Root Dentin Translucency based Dental Age Estimation in Adults: A Systematic Review

P. T. Abhirami¹ and C. Tinky Bose^{2*}

¹PG Student, Department of Oral Medicine and Radiology, Government Dental College Thiruvananthapuram, Thiruvananthapuram – 695011, Kerala, India ²Professor and Head, Department of Oral Medicine and Radiology Government Dental College, Thiruvananthapuram – 695011, Kerala, India; drtinkybose@gmail.com

Abstract

Background: In Forensic practice and research, the Gustafson technique is the most popular dental age estimation method that uses six variables, among which Root Dentin Translucency (RDT) is considered to be the best single parameter for dental age estimation as it is the least affected by environmental and pathological factors. Dental age estimation by RDT has been tested on different geographic groups in order to determine its applicability and it has been found that there was an under/overestimation of the age of the subjects in different populations. No systematic review of these studies has yet been published to check the reliability and accuracy of this novel method in estimating chronological age. **Objective:** To assess the accuracy and reliability of RDT-based dental age estimation in different academic and forensic scenarios by qualitatively summarising the results of RDT-based dental age estimation studies in diverse population samples. **Evidence Review:** Studies were searched in the Medline, Embase, Directory of open access journals, Cochrane library and Google Scholar databases up to December 2019 with previously defined inclusion and exclusion criteria. The outcome of interest was the difference between chronological age and the age estimated from RDT. **Results and Conclusion**: A total of 1754 subjects from 16 published studies were included in the final review. Our findings proved that the RDT method tends to overestimate chronological age for both sexes in most of the study population. The overestimated dental age ranges from 2.24 to 15.1 years.

Keywords: Dental Age, Root Dentin Translucency Area, Root Dentin Translucency Length

Introduction

Background

Age is one of the essential factors to establish the identity of a person for any forensic or medicolegal process¹. Teeth are one of the most durable and strongest structures in the human body; to some extent, it can resist burnt injuries, post-mortem decomposition environmental and pathological insults. Therefore dental remains offer the most rapid, reliable and useful methods of forensic identification to the scientific community². Different methods have been proposed to estimate dental age using different tooth parameters. Gustafson's morphohistologic approach is the most widely used method and includes the following six parameters: attrition, gingival recession, the thickness of secondary dentin, cementum

*Author for correspondence

apposition, root resorption and root dentin translucency². Among these "*Root dentinal translucency*" is the best single parameter for age estimation, not only in terms of accuracy but also in terms of simplicity³.

Transparency of root dentine increases with age from apical to coronal aspect and is apparently not very closely related to pathologic conditions or treatment. This makes it a worthwhile tool for developing and testing accurate age estimation techniques. Moreover, it has also shown a symmetrical distribution on both sides of the jaws². Furthermore, translucency can be assessed macroscopically on the intact tooth, although tooth sections provide better details³. RDT measurements like RDT length and RDT area can be used for age estimation. RDT area gives more correlation than length with chronological age, as it represents two-dimensional measurements⁴. There are Digital and Conventional Methods of RDT Measurements. Conventionally Vernier callipers were used for RDT measurements, more recently custombuilt softwares were introduced for the same. RDT measurements by Digital method has some advantages over the conventional method³. The digital method allows better visualization giving scope for "fine-tuning" the measurements, "touch-free/non-invasive" digital evaluation prevents potential damage to thin tooth sections, and the scanned image can be easily stored and conveniently retrieved for further use³.

Rationale

The method of age estimation should be as accurate as possible so that it enables the investigator to arrive at an age which is close to the chronologic age²¹. Dental age estimation by RDT has been tested on different geographic groups in order to determine its applicability and it has been found that there was under/overestimation of the age of the subjects in different populations. No systematic review of these studies has yet been published to check the reliability and accuracy of this novel method in estimating chronological age.

Research Question

Does the Root Dentinal Translucency method provide an accurate and reliable estimate of chronological age in diverse population samples?

