EFFECT OF ARTIFICIAL BRACHYCEPHALIZATION
ON THE CRANIOFACIAL STRUCTURES
OF ADENA INDIANS

A Thesis

Presented in Partial Fulfillment of the Requirements for
the Degree of Master of Art
Graduate School of The Ohio State University

by

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* * * * *

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1991

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To my love, Rozita
ACKNOWLEDGMENTS

I express sincere appreciation to Dr. Paul W. Sciulli for his guidance and insight throughout the research. Thanks go to the other members of my advisory committee, Drs. Frank E. Poirier and James G. Burch for their suggestions and comments. Gratitude is expressed to the Ohio Historical Society and Mr. Brath Baker for providing us with the skull samples. To The Ohio State University, Department of Anthropology, College of Dentistry and Department of Orthodontics: I thank you for being so kind and generous to me. To my wife: Rozita, I offer sincere thanks for your unshakable faith in me and your willingness to endure with me the vicissitudes of my endeavors. To my mother, brother and sister: I thank you for understanding my goals in life and your emotional support through my education.
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CHAPTER I
INTRODUCTION

Initial interactions between physical anthropology and archaeology in North America led osteologists to become increasingly concerned with the description of cranial shape to explain the evolution of native Americans. Craniometrics in America as well as Europe began to discover variability within the American race. Some authors (Retzius, 1855), were stressing the fact that brachycranic and dolichocranic skulls were figured among the plates of *Crania Americana*, while others (Morton 1852), were insisting upon a typical brachypanic mound skull in eastern northern America.

Following initial attempts at cranial morphometrics, several archaeologists began relying on skeletal data in their reconstruction of cultural history. Putnam (1890), discussed the (peaceful) mixing between the "long or narrow-headed race" and that of the short, broad skull. A common assumption at this time was that each type or "race" had derived from a distinctive migration into the New World. The Ohio Valley was a critical point in this process and probably nowhere was there more marked evidence (according to this idea) of the
meeting between these two races than in the Ohio Valley. According to Putnam, the variation in the character of the burial-places and sepulchral mounds of different kinds in this area agrees with the skulls found in them. Some burial sets contained the brachycephalic type alone. In others, both brachycephalic and dolichocephalic forms were found with many of the mesencephalic or intermediate forms, indicating a mixture of the two principal types, which seem to be of different races or subraces.

Other interpretations of the marked variability in crania from Ohio Valley mounds included discussions of warfare between the long and short-headed folks. Moorehead (1892), later elaborated on the theme of hostile interactions by suggesting that, at the Hopewell site, the dolichocephalics were characterized as servants or perhaps slaves of the dominant brachycephalic group.

The distributional pattern and the similarity in cranial deformation between Adena and Mexican crania led Snow (1945, 1957) to hypothesize a Mexican origin for the populations participating in the Ohio Valley. The brachycephalic nature of the Adena type is somewhat arbitrary, however, because 92% of the series used to define the type was artificially deformed. Snow justified the use of deformed crania by
assuming that cradleboarding only exaggerated the essentially round-shaped heads of the individuals.

Griffin (1948) and Neumann (1952) defined the dolichocephalic samples from late Archaic burial complexes as Lenapid type (moderately rugged facial and cranial morphological features and mid range cranial, nasal and orbit indices) found frequently in eastern and northeastern North America. In contrast, skeletal samples from the Adena burial complex (Webb and Snow, 1945, Webb and Baby, 1957; Dragoo, 1963; Fitting and Brose, 1971), were assigned to the Walcolid type (a rugged, muscular, brachycephalic type) found frequently in southern and southwestern North America.

Neumann (1960) revised his position in favor of a northern origin for Adena populations. He argued for a process of brachycephalization which transformed the Late archaic Lenapid groups of the southern margin of the Great Lakes, into the Adena physical type.

INFLUENCE and EXTENSION OF ADENA

The basic Adena manifestation is concentrated in the Ohio Valley, within a radius of 159 miles of Chillicothe, Ohio. Radiocarbon dating indicates that the culture in this area attained relatively high development as early as 800 B.C. and
that it was still thriving as late as 100 A.D. There is evidence of Adena-like manifestations and the possible existence of Adena people in other parts of eastern United States. As early as 1937 Ritchie recognized the occurrence of numerous Adena-like artifacts associated with Middlesex type sites in central and eastern New York State. These items do not appear alone, but are part of the local artifact assemblage. It would appear, therefore, that the Middlesex people were strongly influenced by the Adena Culture of the Ohio Valley.

The location of 66 sites in the Ohio River Basin, classified by Greenman (1932) as Adena Sites are distributed by states as follows:

Ohio ............................................. 45
West Virginia ................................. 15
Indiana ......................................... 5
Pennsylvania ................................. 1

To the 66 Adena Sites in the states of Ohio, West Virginia, Indiana, and Pennsylvania, there have been added 20 more sites in Kentucky, which have been recently excavated and classified as Adena. The distribution of these 86 sites in five states, which have been previously classified as of Adena
origin, may be taken to indicate the known area of Adena occupation in the Ohio River Basin.

