RESEARCH ARTICLE

Radiographic association of chronological age based on the root pulp and periodontal ligament visibility in lower second molar teeth in a subset of the Pakistani population

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Abstract

Objective: To find radiographic association of the root pulp visibility and periodontal ligament visibility stages of lower second molar teeth with chronological age.

Method: The prospective, analytical, cross-sectional study was conducted after approval from the ethics review committee of Ziauddin University, Karachi, and comprised digital orthopantomograms from 2020 to 2022. The orthopantomograms related to lower second molar teeth from the left side of the mandible of individuals of either gender aged 18-40 years. The orthopantomograms were subjected to stage classification to assess the radiographic root pulp visibility and periodontal ligament visibility of the lower second molar teeth. Data was analysed using SPSS 25.

Results: Of the 260 orthopantomograms, 140(53.8%) belonged to female subjects and 120(46.2%) to male. The overall median age of the subjects was 24 years (interquartile range: 7 years). There were 164(63.1%) subjects aged 18-25 years, 70(26.9%) aged 26-33 years, and 26(10%) aged 34-40 years. A positive correlation was noted between age and stages of radiographic root pulp visibility and periodontal ligament visibility ($p<0.05$). The individuals found at stages 0 and 1 for root pulp visibility were aged at least 18 years, and for stage 2, the corresponding value was 21 years. For periodontal ligament visibility, the minimum age for stage 0 was 18 years, while for stages 1 and 2, the corresponding values were 21 and 25 years.

Conclusion: Lower age was found to be associated more with stage 0 of root pulp visibility and periodontal ligament visibility.

Keywords: Panoramic radiography, Periodontal ligament, orthopantomography, Dental pulp. (JPMA 74: 1937; 2024)

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Introduction

Age is a fundamental biological parameter secondary to gender. Estimation of age, especially the 18-year threshold of an individual holds an important value for solving legal, civil and ethical issues as well as paediatric categorisation, planning treatment, including orthodontic treatment, and generating death reports.[1,2] Many techniques have studied different body parts for an accurate assessment of age. The majority of these techniques study changes in the skeleton and use them to estimate the age of an individual. However, these methods are time-bound to the time of ossification of the particular bone under study.[3,4]

The third molar (3M) teeth have been studied for age estimation purposes because their development continues from the late teen years to the early 20s.[5,6] Dental tissues also tend to show high resistance to thermal, mechanical and chemical stimuli, and undergo the least variation due to environmental, genetic, hormonal and nutritional changes unlike skeletal and sexual development indicators and any other biological tissue. Therefore, they are considered a distinct parameter for the estimation of age.[1,7-9] Olze et al. conducted research on two new criteria, which were based on studying root pulp visibility (RPV) and periodontal ligament visibility (PLV) radiographically of the lower 3M teeth for the estimation of dental age, once their root development has been completed.[10,11] These methods have been confirmed as one of the reliable age markers for 18-year and 21-year thresholds for different populations.[12-15]

The secondary dentine deposition (SDD) process begins when the tooth becomes functional in the oral cavity, and continues lifelong. SDD gradually narrows the pulp canals and the radio-opacity of the overlying tissues increases, resulting in obscured pulp on a panoramic radiograph. The periodontal ligament also tends to thin overtime with increase in radio-opacity of the overlying tissues, resulting

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in obliteration of the ligament space on a panoramic radiograph.[16,17]

Agenesis of 3M teeth has a high percentage, varying from 17% to 28% in different populations.[18,19] Lower second molar (2M) teeth have an advantage over lower 3M teeth as they show fewer congenital dental anomalies, like agenesis, dilaceration, microdontia and impaction. Lower 2M teeth also have an advantage over lower first molar (1M) teeth as they show less acquired dental anomalies, like caries, missing or being endodontically treated. It would be beneficial to find a method which uses lower 2M teeth for estimating whether an individual is above the 18-year threshold.[1]

Recent literature states that there is a difference between studies in different ethnic groups, and more data of different populations should be collected for RPV and PLV radiographically.[20-22] To the best of our knowledge, there have been no studies exploring the association of chronological age with the RPV and PLV radiographic stages in lower 2M teeth of the Pakistani population. The current study was planned to fill the gap by exploring the radiographic association of RPV and PLV stages of lower 2M teeth with chronological age.

