Comparative Evaluation of Age Estimation Methods in North Indian Adults: Drusini's vs. Jeon's Approaches

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ABSTRACT

BACKGROUND

Accurate age estimation is crucial in forensic anthropology and odontology for identifying individuals in legal proceedings. Dental characteristics, such as secondary dentin deposition, offer valuable insights into age determination.

OBJECTIVE

This study aims to comprehensively evaluate and compare the effectiveness of two prominent dental age estimation methods, namely Drusini's and Jeon's approaches, specifically in the context of North Indian adults.

METHODS

A total of 300 panoramic radiographs of mandibular first molars from North Indian individuals were analyzed using both Drusini's and Jeon's methods. Estimated ages were meticulously correlated with chronological age, and potential gender differences were assessed. The study employed statistical analyses to determine the significance of the correlations and compare age estimates across gender and age groups.

RESULTS

Both Drusini's and Jeon's methods exhibited significant positive correlations with chronological age, with Jeon's method demonstrating an almost perfect alignment ($r = 0.998$, $p < 0.001$) and Drusini's method showing a robust correlation ($r = 0.987$, $p < 0.001$). Furthermore, no significant differences in age estimation were observed between genders.

CONCLUSION

This comprehensive assessment reveals that both Drusini's and Jeon's methods offer accurate age estimation in North Indian adults, with strong correlations with chronological age. These findings carry significant importance for reliable dental age estimation techniques in forensic investigations and legal proceedings.

KEYWORDS

Age estimation, Forensic odontology, Secondary dentin deposition, Drusini's method, Jeon's method, Panoramic radiographs.

INTRODUCTION

In the fields of forensic anthropology and odontology, estimating the age of a person is an important part of individual identification. Forensic professionals are often called upon to estimate the age of unidentified cadavers and human remains, to construct a post-mortem profile. Age estimation is a crucial step in various legal and civil proceedings (1). Nowadays, there is an increasing need to estimate the age of living people too, such as refugees and asylum seekers who may not have any documentation to prove their identity. This demand is also present in cases of human trafficking, where it is necessary to determine whether a person has reached the age of majority, the criminal responsibility age, or the age of marriage (2). Dental characteristics are unique to individuals and can be particularly helpful in identifying a person. Teeth are a reliable tool for estimating age since they are very resilient and maintain their structure longer than other organs. They also have modest metabolic properties, therefore data from tooth development yields more reliable findings than data from other structures (3). Age estimation in children is pretty straightforward based on tooth eruption and growth phases. On the other hand, estimating age in adults can become complex and challenging (4). Changes associated with aging may include attrition, periodontal health, apical root resorption, root smoothness, secondary dentin deposition, cementum deposition, and dentin transparency (5). However, these methods require teeth extraction, which is not ethical or practical in living individuals. In the case of deceased persons, retaining their teeth is important for cultural and legal reasons. With the development of radiography in forensic science, age estimation can be done using radiographic images, without causing any harm to the tooth or dental structure. This technique is a more conservative and yet reproducible approach for age estimation (6). Throughout our lifetime, the odontoblasts continue to deposit secondary dentin, which causes changes in the coronal pulp cavity. The gradual changes in the coronal pulp cavity throughout life can provide useful information for age estimation. However, the amount of secondary dentin produced varies depending on the type of tooth. For instance, molars typically have a higher production of dentin on the floor of the pulp chamber, while the occlusal and lateral walls have lower levels of dentin formation (7). Previous researchers, such as Dalitz, Johanson and Kvaal *et al*, have proposed various methods associated with secondary dentin deposition (8-10). Cameriere *et al* examined the pulp/tooth area ratio in mandibular premolars and canines using orthopantomograms (OPGs) and peri-apical X-rays, deriving formulae based on various morphological and radiographic criteria (11). Drusini *et al* developed a technique, the tooth coronal index (TCI), to link age-related changes in the coronal pulp cavity (12). Jeon developed a method that takes into account the deposition of secondary dentin and the reduction of pulpal volume with age (13). The present study endeavours to evaluate and compare age estimation methods in North Indian adults by employing Drusini's and Jeon's approaches. The primary objective is to establish a correlation between the results obtained by both methods and the chronological age of the participants. By doing so, this study aims to contribute to the existing knowledge on the accuracy and reliability of these two approaches in estimating age in North Indian adults. The findings of this study may have significant implications in the fields of forensic medicine, anthropology, and other related disciplines.

