Forensic Science International 280 (2017) 246.e1–246.e7

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic Anthropology Population Data

The auricular surface as age indicator in a modern Greek sample: A test of two qualitative methods

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ARTICLE INFO

Article history:
Received 2 December 2016
Received in revised form 3 August 2017
Accepted 4 August 2017
Available online 20 August 2017

Keywords:
Forensic population data
Auricular surface
Age estimation
Cretan collection

ABSTRACT

The auricular surface is often found very well preserved, thus age-related changes in this anatomical area can be important for any set of human remains that require identification under different taphonomic conditions. This study tests the Buckberry and Chamberlain (2002) and Schmitt et al. (2005) methods in predicting the age of individuals in a documented sample from Crete, Greece. Both methods were used to record changes on the auricular surface in a mixed-sex sample of 74 individuals, directly as well as through photographs, by two independent observers. Cohen's kappa and intra class correlation coefficients (ICC) were used in order to assess inter-observer and intra-observer agreement. Results showed than none of the methods predicted age with sufficient accuracy, as high error rates were recorded. The Schmitt et al. (2005) method performed better, mainly because the age ranges it uses are broader. Scoring through photographs does not seem to introduce bias in predicting age, as demonstrated by the high intra-observer agreement rates. Inter-observer agreement was also high. The low intra- and inter-observer error rates suggest that the poor performance of both methods in the Cretan sample is not due to a lack of clarity in the description of the morphological changes recorded on the auricular surface; rather it should be attributed to a poor correlation between these changes and age at death in our material.

1. Introduction

Age has always been an issue of major importance in the study of unidentified skeletal remains. During the past decades, great effort has been devoted to the study of the age at death of individuals based on skeletal evidence, using different schemes, as well as different anatomical parts of the body. The literature on age estimation methods shows a variety of approaches, macroscopic, microscopic and analytical. Cranial suture closure [1], pubic symphyseal surface morphology [2], sternal rib end morphology [3], and auricular surface morphology [4] constitute typical examples of macroscopic morphological methods for age estimation. On a microscopic and analytical level, bone histomorphometry methods rely on the quantification of age-related remodelling changes of the bone on different skeletal elements [5,6]. Chemical/analytical methods range from aspartic amino-acid racemisation [7,8] and bone material properties quantification [9,10] to DNA methylation techniques [11,12]. Each technique presents strengths and weaknesses related to reliability, applicability, cost- and resource-effectiveness and despite the general guidelines of all professional bodies (to "use a combination of all available methods"), this is not always feasible, especially in forensic facilities with few non-medical specialists. From this point of view morphological methods are more popular as they do not require sophisticated equipment and expertise. Yet, these techniques are sensitive to observer and population bias, thus, their reliability must be demonstrated before application in forensic settings.

The current paper focuses on the morphology of the auricular surface of the os coxae as an age marker. The auricular surface is often found very well preserved, thus age-related changes in this

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http://dx.doi.org/10.1016/j.forsciint.2017.08.004
0379-0738/

anatomical area can be important for any set of human remains under different taphonomic conditions. The first to propose aging standards based on morphological changes on the auricular area were Lovejoy et al. [4]. Lovejoy's study uses eight modal age stages of 5 years each, starting from juveniles and ending in 60+ years, and describes in detail the changes in the appearance of the auricular surface in every age group. The features recorded include grain and density, macroporosity, billowing, striations, apex lipping, activity in the retroauricular area and transverse organization. Several scholars applied Lovejoy's method in different samples and noted that older individuals tended to be underaged, whereas the age of younger individuals was overestimated [13–17]. In addition, many studies found that the 5-year intervals proposed by Lovejoy et al. [4] are unrealistically narrow [14,18].

More recently, Buckberry and Chamberlain [18] revised this method (hereafter B-C) to improve age predictions and developed a scoring system where the features recorded on the auricular surface include transverse organization, surface texture, porosity and apex sharpness. The revised method examines each feature as an independent variable and suggests that it is scored separately using an ordinal scale. Subsequently, all individual scores are summed per element and age is estimated according to the total score. Similarly, Schmitt et al. [19] (hereafter SC) developed a method that focuses on the same overall attributes as the Buckberry and Chamberlain [18] method, as well as the entheseal changes on the iliac tuberosity. In this case, all variables are recorded in a binary scale, except for granulation and porosity (SSPIB), for which an ordinal system is used. Finally, Igarashi et al.'s [17] approach is based on the binary scoring (presence–absence) of 13 variables per individual, mainly concerning surface texture, porosity, granularity and hypertrophy.

