Forensic Anthropology

THE CONTRIBUTION OF DENTISTRY IN AGE ESTIMATION OF YOUNG ADULTS.

A contribuição da Odontologia na estimativa da idade em adultos jovens.

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ABSTRACT

Estimating the age of young adults remains a challenge and cannot be performed with high accuracy, however, this estimate may contribute to an elucidation of expert cases. This study aims to describe and analyze the different techniques and methodologies used by Forensic Odontology to make these estimates. For this, scientific articles were analyzed from the use of "forensic anthropology" and "dental age estimation" as keywords in PUBMED. Studies published between 2003 and 2016 in English were included, as well as the revisions and studies aimed at children or other purposes were excluded. In a total of twenty-eight articles selected, the nationality, homogeneity and gender of the samples were analyzed, as well as the type of imaging tests and the different techniques used, such as: morphological, histological, biochemical or the combination between them. In addition, the use of teeth or bones and the dental group chosen to constitute the sample were evaluated. Through this search, it is concluded that the profile of global scientific study aimed at the age estimation of young adults uses homogeneous samples of both genders, using one-root and multi-root dental elements. The general design is also characterized by the morphological analysis of the sample and the use of imaging exams, preferably panoramic radiographs. Although the articles cover different nationalities, the Indian population presented the most significant expression in the present study. Under those circumstances, the selected literature reflects the reality of studies in different populations, emphasizing the need to stimulate scientific research in Brazil, since the population standards alter the efficiency of the indicators used. The improvement of current techniques is also necessary to make them less invasive, with the predominant use of CT scans, radiographs and photographs.

KEYWORDS

Age determination by teeth; Young adult; Forensic anthropology; Forensic dentistry.

INTRODUCTION

The chronological age estimation can be considered as the process of evaluating the stage of evolution or involution of an organism[1]. It is not an accurate valuation, so the term "age determination" is not correct, as long as genetic, environmental, metabolic and

nutritional variables are involved and are inherent to each individual[2].

There are several methods for age estimation in Forensic Anthropology, such as histological[9,22,27,30], biochemical[15] and morphological[10-14,16-21,23-26,28-29,31-36] approaches and the most applicable for each case should be chosen, considering the type of sample evaluated. The tooth has a great relevance in human identification processes due to its high degree of resistance to external physical and chemical factors, including the thermal action[3]. Furthermore, dental development is not easily affected by exogenous or endogenous factors[3]. Regarding the degree of mineralization, dental assessment provides a better estimate of chronological age than the bone mineralization, since teeth are less affected by the individual's nutritional and endocrine status[4].

The origins of Dental Anthropology were established in Greek civilization by Aristotle and Hippocrates, and their systematic investigations[5]. However, Forensic Odontology just achieved greater visibility after Second World War and the increasing number of air catastrophes[6], in which the use of other methods of identification was not possible due to the carbonization of bodies.

Although, only in 1950, after Second World War, that Gustafson designed his method for age estimation through dental elements. This arrangement adopted six different criteria, which are considered as regressive dental changes: wear, periodontitis, secondary dentin deposition, cement apposition, apical resorption and root translucency. Each characteristic is scored from zero to three according to its intensity. His methodology was modified and adapted by several researchers; henceforth, new techniques have arisen, based on morphological, histological and biochemical evaluations.

Nonetheless, after a certain age, the examination of the dental elements becomes complementary to the expert investigation compared to the analysis of other regions of the body, since an age group essential for the judicial point of view still cannot be precisely established. The accuracy of estimating the criminal majority in Brazil has the capacity both to generate legal implications and to guarantee undue benefits or damages to individuals[7]. In Brazil, the civilian adulthood is reached at 18 years old since the advent of the 2002's Civil Code[8]. At this stage, the development of all teeth has been completed, except for the third molars. Conversely, age estimation through third molars becomes difficult as these teeth may erupt at different times or even fail to erupt due to lack of the dental germ. Therefore, in the adult dentition, the dentist must use other variables of dental development, which improves the study of different methods able of reducing this imprecision[6].

