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Technical note

Technical note: The two step procedure (TSP) for the determination of age at death of adult human remains in forensic cases

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ABSTRACT

This paper presents the principles and results of TSP (the two step procedure), a comprehensive (combined) method of age estimation in mature human skeletal remains. The first step consists of the examination of the pubic symphysis using the Suchey–Brooks system for a "pre-choice". Then for SBS phases I, II, III, (young adults up to about 40) the age estimate is given using the chronological interval corresponding to each phase. For SBS phase is IV, V or VI (mature adults, about 40 to 60), then (second step) the dental method of Lamendin (using single rooted tooth) will be applied alone. Both methods are fast, easy to learn and to use (requiring no preparation except cleaning soft tissues from the pubic bone) and are not expensive, making TSP usable by all pathologists or anthropologists in any Forensic unit. It is also of great practical use in mass disaster and mass grave situation. After 15 years of use, a literature review and four evaluation studies we confirm that TSP is more accurate than any single method for aging adults and at least as good as more complicated combined methods. Despite its advantages TSP is, like all other aging methods, not efficient in adults over 65 years of age.

1. Introduction

Among the criteria of the biological profile (ancestry, gender, height and age), age is one of the most difficult to precisely estimate.

There is no single method which works for the entire life span, i.e. before choosing a method for aging of human remains the first step is determining whether it is an infant, child, adolescent or adult [1]. It is widely admitted that dental development (growth and eruption) is the reference method during infancy and that the stage of union of epiphyses of the post cranial skeleton is the most effective method to age adolescents [1]. Unfortunately it is also a fact that no reliable method is available for the elderly (over 65) [2].

In this paper we will propose a method designed for aging adult corpses (i.e. from 18 to 65 years) which we have called TSP (Two step procedure) or TSS (two step strategy) in some papers [3]. TSP is a comprehensive (combined) method based on two individual methods: the Suchey–Brooks system (SBS) for the pubic symphysis [4] and the dental method of Lamendin (LM) [5,6].

TSP was presented initially in French in 1991 [7], then in English at an AAFS meeting in 1997 [8] and since then was evaluated by several teams [3,9–11].

For the first time, its principles and designs are presented in detail along with a synthesis of the results of the four verification studies performed so far.

2. Pubic symphysis examination with the Suchey–Brooks system (SBS)

2.1. Characteristics of SBS: Advantages and weaknesses

Among the macroscopic aging methods [1], the Suchey–Brooks System has several obvious advantages. Morphological modifications are divided into only 6 phases (I to VI). Commercial plastic pubic casts are (also) available for visual comparison which is of great assistance to less experienced observers [7,12]. This method has been developed from a large and modern forensic population (autopsy samples of Los Angeles Coroners Office) and the data processing takes into account the variability between individuals.

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For each phase, two age intervals are provided: the 66% and 95% confidence interval (Table 1). Working with this technique since 1988, Baccino [7,12] has shown that it can be used with reliability on a European sample for individuals aged under 40 years old. Recent studies showed that age estimation of a Balkan sample with SBS gives low rates of reliability (in particular for women) and suggested that a population-specific standards are needed [13,14]. Then, Kimmerle et al. has published a new age estimates for Balkan populations [13].

However, the SBS presents some disadvantages. Gender and ancestry determination are pre-requisites and the symphyseal face of the pubic bone is often damaged in ancient skeleton cases and in charred bodies. Also, the age estimates depend on the reference sample and that could bring some bias. This phenomenon, as also known "age mimicry", could originate a loss of accuracy [15–17]. To solve this problem, Godde et al. proposed to use a transition analysis combined with a Bayesian's approach that seemed to give more accurate results than SSB technique alone on archeological cases [15].

2.2. Collection and preparation of pubic symphysis

After dissection of soft tissues (often abundant in forensic cases), an electric saw is used to cut the ischio and ilio-pubic ramus (at least 2 cm long). After removing as much soft tissue as possible with a scalpel, forceps and a metallic brush, the bone sample is kept in boiling water from ten minutes to an hour depending on the density of bone and how strongly cartilage is attached to the bone surface. The process must be checked regularly in order to avoid damaging the articular surface whilst cleaning the symphyseal surface. The dry sample can be stored indefinitely at room temperature without conservative.