From investigations in New York, Maryland, Alabama, and Georgia, it has been concluded that the Adena cultural influence spread far beyond its area of concentration in the Ohio Valley, and was a potent influence on much of the eastern half of the United States about 800 years B.C. and for perhaps 900 years thereafter.

Excavations of Archaic sites have yielded many traits and burial customs so similar to Adena that contact, on an ancestor-descendent relationship of these basically different cultural complexes has been suspected.

The Terminal Late Archaic samples represent populations participating in a Archaic burial complex (Griffin, 1948, Fitting and Brose, 1971). The known geographical distribution of Terminal Late Archaic sites includes central and northwestern Ohio, northern Indiana, southern Michigan and parts of southwestern Ontario (Cunningham, 1948; Fitting and Borse, 1971). The temporal placement of the Terminal Late Archaic complex has been considered Archaic, based on artifact association and the lack of ceramics.

The estimation of the time gap between the Terminal Late Archaic (ca. 1500-500 B.C.) and Adena (ca. 1000 B.C. – A.D. 0)
is now possible as the result of radiocarbon dates obtained in the last two years. The probability is that this gap will be diminished and disappear.

This suggestion is supported by the discovery of significant similarities between the Archaic and Adena, a few of which seem to indicate at least contact between these peoples:

1. The use of red ocher in burials.
2. Cremation.
3. Animal masks and headdresses.
5. Conical tubular pipes.
7. Atlatls and atlatl weights.

ADENA PORTRAITURE

The identification of the Adena characteristics has been well established and consistent ever since Hertzberg (1940) described the first Kentucky Skeletal series as a "a large, round-headed, long-faced medium stature group with occasional tall members". He noted the presence of occipital deformation. The accompanying plate 1 (from The Adena People by Webb and Snow) portrays well the craniofacial
characteristics of the Adena male and female.

It is pertinent to quote the interesting and useful description by Samuel George Morton in his famous catalog of American crania where he described the distinctive, deformed Adena male skull from Chillicothe, Ohio, now preserved in the Philadelphia Academy of Natural Sciences:

This is, perhaps the most admirably-deformed head of the American race hitherto discovered. It possesses the national characteristics in perfection, as seen in the elevated vertex, flattened occiput, great interparietal diameter, ponderous bony structure, salient nose, large jaws and broad face... Similar forms are common in the Peruvian tombs, and have the occiput, as in this instance, so flattened and vertical as to give the idea of artificial compression; yet this is only an exaggeration of the natural form, caused by the pressure of the cradleboard in common use among the American nations.

The outstanding facial profile described above is a distinctive feature of the Adena male face, and is found in nearly all of the male skulls in combination with a large face (both length and breadth). The most outstanding single dimension of the head is that of height, which is undoubtedly increased by the pronounced deformation of the back-head. These deformed Adena skulls are the highest recorded in any human group. The forehead is typically prominent, bordered below by fairly sizeable brow-ridges. The root of the nose is of average proportions and continues on to a prominent
convex bridge, one of the prominent features of the face.

The characteristic bulge of the upper and lower jaws (alveolar prognathism) is moderate in projection and is supported by a chin that is unusually prominent for American Indian samples. Usually the cheek bones are not only large but they have a forward and lateral prominence that must have formed a characteristic feature of these prehistoric Indian faces. The lower face (mouth and lower jaw sections) is moderately full as seen from the front. One of the particular features present in at least one-half of the observed examples is the great width of the bony chin, formed by bilateral eminences rarely found among the skulls of the much earlier Shell Heap People (Snow, 1948), or among the later Hopewell People (Snow and Baby, unpublished).

In a detailed survey of America Indian varieties associated with archaeological province, Neumann (1952) indicated his agreement with the identification of the physical type in Kentucky, described by Hertzberg, by listing the rugged brachycephals which appear in Adena as members of his Walcolid variety.

Plates 2, 3, 4, offer the opportunity to compare Adena and Archaic crania. The skull of these individuals, represent an average of these population groups. It will be noted that the
Archaic skull from Berry Hill is longer and smaller than that of the well preserved Adena skull from Cowan Creek Mound. One of the interesting facial features which occurs commonly among the Adena male specimens, is the malar tuberosity. This bony eminence, providing muscular attachment, is often very large and prominent on rugged skulls, so much so as to suggest its utility as a minor sex criterion much like the brow ridges or mastoid processes. This prominence on the cheek bones gives additional jut to the already outstanding malars of the Indian face and doubtless contributes to the characteristic "flat face" of Adena males.

According to Webb (1945), approximately 92% of the Adena skulls (89% male, 5% female of all ages) are deformed at the back to moderate or pronounced degrees. Nearly one-third show flattened areas on each side of the forehead just above the frontal bosses. It is possible that these skeletal remains are from those individuals apparently distinguished from all others by virtue of their rank, honor, and birth, as determined by the social values of their contemporaries (Webb, 1957).

