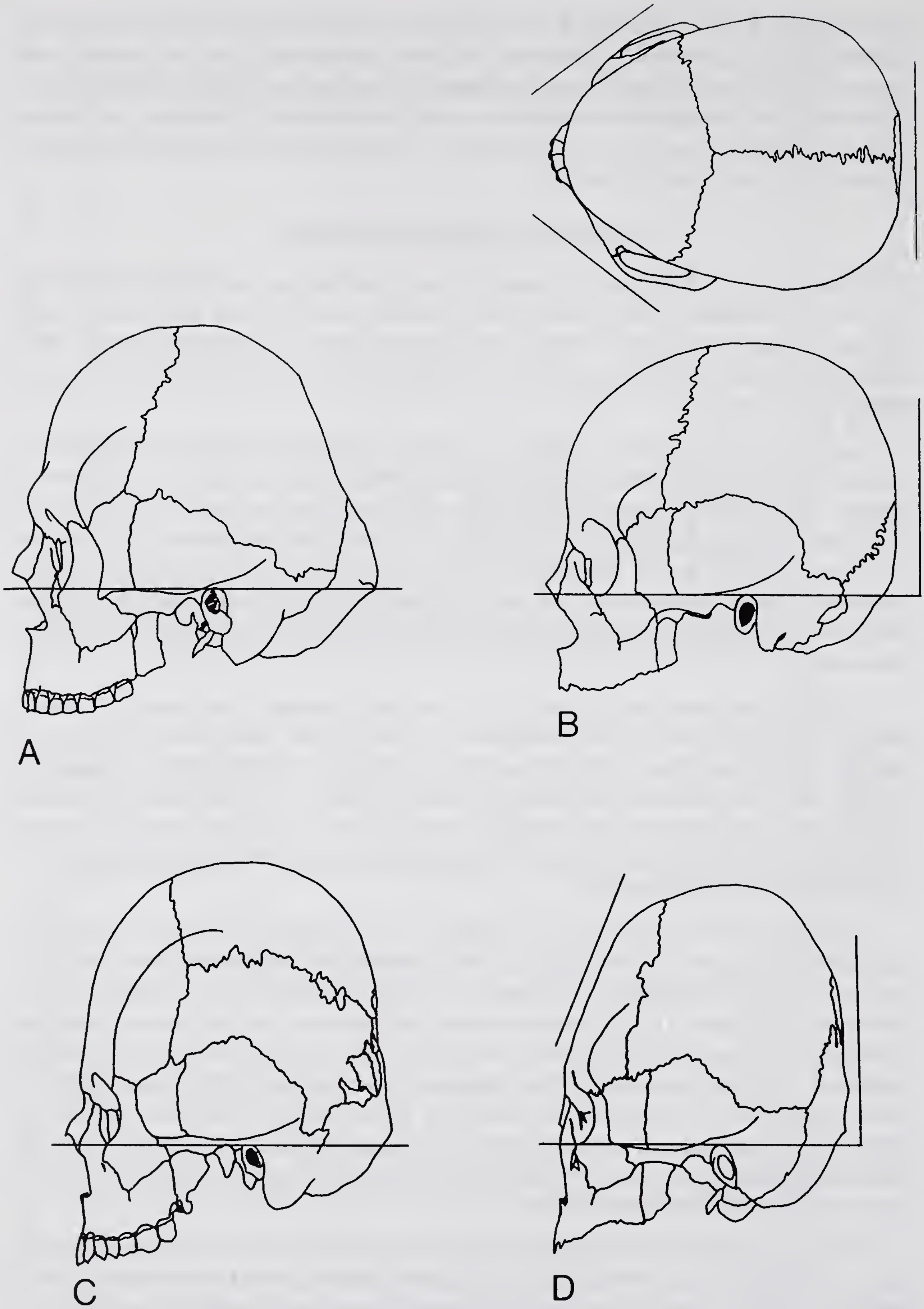

FIGURE 1. Four of Neumann's types of artificial cranial deformation: **A.** lambdoid; **B.** bifronto-occipital; **C.** occipital; and **D.** fronto-verticooccipital (adapted from Neumann, 1942, p. 307).

TABLE 2. Incidence of deformation of by plane of flattening and sex of individuals.