Materials and Methods

The prospective, analytical, cross-sectional study was conducted after approval from the ethics review committee of Ziauddin University (ZU), Karachi, and comprised digital orthopantomograms (OPGs) from 2020 to 2022. By taking the prevalence of accurate prediction based on pulp visibility stages as 80.7%,[15] the sample size was calculated using the OpenEpi calculator[23] with 95% confidence interval (CI) and 7% margin of error. The sample size was inflated by <10% to reduce error, and to increase the validity of the findings.[15] The samples were recruited using non-probability consecutive sampling technique from the Department of Orthodontics, ZU Hospital, Clifton campus, and Karachi X-rays.

Digital OPGs of lower 2M teeth from the left side of the mandible of individuals of either gender aged 18-40 years were included. Digital OPGs with good contrast, showing a good quality image and good morphology of the tooth with complete root formation were included. Digital OPGs were excluded in cases where none of the teeth to be studied was available, teeth under study had a filling, teeth under study were either inflamed or decayed, and teeth under study presented with anomalies, like fused roots, single roots and dilacerations.

Patients' date of birth, date of radiograph taken and gender were recorded. The digital OPGs were examined and analysed on a computer screen using Clear Can-vas RIS/PACS (Radiology Information System- RIS and the Picture Archiving and Communication System- PACS) Version 2.0 12729. 37986 SP1 Software.

The first examiner was a general dentist with 1 year of clinical experience, and the second examiner was an orthodontist with 9 years of experience. The result for inter-examiner reliability was assessed using Cohen's Kappa coefficient. Intraclass correlation coefficient (ICC) interpretation was done at 3-day intervals.

Olze stage classification[10] was used to assess the radiographic RPV and PLV of the lower 2M teeth with its root being completely formed with apical closure from the left side of the mandible by assessing it on the digital OPGs.

According to the Olze classification for radiographic RPV, stage 0 = the lumen of all root canals is visible all the way to the apex of the root, stage 1=the lumen of one root canal is not fully visible all the way to apex of the root, stage 2=the lumen of two root canals are not fully visible all the way to the apex, or one canal is not visible at full length, and stage 3=the lumen of two root canals is not visible in full length.[10]

According to Olze classification for radiographic PLV, stage 0=the periodontal ligament is visible along the full length of all roots, stage 1=the periodontal ligament is not visible in one root from the apex to more than half of the root, stage 2=the periodontal ligament is not visible along almost the full length of one root or along part of the root in two roots or both, and stage 3=the periodontal ligament is not visible along almost the full length of two roots (Figure 1-2).[11]

Data was analysed using SPSS 25. Normality of data was

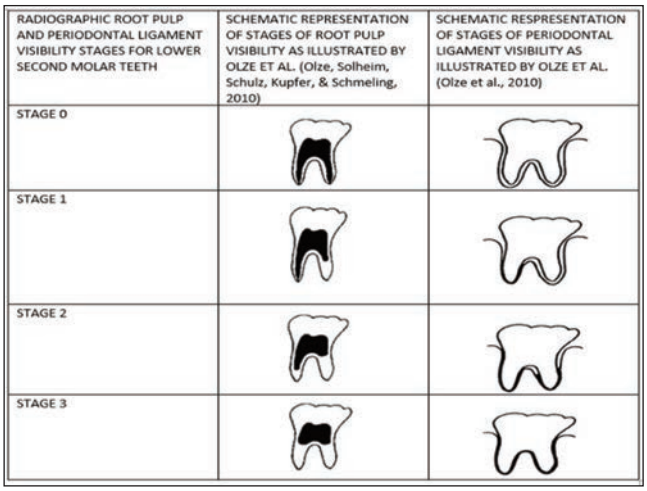

Figure-1: Schematic representation of stage classification for radiographic root pulp visibility and periodontal ligament visibility in lower second molar teeth.