There are a few skulls of both sexes which show little or no deformation. These appear somewhat different in their morphology. They are narrower with longer, less prominent
HEAD DEFORMATION

The presence of so many Adena skulls with deformation leads to a discussion of the custom of artificial head deformation. Here the skulls of infants and young children are particularly instructive since they retain most strongly the flattening effect of the deformation. It is surmised that cradleboarding prevailed (as it still does among many Indians). Plate 5 is an attempt to illustrate the use of such a cradleboard (Adena materials recovered from the Rock Shelters of Eastern Kentucky). It is supposed that in order to help hold the ungainly head, a binding of some sort was bound across the forehead. The soft bones of the infant head were thus brought against the flat surface of the cradleboard producing in time, the characteristic flat occiput. In some cases due to the stresses of the binding on each side of the forehead the bifrontal flat areas were produced. In combination with cradleboard swaddling, binding cords or thongs were apparently wrapped tightly around the head. These cords apparently passed from the forehead, above the eyebrows, along the sides of the head just above the ears, and around the back of the head. This particular placement of the confining cord seems to be suggested by the depressed groove
or furrows (swails) extending from the posterior borders of the temporal to the adjoining parts of the occipital bone, if not by the supraorbital depression (groove). Some of the more extreme cases even present grooves which run horizontally across the back of the occiput (Webb, 1957).

In addition to this circular shaping-pressure, perhaps pads were placed on each side of the forehead to hold the head firmly in position, with the back of the head pressed flat against the surface of the cradleboard. There are a few examples of higher flattening on the back of the vault which technically can be defined as lambdoidal flattening (Williams, 1942). Such variations could easily have been caused by placing pads behind the baby’s head, similar to the methods used by the Pueblo Indians of the Southwest.

The metric data reflect the strong probability that this pseudo-circular type of head binding produced the characteristic Adena skull form. It will be noted that the Adena skulls, deformed as they are, are the tallest known in the world. The extreme height of the skull vault would certainly be the sort of compensatory change which would result from such compressive forces. These forces would tend to limit the growth of the head in the horizontal axis and to increase the transverse axis (breadth) as well as the
height (Snow, 1951).

It is possible that the natural head shape would influence the ease with which deformation is brought about. The flattening of the head of a long headed infant could be a more difficult process than the flattening of a round headed baby. Babies with long heads lie naturally with the head to the sides, whereas babies with round heads usually lie on the back of the head. A round head could be more easily kept in place against the cradleboard than a long head. This fact appears to be supported by the more frequent occurrence of occipital flattening among Indian groups of round headed ancestry than those of long headed stock (Webb, 1945).

The occipital deformation which occurs in 92% of both sexes of the Adena skulls appears as a flat plane above the line of the neck musculature and extends in pronounced degrees up on the parietales to obelion. Nearly one third of the adult Adena skulls show some bifrontal flattening in association with occipital flattening. The flat areas are on each side above the frontal bosses and often meet to form a median crest. Usually the deformation disappears near the frontal side of the coronal suture although the adjoining parietal may share the sloping "roof like" flattening (Webb, 1945).
Plate I: Craniofacial characteristics of Adena male and female.
Plate II: Frontal view of Terminal Late Archaic male skull (left), and Adena male skull (right).
Plate III: Lateral view of Terminal Late Archaic male skull (left), and Adena male skull (right).
Plate IV: Top view of Terminal Late Archaia male skull (left), and Aena male skull (right).
Plate V: The use of cradleboard.
CHAPTER II
OBJECTIVES

Based on the above review the objective of this investigation is threefold. First, it is necessary to interpret variation in undeformed skull samples from the Terminal Late Archaic and Adena, in light of an alternate theory of population variation. With this view, I will consider both within sample and between sample within complex diversity as potential sources of a significant amount of variation. Second, by comparing the normal growth in undeformed skulls with what is created by the use of headbands and cradleboards in deformed skull samples from Adena, I will be able to evaluate the effect of artificial brachycephalization on the normal pattern of growth and development of the craniofacial structures. Third, I will evaluate Neumann's (1960) hypothesis of an ancestor-descendant relationship between Terminal Late Archaic and Adena populations.
CHAPTER III
MATERIALS & METHODS

The undeformed skull samples are from seven adult individuals from Watts Cave in Kentucky, and Berry Hill in Ohio. These sites are referred to the Terminal Late Archaic burial complex, which occurred in the southcentral Great Lakes area during the latest phase (c. 3000-2500 B.P.) of the Late Archaic (6000-2500 B.P.) period.

Ten undeformed Adena adult skull samples are from Holmes Mounds, McMurray Mounds and Cowan Creek Mounds, Adena sites from Early woodland Adena (ca. 1000 B.C. - A.D. 0) in the Great Lakes and Ohio Valley regions. Five deformed skull samples representing the Adena complex are from three sites, Holmes Mound, Cowan Creek Mound and the Berry Hill site.

The samples in this study are relatively small, the criteria for inclusion in this study are that the skull must be complete, i.e., all internal structures must be present. Over 100 skulls were reviewed and examined and 22 were found to contain all needed landmarks.

Cephalometric roentgenograms of 22 skull samples were taken with Zise cephalometric roentgenogram unit. The X-ray beam pointed toward the right side of each skull at fixed
distance between each skull to the X-ray film (17 cm). All settings on the roentgenogram unit were the same for all subjects. This insured consistency.

