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APPLICATION OF NOLLA'S METHOD FOR AGE ESTIMATION: A CBCT STUDY ON MAXILLARY SECOND MOLARS AND CANINES IN THE RAJASTHAN POPULATION

Forensic Dentistry

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ABSTRACT

The study aimed to assess the correlation between dental age and chronological age using Nolla's radiographic method, specifically evaluating mineralization stages of maxillary canine and second molar for sub-adult tooth age estimation. This retrospective single-centre study, conducted at the Department of Oral Medicine and Radiology, RUHS College of Dental Sciences in Jaipur, Rajasthan, aimed to assess age using Cone Beam Computed Tomography (CBCT) scans. CBCT scans of thirty patients (15 males, 15 females), aged 8 to 14 years were randomly selected and evaluated, focusing on developmental stages of maxillary canine and second molar for dental age estimation. Inclusion criteria ensured participants' oral health and normal growth, while exclusion criteria ruled out systemic diseases, congenital anomalies, and dental pathologies. Statistical analysis employed SPSS Version 29, utilizing one-way ANOVA for intergroup comparisons. Results, presented as P values and F-static values, highlighted the study's precision in dental age estimation. Dental age was estimated using CBCT while categorizing subjects aged 8-14 into six subgroups (1-6). Group-wise analysis revealed non-significant differences between chronological and dental age. Molar and canine dental age showed overall underestimation, with subgroup variations. The reliability of dental age, evaluated particularly through Nolla's method, underscores its efficacy as a trustworthy indicator for assessing dental maturity. The demonstrated validity of Nolla's dental age estimation further solidifies its utility as a robust dental maturity indicator.

KEYWORDS

Dental age estimation, Chronological age, Nolla's method, CBCT, forensic dentistry

INTRODUCTION

Determining an individual's age is paramount when the birth date is elusive. The essence of diverse age estimation methods lies in juxtaposing physical maturity measurements with time. Growing individuals diverge in the timing of their maturation events and the sequence, unveiling a fascinating mosaic of development. The assessment of chronological age (CA), representing the actual time elapsed since a person's birth, is conducted through tooth analysis. It includes both morphological and radiological aspects of the development of tooth bud. This method has become indispensable in fields such as planning orthodontic and pedodontics treatments, as well as in forensic dentistry and bioarchaeology.[1] In numerous societies, chronological age is significantly important for school and sports enrolment, employment opportunities, and marriage eligibility.[2] Various methods are employed which include diverse measurements and radiological examinations to ascertain the age, with teeth and hand-wrist assessments being commonly utilized. However, utilizing tooth development for age estimation holds advantages over other skeletal indicators like Fisherman's [3], which can be significantly influenced by multiple factors, exhibit greater variability, and are more prone to errors compared to methods based on tooth maturation.[4] Therefore, dental age stands as an excellent indicator in forensic odontology and for medico-legal purposes.[5]

Human dentition undergoes a consistent and predictable developmental sequence, starting around four months after conception and progressing until the mid-third decade of life, concluding with the full development of all permanent teeth.[6] Teeth are known for their strength and along with the skeletal system they undergo a series of developmental changes that serve as reliable indicators for determining age.[7,8] To explore age-related alterations in teeth, several techniques, morpho-histological, molecular, and radiographic have been widely used. Yet, for adult teeth, histological and molecular analyses yield more accurate and trustworthy results compared to radiographic methods. However, when assessing the age of developing teeth in adolescents, radiological techniques are commonly employed.[9,10]

The maturation of teeth is a complex process involving several stages, starting from the initial mineralization of a tooth, followed by crown formation, root growth, the tooth's eruption into the mouth, and completing with the maturation of the root apex.[11] Nolla's radiographic method, relying on dental developmental stages, is a commonly employed technique for age estimation in sub-adult teeth across various fields of forensic sciences, used extensively for teaching and research purposes. This method specifically evaluates the stages of mineralization in permanent dentition. Studies have shown that Nolla's method exhibits greater accuracy in estimating dental age when compared to the Demirjian, Willems, and Haavikko methods.[12-14]

