Application of the Maxillary Suture Obliteration Method For Estimating Age at Death in Greek Population

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Abstract: A recently developed method for estimating adult skeletal age is based on maxillary suture obliteration. The purpose of this study is to test the accuracy of the revised maxillary suture method in estimating age at death on a skeletal sample from Greece. The sample consists of 271 skeletons (150 males, 121 females) of known age and sex and comes from several cemeteries of the country and from Human Skeletal Athens Collection. By using the method of Mann *et al.* we correctly estimated age for 89% of males and 84% of females. This finding suggests that the method is applicable to estimate the age-at-death in Greek population.

Keywords: Age estimation, maxillary suture, forensic science, human skeleton.

INTRODUCTION

The accurate determination of adult age at death is basic in the description of skeletal populations. Many macroscopic methods (qualitative and quantitative) and standards are often available for the adult age estimation from several skeletal indicators [1-9]. Most of them are based on morphological and degenerative changes in the human skeleton related to age. Until now none of these is wholly satisfactory to provide age estimates that are precise and accurate [10] because of the variability between different individuals and populations.

Forensic anthropology often utilizes multiple methods on the skeletal remains to create an age range for the identification of the skeleton. One of these age estimating techniques is the maxillary suture obliteration, introduced in 1987 by Mann and colleagues (referred to as original method) [11]. The original method was developed on a sample of 36 individuals, of known age and sex. The ancestry of this small sample was predominantly European. In 1991 Mann *et al.* published a revision of the maxillary suture method (referred to as revised method) [12]. The revised method was developed on a larger sample in an effort to overcome some of the restrictions of the original method. The sample included 186 individuals of European and African American ancestries.

Since then both methods (original [11] and revised [12]) have been subject to testing [13-15] and the results of these

tests indicate that the obliteration of the maxillary sutures could be a useful age estimating indicator. But the question whether the revised maxillary suture method can be successfully applied to genetically different samples, still remains.

The purpose of this study is to investigate whether the revised maxillary suture method, developed on samples of American, European and African descent, can effectively estimate age at death in a sample from the Greek population.

MATERIALS AND METHODOLOGY

Materials

The sample consisted of 271 (150 males, 121 females) skeletons of known age and sex from cemeteries from several regions of Greece and Human Skeletal Athens Collection. The remains belonged to individuals who lived mainly in the second half of the 20th century. The age distribution for the sample is shown in Table **1**.

In the sample were included only the maxillae that satisfied the criteria presented by Mann, who stated that the maxillary region must be complete and undamaged and the maxillae that have been sagitally sectioned should be excluded. None was rejected based on unusual morphological or pathological traits (such as extensive tooth loss, torus palatinous, edentulism)

METHOD

The maxillary suture method consists of dividing the maxilla into four sutures modified by Kopsch [16]: incisive (IN), anterior median palatine (AMP), transverse palatine (TP), and posterior median palatine (PMP). Although the rate and the amount of obliteration is quite variable, Mann

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Table 1.   Sample Age Distribution

Chronological Age (years)	Males	Females	Total
20-24	15	9	24
25-29	15	8	23
30-34	15	4	19
35-39	15	15	30
40-44	15	10	25
45-49	15	15	30
50-54	15	15	30
55-59	15	15	30
60-64	15	15	30
64+	15	15	30
All ages	150	121	271

and colleagues found that the sutures follow a general pattern of obliteration with the IN being the first to obliterate and followed by the PMP, then the TP and finally the AMP. Obliteration was defined as any portion of a suture no longer visible. Then the percentage of obliteration for each suture calculating and assigning a value of obliteration between 0 and 4 (Table **2**). The age estimate is based on the latest suture exhibits obliteration [11]. For example, if the IN is completely obliterated the next suture for examination is the PMP. If the PMP shows no obliteration but TP does, age estimation will be based on the TP suture.