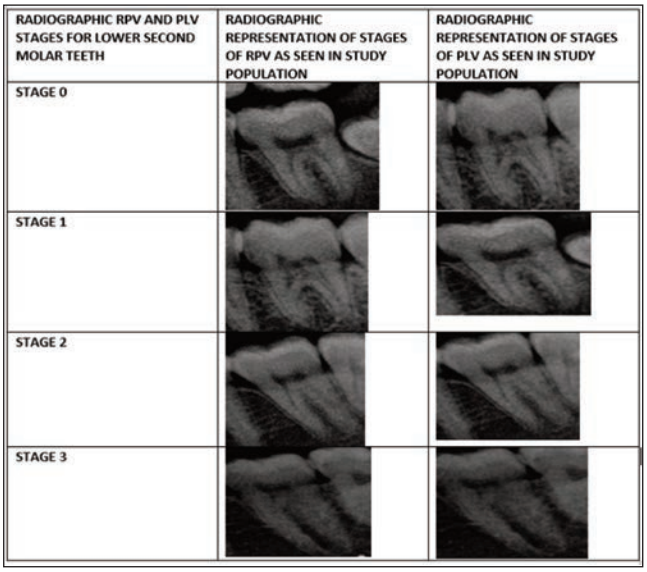

Figure-2: Radiographic representation of stage classification of radiographic root pulp visibility and periodontal ligament visibility in lower second molar teeth.

assessed using Shapiro-Wilk test of normality. Quantitative data was expressed as median and interquartile range [IQR]. Qualitative data was presented as frequencies and percentages. Chi-square test was applied to find the association between different stages of radiographic RPV and PLV with age and gender. P<0.05 was considered statistically significant.

Results

Of the 260 OPGs, 140(53.8%) belonged to female subjects and 120(46.2%) to male. Age was not a normally distributed parameter ($p \leq 0.05$). The overall median age of the subjects was 24 years (IQR: 7 years). There were 164(63.1%) subjects aged 18-25 years, 70(26.9%) aged 26-33 years, and 26(10%) aged 34-40 years. (Table-1).

Age distribution was found to be significantly different with respect to age groups (Table-2). Gender was not significantly associated with stages of radiographic RPV and PLV (Table-3). A positive correlation was noted between age and stages of radiographic root pulp visibility and periodontal ligament visibility ($p<0.05$). The individuals found at stages 0 and 1 for RPV were aged at least 18 years, and for stage 2, the corresponding value was 21 years. For PLV, the minimum age for stage 0 was 18 years, while for stages 1 and 2, the corresponding values were 21 and 25 years (Table-4).

Cohen's Kappa coefficient for inter-examiner reliability for RPV was 0.67, showing good agreement between the 2 examiners. PLV, however, showed moderate agreement for inter-examiner reliability (0.51). ICC interpretation showed good reliability (0.8), while PLV showed moderate reliability (0.55).

Table-1: Demographic characteristics (n=260).

Variables			n (%)
Age (years)			Median [IQR] = 24 [7]
18-25			164 (63.1)
26-33			70 (26.9)
34-40			26 (10.0)
Gender			
Male			120 (46.2)
Female			140 (53.8)
Radiographic root	**Stage 0**	**Stage 1**	**Stage 2**
pulp visibility of lower 2nd molar teeth	196 (75.4)	53 (20.4)	11 (4.2)
Radiographic periodontal	**Stage 0**	**Stage 1**	**Stage 2**
lig-ament visibility of lower 2nd molar teeth	219 (84.2)	31 (11.9)	10 (3.8)

n: number of participants with selected teeth, IQR: interquartile range

Table-2: Comparison of stages of radiographic root pulp visibility and periodontal ligament visibility of lower 2nd molar teeth with age groups [n(%)].

Age (years)	**Stage 0**	**Stage 1**	**Stage 2**	**Total**	***p*-value**
Radiographic root pulp visibility of lower 2nd molar teeth					
18-25	142 (86.6)	20 (12.2)	2 (1.2)	164 (100)	<0.001
26-33	41 (58.6)	24 (34.3)	5 (7.1)	70 (100)	
34-40	13 (50.0)	9 (34.6)	4 (15.4)	26 (100)	
Radiographic periodontal ligament visibility of lower 2nd molar teeth					
18-25	156 (95.1)	7 (4.3)	1 (0.6)	164 (100)	<0.001
26-33	50 (71.4)	17 (24.3)	3 (4.3)	70 (100)	
34-40	13 (50.0)	7 (26.9)	6 (23.1)	26 (100)	

Table-3: Comparison of stages of radiographic root pulp visibility and periodontal ligament visibility of lower 2nd molar teeth with gender [n(%)].

