J Forensic Sci, Oct. 1978, Vol. 23, No. 4

Michael Finnegan,[1] Ph.D. and F. P. Schulter-Ellis,[2] Ph.D.

The Tympanic Plate in Forensic Discrimination Between American Blacks and Whites

Skeletal material of forensic nature is often accompanied by relatively diagnostic cultural goods which can be used to infer provenience and help in the determination of race. However, when the skeletal material is recent or without associated cultural material, the racial assessment becomes more difficult. When only a cranium is recovered, one usually employs subjective criteria for determination of race. These might include prognathism, the existence of a depression posterior to the coronal suture, the relative flaring of the zygomata, or the morphology of the nasal roots. Inevitably, the cranium comes to light which does not permit a differential diagnosis of race based on such subjective assessments. The necessity for accuracy becomes most critical when the analysis is to be used for forensic purposes [*1*]. In such case, a quantitative tool can be of great value in the identification of a single cranium. Several multivariate approaches to this problem have been developed [*2*].

Recently, Schulter [*3*] and Schulter and Finnegan [*4*] assessed racial distance by generating angular measurements taken from roentgenographic films of Eskimos, Indians, and American whites. These data produced large Mahalanobis' D^2 distances between the above racial groups, and discriminant analysis showed that a cranium could be placed in one of these groups with an overall accuracy of 94% in male and 95% in female samples [*4*].

The purpose of this paper is to present data pertinent to the discrimination of crania between white and black populations.

Material and Methods

Samples we used were gathered from the Terry collection at the Smithsonian Institution. Ninety-eight American white and 48 American black crania with the sexes evenly divided were used. Roentgenographic films were made of the normal lateral and normal vertical views. From these films, landmarks defined lines and intersecting lines defined angles that were used in the analysis. (For a complete description of the roentgenographic methods see Ref *3*.) From 23 original variables, a subset of eight variables was picked, based on univariate t and F tests, multivariate canonical analysis plots, and principal component analysis [*3,4*]. The following eight variables were used in the current analysis:

1. Porus Shape Index: Measurements of the maximum and minimum diameters of the

Received for publication 14 Nov. 1977; accepted for publication 11 Jan. 1978.
[1]Associate professor, Osteology Laboratory, Kansas State University, Manhattan, Kans.
[2]Assistant professor, University of Maryland School of Medicine, Baltimore, Md.

porus were made with needlepoint dividers read on centimetre-scaled paper. An index of shape was obtained by the formula

$$\frac{\text{minimum diameter} \times 100}{\text{maximum diameter}}$$

2. Maximum Cranial Length: The measurement of the maximum cranial length was taken in the conventional manner.

3. Mastoid Length: The linear measurement of the mastoid process represents the distance from porion to the tip of the process.

4. Deflection Angle: Reference points used for the construction of the cranial base angle of deflection (NA-S-BA, Fig. 1) were nasion (NA); sella point (S), the center of the bony depression which lodges the hypophysis cerebri; and basion (BA). This angle is essentially as Stramrud [5] defined it.

5. Squama Shape Index: A line was drawn passing through porion (PO, Fig. 1) and the lowest point on the inferior margin of the left orbit, and extending from glabella to the opisthocranion. This line (D-E) coincided with the horizontal plane on which all of the crania were oriented. To obtain the maximum length of the squama, lines perpendicular to the horizontal were extended to pass through its most anterior and posterior (above the supramastoid crest) extent (B-A, Fig. 1). To measure the maximum height of the squama, a perpendicular line was drawn through porion and the auricular point (PO and AU, respectively). A second line was drawn parallel to the initial horizontal (D-E) and passing through a marker at the most superior aspect of the squama to intersect the

