Age Estimation Methods in Forensic Dentistry: Literature Review of Indian Studies

[1]Dr. Deepali P Mohite, [2]Dr. Prakash M Mohite, [3]Dr. Devendra Palve, [4]Snehal Udapure, [5]Dr. Shilpa Warhekar

[1]M.D.S., Associate Professor, Department of Oral and Maxillofacial Pathology, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur.
[2]M.D., PhD, Professor, Department of Forensic Medicine and Toxicology, Jawaharlal Nehru Medical College, Sawangi (Meghe), Wardha
[3]M.D.S., Professor and Head, Department of Oral and Maxillofacial Pathology, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur
[4]Post Graduate Student, Department of Oral and Maxillofacial Pathology, Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur.
[5]M.D.S., Associate Professor, Government Dental College and Hospital Nagpur.
Corresponding Author: Dr. Prakash Mohite
(drprakashmohite@rediffmail.com)

Abstract

Introduction: Estimation of age is an essential aspect in human identification, not just for beneficiaries of various policies for children and adolescents but also in aiding decisions in lawsuits. Development and maturation of teeth provide better estimates than other structures and the dental changes can be grouped in different age estimation methods.

Objective: The purpose of this literature review was to present the main methods in age estimation that are being used to assess age in Indian subjects.

Material and Methods: The database searched was PubMed and the terms used were "*Age Estimation*", "*Oral Structures*", "*Teeth And Bone*". Original articles about age estimation methods written in English between 2016 and January 2021 were selected.

Results: Demirjian's method was found to be the most commonly compared method in Indian Population. The method led to consistent overestimation of age in Indian population. Various other methods have also been used with relatively greater accuracy of estimation of age. Besides developmental stages, skeletal radiographs and histological sections of teeth have also served as assessors of age.

Conclusion: The most dental age estimation methods were based on developmental stages of the teeth through radiographs and they were applied in children and sub-adults in different regions.

Introduction

Age estimation forms an integral part of Forensic study and is an important part of any forensic investigation. It becomes more significant when the chronological age of the individual or deceased person is not available. The estimation of age assumes greater importance when the decision is for individuals facing medicolegal issues like illegal immigrants, employment (child /adult), assigning legal punishments etc. where children are to be dealt with a more humanitarian approach.

According to the United Nations Children's Fund (UNICEF), a substantial share of birth goes unregistered, particularly in developing countries. This problem is further accentuated in rural areas due to lack of awareness and information on birth registration processes. Without birth certificate, children may be denied of their basic rights like health care and education. Identification documentation is also important to provide appropriate age related services to immigrants, refugees, asylum seekers and orphans.[6] Due to inconsistencies in registering births; it may not be always possible to produce a valid birth date document. In India, an individual younger than 18 years of age is considered as a minor. In 2017 alone, there has been a 5.93% rise in juvenile crimes in western Indian state of Maharashtra. According to the Juvenile Justice Act 2015, any juvenile between 16-18 years of age can be charged as an adult as is decided by the juvenile justice board. Therefore, an accurate birth date is of critical importance to individuals and authorities

involved with legal proceedings.[3]

Teeth, skeleton or both structures are used for age estimation as maturity indicators. However the maturation of teeth serves as a better index of maturation than other indices because of low variability in dental development as it takes place in a relatively inert environment (tooth development is not directly affected by local environmental and systemic diseases). As there are no established methodologies to estimate age in the Indian population and from a statistical-methodological point of view, a combination of different measurement methods and a more conscious use of the relevant statistical methodology for more reliable estimation and better quantification of age.[23,10]