METHODOLOGY

A total of 300 (130 females and 170 Males) panoramic radiographs of the North Indian population showing good quality images of mandibular first molar obtained from the archives of the department of the institution between March 2023 to December 2023. The selected radiographs were divided into three study groups depending on the age range, i.e., 0-20, 21-40, 41-60 (Table 1). The permission to conduct this study was obtained from the Institutional Ethics Committee. Only high-quality radiographs devoid of pathologies such as fractures, trauma, or ongoing orthodontic treatment were considered for analysis. Teeth displaying gross destruction, caries, periapical lesions, developmental anomalies, malalignment, rotation, overlapping, or those subjected to endodontic filling or prosthetic treatment were excluded from the study. Specifically, the research focused exclusively on the vital permanent mandibular first molar. This tooth was selected due to its early eruption and longevity, providing a reliable long-term record of age-related dental changes. Its excellent radiographic visibility of the pulp chamber allowed for precise assessment, rendering it ideal for radiographic techniques. The panoramic images captured were saved in DICOM format and subsequently exported to Micro DICOM software for linear measurement of the required parameters. The same observer conducted each measurement to ensure consistency, and the radiovisuographs were re-evaluated under blinded conditions after two weeks to confirm intra-observer reliability, thereby facilitating inter-observer agreement evaluation. Jeon's method necessitated the calculation of two ratios, namely: F/L and D/L to estimate age. F- distance between floor of pulp chamber to highest point on the root furcation; L – height between start point of linqual groove to highest point on the root furcation; D -Depth of pulp chamber / height between floor of pulp chamber to roof of pulp chamber.

Estimated age = $43.311+47.692\times(F/L) -197.419\times(D/L)$

In the Drusini method, Tooth coronal index (TCI) = CPCH × 100/CH; CPCH- Coronal pulp cavity height/distance from the cervical line to the coronal tip of the pulp chamber; CH- coronal height/distance from the cervical line to the tip of the highest cusp of the tooth The TCI (Tooth Crown Index) was accurately computed for the mandibular first molar and calculated age;

Estimated age = 76.073 - 1.4576X (TCI)

The above-mentioned parameters in both the methods have been described in Figure 1. Data collected was entered in MS Office Excel sheet and was subject to statistical analysis using a statistical software package International Business Machines Corporation, Statistical Package for the Social Sciences (IBM SPSS version 26.0). Jeon’s and Drusini’s methods calculated and estimated correlations with actual age. Comparison of mean differences of actual age versus age determined by Jeon’s method and Drusini’s method between the three age groups was done using a one-way analysis of variance (ANOVA) followed by Post hoc test (Bonferroni test) for intragroup comparisons. In order to compare the differences between actual age and estimated age determined by Jeon's method and Drusini's method across genders, a t-test was conducted. $P < 0.05$ was considered to be statistically significant.

RESULTS

- The mean chronological age was found to be 24.3967± 9.46385. The mean age estimated using Jeon's method is 24.529688± 9.5394204, and the mean age estimated by Drusini's method is 25.097± 9.69308 (Table 1).
- It was also found that there was no significant difference between various age categories calculated using Jeon's method and Drusini's method ($r = 0.985$) (Table 2).
- Pearson correlation analysis was conducted to examine the relationships between all variables included in the age estimation formulas used in both Drusini's and Jeon's methods. This analysis allowed for the assessment of how each variable correlates with chronological age (Table 4) (Figure 2).
- Pearson's correlation coefficients were used to examine the relationship between the actual age and the age estimated by Jeon's and Drusini's methods in the total sample. The results showed a strong positive correlation between chronological age and the age estimated by Jeon's method ($r = 0.998$, $p < 0.001$). Similarly, there was also a strong positive correlation between chronological age and the age estimated by Drusini's method ($r = 0.987$, $p < 0.001$) (Table 3).
- Comparison of two estimated ages based on gender independent t-test is used. Here the differences are not significant ($p = 0.45$ and 0.399). It means that the means of the ages estimated by two methods within gender (male and female) are almost equal or not significantly different (Table 5).

