Review Article

Challenges in Forensic Odontology Age Estimation Methods

Johanna Namene, Nagabhushana Doggalli

Form the Department of Forensic Odontology, JSS Dental College and Hospital, JSSAHER, Mysore, Karnataka, India

ABSTRACT

One of the major roles of the forensic odontologist in identification is age estimation. There are a wide range of methods available in literature for age estimation. Methods have been tested on different populations, modified, and remedied. Contradictions and discrepancies between researchers often occur when the same method is applied and gives different results. There are a lot of factors leading to these discrepancies, mainly the lack of standardization of methods and procedures. However, this can be challenging because of differences in population ethnicity. Irrespective of these drawbacks, accuracy and reliability still need to be maintained. This article aims to review the limitations of various techniques used in forensic odontology, challenges faced as well as future recommendations.

KEY WORDS: *Age estimation, challenges, forensic odontology, human identification, limitations*

INTRODUCTION

Forensic odontology is a broad subject in which many methods and procedures are used for identification. Monali *et al*.[1] described forensic odontology as an investigative aspect of dentistry that analyzes dental evidence for human identification. A wide range of methods have been developed in the past and have been practiced. Old methods have been modified and remodified, and new methods keep emerging. Provided that there are a lot of methods available in the field of forensic odontology, the main problem a forensic odontologist faced is choosing the correct method to use for a particular case. This is challenging because there is a lack of uniformity of procedures and methods to be used worldwide. In addition, it is difficult to set such standards because these methods are population specific. In most cases, the results are either overestimated or underestimated when applied on different populations because of differences in ethnicity and race.

Giving identity to an individual in both the living and the dead is one of the most important aspects in forensics. In the dead, it is necessary to provide identity of the disease in order to give proof to the grieving family for closure.[2] Practically, the antemortem data of the deceased is compared to the postmortem data to yield an identity. One can imagine that it is as easy as it sounds, but obtaining the antemortem records can be challenging. This is a setback in the identification process and thus the importance of record keeping. In the living, especially in knowing, an individual's age plays an important role in issues dealing with the law. For example in criminal cases, needs may arise to distinguish juvenile/minor from adults/major, in order to lawfully punish offenders according to their ages.[3]

CHALLENGES IN AGE ESTIMATION METHODS

Reviews in age estimation methods using teeth as a tool indicator have been exhausted and are widely available in the literature. However, the issue of challenges faced in using these methods has been neglected. A wide variety of age estimation methods are available for children, adolescents, and adults. Age estimation methods are categorized as histomorphological, biochemical, and radiographic methods.[4]

The main aim every forensic odontologist wants to achieve is for dental age to correlate as closely as possible with the chronological age and set up an independent time frame that is not affected by external factors such as nutrition and diet.[5] In children, dental age assessment is based on the calcification and mineralization of teeth as well as the time of emergence of deciduous teeth in the oral cavity.[5] However, teeth eruption seem to be affected by a number of factors such as gender, ethnic origin, physical and sexual development, craniofacial morphology and thus is not an ideal age indicator. Several methods of age assessment in children and adolescents are available, and among others, the most commonly used ones are Nolla,[6] AlQahtani,[7] and Demirjian's[8] method may be because of well-defined stages. The accuracy of these methods has been tested, in quest to find the method that will give accurate results. In most cases, the methods of choice depend on the simplicity of the method. Researchers prefer to use a simple method that will give accurate results within a short period of time. In addition, when working with court cases, one needs to choose a method that will not take a longer time to produce reliable results. Time in forensic

Address for correspondence:
Ms. Johanna Namene, E-mail: jnamene3@gmail.com

How to cite this article: Namene J, Doggalli N. Challenges in forensic odontology age estimation methods. Int J Forensic Odontol 2018;3:46-9.