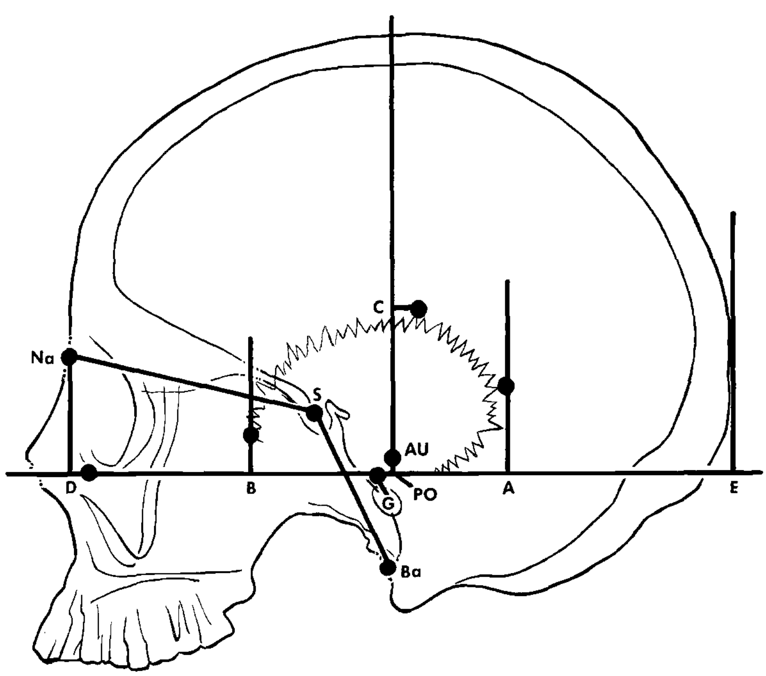

FIG. 1—*Norma lateralis. Lead markers are on the left side. Abbreviations are Na, nasion; S, sella point; Ba, basion; C, most superior point of squama; AU, auricular point; PO, porion; A, most posterior point of squama; B, most anterior point of squama; G, mid-point of maximum length of squama; D, glabella; and E, opisthocranion projected onto the modified Frankfort plane.*

vertical line at the point C. The maximum height of the squama was then read at AU-C (Fig. 1). An index of shape was calculated [6] as

$$\frac{\text{Au-C} \times 100}{\text{B-A}}$$

6. Position Index for Porion: This index was calculated [6] as

$$\frac{\text{PO-A} \times 100}{\text{B-A}}$$

7. Petrosquamosal Angle: The axis of the petrous portion of the temporal bone is represented by a line passing through the stylomastoid foramen (SMF, Fig. 2) and the lateral-most extent of the spheno-occipital synchondrosis (SYN). The petrosquamosal angle is formed by the intersection of the petrous axis with a line that passes through the auricular point (AU, Fig. 2) and the juncture of the sphenosquamosal suture with the infratemporal line (ITL).