DISCUSSION

Determining the age of an individual in adulthood can be a complex task due to the completion of dental development, which limits the availability of reliable indicators for assessment. However, two commonly employed criteria for ascertaining adult age involve assessing the volume of the pulp cavity and evaluating the development of third molars. These methods offer valuable insights into the aging process and are particularly useful in forensic contexts where accurate age estimation is essential (14). One method involves examining the length of the coronal pulp cavity, which is significantly correlated with an individual's chronological age. Radiographs can be utilized to evaluate the reduction in the size of the pulp cavity resulting from the deposition of secondary dentine with aging (15). The concept of secondary dentin deposition as a marker of aging was first established by Bodeckar in 1925 and later incorporated into age estimation methods proposed by Gustafson (16,17). As a person ages, the dimensions of the pulp chamber of the tooth decrease due to the deposition of secondary dentin. It can also be influenced by environmental factors such as dental caries and attrition. This reduction in pulp chamber size can be quantified through radiographic measurements and correlated with adult forensic age estimation (18,19). One significant study by Kvaal *et al* in 1995 presented a radiographic method for age estimation based on secondary dentin deposition. This method involved measurements of the lengths and widths of the pulp cavity and tooth, with ratios between these measurements correlated with age. This pioneering study demonstrated the reliability of radiologic evaluation of secondary dentine deposition for age estimation. This technique, though reliable, is complex and time-consuming due to multiple calculations required (10). Subsequent research by Cameriere *et al* focused on correlating the pulp-to-tooth area ratio (PA/TA) of canine teeth with age. One drawback is its reliance on specific tooth types, such as premolars and canines, which may not always be available or suitable for analysis, particularly in cases of missing or damaged teeth (20). This is overcome by the approach of Drusini *et al* introducing another parameter, the Total Coronal Index (TCI), which also relies on the principle of secondary dentin deposition for age estimation (14). Additionally, Jeon et al. developed a formula based on three distinct ratios such as the ratio F/L, D/L, R/L (21).

In the context of the North Indian population, represented by the Uttar Pradesh region, we conducted study to evaluate the feasibility of Drusini and Jeon methods. The results of our study revealed a significant negative correlation between pulpal depth ratio and age (r= -0.958). Conversely, a positive correlation was observed with floor-to-furcation distance (r = 0.728), which suggests that thickness comparatively increases with age due to the deposition of secondary dentin. Notably, the Drusinis method also showed statistically significant negative correlation emerged between age and CPCH (r = -0.959), as well as TCI and age (r = -0.987). In addition, a weak negative correlation was found between age and CH (r = -0.5). Both studies have established that as individuals advance in age, the depth of the pulp decreases and the thickness of the dentin increases. Nevertheless, the reduction in pulpal thickness has a more significant correlation than dentin thickness due to the loss of crown structure as a result of attrition that is commonly experienced with age. This loss necessitates compensation through secondary dentin deposition.

The study results align with previous findings by Drusini (22), Zadinska (23), Shrestha (24), Khattab (25), and Karkhanis *et al* (26), suggesting no discernible sex difference in TCI. These studies collectively suggest that the sex of an individual does not significantly affect age estimation, rendering sex-specific formulas unnecessary for estimating age in specimens of unknown sex. This conclusion contradicts the findings of Agematsu (27) and Igbigbi *et al* (28) who proposed that gender exerts a significant influence on age estimation through TCI. According to them, the influence of estrogen on the formation of secondary dentin necessitates sex-specific formulas in the sampled population.

The research findings highlights the robustness of Jeon's and Drusini's methods in estimating age based on dental parameters. Notably, there exists a strong positive correlation between chronological age and age estimated by these methods. Jeon's method, in particular, demonstrates an exceptionally high correlation coefficient (r = 0.998, P < 0.001), suggesting nearly perfect alignment between estimated age and chronological age. This underscores the method's accuracy and reliability in age estimation. Similarly, Drusini's method also reveals a strong positive correlation (r = 0.987, P < 0.001), although slightly lower than Jeon's method. Nonetheless, this reaffirms the efficacy of Drusini's approach in age estimation.