Methodology

Criteria for Considering Studies

Original studies in human teeth reporting the use of RDT method of dental age estimation based on RDT length or area (Conventional/Digital) that preferably reported inter and intra-observer variation and that expressed results in Standard Error of Estimate (SEE)/Mean Absolute Difference of age were considered for the qualitative analysis.

Methods of Literature Search

To identify relevant studies to include in our review, we performed a comprehensive literature search based on a well-designed three-step search strategy. A Computerized search of articles which employed RDT-based dental age assessment published in English language journals between 2007 to 2019 was carried out. An initial limited search of MEDLINE and Embase was undertaken, followed by an analysis of the text words contained in the title and abstract, and of the index terms used to describe articles. A second search using all identified keywords and index terms was then conducted across all the included databases such as Medline (NLM), Directory of Open Access Journals (DOAJ), Embase, Science Direct Journals (Elsevier), Wiley Online Library and Google Scholar. Thirdly, the reference lists of all identified reports and articles were searched for additional studies. The selection of papers suited for inclusion in the review was independently carried out by two authors. The key search words were "dental age", "root dentin translucency length and dental age estimation", "root dentinal translucency area and dental age estimation", "Chronologic age estimation using root dentinal translucency".

Data Collection and Analysis

Selection of Studies

The initial selection of the studies was based on the title and then abstract. A significant number of articles were filtered from journals like the Journal of Forensic Odonto-Stomatology, Forensic Science International, Journal of Forensic Dental Sciences, and Journal of Indo-Pacific Academy of Forensic Odontology. The inclusion and exclusion criteria for the review are briefed below

• Inclusion criteria

Only relevant original research articles with RDTbased age determination, either for validating its applicability or for creating an adapted data set were included in the study. Studies expressing the results in SEE/Mean Absolute Difference of age alone were included for systematic review.

• Exclusion criteria

Studies expressing age estimation results in median or percentages were excluded. Furthermore, studies using the grading of RDT-based age estimation, single case reports, literature reviews, studies without full texts were also excluded.

Data Extraction and Management

Two reviewers (TB, AP) extracted data from the accepted studies independently. Disagreements between authors concerning the data extracted were solved through discussion and consensus. Then the data collected from the different articles were organized in an excel spreadsheet as follows: Author, year, country, sample size (male and female), sample selection method, age, type of study design, intra and inter-observer agreement assessment, type of Root Dentinal Translucency measurement (Length/Area), Tools used for measurements, the correlation coefficient between age and RDT length/area and Outcome (SEE/Mean Absolute Difference of age).

Assessment of Methodological Quality and Risk of Bias

Articles selected for this study were assessed by two independent reviewers for methodological validity prior to inclusion in the review using a QUADAS tool, the tool for the quality assessment of diagnostic accuracy studies included in systematic reviews. This has a list of 14 questions which should be answered "yes", "no", or "unclear". Included studies were assessed according to the checklist and papers that had 10 or more 'Yes' responses were regarded as having high methodological quality. Notably, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool is often used in systematic reviews to rate the quality and certainty of the included evidence. However, the current systematic review was not a typical diagnostic accuracy assessment study, where one presents positive/negative results with sensitivity and specificity analysis. Therefore, evaluating evidence quality by GRADE could not be conducted in the current systematic review. To reduce 'Author bias', the results were analysed by comparing individual papers, and then grouping them per author.

Outcome Measures

SEE (Standard Error of age estimated)/MAD (Mean Absolute Difference in age) that is, the mean difference between the estimated Dental Age(DA) and the Chronological Age (CA) was taken as the outcome measure. For the studies in which age estimation differences was not presented in the text, but in table, MAD /SEE was obtained by table values.

