

Robert W. Mann,¹ B.A.; Steven A. Symes,¹ M.S.; and William M. Bass,² Ph.D.

Maxillary Suture Obliteration: Aging the Human Skeleton Based on Intact or Fragmentary Maxilla

REFERENCE: Mann, R. W., Symes, S. A., and Bass, W. M., "Maxillary Suture Obliteration: Aging the Human Skeleton Based on Intact or Fragmentary Maxilla," *Journal of Forensic Sciences*, JFSCA, Vol. 32, No. 1, Jan. 1987, pp. 148-157.

ABSTRACT: Obliteration of the four sutures of the bony palate is examined to determine its value as an age indicator. Thirty-six maxillae from a predominately white series representing both sexes and a wide variety of ages are studied. It is concluded that the amount of obliteration of these sutures is useful in estimating general biological age.

KEYWORDS: physical anthropology, musculoskeletal system, human identification, maxilla, suture, age estimation, human skeleton

Although the human maxilla has been given attention by many authors [1,2], most research has focused on embryonic development as it relates to cleft lip and cleft palate. Ashley-Montagu [3] has demonstrated that the incisive suture of human and nonhuman primates obliterates with age. With the possible exception of his study, there is a paucity of data on age-related suture dynamics of the bony palate. The present study proposes to examine the obliteration of these sutures as a potential estimator of biological age.

Background

To understand better the process of suture fusion, a brief description of the embryonic development of the maxilla (bony palate) is necessary. The maxilla develops from two parts known as the primary and secondary palates. The primary palate begins to develop during the fifth embryonic week [3], contains membrane bone that will later develop into the premaxilla, and houses the incisors. The incisive suture, which in the embryonic stage separates the premaxilla and maxilla, fuses before birth. By age five, the facial aspect of this suture obliterates [4]. However, the lingual surface of the premaxilla/maxilla exhibits a visible suture line that may persist into adulthood.

At birth, the secondary palate is composed of four bones (right and left maxilla and the right and left palatine) joined by broad sutures. With increasing age, the gaps visible between suture edges decrease, fuse, and ultimately obliterate. Accompanying suture closure and obliteration, the maxilla tends to get smoother and thinner.

Received for publication 11 Jan. 1986; revised manuscript received 2 April 1986; accepted for publication 3 April 1986.

¹Graduate assistants, Department of Anthropology, University of Tennessee, Knoxville, TN.

²Professor and head, Department of Anthropology, University of Tennessee, Knoxville, TN and Tennessee state forensic anthropologist.

Materials and Methods

The sample consists of 36 known age, sex, and race (predominately white adults) skeletons donated to the Anthropology Department of the University of Tennessee, Knoxville, for research and curation. The skeletons studied range in age from 13 to 79 years. Only individuals having complete maxillae were included.

The method used in the study consists of dividing the maxilla into four distinct sutures modified from Kopsch [5]: incisive (I), (anterior) median palatine (AMP), transverse palatine (TP), and (posterior) median palatine (PMP) (Fig. 1). Because of the modification of the median palatine suture in this study and variability in suture patterns, the following criteria describe each suture. The incisive suture extends from between the lateral incisors and canines to the posterior border of the incisive foramen. In determining the amount of obliteration of this suture, the maxilla is divided into halves; the half exhibiting the least obliteration is used. In this study, the median palatine suture is divided into two discrete sutures to score and correlate better the rate of obliteration with age. The AMP suture originates at the most posterior junction of the incisive foramen and extends posteriorly to the palate bones. The TP suture divides the palatine and maxillary bones, runs perpendicular to the midline of the maxilla, and continues into the greater palatine foramina. The PMP suture is that portion of the median palatine suture that divides the palatine bones along the midline.

Each suture was examined to determine the amount of obliteration. Obliteration was defined as any portion of a suture no longer visible. A sliding caliper was used to measure the amount of obliteration present in each suture. The percentage of obliteration for each suture was then calculated and plotted on a graph in five intervals to study the sequence of obliteration with age.