Several studies have proposed, in order to avoid destruction during preparation of samples, a CT scan or laser approach often associated with 3D modeling to visualize pubic symphysis [18,19]. These methods seemed to give same results [18] but with less inter-observers accuracy [19] compared to direct observation [20].

2.3. Age at death assessment with SBS

Using the casts for comparison, even a novice will, most of the time, only hesitates between two adjacent phases, and using Suchey–Brooks' detailed criteria, it takes only a few minutes to assign the symphyseal surface to the correct phase.

The first criterion to observe is the aspect of the articular surface with ridges and furrows in young individuals. The surface becomes flatter around age 40 and eventually becomes excavated and irregular due to porosity and bone remodeling.

The second criterion is the dorsal and ventral rims which are absent in the initial stages. The dorsal formation begins first, the upper part of the ventral margin being the last to be completed. Only in the fourth phase, an oval articular surface is achieved.

The last criterion is the evaluation of the completion of the upper and lower extremities; it is crucial to differentiate the three earlier phases. Completion is absent in phase I, partial in phase II and complete in phase III.

A few practical recommendations can be made. It is necessary to compare both sides of the articulation as maturation may vary (from one phase) between the left and the right side. In case of two different phase assessments are visualized between the right and the left part of pubic bone, the older phase must be retained, at least on the French sample [7,21]. In order to better see the billowing, the articular surface should be examined against a dark background. The articular surface must be moved during visual examination to see the front, profile and oblique view.

3. The dental method of Lamendin (LM)

3.1. Characteristics of the Lamendin method

In the 1980 s Lamendin [5], on a large modern sample collected in dental offices (400 individuals), applied multivariate analysis to the Gustafson's seven aging criteria [22,23] and showed that root's translucency was the most important one. Lamendin also demonstrated that, among the other criteria, periodontosis was the only which was statistically independent from root's translucency and which improved significantly (albeit slightly) the accuracy of the age estimate. Translucency is due to the deposition of hydroxyapatite crystals in the dentin tubuli and begins after the age of 25 (which explains the value of the constant of the formula, see below). It is a natural process independent from acquired factors whereas periodontosis is strongly influenced by diet and oral hygiene. The use of root length as a denominator for both criteria eliminates the influence of the tooth size on the age evaluation.

3.2. Age at death assessment with Lamendin method

A single rooted tooth (incisor or canine), a light source (such as a 16 watts light box), a ruler and a calliper square are the only equipment needed. The measurements are made on the entire extracted tooth without any preparation (no sections, no microscope). The type and side of the tooth (as long as it is single rooted) on which measurements are made has no effect on the performances of the method.

The measurements of translucency, periodontosis and root's height must be done on the same side of the tooth; this side will be chosen as the one where the measurements seem the easiest to take (for example: clear cut upper limit of translucency, obvious soft tissue attachment line, no irregularity of the crown, etc.).

Using the mean value of measurements obtained from different teeth of the same individual did not provided a better accuracy than measurements made on a single tooth [6].

Root length is the distance between the apex of the root and at the crown (cementoenamel junction). Periodontosis is the distance

Table 1
Mean age, standard deviation, 66% and 95% confidence interval for each phase from the Suchey–Brooks system.

Phase	Female				Male			
	Mean	S.D.	66% Range	95% Range	Mean	S.D.	66% Range	95% Range
I	19.4	2.6	17–22	15–24	18.5	2.1	17–21	15–23
II	25	4.9	20–30	19–40	23.4	3.6	20–27	19–34
III	30.7	8.1	23–39	21–53	28.7	6.5	22–35	21–46
IV	38.2	10.9	27–49	26–70	35.2	9.4	26–45	23–57
V	48.1	14.6	34–63	25–83	45.6	10.4	35–56	27–66
VI	60	12.4	48–72	42–87	61.2	12.2	49–73	34–86

From Ref. [4].