Skulls were marked with lead at all points that were to be studied in order to determine the accuracy of each point.

These points are:

ACANTHION (Ac.). Tip of anterior nasal spine.
ARTICULARE (Ar.). The point of intersection of the dorsal contours of processus articularis mandibulae and os temporale.
BASION (Ba.). The most forward point on the anterior margin of the foramen magnum.
BOLTON POINT (B. P.). The highest point in the profile of the notches at the posterior end of the condyles on the occipital bone.
CONDYLEON (Co.). The most superior and posterior point on the upper border of the mandibular condyle.
GNATHION (GN.). The lowest point of the median plane in the lower border of the chin.
GONION (Go.). The lowest, posterior and most outward point of the angle of the mandible.
MENTON (M.). The lowest point from which facial heights are measured.
NASION (N.). The middle point on the frontonasal suture. The
point at the root of the nose, intersected by the median sagittal plane. The root of the nose corresponds to the frontonasal suture.

ORBITALE (Or.). The lowest point on the margin of the orbit.

POGONION (Pg.). The most anterior prominent point on the chin.

PORION (Po.). The mid-point on the upper edge of the external auditory meatus.

SELLA TURCICA (S.). The pituitary fossa of the sphenoid bone.

SUPRAMENTALE (Sm.). or B point. The deepest point on the contour of the alveolar projection, between infradentale and pogonion.

SUBSPINALE (SS.). or A point. The deepest point on the midline contour at the alveolar process between the anterior nasal spine and prosthion.

Each roentgenogram film was traced and all angular and metric measurements were performed on these tracings including:

Total Anterior Facial Height. The distance from Nasion to Menton.

Upper Facial Height was measured from Nasion to Anterior Nasal Spine.

Posterior Facial Height was measured from Sella to the mandibular plane, tangent to the posterior border of the ramus
at the gonion angle.
Maxillary length was measured from A point to condyleon point on the most superior and posterior border of the mandibular condyle.
Mandibular length was measured from Condyleon to Gnathion.
Ramus height was measured from Condyleon to Gonion.
Mandibular body length was measured from Gonion to Gnathion.
Length of cranium was measured on the Frankfurt Horizontal Plane, between the projected points of Nasion and tangent to the height of contour of posterior convexity of cranium over Frankfurt Horizontal Plane.
Height of cranium was measured between projected points of Bolton point and tangent to the height of vertex over the plane perpendicular to Frankfurt Horizontal Plane.
A-N-B. The angle formed by maxillary A point, nasion and mandibular B point; indicates anteroposterior relationship of maxillary and mandibular basal arch.
N-S-B. Formed by the lines Sella Nasion and Sella Basion.
Mandibular Plane Angle, Angle formed between Frankfurt Horizontal Plane and tangent to the lower border of the mandible.
Gonial angle, angle read between tangent to the posterior border and inferior border of the mandible.
Anthropometric measurements performed directly on each skull by means of calipers, included:
Bizygomatic width, distance between right and left zygomatic processes.
Biganal width, distance between the most laterally protruded points at right and left mandibular gonial regions.
Cranial breadth, widest breadth of the vault taken at the maximum width between the most laterally projected points of parietal bones on each side.

STATISTICAL METHODS
Data from metric measurements are expressed as mean millimeter ± S.D.. Also the data from angular measurements are shown as mean degree ± S.D.. Principal Component Analysis was used to test significance of differences amongst the values.
CHAPTER IV

Results

Tables 1 and 2 present the mean value and standard deviation for 13 cranial metric and 4 angular measures in seven terminal Late Archaic, ten Adena undeformed skull samples and five Adena deformed skulls. Adult status was determined from completion of dental development and epiphyseal fusion. Due to the absence of point S in most of skulls, the analysis was not able to demonstrate the significance of one metric measure (S-Go) and one angular measure (N-S-Ar), and made us eliminate these measures from our list.

Three cranial measurements, length, breadth and height of cranium, show the most difference between these two samples. The mean values of these variables, demonstrate that increase in the height of cranium in the deformed samples has been concomitant with increase in its breadth and decease in the length. The difference between values is more than one standard deviation.

Interestingly enough, amongst the remaining facial metric measurements, the only observable increment due to changes in the cranium in deformed skulls are in facial height (from
Nasion to the Menton) and facial breadth (Bizygomatic and Bigonial distances), other measurements do not demonstrate any significant variation.

The mean values from angular measures demonstrate that, in general, the mandibular plane angle is slightly more flat and more parallel to palatal plane in Adena deformed skulls. The ramus also has more vertical attachment to the body of the mandible than in undeformed skulls. These differences in the mean values are less than one standard deviation and do not call for a significant variability between these two facial configurations.

Multivariate analysis of the cranial metric data began with a principal components analysis of the 13 X 13 variance-covariance matrix, in order to examine the possibility of discarding variables. The following variables were discarded since they were important for Eigenvectors whose Eigenvalue accounted for very low percentage of the total variation, and they appear consistently uninformative (Nasion to Anterior Nasal Spine, A point to Nasion perpendicular, Condyleon to A point, Condyleon to Gnathion, Pogonion to Nasion perpendicular, Condyleon to Gonion and Gonion to Gnathion).