	Frontal	Bifrontal	Lambdoid	Occipital	Asterion	
MALES (no = 14)	9 (64.3)	4 (28.6)	11 (78.6)	6 (42.8)	6 (42.8)	Count (%)
FEMALES (no = 11)	4 (36.4)	2 (18.2)	11 (100.0)	6 (54.5)	1 (9.1)	Count (%)
TOTAL	13 (52.0)	6 (24.0)	22 (88.0)	12 (48.0)	7 (28.0)	Count (%)

1981, Table 10). For each of the four flattening planes, the crania from Angel were arranged in a continuum from no flattening to most flattened. This continuum was then collapsed into three groups: no flattening, slight flattening, and marked flattening. Approximately two weeks later, the scoring was repeated. Seventy-six percent of the flattening planes were assigned to the same rank in the second scoring as in the first. About one-half of the discrepancies involved difficulties in separating the lambdoid and occipital flattening planes.

While scoring the four more conventional kinds of flattening, a fifth asymmetrical plane of flattening, centered at *asterion* (the point at which the occipital, parietal, and temporal bones meet) and which could not be attributed to premature suture closure or post-mortem warping, was noted on seven skulls. Neumann (1942) suggested that occipital deformation could be markedly asymmetrical, and asterion flattening could be an illustration of this asymmetry. Due to its infrequency and ambiguous importance, it was scored present or absent, and the side on which it occurred was noted.

DISCUSSION

Table 1 presents the data collected on artificial cranial deformation within the Angel sample. Both classifications (Neumann's, as expanded here, as well as the independent scoring of flattening planes) are given. The following types of deformation, in Neumann's terms, were observed: lambdoid deformation (no. = 4), bifronto-occipital deformation (no. = 2), fronto-verticooccipital deformation (no. = 8), bifronto-lambdoid deformation (no. = 1), and fronto-lambdoid deformation (no. = 4). Five skulls exhibited patterns of cranial deformation which did not fit neatly within Neumann's classification. Only one skull did not exhibit any form of deformation. However, while deformation was the rule within the Angel series, it was much more subtle than that present in South American, Northwest Coast, or Southwestern U.S. series (Shipman, *et al.*, 1985, Figure 16-4; Flower, 1881).

Table 2 summarizes the incidence of the five planes of flattening observed within the Angel series. For the four conventional planes of flattening, the occurrence of deformation appears more frequent at Angel, when compared to Droessler's (1981) results from the Schild and Yokem Mississippian series. At Angel, lambdoid flattening occurs most frequently; 88% of the crania exhibited this type of flattening. This is slightly higher than the incidence at both Schild (81.4%) and Yokem (74.4%) but seems comparable. Fifty-two percent of the Angel crania exhibited frontal flattening; this also appears to be more frequent than at Schild

(36.1%) and Yokem (10.0). Occipital flattening is present on 48.0% of the Angel crania, and this would rise to 64.0% if asterion flattening is an asymmetrical variant of occipital flattening. This value is quite high, when compared to Schild (12.5%) and Yokem (10.0%). Twenty-four percent of the Angel skulls exhibited bifrontal flattening. This seems roughly comparable to Schild (19.4%), and both are high, when compared to Yokem (7.5%). Finally, flattening at asterion appears to occur preferentially on the left side.

The chi-square statistic was calculated for the frequencies represented by the percentages just enumerated. At a 95% confidence level for a one-tailed test with 6 degrees of freedom, the null hypothesis was rejected, and it was concluded that there is a significantly greater frequency of cranial deformation at Angel than at Schild and Yokem.

At least part of this difference may be explained in terms of the relative positions of the sites being compared in their respective settlement hierarchies and, by extension, the sites' inhabitants in their respective socio-political hierarchies. Angel was the "capital" of a relatively small, peripheral Mississippian polity, and the individuals buried there should include the highest ranking persons in the socio-political hierarchy. In contrast, the Schild and Yokem cemeteries served hamlet and farmstead residents in the hinterlands of the much larger Cahokia polity (Cook, 1983; Goldstein, 1980; Perino, 1971a, 1971b). Thus, the individuals buried at Schild and Yokem should have been of relatively lower status than those buried at Angel. Additionally, Cook (1983) has suggested that some portion of the Schild burial population, especially adult males, was buried or processed elsewhere, possibly at Cahokia. If, as Harn (1971) has suggested for the Dickson Mounds Mississippian burial population, artificial cranial deformation is indicative of high socio-political status, then it is not unexpected that the residents of Angel should show greater frequencies of artificial cranial deformation than the individuals residing in the vicinity of the Schild and Yokem cemeteries.