The intervals are:

- 0 = 0% obliteration,
- 1 = 1 to 25% obliteration,
- 2 = 26 to 50% obliteration,
- 3 = 51 to 75% obliteration, and
- 4 = 76 to 100% obliteration.

General bone morphology of the maxilla was also studied to determine any gross age-associated changes.

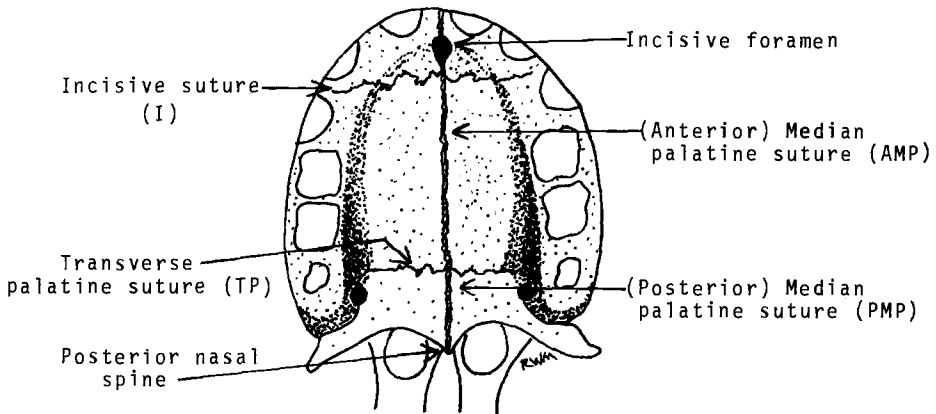


FIG. 1—Sutures of the maxilla (child under two years of age).

TABLE 2—Stage of obliteration—incisive suture.^a

| Age in Years | Stage | | | | |
|--------------|-------|---|---|---|----------------|
| | 0 | 1 | 2 | 3 | 4 |
| 79 | | | | | + ^b |
| 75 | | | | | + |
| 73 | | | | | + |
| 73 | | | | | + |
| 72 | | | | | + |
| 62 | | | | | + |
| 59 | | | | | + |
| 58 | | | | | + |
| 48 | | | | | + |
| 43 | | | | | + |
| 38 | | | | | + |
| 36 | | | | + | |
| 36 | | | | | + |
| 35 | | | | + | |
| 35 | | | | | + |
| 34 | | | | + | |
| 32 | | | | | + |
| 32 | | | | | + |
| 31 | | | | | + |
| 31 | | | | | + |
| 30 | | | | | + |
| 29 | | | | + | |
| 26 | | | | + | |
| 25 | | | | | + |
| 25 | | | | + | |
| 24 | | | | + | |
| 23 | | | + | | |
| 22 | | | | | + |
| 21 | | | | + | |
| 17 | | | | + | |
| 16 | | | | + | |
| 16 | | | + | | |
| 15 | | | + | | |
| 15 | | | | + | |
| 15 | | + | | | |
| 13 | | | + | | |

^aIntervals:

- 0 = 0% obliteration,
- 1 = 1 to 25% obliteration,
- 2 = 26 to 50% obliteration,
- 3 = 51 to 75% obliteration, and
- 4 = 76 to 100% obliteration.

^bdenotes presence of obliteration in each stage.

The AMP and TP sutures are next to obliterate. Although variable, obliteration of the AMP suture begins at the AMP/TP junction and progresses towards the incisive foramen. The TP suture usually starts to obliterate within the greater palatine foramen. The earliest age of AMP or TP suture obliteration is present in a black female 43 years of age. This female represents the only individual exhibiting complete endocranial and ectocranial suture obliteration, as well as complete obliteration of all maxillary sutures. It is probable, however, that obliteration in these 2 sutures begins in the fifth decade.