Jeon's method employs a unique approach to mitigate errors induced by attrition. By measuring the length of tooth in the ratio in their formula from the lingual groove rather than cuspal height, it accounts for the effects of attrition on tooth structure, resulting in a more accurate estimation of age. Conversely, Drusini's method involves measuring proper cuspal height and incorporates secondary dentin deposition to compensate for attrition-related variations. Despite methodological differences, both approaches exhibit strong correlations with chronological age. It is worth noting that Jeon's method tends to yield a slightly higher correlation compared to Drusini's, suggesting potentially greater precision, especially in populations with significant attrition patterns like those observed in the Lucknow area because of extreme usage of Gutka.

These findings underscore the importance of considering local factors such as dietary habits and dental characteristics when selecting age estimation methods. The adjustments made in Jeon's and Drusini's methods to address attrition-related errors highlight the significance of methodological nuances in accurate age determination. Overall, both approaches offer valuable insights into age estimation, with Jeon's method potentially providing a more accurate assessment in populations with pronounced attrition patterns.

LIMITATIONS

1. It has been noted that there is a disparity in the number of female and male participants, signifying that the sample size is not representative of both genders.
2. The number of individuals in each age category is not the same. Specifically, there is a discrepancy in the count of individuals across different age groups.

CONCLUSIONS

In conclusion, our study examines age estimation in the North Indian adult population, focusing on Drusini's and Jeon's methodologies in forensic anthropology and odontology. Both approaches demonstrate strong correlations with chronological age, emphasizing their efficacy and reliability. Jeon's method, addressing attrition-induced errors by measuring tooth parameters from the lingual groove, shows remarkable precision with a high correlation coefficient. Drusini's method, incorporating secondary dentin deposition, also displays a strong correlation, albeit slightly lower. The findings stress the importance of considering local factors like dietary habits and dental characteristics in method selection, particularly in areas like Lucknow with notable attrition patterns due to gutka usage. Overall, these methodologies contribute valuable insights for precise age determination in various forensic contexts, highlighting the need for meticulous methodology and contextual considerations.

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DECLARATIONS :

i. Funding – Not Applicable

ii. Conflicts of interest/Competing interests- The authors declare that they have no known conflict of interest.

iii. Ethics approval - Ethics approval and consent to participate: This study protocol was submitted to the Institutional Ethical Committee of King George's Medical University Institutional Ethics committee for evaluation and clearance. The ethical clearance number was obtained vide Letter No.1200/Ethics/2022, (REGISTRATION NUMBER: ECR/262/Inst/UP/2013/RR-19). This article does not contain any studies with animals performed by any of the authors. The informed consent was waived off due to the retrospective nature of the study.

iv. Consent to participate - Not Applicable

v. Consent for publication - Not Applicable

vi. Availability of data and material - Not Applicable

vii. Code availability - Not Applicable

viii. Authors' contributions – All the authors contributed significantly to this manuscript

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TABLE AND LEGENDS:

Table 1: Descriptive statistics of both chronological age with estimated age using the Jeons and Drusinis method

	Mean	Std. Deviation	Minimum	Maximum
Chronological Age	24.3967	9.46385	6	60
Age Estimated by Jeons Method	24.529688	9.5394204	5.9052	60.9164
Age estimated by Drusini's Method	25.097	9.69308	6.5	60.8

Table 2: Intra-group comparison using Posthoc test between various age categories in both Drusini and Jeon method