Results

Characteristics of Included Studies

At first, we carried out the so-called selection criteria stage. A total of 83 articles from peer-reviewed journals were selected as meaningful to justify the aims and objectives of the present review. Out of these, 67 studies were rejected as irrelevant studies (after getting inspected the article titles and abstracts) in order to meet the exclusion criteria. The excluded studies either used other methods of age estimation, reported results in percentages or median, or used the Gustafson age estimation technique by 6 parameters, or grading of RDT instead of RDT measurements. Finally, 16 studies were further scrutinized for systematic review. Two examiners performed this stage so the studies were only included if there was an agreement between the two examiners. During the selection process, any disagreement in the selection of articles between the review authors was resolved by discussion. The literature search and study selection process was described in the Prisma flow diagram (Figure 1).

The final 16 independent articles which met the inclusion and exclusion criteria are listed in Table 1. Regression formulas used in included studies are represented in Table 2.

Repeat RDT measurements in studies showed minimal Intra and inter observer differences, which were statistically insignificant. Translucency measurements like maximum and average translucency length and translucency area were used. Among these most of the studies showed the maximum translucency length had the highest correlation with age. The correlation coefficient was statistically significant for both conventional and digital methods for almost all studies. Most of the studies show the correlation was slightly higher for digital measurements, except for study by Chopra *et al*¹³.

Most of the studies used linear regression analysis separately for RDTL and RDTA for chronological ages. Studies by Acharya⁴ used quadratic regression analysis for RDTL and RDTA shows better correlation than linear regression. Study by Kottappagari *et al.*,¹² on multilinear regression analysis to estimate age by both parameters Area and length, showed a high correlation coefficient.

More than 95% of samples were single-rooted teeth except for a comparative study by Puneeth *et al.*,¹⁵ that showed double-rooted teeth provided more accurate age estimation than single-rooted teeth with a minimal age difference.

Comparison between Chronologic Age and RDT-Based Dental Age

Over-estimation of age was found generally in all the examined studies, except for a few. Conversely, underestimation of age was reported in higher age groups



Figure 1. Flow diagram of the selection process of the included studies and the specific reasons for exclusion from the systematic review.

in North Indian study by Arora *et al.*,⁸ and in Rohthak population by Rai *et al*⁵. In most of the studies, the calculated age was overestimated in younger individuals up to 15 years. While evaluating the age estimation results for the global population, the variations in the estimated age ranged from +2.24 to +15.1 years. Minimum difference of ± 2.24 yrs was reported for the Shimla population by Singhal *et al.*,⁷ and Maximum difference of ± 15.1 yrs in South African population by Ackermann *et al*¹¹.

Discussion

Age estimation from the dentition is of great interest for forensic cases for identification of unknown victim²⁰. The Gustafson's morpho-histologic approach is the most widely accepted method in which RDT is considered the best single parameter for age estimation²¹. The use of dentition is the method of choice in the identification of the unknown. Root dentin translucency is considered to be one of the best parameters for dental age estimation. Traditionally, root dentin translucency was measured using calipers. Recently, the use of custom built software programs have been proposed for the same. OBJECTIVES The present study describes a method to measure root dentin translucency on sectioned teeth using a custom built software program Adobe Photoshop 7.0 version (Adobe system Inc, Mountain View California). With advancing age, mineralization within the dentinal tubules leads to an increase in the translucency of root dentin which extends gradually from the root toward the crown⁸. The underlying process behind the translucency of dentin is a result of fatty degeneration, physiological hardening during the lifetime of the tooth due to increased deposition of the calcific matter, consolidation of dentinal tubules, equalization of the normally different indices of refraction of the tubules and the calcified dentin matrix, decreased diameter of dentinal tubules caused by increased intra tubular calcification¹³.