In fact, the age estimation in young adults, both ante-mortem and post-mortem, is still a challenge for Forensic Odontology. The aim of this review is to analyze and compare the main techniques developed for the age estimation in this group as well as to point out practical information that may be relevant when choosing the methodology to be used in the expert routine.

METHODOLOGY

For the current study, a literature search was performed on the PUBMED platform, using the terms "forensic anthropology" and "dental age estimation" as keywords, resulting in 120 studies.

Next, only the articles that followed three inclusion parameters were maintained: the first two related to the publication, year and language, and the third to the methodology adopted. In that case, the studies published between 2003 and 2016 in the English language were selected for the sample. In addition, those who adopted primarily dental methodology also entered the listing, totalizing 62 articles.

On the other hand, for a more rigorous selection, all reviews of literature and studies focused to children were excluded, resulting in a sample of 26 articles. At last, two articles from related articles were including in final sample, since them follow all parameters previously described, finally resulting in 28 studies.

RESULTS

Nationality, Homogeneity and Gender of samples

A total of 28 articles were selected whose samples are from different nationalities, as shown in figure 1. In this sample, only five populations were studied in more than one article, and India is the country with the most prominence. Only three articles applied the methodology to individuals from different nationalities, concern to the use of a heterogeneous sample, in favor of observe possible and significant differences in the results of age estimation (Table 1). On the other hand, in relation to possible differences between genders in the results (Figure 2), 22 of 28 articles used a mixed sample. Among the six remaining articles, two were case reports, one male and the other female, and four studies did not consider the gender to establish the sample.
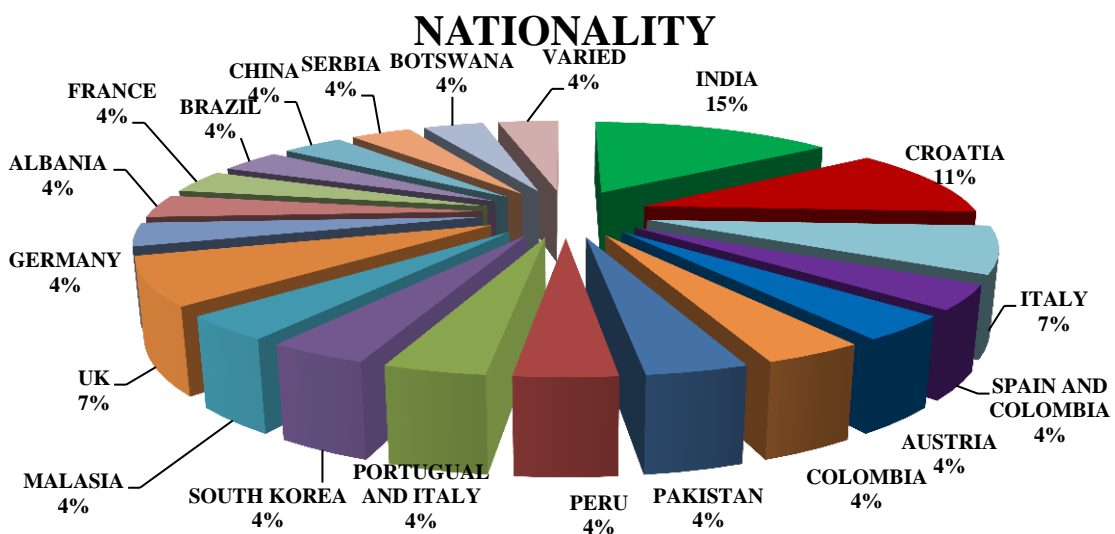

Figure 1. Nationalities of selected literature sample, total of 28 articles.

Table 1- Table 1- Selected articles listed by authors, year of publication, homogeneity, use of image exams (IE), methodology and its corresponding chronology.