Although the revised method was developed on the same principle as the original (skeletal age can be estimated by maxillary suture obliteration), there are some differences between the two. The revised method examines the greater palatine foramen and transverse palatine suture separately and thus expands the number of sutures and the number of age phases from four to five (Table **3**). The revised method also suggests that an assessment of the hard palate (absence or present of teeth, condition of maxillary bone, alveolar resorption), should be considered in assigning the final age estimate [12]. Although that type of information can introduce a level of subjectivity in the method, however the condition of hard palate doesn't overcome the suture information.

Table 2.   Evaluation of Obliteration

Obliteration of Suture	Value of Obliteration
0%	0
1-25%	1
26-50%	2
51-75%	3
76-100%	4

RESULTS

The revised maxillary suture method placed the 87% of our sample in the correct age category (Fig. **1**). Age was correctly predicted more often for males than for females, like the results of other researches [11-15]. The proportion of correct age estimates was 89% in males and 84% in females (Table **4**), but the sex difference was insignificant ($x^2=1,510$, p=0,219, df=1).

The revised maxillary suture method yielded 35 incorrect age estimates of the total 271 individuals, most of them deviate from the actual age phase by ± one phase (Table **5**). In the current study where error exists, age was predominantly underestimated (80%). Although the underestimates range from one to three phases, most of them differ from the actual age by one phase.

The precedence of correct age estimates for individuals over 50 years of age was 86% and for individuals under 50 years of age was 80%. Of course, older individuals had a higher proportion of correct age estimates than younger individuals but also these differences are not statistically significant [$\chi^2=1,36$, p=0,243, df=1].

DISCUSSION

The estimation of adult skeletal age is one of the most difficult tasks in anthropology and forensic science because the condition of the human skeleton may be affected by many factors such as diet, sex, socioeconomic status, disease, environment and culture. Even in the same population two individuals may have different rate in skeletal metamorphosis and degeneration.

In 2005 Ginter published research of the effectiveness of the revised maxillary method [15]. The skeletons used in this study came from the Department of Anatomy and Cell Biology, University of Cape Town (UCT collection). The sample consisted of 155 individuals: 11 "black" (9 males, 2 females), 112 "white" (68 males, 44 females), 23 "colored" (13 males, 10 females) and 9 of unknown ancestry (6 males,

Table 3. **Age Range Phases for Original and Revised Method**

Original Method		Revised Method	
Sutures	Age Range Phases	Sutures	Age Range Phases
IN	<25	IN	20-24
PMP	25-42	PMP	25-29
TP	43-60	GPF	30-34
AMP	60+	TP	35-50
		AMP	50+
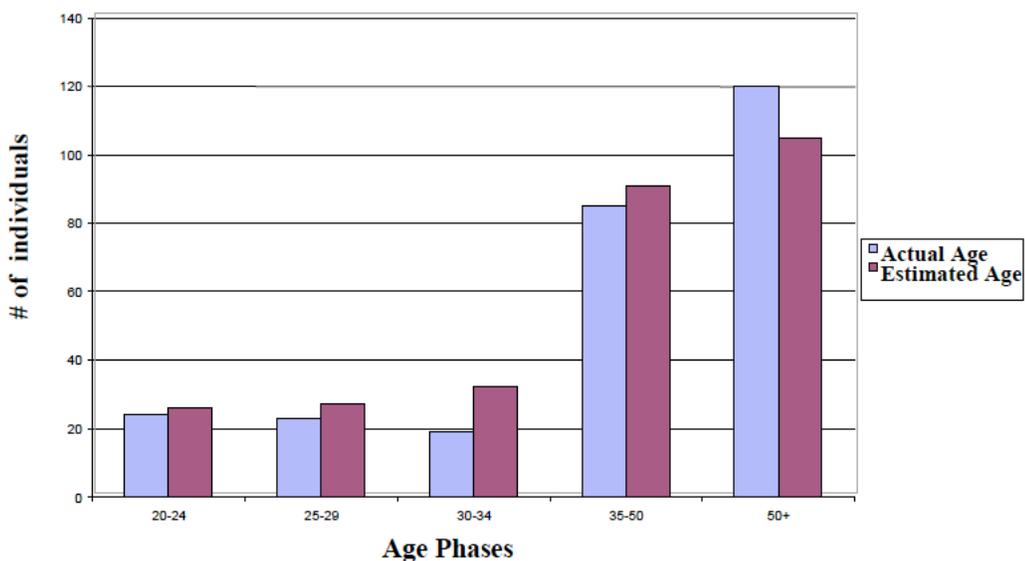
Fig. (1). The revised method: Comparison of the actual age distribution of the sample with the estimated age distribution.