8. Petrotympanic Angle: A line drawn on the tympanic plate parallel to the anterior

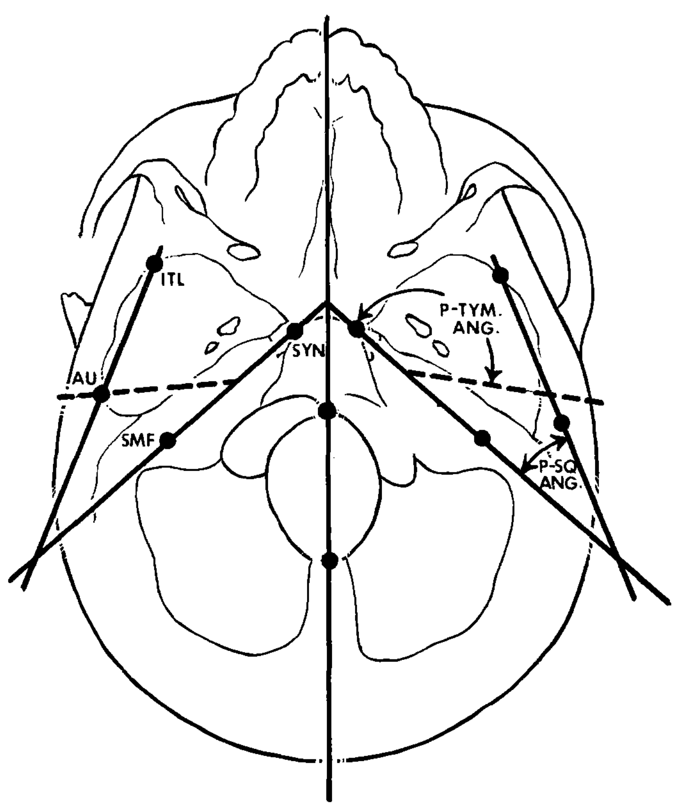

FIG. 2—*Norma verticalis. Abbreviations are AU, auricular point; ITL, juncture of the infratemporal line and the sphenosquamosal suture; SMF, stylomastoid foramen; SYN, spheno-occipital synchondrosis; P-TYM. ANG, petrotympanic angle; and P-SQ. ANG., petrosquamosal angle.*

wall of the external auditory meatus intersects the petrous axis to form the obtuse (anterior) petrotympanic angle (Fig. 2).

Although there was some evidence of asymmetry in our earlier work, the pattern was consistent as to sides. Therefore, all our discussion in the present study pertains to the left sides of the crania.

Results

Only seven of the observed variables could be used across the black and white samples. Variable 8, the petrotympanic angle, could not be generated from the roentgenographic films of the black crania. Forty-five of the 48 roentgenographs (23/24 females, 22/24 males) reveal a highly curved anterior wall of the external auditory meatus and do not dictate a reproducible line for angle formation.

Basic univariate statistics were generated for each sample and t and F tests were applied to each possible pairing. These data are presented in Table 1.

The outcome of the discriminant analysis can best be described in terms of the error production in placing a cranium in a particular racial group, with sexes treated separately. Of the males, 78.08% were correctly placed between American black and white. Of females, 86.3% were correctly placed. In males and females the Mahalanobis' D^2 statistic generally increases as the percentage of correct placement increases. The factor analysis suggests that shape is more important than size, which indicates that in the female samples blacks and whites display the same relative size but differ in shape characteristics. The same is true of the male sample comparisons. The high (86.3%) production of correctly placed white and black females suggests that the variables used in this study are of value in placing a particular cranium into one of these two racial groups.

Discussion

As previously stated, we could not use the petrotympanic angle in our analysis because we could not define a straight anterior wall of the external auditory meatus in black crania. The whites in this study and racial groups in previous studies display no prominently curved anterior wall [*3,4*]. When this variable is treated as a non-metric morphological trait, 93.8% of the crania are correctly placed without regard to sex. Therefore, black crania can be placed as accurately on the basis of this one trait as by considering all of our other variables, and more accurately than with the use of other discriminant analyses by measurement [*2*] or subjective morphology [*1*].

We are also interested in the discriminatory value of the listed variables between white and black samples. Generally, the t ratios between black and white are smaller than the t ratios between any other racial pairings where males and females are treated separately. This difference is also displayed in the lower Mahalanobis' D^2 values and in the increased error production generated in placing a particular cranium in one or another racial group. The pattern seems to parallel the greater difficulty in placement by means of subjective criteria and is perhaps the result of an accumulated amount of white admixture in the American black, variously estimated at between 10 and 30% [*7-9*]. If we were to assume a 20% white gene influence in the black sample the resulting error production should not be out of line with our expectations even though our ability to discriminate between black and white crania is not enhanced.