Methodology

A literature search was performed using specific keywords (Age estimation; Oral Structures; Teeth and Bone) in different combinations in Pubmed search engine. The keywords were intentionally picked to be as inclusive as possible in order to ensure that no relevant study would be missed out. An example of a search strategy used in Pubmed database is as follows: *Age Estimation [All Fields] AND Oral Structures [All Fields] AND "Teeth And Bone"[All Fields].* Websites of known forensic odontology journals were also visited and the archives searched using the same keywords. Only studies conducted on Indian population and published in English language up to last 5 years and upto January 2021 were included. Studies were included if they met the following criteria: • Original research studies (cross-sectional or non-cross-sectional in design) • Studies using Radiographs, Specialised radiographic techniques or histologic methods for estimation of age• Full text articles only (abstracts or conference proceedings without full report were not included) • Study participants (those that included subjects beyond this age were also considered for inclusion only if they provided data according to different age groups) • the language of publication was English. Both reviewers (DM and SU) extracted essential data from the 32 selected studies, independently, in a Microsoft Excel sheet. The data that were extracted included first author name, year of publication of the results, place of study, population studied, age estimation methods used, sample sizes, techniques used for studying age, age of the study population (mean and standard deviation) and regression equation if obtained for the study population.
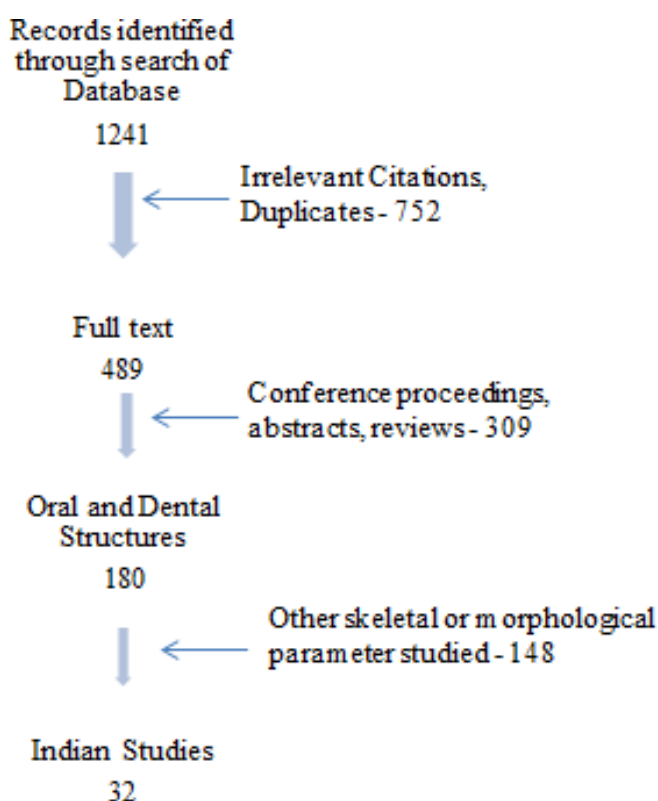
Records identified through search of Database
1241

Irrelevant Citations, Duplicates - 752

Full text
489

Conference proceedings, abstracts, reviews - 309

Oral and Dental Structures
180

Other skeletal or morphological parameter studied - 148

Indian Studies
32

Fig 1 Flowchart

Results

Our initial search resulted in the identification of 1241 (Age Estimation) potentially valid results. After the application of filters we were left with 489 full text articles dealing with various age estimation methodologies in the last years. Further application of filters using only Oral Structures resulted in 180 full text articles. These articles were accessed and both the reviewers (DM and SU) went through the methodology in each one of them to assess for their inclusion in our study. This screening resulted in 159 full text articles which involved oral and dental soft and hard tissue structures for the estimation of age. Of these only 32 studies were conducted on Indian population.

The highest number of studies were performed in the year 2019 (09), followed by year 2017 (08) and then in 2020 and 2018 with 6 and 5 studies respectively. The Journal of Forensic Dental Sciences had the greatest number of publications relating to estimation of age (10) followed by Journal of Forensic Odonto-Stomatology 5 and then by other journals like Journal of International Society of Preventive & Community Dentistry, Forensic Science International, International Journal of Legal Medicine amongst few. Regions from South India,i.e., Karnataka, Tamil Nadu, Telangana and Andhra Pradesh have more number of published studies on forensic dentistry, Mumbai in Maharashtra follows the researches from South India. Few studies are also reported from Meerut, Bhubaneshwar and Ahmedabad.

Discussion

Forensic odontology has generated a lot of interest in the past few decades, which is evident in the numerous literature published. Research involving dental tissues is further gaining importance because of the fact that teeth start developing at early embryologic period. In children the growth and development of teeth serve as an important tool in estimation of age. The developing third molars in adolescent and young adults have been used as adjuncts when age is expected to be around the age of development and eruption of these teeth. Beyond these ages the regressive changes in the teeth make way for the estimation of age. More interesting is the fact that tooth are resistant to taphonomic processes.[10]

Gustafson {1950} is accorded with being the first to introduce scientific technique for age estimation in adults. It was based on longitudinal ground sections of teeth. Scores from 0-3 were assigned for the presence and amount of age-related changes such as attrition, periodontal ligament retractions, secondary dentin formations, root translucency, and root resorption. The scores were added and a regression analysis with age was performed.[20] The standard error of estimate with Gustafson's study was ±3.6 years. According to Gustafson the advantage of taking many factors into consideration for total score is that an occasional change within a single factor does not essentially affect the result.[19]

Many techniques and different oral tissues have been used since then to assess age in individuals. According to literature, the most commonly used technique was radiographic method like Demirjian's and Cameriere's using developing teeth as guides, others methods were those described by Olze, Kvaal, Willems, Chaillet or the Häävikko's method.[12,11,3, 4,1,13,14,22,9,15,18] Few investigators have developed their own population specific datasets, and one such dataset was created by the Dental Age Research London Information Group (DARLInG). This group has developed reference datasets for different identifiable human groups including the United Kingdom Caucasians, Hong Kong Chinese, Afro-Caribbean and Maltese populations.[3] The efficacy in assessing age in Indian children and adolescents is yet to be validated.