MATERIALS AND METHODS

The study was a retrospective, single-centre investigation conducted at the Department of Oral Medicine and Radiology, RUHS College of Dental Sciences, Jaipur, Rajasthan. The research focused on evaluating pre-existing Cone Beam Computed Tomography (CBCT) scans from 30 patients, comprising 15 males and 15 females, stored in the Department of Dental Radiology. We randomly selected and evaluated CBCT scans of 30 patients, aged between 8 and 14 years.

All CBCT images studied were taken using Carestream CS9300 imaging system (CS 3D Imaging v3.5.7; Carestream Health, Inc.) using an FOV of 10 x 10 cm. Image volume was reconstructed with isotropic isometric 180 x 180 × 180 um voxels. The standard parameters of the machine used were tube voltage ranging from 80 to 90 KVp, and tube current 4 mA with an exposure time of 8 s. Exposure to the patient ranged from 503 to 885 mGy-cm. Two dentomaxillofacial radiologists evaluated the reconstructed panoramic and paraxial view, of maxillary second molars and canines at a slice thickness of 180µm in a darkened quiet room with dual monitors (Dell 24-inch nonglossy monitor 1920 x 1200 resolution) with a Dell Precision Workstation using CS 3D software (v3.5.7).

Observers were allowed to zoom and adjust brightness and contrast of the images using the image processing tool in the software to ensure optimal visualization. Any divergences or conflicting opinions between the examiners were resolved by discussion and reached to a consent.

Inclusion Criteria

The criteria for participant selection encompassed several key aspects:

1. Presence of maxillary molars and canines, irrespective of whether they were erupted or unerupted.
2. Subjects having good physical health and adequately nourished.
3. Subjects exhibiting normal growth and development.
4. Absence of any prior surgical or medical conditions that might influence the development and presence of the specified teeth.

Exclusion Criteria

The criteria for excluding participants were as follows:

1. Presence of unclear CBCT images or image distortions that hindered the visualization of maxillary permanent teeth
2. Presence of systemic diseases in patients.
3. Congenital anomalies involving oral and maxillofacial regions, including conditions such as cleft lip and cleft palate.
4. Dental anomalies, such as aplasia, hypodontia, hyperdontia, supernumerary teeth, tooth impaction, missing teeth, tooth transposition, and malocclusion.
5. History of permanent tooth extractions, facial trauma or injury; and the presence of significant dental pathologies.

Informed Consent- Written consent was signed by participants.

Ethical Approval - Approval for research from the institutional ethics committee has been granted. Ethical clearance was secured from the institution's ethical committee. Top of Form (letter no: RUHS-CDS/EC/2022/Proposal/005)

Nolla's Method

In 1960, CM Nolla introduced a new way to understand how teeth develop.[15] He classified the stages of dental development into ten phases that every tooth goes through (Figure 1). These stages were assigned a numerical score. These scores were then added up to get a total 'sum of stages' score. This score was then divided by the number of teeth considered to determine the dental age.

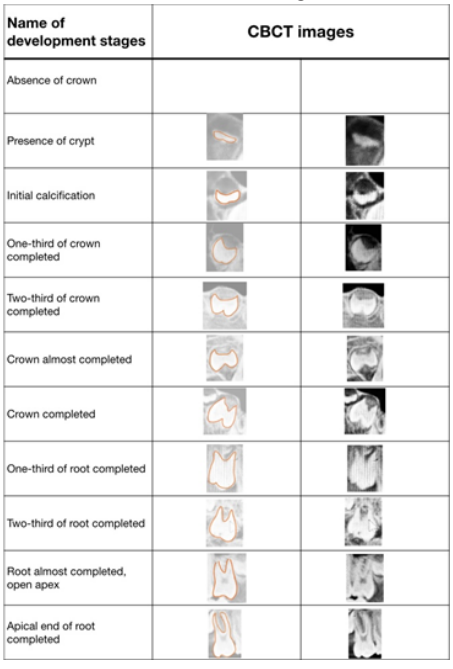

Figure 1- Nolla's developmental stages of Maxillary 1st molar

Statistics

All data was entered into an Excel sheet and was analysed using Statistical Package for Software Science (SPSS Version 29).