In advanced age, the maxilla displays a flat, smooth lingual surface. The central portion is

TABLE 3—*Stage of obliteration—(posterior) median palatine suture.*

| Age in Years | Stage | | | | |
|--------------|-------|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 79 | + | | | | |
| 75 | | | | | + |
| 73 | | | | | + |
| 73 | | | | | + |
| 72 | | | | | + |
| 62 | | | | | + |
| 59 | | | | + | |
| 58 | + | | | | |
| 48 | | | | | + |
| 43 | | | | | + |
| 38 | | | + | | |
| 36 | + | | | | |
| 36 | | | | | + |
| 35 | + | | | | |
| 35 | | | | + | |
| 34 | | | | + | |
| 32 | + | | | | |
| 32 | + | | | | |
| 31 | | | | + | |
| 31 | + | | | | |
| 30 | | | + | | |
| 29 | + | | | | |
| 26 | | + | | | |
| 25 | + | | | | |
| 25 | | + | | | |
| 24 | + | | | | |
| 23 | + | | | | |
| 22 | + | | | | |
| 21 | + | | | | |
| 17 | + | | | | |
| 16 | + | | | | |
| 16 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 13 | + | | | | |

thin and the four sutures may exhibit some, if not complete, obliteration. In this study, all seventh decade and older individuals exhibit some obliteration of at least three of the maxillary sutures.

After examining the maxillae, it is apparent that much variability exists in the amount of suture obliteration present at various ages. However, maxillary observations do suggest predictable aging patterns that can be associated with general age categories. The most obvious age categories discernible from Table 7 are:

- (1) earliest age of complete obliteration of the incisive suture occurs at 25 years,
- (2) below 25 years of age there is no obliteration of the PMP suture,
- (3) below 43 years of age there is no obliteration of any segment of either the AMP or TP sutures, and
- (4) At 60+ years of age at least 2 of the 4 maxillary sutures are completely obliterated.

TABLE 4—*Stage of obliteration—(anterior) median palatine suture.*

| Age in Years | Stage | | | | |
|--------------|-------|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 79 | | | | | + |
| 75 | | + | | | |
| 73 | + | | | | |
| 73 | | + | | | |
| 72 | | + | | | |
| 62 | | + | | | |
| 59 | + | | | | |
| 58 | + | | | | |
| 48 | | | + | | |
| 43 | | | | | + |
| 38 | + | | | | |
| 36 | + | | | | |
| 36 | + | | | | |
| 35 | + | | | | |
| 35 | + | | | | |
| 34 | + | | | | |
| 32 | + | | | | |
| 32 | + | | | | |
| 31 | + | | | | |
| 31 | + | | | | |
| 30 | + | | | | |
| 29 | + | | | | |
| 26 | + | | | | |
| 25 | + | | | | |
| 25 | + | | | | |
| 24 | + | | | | |
| 23 | + | | | | |
| 22 | + | | | | |
| 21 | + | | | | |
| 17 | + | | | | |
| 16 | + | | | | |
| 16 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 13 | + | | | | |

Summary

A preliminary study of a limited sample of 36 human maxillae suggests that suture closure and age are correlated. By determining the amount and general pattern of maxillary suture obliteration in an intact or fragmentary maxilla, a broad age category may be established for an individual. Based on the authors' experiences, this method has been used to sort commingled skeletons and corroborate age estimates based on other aging techniques. Further research using a larger sample (Terry Collection) representing a wide age, race, and sex distribution is now in progress.