Gender	**Stage 0**	**Stage 1**	**Stage 2**	**Total**	***p*-value**
Radiographic root pulp visibility of lower 2nd molar teeth					
Male	91 (75.8)	25 (20.8)	4 (3.3)	120 (100)	0.798
Female	105 (75.0)	28 (20.0)	7 (5.0)	140 (100)	
Radiographic periodontal ligament visibility of lower 2nd molar teeth					
Male	99 (82.5)	17 (14.2)	4 (3.3)	120 (100)	0.556
Female	120 (85.7)	14 (10)	6 (4.3)	140 (100)	

Table-4: Descriptive analysis of chronological age for different stages of radiographic root pulp visibility and periodontal ligament visibility of lower 2nd molar.

	Radiographic root pulp visibility of lower 2nd molar teeth				**Radiographic periodontal ligament visibility of lower 2nd molar teeth**			
Stages	**n**	**Min age**	**Max age**	**Mean±SD**	**n**	**Min age**	**Max age**	**Mean±SD**
0	196	18	39	24.09±4.751	219	18	40	24.16±4.824
1	53	18	40	28.25±5.808	31	21	40	29.81±4.778
2	11	21	40	31.00±6.309	10	25	39	34.30±4.473

n: number of individuals with selected tooth, Min: minimum, Max: maximum, SD: standard deviation.

Discussion

Every individual's teeth are unique, just like individual fingerprints, and show a complex and dynamic process of growth with increasing age.[7] According to previous research, ethnicity has shown to play a crucial role in tooth development, and, hence, reference data specific to a particular population could increase the accuracy of dental age assessment.[22]

Narrowing of the pulp canal through SDD and thinning of the periodontal ligament continues throughout life. The staging method, as described by Olze et al.,[10,11] for the radiographic evaluation of RPV and PLV for age estimation has been used in various studies. However, it was not convenient to use the staging method for the maxillary teeth due to the frequent shading of posterior teeth by the bony structures present.[10,11] Hence mandibular teeth, mainly the mandibular 3Ms, have been studied by various researchers, and, from the overall results, a strong positive correlation has been seen to exist between the chronological age and different stages of radiographic RPV and PLV.[10-14,18,24]

In many studies, 3M teeth have been used to evaluate Olze et al.'s method for radiographic RPV and PLV, but some studies have reported certain limitations that exist with 3Ms. These limitations include incomplete root formation, and certain congenital and positional anomalies.[1,22]

Studies that included mandibular 1M to evaluate radiographic RPV for age estimation also reported certain limitations, such as carious lesions, missed or endodontically treated teeth and root anomalies.[18] Considering these limitations with 1M and 3M teeth, the lower 2M was evaluated.

Gok. E et al. in 2020 analysed radiographic RPV of 9,059 digital OPGs for lower 3M teeth of both males and females aged 18-40 years. Their findings showed no significant difference with respect to stages in different gender.[25] The current study had similar findings.

Balla et al.[26] investigated the lower 2M teeth for radiographic RPV using the Olze stage classification[10] for age assessment. They evaluated 936 OPGs for males and females aged 14-22 years. A strong, positive correlation was found between the chronological age and RPV stages, and they did not find any case of stage 3 teeth. The current study also did not find any stage 3 sample. The earlier study also concluded that stage 2 was to be found at age 18.6 years and 15.2 years in males and in females, respectively, at the earliest.[26] Comparatively, in the current study, for radiographic RPV of both males and females, stage 2 was first achieved at 21 years of age. This could be because of the difference between lower and upper age limits of subjects included in the study samples.

Serin et al., in 2023 evaluated radiographic RPV of lower 2M teeth through cone-beam computed tomography (CBCT) images for age estimation using 699 CBCT of individuals aged 15-75 years and concluded that stage 3 was not present.[1] Similar results were found in the current study.

A study in 2014 analysed 330 OPGs of patients aged 14-76 years for radiographic PLV in lower 3M teeth, and graded them in 4 stages. It concluded that radiographic PLV scoring can be used as an adjunct to other age estimation methods.[2] The current findings were similar.

Guo et al. studied 1,300 conventional OPGs of northern Chinese people aged 15-40 years to assess if Olze classification stages for radiographic PLV[11] could be used for the 18-year threshold. Stage 1 was found at 18.52 years in male subjects and 19.59 years in female subjects. Stage 3 was first observed at 26.85 years in male subjects and 24.92 years in female subjects.[22] In the current study, stages 0, 1 and 2 were first achieved at 18, 21 and 25 years in total for both males and females, respectively. Stage 3 was not seen in the study population. This variation in results could be due to the different ethnicity of the population under study. However, the conclusion remains the same that stage 1 indicates that an individual is aged at least 18 years.