In the recent past, the suitability of this method has been broadly examined in diverse population groups and, uncertainty has been raised about the accuracy and precision of this method. Therefore, the present study aimed to carry out a systematic review of various studies published during the decade of 2007-2017 RDT-based age estimation in the adult age group. Studies that reported the results in SEE/MAD of estimated age were included in

Table	1. Age estimation results among d	ifferent popula	tion groups using	RDT measu	Irements			
SI No	Author & year	Place of study	Research type	Sample size	Age group (yrs)	Method	Parameter Area /Length	Outcome SEE/MAD
1	B Rai ⁵ (2007)	Rohthak	Original research	56	38-43	Conventional	Length	SE=
2	Ashith B Acharya , V Simi ⁶ (2009)	Karnataka	Original research	100	19-82	Digital	Length	MAE=±8.29
3	Ashit B Acharya ³ (2010)	Karnataka	Original research	81	19-82	Conventional & Digital	Length	$SE = \pm 5$
4	Singhal <i>et al.</i> , 7 (2010 Jan)	Shimla	Original research	50	27-77	Conventional	Length and Area	SE= 2.24
5	Arora <i>et al.</i> , ⁸ (2012 July)	Punjab	Original research	89	21-80	Digital	Length	Males
								$SE = \pm 4.59$
								Females SE- +3 77
9	Ramshaler <i>et al.</i> , (2013)	Heidelberg	Original research	129	26-89	Digital (luminance)	Arithmetic mean	$SE = \pm 7.69$
,		0	0				of luminescence	
	Singh <i>et a.</i> , p (2013)	Puducherry	Original research	50	20-75	Conventional & Digital	Length	$SE = \pm 5$
8	Sabarad <i>et al.</i> ¹⁰ (2014)	Karnataka	Original research	50	15-75	Conventional	Length, Area	SE=±10.93 for
								length SE=±8.26 for area
6	Ackermann <i>et al.</i> , ¹¹ (2014)	South Africa	Original research	537	20-90	Conventional	Length	SE=±15.1
10	Kottappagari <i>et al.</i> , ¹² (2014)	Andhra	Original research	50	51-65	Conventional	Length, Area	Males
		Pradesh))	$SE = \pm 13$
								Females
								3E= I11.2/
11	Acharya ⁴ (2014)	Karnataka	Original research	100	19-82	Digital	Area	SE=±11.73
12	Sushmma <i>et al.</i> , ² (2015)	Maharashtra	Original research	50	21-80	Conventional & Digital	Length	$SE = \pm 5$
								for both
13	Chopra <i>et al.</i> , ¹³ (2015)	Puducherry	Original research	200	20-79	Conventional & Digital	Length	$SE = \pm 5$
								for both
14	Puneeth <i>et al.</i> , ¹⁴ (2016)	Chennai	Original research	120	20-50	Digital	Length	Single rooted
								Double "00124
								SE=6.02±1.4
15	Gupta <i>et al.</i> , ¹⁵ (2017)	Jarkhand	Pilot study	62	21-62	Digital	Length	Males
	4))	SE =±5.85
								Females
								SE=±4.25
16	Gopika <i>et al.</i> , ¹⁶ (2017 Jan)	Chennai	Original research	30	25-55	Digital	Length	$SE=\pm 10$