Access this article online

Quick Response Code:

Website: www.ijofo.org

DOI: 10.4103/ijfo.ijfo_16_18

cases is one important factor that needs serious consideration. A method that is quick gives accurate results and user-friendly is ideal to the judicial time and requirements. Demirjian's method has been widely researched and used in age estimation and is among the most accurate of classification systems as well most accepted by forensic scientists, probably because of their simplicity[9,10] and its well radiographic and schematic illustrations of tooth development and accompanying description.[11,12]

Although there are many techniques available, these techniques are said to be population specific, so what work for one population might not work for the other.[2] Results are either under- or over-estimated when applied on different populations because of ethnicity differences. It is, therefore, the duty of the forensic odontologist to derive specific formulas for their population. In countries such as India, forensic odontology is widely practiced for many years back. To date, there are quite a considerable number of Indian population-specific formulas that one can use and reach an acceptable conclusion. However, in countries especially most African countries where forensic odontology has gained little attention, it can be very challenging because there is a lack of population-specific formulas. If a case is presented to us and there are no ready data available for that population, it can be difficult.

Age Estimation in Adults

Unlike in children and adolescents, tooth development in adults has already settled and the method of tooth calcification cannot be used for age estimation. This also means that the error range in adults is higher as compared to younger ones. The acceptable standard error by many authors in age estimation for adults is ± 10 years.[13] Because of this, it is ideal to use a combination of methods instead of just using one. Furthermore, two or more forensic odontologists should work together and should reach the same conclusion.[2] To our knowledge, very few noninvasive methods are available in this group for age estimation. These are pulp-tooth ratio and gonial angle, which are both radiographic methods. Among the noninvasive methods, invasive methods can also be employed. The limitations of using destructive methods are that sectioning of teeth destroys evidence and may not be permitted in cases where dental evidence need to be preserved for court purposes.[14] Moreover, these methods cannot be applied in living individuals as it will require extraction of teeth.

Radiographic Methods in Age Estimation

Radiology is of the utmost importance in human identification. It is a nondestructive method and simple to use. Radiographic methods have advantages over biochemical and histological methods because it does not require extraction of teeth.[4] In addition, invasive methods involve destruction of evidence which in some cases, if not all, not allowed by the law. The basis of radiographic images in identification is that they should be able to show relevant information necessary to obtain an identity and the information should be clear and of good quality. To obtain a good quality radiographic images, a well-trained and qualified personnel must take the radiographs, taking into consideration important measures such as exposure time, amount of radiation used, positioning of the X-ray film, and processing. Images not taken properly may be distorted, elongated, blurry, or areas of interest not covered, just to mention a few. If the radiographic image is of poor quality, it is as good as no image at all. Moreover, trying to assess one will lead to wrong diagnosis and in the end wrong results. However, although noninvasive, in the living, the society is against taking radiographs if not for clinical purposes because of the risks associated with ionization radiation exposure.[15]

Method of Comparison with Antemortem Data

Dental identification with antemortem data is mainly based on two things: the availability of the antemortem dental records and the accuracy and completeness of those records.[2] If the antemortem dental records can easily be located or are at all available, then the work of the forensic odontologist in this case will be made easier. However, there are people who have never visited a dentist in their life and do not have dental records. Furthermore, some centers do not practice record keeping, or they will discard their old records after sometime due to space availability, so although the person has visited the dentist before, the records might have been thrown away, which might have information that could help. In addition, as discussed earlier, although dental records may be available, if they are of poor information, they are of no use. Sometimes, dental records might be available, but allocating them can be very challenging and difficult.[2] In addition, identification of comparison with dental records will only work if there is a lead of who the deceased could possibly be. For example, there is a skull with the intact mandible and no missing dentition found somewhere in the forest. It is estimated to have been there for some months close to a year. The police have not received any report of a missing person in around that time and no family have reported to have been looking for a missing relative. With the intact mandible and all dentition present, positive identification can be possible if there was a lead on who the person is, which can help in allocating the antemortem data, if available, to assist in the identification process. In such cases, the forensic odontologist is only limited to obtaining other identification measures such as age, sex, and race. Other than that, a positive identification cannot be made.