	(I) Age in Categories	(J) Age in Categories	Mean Difference (I-J)	Std. Error	Sig (p value)	95% Confidence Interval	
						Lower Bound	Upper Bound
Age Estimated by Jeons Method	Age less than or equal to 25	Age >40	-30.55*	1.24	**<0.001**	-33.000956	-28.114403
	Age >25 and <=40	Age >40	-18.03*	1.29	**<0.001**	-20.570686	-15.503815
	Age >25 and <=40	Age less than or equal to 25	30.55*	1.24	**<0.001**	28.114403	33.000956
Age estimated by Drusini's Method	Age less than or equal to 25	Age >40	-31.01*	1.28	**<0.001**	-33.5354	-28.4942
	Age >25 and <=40	Age >40	-18.43*	1.33	**<0.001**	-21.0459	-15.8187
	Age >25 and <=40	Age less than or equal to 25	31.01*	1.28	**<0.001**	28.4942	33.5354
One way ANOVA used. Post hoc test (Bonferroni test) is used for intergroup comparisons. The mean difference is significant at the 0.05 level (p value).							

Table 3: Correlation analysis of the parameters used in both studies with chronological age

Chronological Age vs Depth of Pulp Chamber	Pearson Correlation	-0.958
	p value	<0.01
Chronological Age vs Floor to Furcation	Pearson Correlation	0.728
	p value	<0.01
Chronological Age vs Root Furcation	Pearson Correlation	-0.214
	p value	<0.001
Chronological Age vs Lingual GRV Furcation	Pearson Correlation	-0.57
	p value	<0.01
Chronological Age vs F/L	Pearson Correlation	0.787
	p value	<0.01
Chronological Age vs D/L	Pearson Correlation	-0.953
	p value	<0.01
Chronological Age vs CH	Pearson Correlation	-0.5
	p value	<0.01
Chronological Age vs CPCH	Pearson Correlation	-0.959
	p value	<0.01
Chronological Age vs TCI	Pearson Correlation	-0.987
	p value	<0.01
Pearson correlation coefficient used P<0.05 is significant		

Table 4: Correlation analysis of estimated age using both methods with chronological age

Correlations		**Chronological Age**	**Age Estimated by Jeons Method**	**Age estimated by Drusini's Method**
Chronological Age	**Pearson Correlation**	1	.998	.987
	Sig. (p value)	.	<0.001	<0.001
Age Estimated by Jeons Method	**Pearson Correlation**	.998	1	.985
	Sig. (p value)	<0.001	.	<0.001
Age estimated by Drusini's Method	**Pearson Correlation**	.987	.985	1
	Sig. (p value)	<0.001	<0.001	.
****Persons Correlation Coefficient used. is significant at the 0.05 level (2-tailed)**				

Table 5: Comparison of means between two estimated ages based on gender

	t value	p-value (Sig)	Mean Difference	95% CI of the Difference	
				Lower	Upper
Age Estimated by Jeons Method	0.756	0.45	0.84	-1.34	3.029
Age estimated by Drusini's Method	0.845	0.399	0.95	-1.26	3.178
Independent t-test for Equality of Means is used. P<0.05 is significant.					

Figure 1: Diagrammatic representation of various parameters used in the Drusini and Jeon method : D: Depth of pulp chamber; F: Depth from floor of pulp chamber to highest point of furcation; L: start point of lingual groove to highest point of furcation

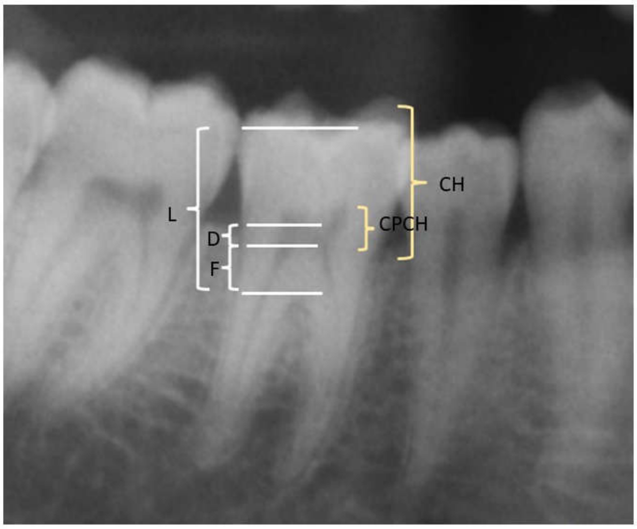

Figure 2: Graphical representation of correlation among chronological age with the estimated age within two methods