Table 2. Regression formulas use	d for different geographic population			
Author & Year	Study Title	Sample size	Regression equation	<u> </u>
B Rai (2007)	Age determination from dental root ⁵	56	Not given	
Ashith B Acharya, V Simi (2009)	Effectiveness of Bang and Ramm's formulae in age assessment of Indians from dentin translucency length ⁶	100	Linear regression Age = $35.5619 + (3.4828 \times TL)$ Quadratic regression Age = $29.9074 + (7.4507 \times TL) + (-0.4369 \times T^2)$	
Ashit B Acharya (2010)	A new digital approach for measuring dentin translucency in Forensic age estimation ³	81	For conventional method Age = 41.1196 + (1.8424 × TL) For digital method Age = 40.0391 + (2.1063 × TL)	r
Singhal <i>et al.</i> , (2010)	A comparative analysis of root dentin transparency with known $age^{\tilde{\it Z}}$	50	For translucency length Age =22.25 +77.04 × TL For translucency area Age =31.42 +79.51 ×TA	
Arora <i>et al.</i> , (2012)	Age estimation in north Indians by digital assessment of root dentin translucency $^{\rm 17}.$	89	Linear regression Age = 31.162 + (2. 3015 × TL)	
Ramshaler <i>et al.</i> , (2013)	Validity and reliability of dental age estimation of teeth root translucency based on digital luminance determination	129	Age (F) = (-0.6175) + (0.5096×LUM mean) Age (M) = (-1.5335) + (0.5218×LUM mean)	
Singh <i>et al.</i> , (2013)	Digital approach for measuring dentin translucency in forensic age estimation ¹⁸	50	Conventional age = (32.3103) + (2.9452×TL) Digital Age = (32.0417) + (2.8151×TL)	
Sabarad <i>et al.</i> , (2014)	Chronological age estimation using transparent root dentin: A stereomicroscopic study ¹⁰	50	For translucency length Age =24. 49+4.37 × TL For translucency area Age =27.24 +0.93 ×TA	
Ackermann <i>et al.</i> , (2014)	A test of the Lamendin method of age estimation in South African Canines ¹¹	537	$Age = (0.18 \times P) + (0.42 \times TL) + 25.53$ $P = (Periodontosisheight \times 100/Root Length)$	
Kottappagari <i>et al.</i> , (2014)	Age estimation by assessment of dentin translucency in single- rooted permanent teeth ¹²	50	TL not statistically significant with age Linear regression for TA Age = 32.08 + (0.83 × TA) Multilinear regression by TL&TA Age = 3.0544 + ($7.4446 \times T^2A$) + (0.5591 × T L)	
			(Continued)	~

Table 2. to be continued			
Ashith B Acharya (2014)	Forensic dental age estimation by measuring root dentin translucency area using a new digital technique ⁴	100	Linear regression for TL Age = $35.56 + (3.48 \times TL)$ Quadratic regression Age = $29.91 + (7.45 \times T L) + (-0.44 \times TL^2)$ Linear regression for TA Age = $38.36 + (1.06 \times TA)$ Quadratic regression for TA Age = $31.75 + (2.97 \times TA) + (-0.77 \times TA^2)$
Sushmma <i>et al.</i> , (2015)	Comparative study of age estimation using dental translucency by digital and conventional methods ²	50	For conventional method Age = $25.874 + (5.597 \times TL)$ For digital method Age = $22.809 + (5.364 \times TL)$
Chopra <i>et al.</i> , (2015)	Conventional versus digital approach for measuring dentin translucency in forensic age estimation ¹³	200	For conventional method Age = $29.72 + (4.102 \times TL)$ For digital method Age = $29.823 + (3.930 \times TL)$
Puneeth HK <i>et a</i> l., (2016)	A comparative study of efficacy of single rooted and double rooted tooth in age estimation using dentin translucency ¹⁴	120	Linear regression (If T≥9mm): Age = 35.5619 + (3.4828 × TL) Quadratic regression (if T ≤9 mm) Age = 29.9074 + (7.4507 × TL) + (-0.4369×TL²)
Gupta <i>et al.</i> , ((2017)	Age estimation by dentin translucency measurement using digital method: An institutional study ¹⁵	62	Age = $25.28 + (1.81 \times TL)$
Gopika <i>et a</i> l., (2017 Jan)	Digital measurement of dentinal translucency in correlation with age maturity – A fact or fiction? ¹⁹	20	Age = $40.0391 + (2.1063 \times TL)$

order to examine the accuracy and precision of estimated dental age among diverse population groups.

A total of 1754 subjects from 16 published studies were included in the systematic review. All studies calculated the age differences as the difference in the mean of CA-DA. Here the Chronological age is the "gold standard "for all reported studies. A value $<\pm10$ years is considered "acceptable" in forensic age estimation.

Our findings illustrated that the dental age of adults from the dentin translucency method was overestimated higher than their chronologic age. The overestimated dental age differs from +2.24 to +15.1 years. Younger individuals have shown more translucent zone, which resulted in an overestimation of age. This flaw may be attributed to the presence of periodontal infections and diseases of the pulp. Chronic periodontal infections may stimulate far more mineralization resulting in the increased translucent zone in the root part of dentin.