The initial principal components analysis was performed on the variance-covariance matrix(13 X 13, metric measures)
and (4 X 4, angular measures). The tests were scatter diagrams of the principal component scores for pairs of principal components. Figures 1 and 2 demonstrate a scatter diagram of principal components scores for the first two principal components of the metric and angular values respectively. These scatter plots appear reasonably elliptical and points are reasonably scattered in all four regions of the diagram and do not indicate a substantial difference between the participating values. These results indicate no significant difference in craniofacial metric and angular values between undeformed samples from Terminal Late Archaic and Adena, also demonstrates more uniformity amongst deformed and undeformed skulls.

After discarding seven variables (metric values including Nasion to Anterior Nasal Spine, A point to Nasion perpendicular, Condyleon to A point, Condyleon to Gnathion, Pogonion to Nasion perpendicular, Condyleon to Gonion and Gonion to Gnathion), a principal components analysis was performed on the 6 X 6 variance-covariance matrix for deformed and undeformed samples. The discarded metric variables are all from facial structures which are further away from the cranial base and cranial vault, and the growth and development of brain and cranium has lesser effect on their developmental
pattern.

The tests were scatter diagrams of the principal component scores for pairs of principal components. Figure 1 shows a scatter diagram of principal components scores for the first two principal components of the metric values. This scatter plot demonstrates the concentration of the principal component scores from deformed samples in the lower left region of the diagram and indicates a substantial departure from normality.
<table>
<thead>
<tr>
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<th>Terminal Late Archaic (N = 7)</th>
<th>Adena undeformed (N = 10)</th>
<th>Adena deformed (N = 5)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>S</td>
<td>X</td>
</tr>
<tr>
<td>1. Cranial Length</td>
<td>194 ± 7</td>
<td></td>
<td>187 ± 9</td>
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<tr>
<td>2. Cranial Breadth</td>
<td>137 ± 3</td>
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<td>139 ± 6</td>
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<tr>
<td>3. Cranial Height</td>
<td>157 ± 6</td>
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<td>160 ± 5</td>
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<td>4. Nasion-Menton</td>
<td>130 ± 11</td>
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<td>132 ± 10</td>
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<td>60 ± 4</td>
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<td>6 ± 2</td>
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<td>7. Pogonion to Nasion perpendicular</td>
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<td>1 ± 2</td>
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<td>8. Condyleon to A point</td>
<td>97 ± 6</td>
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<td>9. Condyleon to Gnathion</td>
<td>125 ± 10</td>
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<td>10. Gonion to Gnathion</td>
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<td>11. Condyleon to Gonion</td>
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<td>12. Gonion to Gonion</td>
<td>100 ± 11</td>
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<tr>
<td>13. Zygomatic to Zygomatic</td>
<td>128 ± 7</td>
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<td>130 ± 7</td>
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<td>Terminal Late Archaic (N = 7)</td>
<td>Adena undeformed (N = 10)</td>
<td>Adena deformed (N = 5)</td>
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<tr>
<td></td>
<td>X</td>
<td>S</td>
<td>X</td>
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<tr>
<td>1. Mandibular Pl. to Frankfurt Horizontal</td>
<td>25 ± 3</td>
<td></td>
<td>26 ± 6</td>
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<td>2. Mandibular Pl. to Palatal Pl.</td>
<td>25 ± 3</td>
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<td>25 ± 6</td>
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<tr>
<td>3. Gonial angle</td>
<td>120 ± 7</td>
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<td>119 ± 6</td>
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<tr>
<td>4. A-N-B angle</td>
<td>5 ± 2</td>
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Figure 1. Scatter diagram of scores of principal components 1 and 2 for metric measurements for deformed and undeformed skulls.
Figure 2: Scatter diagram of scores of principal components 1 and 2 for angular measurements for deformed and undeformed skulls.
Figure 3- Scatter diagram of scores of principal components 1 and 2 for metric measurements for deformed and undeformed skulls.
CHAPTER V
DISCUSSION

For the full analysis of the growth of a skeletal element, information is required about changes in its external proportions and internal architecture and about the sites, rates and amounts of bone deposition and resorption which underlie changes in external and internal form. The study of skull growth presents particular difficulty in that the cranial component is a highly complex structure consisting of numerous interlocking bones of irregular and, to some extent, independently variable shape.

Although the significance of the cranial base has long been recognized by biological workers, it is difficult to find it exactly defined. All agree on its importance in cartilage and by its location in the zone which marks the union of cranium and face. Modifications in its form and proportions are held to be the reflection of adaptive changes that have occurred between the brain case and the face as well as those between the head and body including external stimulus from the environmental factors, like sleeping position, breathing posture and climatic influences. The facial complex attaches to the basicranium, and the cranial floor is the template that
establishes many of the dimensional, angular, and topographic characteristics of the face.