In younger ones, age estimation is found to be accurate because more teeth are undergoing development and the interval between the morphological stages is shorter, therefore more precise.[16,17] However, this is not the case in older individuals. After the age of 15 years, all permanent teeth have fully developed, and age assessment results in a large mean difference between dental and chronological age. Other age estimation methods are reliable in adults but may require ground sectioning of the tooth[16] which in most cases contradicts with the ethics, or the intact tooth is needed to be preserved for evidence. Some factors used in age estimation also include attrition. This is the wearing out of the crown as age progresses. Attrition can be affected by a lot of external factors such as chewing habits on one side, type of diet, bruxism, and brushing technique. All these factors can affect the assessment of age and may give false results.

Intra- and Inter-observer Variability

Intra-observer variability is defined as random errors among the observations made by the same observer on the same subject and inter-observer variability as the distances among the "true values" assigned by different observers on the same subject.[18]

This observer variability is mostly seen in methods based on staging of teeth mineralization.[6,8,19] Although it is ideal to use multiple observers to assess the age, as well as one scorer at different time intervals in order to avoid biased results, disagreements may occur between different observers.[8,17] This is one of the important shortcomings to be considered as it plays a major role.[18] Raj *et al*. stated that the fewer the stages, the lesser will be inter-examiner variability.[20] This is true; however, the accuracy of age estimation increases with the number of stages.

Sample Size and Statistical Analysis

The sample size is one of the important factors that can either strengthen or weaken a research study and should be taken into serious consideration. Since there are no standardized methods for use in forensic odontology, whatever new method researchers come up with, the world is ready to accept and start utilizing it. Researchers assume and believe that the journals only publish articles with true and unquestionable results which one can rely on. However, this may not always be the case. For this, researchers should make it a habit to critically analyze such studies whether it was done on adequate sample sizes that are a true representation of the entire population of interest. One should also take into consideration studies done on a single-case study as it can be misleading.[19] The size of the sample studied is a major determinant of the risk of reporting false-negative findings.[21] Therefore, the sample size is important for planning and interpreting scientific research.

Today, statistics is widely accepted as a powerful tool in the scientific research process. The inappropriate use of statistical analysis may lead to incorrect conclusions, unreliable research results, and a waste of valuable resources.[22] There are a number of statistical methods available in forensic odontology for age estimation. The most widely used are multiple regression analysis and polynomial functions. When choosing a statistical test, one has to keep in mind choosing the correct test suitable for that specific study.[23] A wrong choice of statistical test will lead to unreliable results, polluting the scientific world. Furthermore, the huge variety of statistical techniques now available means that the choice of the most suitable and powerful one is not always trivial since many details have to be considered.[22]

Another issue is the insufficient knowledge about statistics among researchers. This makes it difficult for the researchers to analyze their own statistical results or those presented in the literature. Although there are statistical package software available for researchers to analyze their own results, problems still arise from lack of understanding the mathematical concepts or statistical ideas associated with it. Furthermore, the huge variety of statistical techniques now available means that the choice of the most suitable and powerful one is not

always an easy job to do. Researchers have to be encouraged to learn more about statistics as various studies point to a lack of statistical knowledge among medical residents.[24,25] Applying proper statistical methods for the study is important and the efficacy of statistical methods is key to obtaining proper results.

Conclusion and Future Recommendations

The main problem faced in forensic odontology is the lack of uniformity in the methods used. There is no standardized technique for use as it is in many other fields, and this brings about a lot of controversies among researcher.

The importance of record keeping in dentistry cannot be overemphasized, but it can be difficult sometimes to keep old files due to space availability. Therefore, there is a need to create a national database, where all dental data can be kept, and this will make the work of forensic odontologists easier.

Authors are advised to critically analyze published articles before reaching to conclusions. Some results in the literatures can be misleading because of different factors such as studies done on a single-case study, application of different statistical methods, small sample size, inter- and intra-observer variability, different populations of study, and many more.