The current study had limitations. The samples were not distributed equally with respect to age and gender.

In future studies, the influence of different ethnicity, dietary habits and socio-economic status on radiographic RPV and PLV should be investigated. Radiographic RPV and PLV for males and females separately should be evaluated for more accurate results. There should be an extension in the lower limit of the age range by including more data on individuals aged <18 years. Furthermore, an imaging system that uses two-dimensional (2D) methods has certain limitations that are either due to super-positioning, magnification, and/or distortions of structures being examined. To overcome these limitations, 3D imaging systems, such as cone beam computed tomography (CBCT), should be utilised for evaluating these characteristics, since it is being widely used in dentistry and forensic odontology.

Conclusion

In the subset of the Pakistani population studied, stages 0 and 1 for RPV indicated that the individual was aged at least 18 years, and stage 2 indicated that the individual was at least 21 years old. For PLV, stage 0 indicated that the minimum age of individual was 18 years, while stages 1 and 2 indicated minimum age of 21 years and 25 years, respectively.

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References

1. Serin Canpolat S, Bayrak S. Evaluation of radiographic visibility of root pulp in mandibular second molars using cone beam computed tomography images for age estimation. Forensic Sci Med Pathol 2024;20:8-13. doi: 10.1007/s12024-023-00594-6.
2. Shrestha M, Srikant N, Nepal R, Shakya A. Comparative evaluation of two established age estimation techniques (two histological and radiological) by image analysis software using single tooth. J Forensic Res 2014;5:1000237. doi: 10.4172/2157-7145.1000237.
3. Moukarzel M, Angelakopoulos N, De Luca S, Velandia Palacio LA, Aquilanti L, Coccia E, et al. Validity assessment of the third molar maturity index (I3M) in a Lebanese sample of adolescents and young adults. Aust J Forensic Sci 2022;54:499-510. doi: 10.1080/00450618.2020.1805008
4. Davies C, Hackman L, Black S. The epiphyseal scar: changing perceptions in relation to skeletal age estimation. Ann Hum Biol 2015;42:348-57. doi: 10.3109/03014460.2015.1031825.
5. Kurniawan A, Chusida A, Atika N, Gianosa TK, Solikhin MD, Margaretha MS, et al. The Applicable Dental Age Estimation Methods for Children and Adolescents in Indonesia. Int J Dent 2022;2022: e6761476. doi: 10.1155/2022/6761476.
6. Sisman Y, Uysal T, Yagmur F, Ramoglu SI. Third-molar development in relation to chronologic age in Turkish children and young adults. Angle Orthod 2007;77:1040-5. doi: 10.2319/101906-430.1.
7. Verma M, Verma N, Sharma R, Sharma A. Dental age estimation methods in adult dentitions: An overview. J Forensic Dent Sci 2019;11:57-63. doi: 10.4103/jfo.jfds_64_19.
8. Asif MK, Nambiar P, Mani SA, Ibrahim NB, Khan IM, Lokman NB. Dental age estimation in Malaysian adults based on volumetric analysis of pulp/tooth ratio using CBCT data. Leg Med (Tokyo) 2019;36:50-8. doi: 10.1016/j.legalmed.2018.10.005.
9. Veera SD, Kannabiran J, Suratkal N, Chidananada DB, Gujjar KR, Goli S. Coronal pulp biomarker: A lesser known age estimation modality. J Indian Acad Oral Med Radiol 2014;26:398-404. doi: 10.4103/0972-1363.155684
10. Olze A, Solheim T, Schulz R, Kupfer M, Schmeling A. Evaluation of the radiographic visibility of the root pulp in the lower third molars for the purpose of forensic age estimation in living individuals. Int J Legal Med 2010;124:183-6. doi: 10.1007/s00414-009-0415-y.
11. Olze A, Solheim T, Schulz R, Kupfer M, Pfeiffer H, Schmeling A. Assessment of the radiographic visibility of the periodontal ligament in the lower third molars for the purpose of forensic age estimation in living individuals. Int J Legal Med 2010;124:445-8. doi: 10.1007/s00414-010-0488-7.