Authors	Year	Homogeneity	Use of IE	Methods	Chronology
Bilge et al.[9]	2003	Homogeneous	Not used	Teeth and bones	Post-mortem
Brkic et al.[10]	2006	Homogeneous	Used	Teeth	Ante-mortem
Cameriere et al.[11]	2007	Homogeneous	Used	Teeth	Post-mortem
Bhat et al.[12]	2007	Homogeneous	Used	Teeth and bones	Ante-mortem
Meinl et al.[13]	2007	Homogeneous	Used	Teeth	Ante-mortem
González-Colmenares et al.[14]	2007	Heterogeneous	Not used	Teeth	Mixed
Griffin et al.[15]	2008	Homogeneous	Not used	Teeth	Ante-mortem
Ubelaker et al.[16]	2008	Homogeneous	Not used	Teeth	Post-mortem
Rai et. al[17]	2008	Homogeneous	Used	Jaw	Ante-mortem
Cameriere et al.[18]	2009	Heterogeneous	Used	Teeth	Mixed
Lee et al.[19]	2011	Homogeneous	Used	Teeth	Post-mortem
Vodanović et al.[20]	2011	Homogeneous	Used	Teeth and bones	Post-mortem
Johan et al.[21]	2012	Homogeneous	Used	Teeth	Ante-mortem
Gocha et al.[22]	2013	Homogeneous	Not used	Teeth	Post-mortem
Gibelli et al.[23]	2014	Homogeneous	Not used	Teeth	Mixed
Ramsthaler et al.[24]	2014	Homogeneous	Not used	Teeth	Post-mortem
Cameriere et al.[25]	2014	Homogeneous	Used	Teeth	Ante-mortem
Galić et al.[26]	2015	Homogeneous	Used	Teeth	Ante-mortem
Colard et al.[27]	2015	Homogeneous	Not used	Teeth	Post-mortem
Deitos et al.[28]	2015	Homogeneous	Used	Teeth	Ante-mortem
Ge et al.[29]	2015	Homogeneous	Used	Teeth	Ante-mortem
Mallar et al.[30]	2015	Homogeneous	Not used	Teeth	Ante-mortem
Zelic et al.[31]	2016	Homogeneous	Used	Teeth	Ante-mortem
Cavrić et al.[32]	2016	Homogeneous	Used	Teeth	Ante-mortem
Rajpal et al.[33]	2016	Homogeneous	Used	Teeth	Ante-mortem
Badar et al.[34]	2016	Homogeneous	Used	Teeth	Ante-mortem
De Luca et al.[35]	2016	Homogeneous	Used	Teeth	Ante-mortem
Lefèvre et al.[36]	2016	Heterogeneous	Used	Teeth	Ante-mortem

n = 28.

Methodology, Techniques and imaging exams used

About the methodology adopted, 19 studies used imaging resources to evaluate the age group as shown in table 1. Among these are radiographs, cephalometry and computadorized tomography (Figure 3). Furthermore, the data collected in relation to the techniques used to estimate the age in the 28 articles studied are exposed in figure 4. The highest percentage is for morphological evaluations and the lowest for biochemical analysis.

Preferential dental group for analysis

About the use of dental elements for analysis, only one did not use them, replacing them by mandibular evaluation. As well, three studies analyzed the teeth in association with other regions, one with the cranial sutures, one with the palatine suture, and other one with the wrist joint (Table 1). Among those who used dental elements, nine analyzed one-root elements, nine evaluated multi-root teeth and five used a mixed sample, whereas two articles did not report such data (Figure 5). In addition, fifteen used samples from living individuals, eight from cadavers and human remains,

and only three made a combination of these two types of samples according to Table 1.
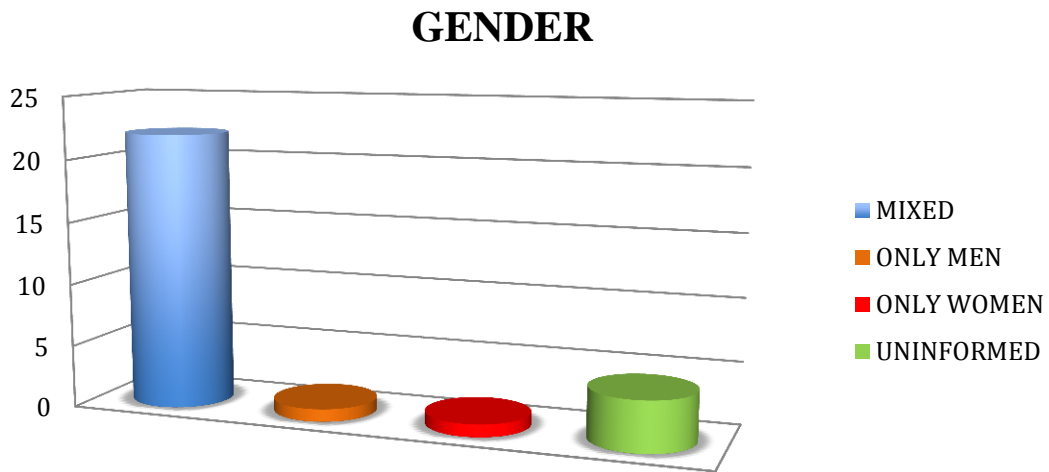
GENDER