CRANIAL DEFORMATION AND POROTIC HYPEROSTOSIS

No systematic attempts were made to identify all paleopathologies during this study. However, while examining the crania during scoring of the deformation, a number of crania were noted that exhibited *porotic hyperostosis* and/or *cribra orbitalia*. These conditions appeared to be most prevalent on crania with the most extreme frontal and lambdoid/occipital flattening (D.C. Cook, personal comm.).

Porotic hyperostosis (also referred to as *hyperostosis symmetrica* and *osteoporosis symmetrica*) and *cribra orbitalia* are lesions of the cranium, which are non-specific indicators of anemias (Cook, 1984). The combination of the widening of the spongy diploe and the thinning of the outer dense cortical bone results in a porous-appearing exterior. Cribra orbitalia is the formation of porous bone on the orbital surface of the frontal bone (Shipman, *et al.*, 1985, Figure 16-9), and porotic hyperostosis occurs on the external surfaces of the frontal, parietal, and occipital bones. Observation of cribra orbitalia on the Angel crania was limited, because in many cases the orbital surfaces of the frontal were not preserved. The incidence of porotic hyperostosis was observed on the parietal behind and above the point of the bosses and on the occipital around and above the external occipital protuberance.

Anterior Flattening

Posterior Flattening	absent	slight	marked
absent	o		x
slight	ox ox	o	
marked	oo	xx oxx xx	oxx ooxx ox

Porotic Hyperostosis / Cribra Orbitalia

x - present
o - absent

TABLE 3. Occurrence of porotic hyperostosis/cribra orbitalia by varying degrees of anterior and posterior artificial cranial flattening.

In general, these conditions have been attributed to a number of anemias: thalassemia, hereditary anemia, sickle-cell anemia, and iron-deficiency anemia. The alteration of the cranial bones is the result of the increased red blood cell production taking place in the diploe. The incidence of porotic hyperostosis/cribra orbitalia in New World populations is usually attributed to nutritional stress (Goodman, *et al.*, 1984). Roosevelt (1984) has suggested that porotic hyperostosis/cribra orbitalia indicates chronic iron-deficiency anemia, which may result from high carrying-capacity (maize) diets that are often low in iron. Goodman, Lallo, Armelagos, and Rose (1984) have documented an increase in the incidence of porotic hyperostosis/cribra orbitalia from the Late Woodland to the Mississippian periods populations at Dickson Mounds in Illinois. During the Late Woodland period, porosity is limited to the orbits, but by the Mississippian period, porosity has involved other cranial bones, suggesting an increasing nutritional stress. They hypothesize that the frequency and degree of involvement of porotic hyperostosis increases with increased maize agriculture.

The incidence of cribra orbitalia and porotic hyperostosis is tabulated in Table 1, and an attempt to illustrate the occurrence of both markers by degree of anterior (frontal and bifrontal) and posterior (lambdoid and occipital) flattening is presented in Table 3. It appears that porotic hyperostosis/cribra orbitalia, hence anemia, is positively correlated with marked posterior and slight-to-marked anterior cranial deformation.

This result seems counterintuitive. If artificial cranial deformation is indeed a status marker, then one would expect that the most deformed skulls would be the least likely to exhibit signs of nutritional stress, if higher status individuals had access to a "better" quality (meaning more meat and less maize) diet. However, this dietary pattern may not be the situation, or this conclusion may be too simplistic. When these individuals were alive the entire population may have been under some type of stress, nutritional or otherwise, that was manifested in part by anemia. In addition, cranial deformation may not be simply a status marker but a marker of some other role, such as clan or society membership. Finally, it seems reasonable to assert that the conditions subsumed under the simple equation "cranial deformation = higher status = better quality diet" are actually much more complex. Hopefully, further work on the Angel and similar burial populations will help clarify the picture.

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