The significant part of my study focuses on the effect of artificial deformation of the head on craniofacial structures, and describing the adaptive changes that have occurred in the morphology of these structures. As in all fields of study, investigation has been limited in this one by a lack of more suitable methodology. I have tried to combine cephalometric roentgenology with anthropometry, as the systematized art for measuring and taking observations on the craniofacial structures of two different skull samples, undeformed skulls from Terminal Late Archaic, Adena and deformed ones from Adena samples. I have included several metric and angular measurements for better understanding and differentiating between different patterns of craniofacial growth. For more clear comprehension of the effect of the normal pattern of growth on the different craniofacial structures, I have tried to utilize a statistical program (Principal Component Analysis, PCA) which, tentatively, is able to evaluate this influence on the utilized metric and angular measurements in this investigation.

The results of PCA demonstrate that in undeformed skulls from Terminal Late Archaic and Adena, the phenomenon of growth
in the craniofacial complex creates an anteroposterior increase in length of the cranium. This relationship is a positive reaction, and more growth of the face always coincides with further increases in the length of cranium in an anteroposterior direction. This positive relationship is also true for horizontal growth of the chin, but is not true for other measurements. For example, normal growth of the head is not always coincide with the increase in the width or height of the craniofacial structures, including total facial height from Nasion to Menton or Width of the mandible from Gonion to Gonion.

Brodie (1941) related the increase in cranium length to the anteroposterior growth of the brain until 8 years of age and also thickening of the skull bone in the later ages. He indicated that the anterior and posterior parts of the cranial base may behave differently in the process of cranial growth. In this investigation, he shows the incremental pattern of the brain case as revealed by superposition of successive tracings of the same individuals throughout the ranges of 3 months to 8 years. The most striking impressions gained from this study are the regularity and steadiness of the growth process and the fact that the morphologic pattern, once attained, does not change. We see no disproportionate increase of length over
height, nor any other change which could be regarded as modifying the form. It is found that such local phenomena tend to remain in their original relations, a finding which can be demonstrated beautifully in frontal picture of asymmetries.

The normal process of growth in undeformed skulls from Late Archaic and Adena samples demonstrates a gradual increase in angle between Mandibular plane, Frankfurt Horizontal and palatal planes. This steepening of the mandibular plane coincides with increases in the gonial angle, which, in turn, creates a more posteriorly inclined ramus. This biomechanical relationship between the body of the mandible and ramus, considering that the length of the mandible (Co-Gn) is a fixed measure, necessitates a shorter height of the ramus in order for the condyle to reach the fixed location of glenoid fossa in the base of the skull. This type of biomechanical relationship does not call for any height increment in anterior facial height for further growth of the rest of facial structure, but it calls for need of anteroposterior increase in the length of the mandible if proportional location of pogonion with regard to the increased anterior cranial length and glenoid fossa is planed by normal growth. According to PCA, these positive reactions of aforementioned
angles is a critical and unseparable preexisting relationship for normal developmental pattern of facial structures for these types of craniofacial characteristics.

The results of cephalometric and anthropometric analyses of the craniofacial structures of undeformed Adena skulls demonstrates a close relationship between these samples and Archaic skull samples. The mean values of metric and angular measurements can not discriminate between these skulls. Even close examination of these samples does not proclaim any difference between them. The scattergram demonstrates that the PC scores of these values are scattered in all four regions of the diagram and does not show any asymmetric characteristics. This resemblance between these skulls is so close that the only clue for recognizing them is the number which is marked on each sample. These skulls generally demonstrate moderate rugged facial features with a muscular morphology. The chin is very strong and frontally projected. They have moderately flat faces which is accentuated by the frontal and lateral prominence of the zygomatic processes.

Sciulli, Lozanoff and Scheider (1984), analyzing the diversity in Glacial Kame and Adena skeletal samples, concluded that the Glacial Kame(Terminal Late Archaic) and Adena populations were not homogeneous, could have shared a
recent common ancestor and that an ancestor (Glacial Kame) - descendant (Adena) relationship is plausible if the groups were allochonic.

Cephalometric and anthropometric analyses of craniofacial structures of deformed Adena skulls represent a population that demonstrates very rugged, muscular facial and cranial morphological features, including all characteristics of a brachyfacial population. They exhibit very wide faces, short craniums and a very high cranial vault. The amount of projection of zygomatic processes and chin is very noticeable, especially the flatness of the face between protruded zygomatic arches.

The results of our study, shows that the deformed and undeformed skulls share very close morphological similarity of the most of their facial and some of the cranial structures.

Of fourteen metric and four angular measurements I analyzed to distinguish these two samples, only a few cranial measurements show significant difference. Differentiating these two entities just by facial characteristics is impossible. As matter of fact, the proximity of these measurements are so close that PCA does not show any significant deviation in the morphology of the facial
structures of deformed and undeformed skulls.