Figure 2. Gender distribution among selected articles. Mixed (78%); female (4%); male (4%); not informed (14%) in a total of 28 articles.
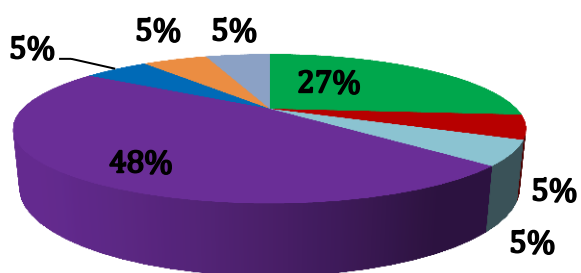
TYPES OF IMAGING EXAMS

Figure 3. Different types of auxiliary imaging tests used in selected literature in a total of 19 articles.
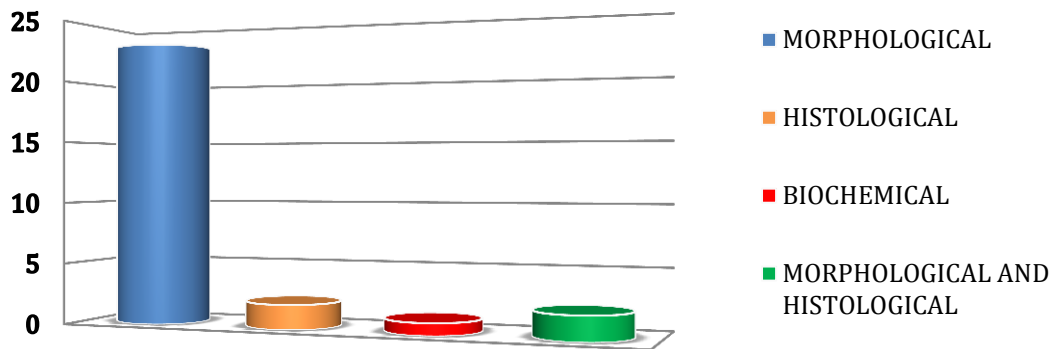
TECHNIQUES

Figue 4. Basic principle of the techniques developed and tested in selected literature: morphological (82%); histological (7%); biochemical (4%); morphological and histological (7%) in a total of 28 articles.
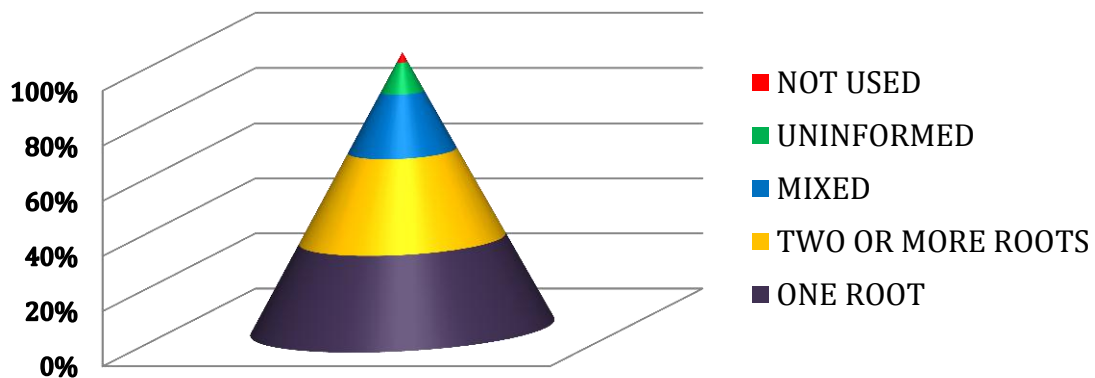
DENTAL SAMPLE

Figure 5. Dental group of choice for estimating age: one-root teeth (32%); multi-root teeth (32%); mixed sample (21%); uninformed (11%); not used (4%) in a total of 28 articles.