As mentioned in this article, the acceptable standard error for adults is ± 10 years. This is quite a wide age range; therefore, there is a need for more research to be done to reduce this error as minimal as possible. In addition, even the error limit in the age range of 10–20 years should also be minimized to months. The aim is to make forensic odontology methods more accurate and reliable.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References

1. Monali C, Pritam P, Tapan M, Kajal D. Gender determination: A view of forensic odontologist. Indian J Forensic Med Pathol 2011;4:147-51.
2. Catherine A, Romina C, Evan S. Forensic Odontology: An Essential Guide. 1st ed. United Kingdom: John Wiley & Sons, Ltd.; 2014. p. 137-66.
3. Redddy NK. The Essentials of Forensic Medicine & Toxicology. 34th ed. New Delhi: The Health Science Publisher; 2017.
4. Bérgamo AL, de Queiroz CL, Sakamoto HE, Alves da Silva RH. Dental age estimation methods in forensic dentistry: Literature review. Peertechz J Forensic Sci Technol 2016;2:4-9.
5. Ciapparelli L. The chronology of dental development and age assessment. In: Clark DH, editor. Practical Forensic Odontology. Oxford: Wright Butterworth-Heinemann Ltd.; 1992. p. 22-42.
6. Nolla CM. The development of the permanent teeth. J Dent Child 1976;27:254-66.
7. AlQahtani SJ, Hector MP, Liversidge HM. Brief communication: The London atlas of human tooth development and eruption. Am J Phys Anthropol 2010;142:481-90.
8. Demirjian A, Goldstein H, Tanner JM. A new system of dental

age assessment. Hum Biol 1973;45:211-27.

9. Hägg U, Matsson L. Dental maturity as an indicator of chronological age: The accuracy and precision of three methods. Eur J Orthod 1985;7:25-34.

10. Olze A, Bilang D, Schmidt S, Wernecke KD, Geserick G, Schmeling A, *et al.* Validation of common classification systems for assessing the mineralization of third molars. Int J Legal Med 2005;119:22-6.

11. Acharya AB. Age estimation in Indians using Demirjian's 8-teeth method. J Forensic Sci 2011;56:124-7.

12. Gupta R, Rajvanshi H, Effendi H, Afridi S, Vuyyuru KK, Vijay B, *et al*. Dental age estimation by Demirjian's and Nolla's method in adolescents of Western Uttar Pradesh. J Head Neck Phys Surg 2014;3:50-6.

13. Solheim T, Sundnes PK. Dental age estimation of Norwegian adults – A comparison of different methods. Forensic Sci Int 1980;16:7-17.

14. Acharya AB, Kumar KK. Age estimation in Indians from extracted unsectioned teeth. Forensic Sci Int 2011;212:275.e1-5.

15. Kirberger RM. Radiograph quality evaluation for exposure variables – A review. Vet Radiol Ultrasound 1999;40:220-6.

16. Gustafson G. Age determination on teeth. J Am Dent Assoc 1950;41:45-54.

17. Mincer HH, Harris EF, Berryman HE. The A.B.F.O. Study of third molar development and its use as an estimator of chronological age. J Forensic Sci 1993;38:379-90.

18. Michael H, Huiman XB, Jingli S, Gruden J. Observer variability: A new approach in evaluating interobserver agreement. J Data Sci 2005;3:69-83.

19. Gunst K, Mesotten K, Carbonez A, Willems G. Third molar root development in relation to chronological age: A large sample sized retrospective study. Forensic Sci Int 2003;136:52-7.

20. Raj M, Shankar KA, Jude J, Krishna PS. Age estimation with third molars using orthopantomograph (OPG): An Indian scenario. Indian J Forensic Odontol 2018;27:3-4.

21. Biau DJ, Kernéis S, Porcher R. Statistics in brief: The importance of sample size in the planning and interpretation of medical research. Clin Orthop Relat Res 2008;466:2282-8.

22. Strasak AM, Zaman Q, Pfeiffer KP, Göbel G, Ulmer H. Statistical errors in medical research – A review of common pitfalls. Swiss Med Wkly 2007;137:44-9.

23. Kang H. Appropriate design of research and statistical analyses: Observational versus experimental studies. Korean J Anesthesiol 2013;65:105-7.

24. Reznick RK, Dawson-Saunders E, Folse JR. A rationale for the teaching of statistics to surgical residents. Surgery 1987;101:611-7.

25. Laopaiboon M, Lumbiganon P, Walter SD. Doctors' statistical literacy: A survey at Srinagarind hospital, Khon Kaen University. J Med Assoc Thai 1997;80:130-7.