The mean values of the angular measurements of the face in the deformed Adena skulls demonstrate few degrees of flattening of Mandibular plane angle with regard to Frankfurt Horizontal and Palatal planes, compared to undeformed Archaic skulls. The amount of gonial angle has decreased in deformed skulls with some uprighting effect of ramus. Although these changes are less than one standard deviation and are not very significant, they still demonstrate some form of facial alteration in deformed skulls compared to undeformed ones. These changes have been created based on significant cranial alterations which have been caused by artificial deformation of cranium, due to the use of cradleboards and the wearing of head-bands.

The PCA demonstrates that the phenomenon of artificial deformation has created an opposite reaction in the development of some the craniofacial measurements in response to normal growth of the head. For example, it is very obvious that these factors have a limiting effect on the development of cranial length, and, in contrast encourage an increase of height and breadth of the vault. As a result, the length of cranial vault has significantly reduced, but height and breadth of the cranium has significantly enhanced in the
deformed skulls. This obvious anteroposterior reduction in the length of the cranium is superficially observable by significant flattening of the back of the deformed skulls. This is the only noticeable characteristic that distinguishes the deformed and undeformed skulls in close examination. Both groups of skulls demonstrate very broad inter-zygomatic and inter-gonial dimensions with very prominent zygomatic processes and gonial points. The mean value of inter-zygomatic dimension for deformed skulls and total facial height from Nasion to Menton is almost one standard deviation larger than in undeformed ones which can be due to the effect of limiting factors on the height and breadth of cranium and translation of these alterations to the facial structures. The amount of frontal uprighting of the forehead is not a very good discriminating factor between these two groups of deformed and undeformed skulls. The frontal view of the skull would not distinguish the deformed and undeformed entity of the skull, and differentiation is possible just by looking at the back of the skull.

The rate of maxillo-mandibular prognathism or retrognathism is the same for both groups and craniofacial deformation has not altered this relationship between the maxilla and mandible. Both groups of skulls have very strong
projecting chin.

According to Neuman (1952), the Terminal Late Archaic Indian population has been represented by people with craniofacial characteristics of the Lenapid variety. The Lenapid variety, according to Neumann, can be briefly described as follows: The skull is relatively large, with a glabello-occipital length of 182.5 mm., a maximum breadth of 137.4 mm., and a basion-bregma height if 141.7 mm. From above the vault is ovoid to ellipsoid in form, yet the temporal region is never as full as in European crania. Muscularity is above medium, as are the size of brow ridges, frontal slope, breadth of frontal, development of parietal eminences, and prosthion of the occiput. The face, on the whole, is only moderate in ruggedness and size in relation to the braincase. All facial dimensions tend to be on the plus side of moderate, with a total facial height of 123.1 mm., and a bizygomatic breadth of 136.5 mm. Although the size of the zygomatic bones and their anterior projection is greater than in Europeans, they are only moderate for American Indians. Lateral projection of the zygomatic arches is medium to pronounced. Prognathism is submedium to medium, while the size of the mandible is medium to large, this is generally accompanied with a bilateral chin and only a small amount of eversion of
the gonial angles. Comparing this variety with Walcolid series, Neumann (1952), believed that here the differences are clearer morphologically than metrically, and possible mixture between the two varieties in Central Illinois, a region peripheral to the Southeast, make the groups stand out less than one could wish.

Considering the Terminal Late Archaic population as dolichocephalals by Neumann (1952, 1960) based on his description of their craniofacial features is not a proper assignment. The understanding of Enlow (1966) from dolichocephalic and brachycephalic type craniofacial morphologies is: Two general extremes exist for the shape of the head, the long narrow(dolichocephalic) head form and the wide short, globular(brachycephalic) head form. The facial complex attaches to the basicranium, and the cranial floor is the template that establishes many of the dimensional, angular, and topographic characteristics of the face. The dolichocephalic head form, therefore, forms a face that is correspondingly narrow, long, and protrusive. Conversely, the brachycephalic head form establishes a broad but somewhat less protrusive face. Because of the difference in breadth of the interorbital region, the dolichocephalic nose is relatively thin, and vertically longer and much more protrusive. Because
the nasal part of the narrow dolichocephalic type of face is more protrusive, the external bony table of the contiguous forehead is correspondingly more sloping, and the glabella and upper orbital rims tend to be much more prominent. The forehead of the wide brachycephalic facial type is more bulbous and upright. The more protrusive nature of the nasal region and the supraorbital ridges in the dolichocephalic type of head forms gives the cheekbones a much less prominent appearance, and the eyes look more deep-set for the same reason. As seen from above as well as well as laterally, the dolichocephalic face is more angular and less flat. In the brachycephalic head form, the wider, flatter, and less protrusive face gives the cheekbones a noticeably square configuration and a more prominent-looking character. The broad brachycephalic face appears quite shallow in comparison to the deep and topographically more bold contours of the dolichocephalic face. The vertically long nature of the midface and the "open" (obtuse) form of the cranial base flexure in dolichocephalics relate to a downward-backward rotational alignment of the mandible. This results in a tendency for a more retrusive position of the mandible and a retrognathic (convex) facial profile. The brachycephalic face relates to a more "closed" basicranial flexure, and as a
result, the lower jaw tends to be variably more protrusive, with a greater tendency for a straighter or even concave facial profile and a more prominent appearing chin.