DISCUSSION

Comparing the efficiency of the Lamendin and Price and Ubelaker techniques, in a white Spanish population and in a mixed-race Colombian population, the Prince and Ubelaker method guaranteed the slightest error (González-Colmenares et al. 2007)[14]. In another study, Ubelaker & Parra (2008)[16], in partnership with Parra compared their technique and Lamendin's one with that developed by Bang and Ramm in a Peruvian sample, concluding that the results for the three techniques resemble those reported in the original publications of those studies. This suggests minimal population interference in the circumstances presented.

However, as shown in table 1, the approach of heterogeneous populations in the same study for the evaluation of this ethnic factor is extremely deficient, having been considered in only three articles analyzed. This fact shows one of the deficiencies in the scientific research profile traced, which can be explained by the

difficulty of exchange and access to material of human origin from another country.

Ramsthaler et al. (2014)[24] adapted a digital measurement form by determining luminance to the Lamendin methodology. It was observed that the standard error was comparable to that observed in the original method and that increased reproducibility did not result in an accuracy gain. On the other hand, in the case of carbonized human remains, Gibelli et al. (2014)[23] observed that the radicular transparency methodology loses its efficiency, which constitutes a great loss in applicability and precision. Likewise, Gocha & Schutkowski (2013)[22] used tooth cementum annulation (TCA) in skeletal remnants exposed to high temperatures and did not achieve good levels of precision.

In general, the adequacy of the use of canines as a morphological indicator for age estimation was recognized, with better results when compared to the standard deviation of techniques based on other structures. This can be explained by the great volume of the canines and its high degree of preservation, since in most cases they suffer less wear when compared to the posterior teeth. In spite of that, Cameriere et al. (2007,2009)[11,18] reported the difficulty in the use of canine teeth in the age groups with higher age, due to probable absence. But, this is not often a problem found in young adults.

Bhat & Kamath (2007)[12] found a strong correlation between third molar development, skeletal maturation and chronological age, despite though these teeth are the most variable in the dentition. However, Johan et al. (2012)[21] established that age estimation with the use of third molar has limitations, since it presents many variations in terms of position, morphology and development. Accordingly, it was noticed in figure 5 that the use of one-root teeth (32%) and two or more roots teeth (32%) is well distributed within the studies aimed at the age estimation, and mixed samples were also relevant (21%).

The studies proposed by Cameriere et al. (2014, 2015)[25,28] made possible the creation of a single linear regression model, unaffected by nationality or gender. Through a collaboration network, the methodology was also tested in a Brazilian population. The results were less satisfactory and the authors concluded that ancestry might be the explanation for the discrepancy in the outcomes, since the population is more mixed in Brazil.

In this study with a Brazilian sample, the authors pointed out that the differences should be considered since the third molars presented earlier stages of mineralization among men. Despite this, Zelic et al. (2016)[31] found that the Serbian population's results were correlated with other studies in white populations, presenting better sensitivity and specificity for both sexes than the Italian, Croatian, Albanian and Brazilian samples. González-Colmenares et al. (2007)[14], also noted the importance of considering sex and ancestry in their study. Based on this, it can be seen from figure 3 that the constituent articles of this study are similarly divided in the use of samples of female and male genders, and the expressive majority made use of a mixed sample with a balanced division between the sexes (78%).

Cement chronology analysis, as well as amino acid racemization, requires a greater investment in technology and staff qualification, resulting in higher costs. In addition, these methodologies need more time for analysis, which in most cases does not fit the reality of the expert. This fact is clearly visualized in figure 4, which shows that the use of histological (7%) or biochemical (4%) techniques is minimal, which means that the research has a purely morphological design (82%). In contrast, Colard et al. (2015)[27] found that there was an age underestimation by all methods, being older than 60 years, except for the cement chronology. In addition, Griffin (2008)[15] concluded that the racemization of aspartic acid is useful.