Acknowledgments

The authors gratefully acknowledge the assistance of Drs. J. T. Francisco, J. S. Bell, O. C. Smith, and Mr. C. Lahren of the Department of Pathology, University of Tennessee, Mem-

TABLE 5—*Stage of obliteration—transverse palatine suture.*

| Age in Years | Stage | | | | |
|--------------|-------|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 79 | | + | | | |
| 75 | | + | | | |
| 73 | | + | | | |
| 73 | | + | | | |
| 72 | + | | | | |
| 62 | | | + | | |
| 59 | + | | | | |
| 58 | | + | | | |
| 48 | | | | + | |
| 43 | | | | | + |
| 38 | + | | | | |
| 36 | + | | | | |
| 36 | + | | | | |
| 35 | + | | | | |
| 35 | + | | | | |
| 34 | + | | | | |
| 32 | + | | | | |
| 32 | + | | | | |
| 31 | + | | | | |
| 31 | + | | | | |
| 30 | + | | | | |
| 29 | + | | | | |
| 26 | + | | | | |
| 25 | + | | | | |
| 25 | + | | | | |
| 24 | + | | | | |
| 23 | + | | | | |
| 22 | + | | | | |
| 21 | + | | | | |
| 17 | + | | | | |
| 16 | + | | | | |
| 16 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 15 | + | | | | |
| 13 | + | | | | |

TABLE 6—*Scores for each suture of the maxilla.*

| Age | I | AMP | TP | PMP | Total |
|-----|---|-----|----|-----|-------|
| 13 | 2 | 0 | 0 | 0 | 2 |
| 15 | 1 | 0 | 0 | 0 | 1 |
| 15 | 3 | 0 | 0 | 0 | 3 |
| 15 | 2 | 0 | 0 | 0 | 2 |
| 16 | 3 | 0 | 0 | 0 | 3 |
| 16 | 2 | 0 | 0 | 0 | 2 |
| 17 | 3 | 0 | 0 | 0 | 3 |
| 21 | 3 | 0 | 0 | 0 | 3 |
| 22 | 4 | 0 | 0 | 0 | 4 |
| 23 | 2 | 0 | 0 | 0 | 2 |
| 24 | 3 | 0 | 0 | 0 | 3 |
| 25 | 3 | 0 | 0 | 1 | 4 |
| 25 | 4 | 0 | 0 | 0 | 4 |
| 26 | 3 | 0 | 0 | 1 | 4 |
| 29 | 3 | 0 | 0 | 0 | 3 |
| 30 | 4 | 0 | 0 | 2 | 6 |
| 31 | 4 | 0 | 0 | 0 | 4 |
| 31 | 4 | 0 | 0 | 3 | 7 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 32 | 4 | 0 | 0 | 0 | 4 |
| 34 | 3 | 0 | 0 | 3 | 6 |
| 35 | 4 | 0 | 0 | 3 | 7 |
| 35 | 3 | 0 | 0 | 0 | 3 |
| 36 | 4 | 0 | 0 | 4 | 8 |
| 36 | 3 | 0 | 0 | 0 | 3 |
| 38 | 4 | 0 | 0 | 2 | 4 |
| 43 | 4 | 4 | 4 | 4 | 16 |
| 48 | 4 | 2 | 3 | 4 | 13 |
| 58 | 4 | 0 | 1 | 0 | 5 |
| 59 | 4 | 0 | 0 | 3 | 7 |
| 62 | 4 | 1 | 2 | 4 | 11 |
| 72 | 4 | 1 | 0 | 4 | 9 |
| 73 | 4 | 1 | 1 | 4 | 10 |
| 73 | 4 | 0 | 1 | 4 | 9 |
| 75 | 4 | 1 | 1 | 4 | 10 |
| 79 | 4 | 4 | 1 | 0 | 9 |

TABLE 7—Percent of maxillary suture obliteration and age^a (N = 36).