One-way ANOVA was used as a statistical test to compare the data obtained in 3 groups and 6 subgroups. P value and F- static value were obtained for each subgroup.

RESULTS

A cohort of 30 subjects, in the age range of eight to fourteen years and inclusive of both males and females were considered for this study. Subsequently, the subjects were categorized into six subgroups based on their age. For each subgroup mean, standard deviation (SD) & standard error in measurement (SEM) were calculated for chronological age, molar dental age, and canine dental age. Insignificant differences were observed between chronological age and calcification stages for all subgroups. P value was found to be non-significant (>0.05) in each subgroup (Table 1). In group-wise evaluation, molar dental age for subgroup 1 had neither underestimation nor overestimation. While in subgroup 2, an overestimation of age is seen. After this subgroup, a trend can be seen of underestimation of molar dental age from subgroups 3 to 6. The overall mean was found to be underestimated (0.24 ± 1.56) but statistically, it was insignificant. A slightly different trend was seen while analysing canine dental age where subgroups 2 & 3 showed a slight overestimation of age while other subgroups showed an underestimation of age. The overall mean of canine dental age was also underestimated (0.49 ± 1.65). Furthermore, comparing the molar and canine dental age, molar dental age showed less underestimation, but the difference was not significant. However significant underestimation of age is seen in subgroup 5 for molar dental age and subgroup 4 of canine dental age (Figure 2).

Table 1- Mean, SD, SEM for chronological age and developmental stage of Molar dental age and Canine dental age; also shows the difference between Molar and Canine dental age and Chronological age

Sub groups	Chronological age			Molar dental age				Canine dental age				F-static value	P value
	Mean	SD	SEM	Mean	SD	SEM	DA-CA	Mean	SD	SEM	DA-CA		
8-9	8	0	0	8	1	0.57	0±1	7.33	0.57	0.33	-0.7	1.00006	0.42
9-10	9	0	0	10	0	0	+1± 0	9	1.41	1	0	1.00002	0.46
10-11	10	0	0	9.66	2.08	1.20	-0.34	10.33	1.52	0.88	+0.33	0.14997	0.86
11-12	11	0	0	10.33	2.87	1.17	-0.67	9.16	1.83	0.74	-1.84	1.33233	0.29
12-13	12	0	0	10.66	1.36	0.55	-1.34	11.33	2.25	0.91	-0.67	1.153	0.341
13-14	13	0	0	12.9	2.07	0.65	-0.1	12.9	2.33	0.73	-0.1	0.01025	0.98

SD- Standard Deviation, SEM- Standard Error in Measurement, DA- Dental Age, CA- Chronological Age

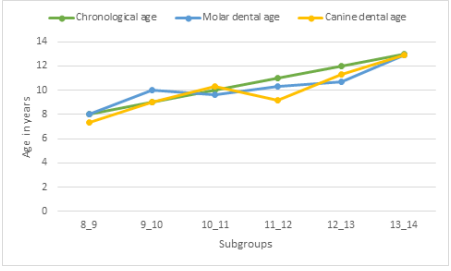

Figure 2- Correlation of chronological age with dental age

DISCUSSIONS

In our research, we conducted a comprehensive investigation into dental age assessment among a group of 30 subjects aged eight to fourteen years, categorizing them into six subgroups. The primary focus of our study was to compare chronological age with calcification stages, exploring potential differences across various subgroups. Our initial analysis revealed non-significant p-values (>0.05) in each subgroup, suggesting no significant distinctions between chronological age and dental age. This set the foundation for a detailed examination of molar and canine dental age within each subgroup and the subsequent group-wise and overall evaluations.