Further advantages are seen in the eight variables used in this study. Evidence indicating considerable stability of the cranial base has been reported by many investigators [*10-17*]. The temporal bone by its location and irregularity of form makes a significant contribution to the cranial base. McGibbon [*18*] reported that the bone showed little or no change

TABLE 1—*Means, standard deviations, and* t *ratios between males and females, races treated separately. Levels of significance:* *P < *0.05;* **P < *0.01; and* ***P < *0.001.* F *ratios are not significant at or above the 0.5 level, showing homogeneity of variance.*

	White					Black					Male White/Black	Female White/Black
	Male			Female		Male			Female			
	$\overline{X}$	σ	t	$\overline{X}$	σ	$\overline{X}$	σ	t	$\overline{X}$	σ	t	t
Porus shape index	67.8	9.7	0.7	69.1	8.9	76.1	8.4	0.7	74.4	7.0	3.3**	2.4*
Maximum cranial length, mm	182.2	7.6	4.4***	176.2	6.1	186.9	7.6	5.8***	175.2	6.4	2.5*	0.7
Mastoid length, mm	31.9	2.7	6.8*	28.3	2.5	33.6	2.9	2.6*	31.5	2.5	2.3*	5.1***
Deflection angle, deg	128.2	5.5	0.0	128.2	4.9	131.3	5.4	1.7	133.7	4.3	2.3*	4.7***
Squama shape index	70.3	8.2	1.2	68.6	6.1	69.4	6.3	0.3	70.0	8.0	0.5	0.8
Porus position index	43.6	4.1	2.1*	41.8	4.1	41.8	4.8	1.2	39.7	7.1	1.7	1.6
Petrosquamosal angle, deg	23.9	4.6	0.3	23.6	4.8	21.5	3.2	2.0	19.4	4.0	2.3*	3.7***
Petrotympanic angle, deg	147.2	6.9	0.2	147.4	7.4			see text			see text	

even where deliberate cranial deformation has been inflicted. In a study of cranial deformation resulting from pathological conditions, Moss [19] found changes in the orientation of the petrous crest but not in the position of the apex.

Growth at the midsphenoidal synchondrosis has been an important influence on the flexion of the cranial base. Fusion of this synchondrosis occurs at or about the time of birth and is obliterated during the first year of postnatal life. Growth at the spheno-ethmoidal synchondrosis, which contributes to the elongation of the anterior limb of the cranial base, appears to end at about six to eight years of age [20].

The above synthesis of material supports the stability of the cranial base and suggests that if the shape characteristics are useful in adult crania they should be useful in younger crania. It will now be necessary to obtain roentgenograms on subadult material where age, sex, and race are known so we can test whether or not the reported stability of the cranial base exists to the extent that we can use these methods for placement of race when subadult individuals are involved in forensic cases.

Summary

Angular measurements taken from normal vertical and normal lateral roentgenograms have distinguished sample populations with great accuracy and show no sexual dimorphism within populations. Results have been so consistent as to suggest the use of these metric angles as discriminating criteria between races for forensic purposes. To this end X-rays were taken of 98 white and 48 black crania. Males and females were evenly divided. Statistical analyses of the data suggest that, while useful, the variables studied do not serve for distinguishing between American black and white population samples as accurately as they have for other racial pairings.

A petrotympanic angle, defined by a line passing through the stylomastoid foramen and the lateral-most extent of the spheno-occipital synchondrosis intersecting a line drawn on the tympanic plate parallel to the anterior wall of the external auditory meatus, has discriminated well between the whites, Indians, and Eskimos. The angle could not be drawn on the films of black crania because the anterior wall of the external auditory meatus is highly curved and does not dictate a straight parallel line for constructing an angle. This was true in 45 of 48 black crania studied and shows no sex dimorphism. We conclude from these data that the inability to define a straight line for the anterior wall of the external auditory meatus denotes black individuals—at least those of the Terry collection.

Acknowledgments

The authors gratefully acknowledge the use of the X-ray equipment housed in the Division of Physical Anthropology, Smithsonian Institution, and the assistance of Mr. Elroy Barnes, Department of Radiology, University of Maryland School of Medicine, in developing the X-ray films.

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Address requests for reprints or additional information to
Michael Finnegan, Ph.D.
Osteology Laboratory
Kansas State University
Manhattan, Kans. 66506