12. Akkaya N, Yılancı HÖ, Boyacıoğlu H, Göksülük D, Özkan G. Accuracy of the use of radiographic visibility of root pulp in the mandibular third molar as a maturity marker at age thresholds of 18 and 21. Int J Legal Med 2019;133:1507-15. doi: 10.1007/s00414-019-02036-x.
13. Timme M, Timme WH, Olze A, Ottow C, Ribbecke S, Pfeiffer H, et a. The chronology of the radiographic visibility of the periodontal ligament and the root pulp in the lower third molars. Sci Justice 2017;57:257-61. doi: 10.1016/j.scijus.2017.03.004.
14. Lucas VS, McDonald F, Andiappan M, Roberts G. Dental age estimation: periodontal ligament visibility (PLV)-pattern recognition of a conclusive mandibular maturity marker related to the lower left third molar at the 18-year threshold. Int J Legal Med 2017;131:797-801. doi: 10.1007/s00414-016-1468-3.
15. Pérez-Mongiovi D, Teixeira A, Caldas IM. The radiographic visibility of the root pulp of the third lower molar as an age marker. Forensic Sci Med Pathol 2015;11:339-44. doi: 10.1007/s12024-015-9688-2.
16. Tangkabutra S, Alzoubi E, Roberts G, Lucas V, Camilleri S. Root canal width as a mandibular maturity marker at the 18-year threshold in the Maltese population. Int J Legal Med 2022;136:1667-74. doi: 10.1007/s00414-022-02868-0.
17. Helmy MA, Osama M, Elhindawy MM, Mowafey B. Volume analysis of second molar pulp chamber using cone beam computed tomography for age estimation in Egyptian adults. J Forensic Odontostomatol 2020;38:25-34.
18. Balla SB, Ankisetti SA, Bushra A, Bolloju VB, Mir Mujahed A, Kanaparthi A, et al. Preliminary analysis testing the accuracy of radiographic visibility of root pulp in the mandibular first molars as a maturity marker at age threshold of 18 years. Int J Legal Med 2020;134:769-74. doi: 10.1007/s00414-020-02257-5.
19. Sujon MK, Alam MK, Rahman SA. Prevalence of Third Molar Agenesis: Associated Dental Anomalies in Non-Syndromic 5923 Patients. PLoS One 2016;11:e0162070. doi: 10.1371/journal.pone.0162070.
20. Tantanapornkul W, Kaomongkolgit R, Tohnak S, Deepho C, Chansamat R. Chronological age assessment based on the root pulp visibility in lower third molars in a group of Thai population: Panoramic Radiographic study. Open Dent J 2021;15:591-4. doi: 10.2174/1874210602115010591
21. Tantanapornkul WB, Kaomongkolgit R, Tohnak S, Deepho C, Chansamat R. Dental age assessment based on the radiographic visibility of the periodontal ligament in lower third molars in a Thai sample. J Forensic Odontostomatol 2021;39:32-7.
22. Guo YC, Li MJ, Olze A, Schmidt S, Schulz R, Zhou H, et al. Studies on the radiographic visibility of the periodontal ligament in lower third molars: can the Olze method be used in the Chinese population? Int J Legal Med 2018;132:617-22. doi: 10.1007/s00414-017-1664-9.
23. Dean AG, Sullivan KM, Soe MM. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version: 3.01. [Online] 2013 [Cited 2024 July 31]. Available from URL: https://www.openepi.com/Menu/OE_Menu.htm
24. Shah R, Angadi PV. Radiographic assessment of periodontal ligament visibility in mandibular third molars as a tool for defining the 18 year threshold among Indians. Aust J Forensic Sci. 2021;53:306-13. doi: 10.1080/00450618.2019.1711179
25. Gok E, Fedakar R, Kafa IM. Usability of dental pulp visibility and tooth coronal index in digital panoramic radiography in age estimation in the forensic medicine. Int J Legal Med 2020;134:381-92. doi: 10.1007/s00414-019-02188-w.
26. M S, Balla SB, Chinni SS, K SPR, Gopalaiah H, et al. Examination of the radiographic visibility of the root pulp of the mandibular second molars as an age marker. Int J Legal Med 2020;134:1869-73. doi: 10.1007/s00414-020-02347-4.

Author Contribution:
MS, SM, FS, QH: Concept, design, data acquisition, analysis, interpretation, drafting, revision, final approval and agreement to be accountable for all aspects of the work.