Based on differentiation of dolichocephalic and brachycephalic head forms by Enlow and the description of Terminal Late Archaic portrait by Nemann, makes them resemble more to brachycephals than dolichocephals. The wide and muscular facial characteristic of these Terminal Late Archaic skulls is too far from being dolichocephalic, and their wide inter-zygomatic breadth with flatter mandibular plane, prominent chin, and gonial features, make them look more brachycephalic than dolichocephalic.

The characteristically high and flattened globular Adena skulls, with their massive faces and prominent, projecting nasal regions and jaws, first described by Hertzberg (1940), had been the subject of many years of study by different investigators.

According to Webb and Snow (1945) the Adena people were a relatively pure type, perhaps having entered the Ohio Valley from the south, As suggested previously by Neumann (1941). Snow's technique for comparison of his Adena sample with other physical stock is open to criticism. This is especially true of Snow's assumption concerning the impact of cranial
deformation upon his interpretations. He measured and observed deformed skulls, noting that 92% (Webb and Snow 1945:106) of the Adena crania showed either "medium" or marked occipital flattening. Though measurements for those deformed skulls are presented separately from those for the few "undeformed" in the series, population comparisons are dominated by observations concerning the deformed skulls. Thus, a cultural attribute markedly biased population comparisons (Buikstra). To him, this is justified because cradleboarding only exaggerates the preexisting skull shape. According to his opinion the natural head shape would influence the ease with which deformation is brought about. The flattening of the head of a long headed infant would be a more difficult process than that of a round headed baby.

Snow continually argues that the "undeformed" skulls show tendencies parallel to the "deformed" skulls. Snow indirectly accepts a Walcolid type, i.e., a southern origin for this brachycephaly.

Snow's reasoning on the parallelism between the craniofacial morphology of deformed and undeformed skulls is very sensible. Our results demonstrate the same resemblance between deformed and undeformed samples. The only issue that does not sound right is the argument for a southern origin for
this Walcolid population.

Neumann (1950) waked to the Adena-rugged Kentucky brachycephaly—were as a possible link between the southern Walcolid type and later northern Walcolid agriculturalists, e.g., Spoon River focus in Illinois. He speculated on the possible southern origins of Walcolid Adena, though a movement from the west was also considered.

Neumann's inferences made the assumption, common to many physical anthropologists of that period, that significant prehistoric migrations to the New World could be identified through the investigation of cranial morphology. His work, based upon the archaeological identification of "pure" or unmixed relict populations from these migrations, contrasted with the Snow methodology. Neumann placed great emphasis upon the identification of the undeformed skulls, thus separating, to the best of his ability, the impact of culture from inherited attributes.

In 1960, by now impressed with the need to consider such factors as, selection, genetic drift, and adaptation, Neumann argued in favor of a northern origin for Adena. The tall, robust "Lenapid" populations were described as ancestral to the brachycephalic Adena groups, the time of differentiation apparently specified for the Middle Woodland period.
My criticism of Neumann's opinion is that the craniofacial morphological features of Terminal Late Archaic Indian population does not coincide with the description of dolichocephalic head type. The craniofacial features of this people represent a moderately brachycephalic head form. Based on the results of this study, I think that there is a very close resemblance between the undeformed head forms from Terminal Late Archaic and Adena skull samples. The existing parallelism between the facial characteristics of the deformed Adena skulls and undeformed skulls from Terminal Late Archaic and Adena samples, makes me think that the process of artificial deformation (artificial brachycephalization) of the heads, early in life, could be the possible source of accentuation of craniofacial features and create transformation of earlier moderately brachycephalic population (Lenapid, Terminal Late Archaic) to later, more pronouncedly brachycephalic population (Walcolid, Adena).
CHAPTER VI
CONCLUSION

This study has demonstrated the following:

1. Craniofacial morphological features of the undeformed skulls from the Terminal Late Archaic and from the Adena Indians demonstrate very close resemblance.

2. Assigning the Terminal Late Archaic Lenapid Indians, to dolichocephals is wrong. The craniofacial metric and angular measurements of their skulls demonstrate more brachycephalic than dolichocephalic characteristics.

3. Cradleboarding and the use of head-bands early in life has created artificial deformation (artificial brachycephalization) of the craniofacial features in Adena Indians.

4. The results of deformation include decreases in cranial length, increases in cranial height and breadth, increases in the inter-zygomatic width and total facial height.

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5. Besides the few metric measurement differences between the deformed and undeformed skulls, facial characteristics of these skulls are very similar.

6. The process of artificial brachycephalization early in life could be the possible cause for transformation of an earlier moderately brachycephalic population (Terminal Late Archaic) to a later, more pronouncedly brachycephalic population (Adena).

7. These results demonstrate that not all variables which have been used in this study are necessary to show the effect of artificial deformation on the craniofacial structures. The most significant variables are cranial length, breadth and height, total facial height, facial breadth at inter-zygomatic and inter-gonial width. In future studies incomplete skulls can be included, and broken internal structures of the cranium do not have an adverse effect on the results. This fact has not been stated before and could help us include more samples in this study.
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