Various techniques have been developed to estimate dental age, considering factors such as anatomy, histology, tooth eruption timelines, and radiographic assessments. However, a unanimous agreement on the most effective method for predicting chronological

age remains difficult to capture.

Cone Beam Computed Tomography (CBCT) is a specialized imaging technique that provides detailed three-dimensional images of anatomical structures. This is particularly advantageous in dental and medical applications where precise visualization is crucial. Although the radiographic exposure of patients is very minimal in CBCT, our study was a retrospective study where we used the pre-recorded scans of patients to study their anatomical stages of development.

Numerous studies in the literature have previously employed Nolla's age estimation method to evaluate dental age within their distinct populations or regions. For instance, Maber et al in England, Kumarsen et al in Malasiya, Miloglu et al. in East Turkey, and Lopes LJ et al in Brazilian children.[16-19] Mixed results have been observed in various studies conducted worldwide, prompting us to undertake this study within this specific population to identify potential discrepancies.

Indian studies present divergent views on age estimation methods. Some endorse skeletal age as superior and Nolla's method as reliable only in younger ages such as Sinha et al.[20], while others, aligning with our findings, affirm Nolla's method as a reliable indicator as stated by Singh et al.[21], Rai B[22], Mohammed et al.[1] This variability underscores the complex nature of age estimation research in the Indian context.

When Nolla's method was applied to Rajasthan's population, the mean difference between actual age (chronological age) and estimated age (dental age) was insignificant. This has been supported by some previous studies such as Green and Lauterstein who stated that chronological age shows more correlation to the number of erupted teeth.[23,24] On comparison of chronological age with maxillary second molar and canine's dental age for all subgroups, the difference was found to be non-significant ($p>0.05$), which shows the development of these teeth advances following increase in chronological age. Anderson and Coworkers supported this study, finding that dental development was more strongly related to morphological development than skeletal development.[25]

The development of maxillary canine was slightly slower than expected and hence the overall mean of canine dental age was also underestimated (0.49 ± 1.65). This was in alignment with the study by Schour and Masseler, "The Development of human dentition".[26] However, a slight overestimation of age was seen in subgroups 2 and 3 which can be justified by the confirmation of attainment of Peak height velocity (PHV) of juvenile growth spurt.[27]

For maxillary second molar, overestimation was seen in subgroup 2 which can be elaborated due to the growth at the tuberosity region during this period leading to a sudden increase in the rate of root growth as stated by Alexander Vardimon in his cross-sectional study.[28] This can also be related to accelerated biological maturation caused by psychological stress as quoted by McDermott.[29] Beyond subgroup 3 to subgroup 6, an underestimation of age was seen, which was also noticed in various studies conducted worldwide such as Kurita et al.; Miloglu et al.[30,18]

In our study, overall underestimation was seen in both molar and canine dental age but was not statistically significant. A maximum underestimation of 1.34 yrs. was seen in molar dental age in subgroup 5 (12yrs-13yrs), and of 1.84 yrs. was seen in canine dental age in subgroup 4 (11yrs -12yrs). Furthermore, the maximum overestimation of 1 yr. was seen in molar dental age in subgroup 2 (9yrs-10 yrs) while in canine dental age, a maximum overestimation of 3 months was seen in subgroup 3 (10yrs- 11yrs).

CONCLUSION

It can be inferred that dental age can be used reliably for assessing dental maturity, as insignificant differences were observed between chronological age and dental age amongst all the subgroups. This also eliminates the use of additional radiographs (hand-wrist radiographs) of patients in orthodontic practice. To further validate the results of our study, it should be carried out on a larger sample size and varied age groups taking into consideration factors like psychological status, environmental variations, ethnicity, effect of increasing background radiation in the present scenario.

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