In this perspective, González-Colmenares et al. (2007)[14] considered the root translucency as the best parameter of correlation with age. Moreover, the studies used predominantly noninvasive methods such as Bang and Ramm[10,16] that assess the length of the translucent zone of the root apex, and the Kvaal method[10,13] that demonstrates the negative correlation of the different portions in the two-dimensional radiographic pulp volume with the chronological age of the individual. Thus, macroscopic examinations, such as the evaluation of the level of dental wear, end up being more used. However, it is known that this parameter should not be used exclusively for estimating the age[19].

Another factor to be taken into consideration is the importance of the imaging tests within this field of research, since 68% of the studies used this feature as a basis for evaluation (figure 4). Next,

figure 3 shows that panoramic radiography (48%) is still the most viable exam used in research aimed at age estimation, also emphasizing the small-scale use of three-dimensional imaging resources such as Cone beam computed tomography (5%), for example. As a result, the dental examination (78%) predominates in front of the bone samples (4%), as seen in table 1, and it can be explained by the fact that bone analysis is more dependent on higher accurate imaging tests.

CONCLUSION

Considering all that was exposed, the importance of extending the study of the different age estimation methods to other populations is emphasized in order to evaluate possible variations since specific rules for different populations contribute to the increase of the accuracy of the age estimation. The incentive of scientific research in this field has vital importance in Brazil.

As far as inaccuracies are progressively different from those detected in other techniques, additional and valuable information can be added on current multifactorial methods. This enhancement aims at developing less invasive techniques, increasing their precision along with the advances in the use of more modern three-dimensional imaging tests and, consequently, capable of giving greater fidelity to the method. Furthermore, the quality of a specific approach should not be evaluated entirely by the accuracy of the estimate, because its reproducibility must also be proven. Thus, Dentistry has a potential field in research on the age

estimation of young adults, and may increase the accuracy of techniques used in

the expert's examinations involving dental elements to estimate the age.

RESUMO

A estimativa de idade em adultos jovens ainda é um desafio e não pode ser determinada com precisão, no entanto, sua contribuição é relevante na atividade pericial. O presente trabalho tem como objetivo, através de uma revista da literatura, descrever e analisar as diferentes técnicas e metodologias empregadas pela Odontologia Legal para realizar estas estimativas. Para isso, foi realizada uma busca bibliográfica, no PUBMED, a partir do uso das seguintes palavras-chave, "forensic anthropology" e "dental age estimation". Foram incluídos apenas artigos escritos em inglês, publicados entre 2003 e 2016. Foram excluídas todas as revisões de literatura, assim como os estudos desenvolvidos em crianças e com outros propósitos. Em um total de vinte e oito artigos selecionados, a nacionalidade, homogeneidade e sexo das amostras foram analisadas, tal como o tipo de exames de imagens e as diferentes técnicas empregadas, sendo estas: morfológica, histológica, bioquímica ou a combinação dessas. Além disso, avaliou-se o emprego de dentes ou ossos, e o grupo dentário eleito para constituir a amostra. Através desta busca, concluiu-se que o perfil da pesquisa científica mundial voltada para a estimativa de idade de adultos jovens utiliza amostras homogêneas, de ambos os sexos, empregando-se elementos dentários tanto unirradiculares como multirradiculares. O delineamento se caracteriza pela análise morfológica da amostra e o uso de exames de imagens, preferencialmente radiografias panorâmicas. Apesar dos estudos abrangerem diferentes nacionalidades, foi possível observar que a população indiana obteve expressão mais significativa. Dessa forma, a literatura selecionada reflete a realidade de estudos em diferentes populações, salientando a necessidade do estímulo à pesquisa científica no Brasil, uma vez que os padrões da população alteram a eficiência dos indicadores utilizados. O aprimoramento das técnicas já existentes também se faz necessário para que estas se tornem cada vez menos invasivas, utilizando-se tomografias computadorizadas, radiografias e fotografias.

PALAVRAS-CHAVE

Determinação da idade pelos dentes; Adulto jovem; Antropologia forense; Odontologia legal.

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