The skeletal landmarks that have been employed to estimate age are the growth and development of bones of the hand and wrist (Bjork, Grave, and Brown's method) and the mandible (gonial angle measurement). There have been fewer studies using histological assessment of mandible probably due to the fact that it is an invasive method and can be used only in post mortem scenario or in teeth that have been removed from the oral cavity. In the data assimilated, the volume of maxillary sinus has also been used as a landmark in assessing age and gender of individuals above 20 years of chronological age.

As the growth and development of teeth is a more regular phenomenon and is not affected by external environment, methods using the developmental stages of teeth have found greater use in assessing age in children and adolescents. The maturity scoring system obtained from these stages can be converted into dental age and so has been modified by other authors to be suitable to different populations. The Demirjian method of estimation of age had been developed from French-Canadian children. The application of this

method has found its way into populations of different countries and also different regions in India. The Demerijian's method was applied to estimate age in child labourers and minor girls in Telangana and it was found that the method resulted in vast margin of error of ±1-3 years.[4] Studies in various regions in India have led to the conclusion that the Demirjian's method resulted in overestimation of age in Indian subjects. Though study by Shaji T. Varghese et al 2018 has resulted in the finding that the Demirjian's method offered better estimate of age in individuals above 21 years of age as compared to age estimated using the Hand-wrist radiograph.[22]

Other studies compared Demirjian's method with Cameriere's or Willems method for Indian Population. The modified methods by Cameriere, Willems and Chaillet were found to be more accurate for both sexes in the Indian population than Demirjian's method (1973 and 1976). It was found that the mean estimated dental age exceeded the mean chronological age in both boys and girls. The Häävikko's 7-stage method was found to be more reliable than the 4-stage method in subjects from Mumbai.[7] The Cameriere's method was found to be more accurate in subjects from Davangere.[2] In a study on individuals from Tiruchengode, it was found that the Willems' method resulted in underestimation of the age, although this was comparatively minimal in the order of 30 to 40 days[14] When comparing the Chaillet method with the Demirjian's method in a study population from Karnataka it was observed that the difference between the two is negligible implying that either of the methods can be employed in clinical practice (0.80 years and 0.89 years respectively).[13]

The other methods and structures that have been used for age estimation in the Indian population are the pulp tooth ratio, incremental lines of cementum, dentin translucency, tooth coronal index and the bone alkaline phosphate levels from saliva and the mandibular dimensions. The pulp tooth ratio was found to have significant correlation in Indian individuals as suggested in the studies by Arpita Rai et al 2016 & Supreet Jain et al.[8] This parameter can be used with convenience in the adult individuals, dimensions were measured at different levels (Pulp Tooth Ratio coronal, axial and axial Cementoenamel Junction) and it was found that the axial dimensions at the Cementoenamel Junction in the permanent mandibular first molar offered the best estimate of age with a mean PTR of ±0.02/ ±0.03. The morphometric dimensions and volume of maxillary sinus has also been used for identifying gender and assessing age in the study by Sanda Usha Rani et al[17] who found it to be relevant by 21.75, 8.96, 11.47, and 47.86 percent (height, width, depth, and volume on the right and left side maxillary sinuses).

Similarly amongst histologic method, incremental lines of cementum has been analysed for assessment of age in individuals above 21 years of age also resulted in a mean difference of ±2 years.[21] Though the translucency of dentin offered a close estimate of age and did not demonstrate differences because of gender, it was found in a study by Shalini Gupta that with increase in the age by 1 year, the length of translucency in the root also increases by 0.018 mm.

Conclusion

The most commonly used dental age estimation methods were based on the developmental stages of teeth through radiographs and they have been applied in children and sub-adults in different regions in India. The age of unknown persons can be calculated through regression analysis by both calculating the total score and then finding the age using population specific regression equations with minimum error of estimation. The age calculation using total score was found to be more accurate than the age calculated using score of single physiological factor. However there is a reasonable margin of error in all methods of estimation of age that have been employed on the Indian population. So to arrive at a common consensus in obtaining a single formula which can be used for the entire Indian population studies using very large sample and tooth-specific equations for age assessment are needed. Therefore, for dental age estimation it should be taken into consideration different ancestrally with its genetic predispositions in a geographical region. Furthermore, firstly, it is important to note the reliability of the dental age method applied in relation to chronological age and compare different dental age methods with each other.

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