The aforementioned methods have been tested in different populations and the results showed a poor to fair performance. In specific, Falys et al. [20] tested the B-C [18] revised method in a sample dating from the late 17th to the early 19th centuries. Results showed that the method was not reliable due to the extensive variation in the morphological changes of the auricular surface and suggested that only very broad age assessments can be reached by adopting it. Moraitis et al. [21] applied the B-C [18] method on a modern Greek sample, namely the Athens Collection, and their results showed a variation of 5.5–12.6 years across all age stages. Stage VII was the one that appeared to correspond better with the known ages of the individuals (56–78 years). However, Moraitis et al.'s [21] study agrees with previous ones that indicated age underestimation for older individuals along with overestimation for younger ones.

The present work tests the B-C [18] and SC [19] methods using a modern Cretan sample, with documented age and sex. The aim is to examine both how accurately these methods can predict the age at death of the individuals and to quantify the inter- and intra-observer error. A secondary goal of the study is to investigate whether high quality photographs can provide reliable enough information to be used in place of direct observations as it is a common phenomenon for forensic practitioners to provide consultation from images rather than direct examination of the body.

2. Materials and methods

The sample used for this study consists of 74 Cretan individuals of known sex and age at death from the Cretan collection, housed at the facilities of the Forensic Pathology Division of the Hellenic Ministry of Justice and Human Rights in Crete. The skeletal remains were exhumed from St Konstantinos and Pateles cemeteries in Heraklion, Crete. The individuals examined here died between 1963 and 1997. More information on the collection can be found in Kranioti et al. [22] and Kranioti and Michalodimitrakis [23]. The age range of the material is shown in Table 1.

Table 1
Sample age distribution.

Age range	No of individuals
19–29	1
30–39	5
40–49	1
50–59	11
60–69	12
70–79	20
80–89	18
90–99	5
>100	1

For consistency, the right auricular surface was observed when possible, whereas data from the left side were only collected when the right one was unobservable. We have chosen the right innominate due to the better preservation of this skeletal element in our sample. Bones showing deformities of a pathological nature that could distort the auricular surface were excluded from the sample. Pictures of each innominate bone analyzed were taken with a Nikon D31000 camera in order to generate a digital image bank. Data collection was performed by two observers and involved both the direct recording of auricular surface morphological traits and the indirect recording through photographs. Observer 1 (E.M.) recorded the auricular traits both directly and indirectly, while Observer 2 (P.N.) recorded them only directly.

The methods described by Buckberry and Chamberlain [18] and Schmitt et al. [19] were applied to all material without prior knowledge of the age at death of the remains. According to the B-C method [18], five features were recorded for each auricular surface: transverse organization (TO), surface texture (ST), microporosity (MI), macroporosity (MA) and apical changes (AP). According to the SC method [19], four features were observed on the auricular surface: transverse organization (SSPIA), granulation and porosity (SSPIB), articular surface modification and apical modification (SSPIC), and iliac tuberosity changes (SSPID).

Correlation coefficients were calculated to examine the relationship between individual auricular surface features and actual age for the SC and B-C methods as well as between the composite score and actual age for the B-C method. For this purpose, Spearman's rho (rs) was used.

The reliability of the B-C method was tested by measures of bias and inaccuracy, following Hens and Belcastro [24]. A similar approach could not be adopted for the SC method because the latter does not produce mean age estimates. The accuracy of each method was also assessed by counting the number of individuals for whom a correct age estimate was attained for each observer, that is, the age at death of the individuals fell within the predicted age interval. The measure traditionally used to test for inter-observer error is Cohen's kappa for nominal data and weighted kappa for ordinal data [25]. This measure was adopted here to compare the results obtained by observers 1 and 2 from the direct recording of auricular morphology using each method. In addition, this measure was used to assess intra-observer error for observer 1 when recording auricular surface morphology directly and indirectly, as well as directly on two separate occasions with a three-month interval between each recording session. An intraclass correlation coefficient (ICC) test was carried out as well in order to examine the intra- and inter-observer error rates [26,27]. The main limitation of this test compared to weighted kappa is that only absolute agreement between observers is taken into account, thus any difference between scores, no matter how small, is considered a disagreement.