| Age in Years | Race | Sex | I | AMP | TP | PMP |
|--------------|------|-----|-----|-----|-----|-----|
| 13 | W | F | 29 | 0 | 0 | 0 |
| 15 | W | F | 21 | 0 | 0 | 0 |
| 15 | W | F | 54 | 0 | 0 | 0 |
| 15 | W | F | 47 | 0 | 0 | 0 |
| 16 | W | F | 53 | 0 | 0 | 0 |
| 16 | W | F | 50 | 0 | 0 | 0 |
| 17 | W | F | 57 | 0 | 0 | 0 |
| 21 | W | F | 67 | 0 | 0 | 0 |
| 22 | W | M | 78 | 0 | 0 | 0 |
| 23 | M | M | 47 | 0 | 0 | 0 |
| 24 | B | F | 69 | 0 | 0 | 0 |
| 25 | W | M | 71 | 0 | 0 | 14 |
| 25 | W | F | 100 | 0 | 0 | 0 |
| 26 | B | M | 69 | 0 | 0 | 6 |
| 29 | B | F | 53 | 0 | 0 | 0 |
| 30 | W | M | 100 | 0 | 0 | 42 |
| 31 | W | F | 88 | 0 | 0 | 0 |
| 31 | W | M | 100 | 0 | 0 | 53 |
| 32 | B | F | 77 | 0 | 0 | 0 |
| 32 | W | F | 100 | 0 | 0 | 0 |
| 34 | W | F | 63 | 0 | 0 | 62 |
| 35 | W | M | 100 | 0 | 0 | 72 |
| 35 | W | M | 62 | 0 | 0 | 0 |
| 36 | W | F | 100 | 0 | 0 | 79 |
| 36 | W | M | 65 | 0 | 0 | 0 |
| 38 | W | F | 100 | 0 | 0 | 40 |
| 43 | B | F | 100 | 100 | 100 | 100 |
| 48 | W | M | 87 | 35 | 56 | 100 |
| 58 | W | F | 100 | 0 | 9 | 0 |
| 59 | W | F | 100 | 0 | 0 | 63 |
| 62 | W | M | 100 | 23 | 40 | 100 |
| 72 | W | M | 100 | 9 | 0 | 100 |
| 73 | W | M | 100 | 5 | 3 | 100 |
| 73 | W | M | 100 | 0 | 4 | 100 |
| 75 | B | F | 100 | 14 | 3 | 100 |
| 79 | W | F | 100 | 100 | 7 | 0 |

^aObliteration of the incisive suture is based on that half of the maxilla displaying the least obliteration.

phis, Tennessee. Thanks are also extended to Dr. R. L. Jantz and Mr. H. Case of the Department of Anthropology, University of Tennessee, Knoxville, Tennessee for insightful suggestions and assistance throughout the study. Special thanks to Drs. H. Berryman and P. Willey for technical and editorial advice. We gratefully acknowledge Kim Johnson for her secretarial assistance. The authors assume full responsibility for the conclusions or omissions or both in this study.

References

- [1] Krogman, W. M., "Craniofacial Growth: Prenatal and Postnatal," *Cleft Palate and Cleft Lip: A Team Approach to Clinical Management and Rehabilitation of the Patient*, in H. K. Cooper, R. L. Harding, W. M. Krogman, M. Mazaheri, and R. T. Millard, Eds., W. B. Saunders and Company, Philadelphia, 1979, pp. 23-107.
- [2] Starr, P., Pearman, W. A., and Peacock, J. L., *Cleft Lip and/or Palate*, Charles C Thomas, Springfield, IL, 1983.
- [3] Ashley-Montagu, M. F., "The Premaxilla in the Primates," *Quarterly Review of Biology*, Vol. 10, 1935, pp. 181-208.
- [4] Moore, K. L., *The Developing Human*, W. B. Saunders and Company, Philadelphia, 1982, p. 206.
- [5] Kopsch, Fr., *Nomina Anatomica*, K.-H. Knese, Ed., Georg Thieme Verlag, Stuttgart, 1957, p. 128.

Address requests for reprints or additional information to
 Robert W. Mann
 The University of Tennessee
 Department of Anthropology
 252 South Stadium Hall
 Knoxville, TN 37996-0720