Table 4. **Revised Maxillary Suture Method: Numbers of Correct Age Phase Estimates by Five Years**

Five years	Males (N=150)		Females (N=121)	
	N[1]	(# Correct)	N[1]	(# Correct)
20-24	15	14	9	8
25-29	15	12	8	7
30-34	15	13	4	3
35-39	15	14	15	10
40-44	15	14	10	9
45-49	15	14	15	12
50-54	15	12	15	12
55-59	15	13	15	13
60-64	15	13	15	14
65+15	15	15	14	
Total	150	134 (89%)	121	102 (84%)

N[1] Numbers of individuals in the sample whose actual ages fall within that age group.

Table 5.   The Number and Magnitude of Incorrect Age Phase Estimates Using the Revised Maxillary Suture Method

	Males (N=150)			Females (N=121)		
	Total	**+**	**-**	**Total**	**+**	**-**
Correct	134			121		
±1	13	4	9	11	2	9
±2	3	1	2	7		7
±3				1		1
Total						
incorrect	16			19		
Total(+)		5			2	
Total (-)			11			17

3 females). By using the revised method, Ginter successfully aged 87% of those classified as having white ancestry. The proportion of correct age estimates for individuals of colored ancestry was 74% and for individuals of black ancestry was 73%. Although the statistical difference wasn't significant between individuals of different backgrounds, the revised method was more accurate for the white ancestry.

In 2007 Sakaue and Adachi from Department of Anthropology of Tokyo, published a study in which they examined the revised maxillary suture method in Japanese [17]. They assessed the effectiveness of the method by using 375 (274 males and 101 females) Japanese skeletons of known age and sex. Although the proportion of correct age estimates was only 36,9% for males and 25,7% for females, the researchers found that the overestimates of age-at-death were seldom. This finding led the revised method to be widely accepted in Japan for estimating the minimum age-at-death in Japanese population.

In the present study we examined the revised maxillary suture method and estimated the effectiveness of the method in Greek population. The sample used in this research consisted of 271 (150 males and 121 females) Greek skeletons of known age and sex. The percentage of correctly aged individuals in this sample using the revised method was 87%. At any given age, males exhibited more obliteration of the sutures than females, a finding consistent with the results of Mann *et al.* [12]. The correct age estimations were 89% for males and 84% for females. All sutures, in both sexes, start obliteration about at the same time, but in females the rate is slower. However, there is no statistically significant sex difference in the accuracy of age estimates.

Other researchers have noticed that cranial suture closure is influenced by population differences [18]. The rate of maxillary suture obliteration may also be affected by cultural or dietary differences. Nevertheless, the results of this study suggest that the revised maxillary suture method can be of value in estimating age at death in the Greek.

CONCLUSION

The revised maxillary suture method was applied to a large sample of skeletons from Greece with known age and sex, in an effort to test the performance of the method in a different ancestral sample. Age was correctly estimated for 89% of the males and 84% of the females without any statistically significant sex difference in the accuracy of the method. To sum up, the high proportion (87%) of correct age estimation in the sample indicates that the method is applicable to estimate age at death in Greek samples.

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