Underestimation of age is very rarely reported in the higher age group of the North Indian population and Rohthak population. This is probably due to the slowing down of the process of sclerotic dentin formation in some individuals for various reasons. Further, beyond the age group, it is also possible that an increase in translucency does not take place because it could have attained the highest level by blocking all the dentinal tubules in that area and thus giving a static value of translucency after a particular age.

Minimum differences were reported for the Shimla population study by Shinghal *et al.*,⁷ with a difference in mean of +2.24 years. Maximum difference of +15.1 years was reported by Ackermann *et al.*,¹¹ (2014) for the South African population. Dental variability in the secondary dentin deposition process existing among distant population groups may be the reason for differences in age estimation threshold.

Reported variations might have been further affected by the methodology, sample size and distribution, examiner expertise, inter-individual variability, or the statistical testing carried out.

Strengths of the Review

• This will be the first and most comprehensive review of the accuracy and reliability of RDT-based dental age estimation in adults.

• Eligible studies screening, data extraction and quality assessment were performed by two independent reviewers to reduce the potential for reviewer bias.

Limitations of the Review

- Exclusion of articles that showed the results in median or percentages, articles which used the grading of RDT for age estimation, articles without full text and articles which were published other than English language.
- Inability to perform Meta-Analysis.
- The present study results warrant further exploratory studies to corroborate or negate the quantitative and qualitative observations of this systematic review. No other systematic review based on RDT-based age estimations was available from the accessible literature. Articles published between 2007 to 2017 were arbitrarily included in the present study because those were recent studies which alleged to give more precise estimates than those published before 2007. It is worth noting that a secular trend in dental maturity has been reported between subjects from different decades.

Recommendation

Studies with samples from different geographic and ethnic populations should be conducted for assessing the accuracy and precision of RDT-based age estimation in adults.

Conclusion

Besides some constraints, the current systematic review possesses some significant findings. According to the literature accessible to the authors, this is the first systematic analysis of age estimation of the adult population using the RDT method. Results clearly indicate RDT method overestimates dental age in nearly every population study for both sexes. Consequently, it becomes necessary to take into account further research on different geographic and ethnic population groups to establish different regression formulae to be able to obtain the most accurate and precise dental age estimates⁶.

Section /Topic	#	Checklist Item	Reported on Page #	
		TITLE		
Title	1	Identity the report as systematic review, meta-analysis or both	1	
Abstract				
Structural summary	2	Provides a structured summary including, as applicable: background: objectives:data sources: study eligibility criteria: participants: results: limitations; conclusions	1	
		Introduction		
Rationale	3	Describe the rationale for the review in context of what is already known	2	
Objectives	4	Provides an explicit statement of questions being addressed with reference to method, outcomes and study design.	2	
		Methods		
Eligibility criteria	5	Specify study characteristics, report characteristics (years considered, language, publication status) used as criteria for eligibility, giving rationale.	2	
Information sources	6	Describe all information sources (e.g., databases, study authors) in the search and date last searched.	2	
Search	7	Present full electronic search strategy for at least one database, including any limit used, such that it could be repeated.	2	
Study selection	8	State the process for selecting studies (i.e., screening, eligibility, included in systematic review)	2,3	
Data collection process	9	Describe the method of data extraction from reports	3	
Results				
Study selection	10	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusion, at each stage with diagram	4,5	
Result of individual studies	11	For all outcome considered for each study, simple summary data for each study group	6,7	
Discussion				
Summary of evidence	13	Summarize the main findings including the strength of evidence for each main outcome, consider their relevance	8,9	
Limitations	14	Discuss limitations at study and outcome level	10	
Conclusion	15	Provide a general interpretation of the results in the context of other evidence, and implications for future research	9, 10	

PRISMA Checklist

References

- Singh C, Singal K. Teeth as a Tool for Age Estimation: A Mini Review. J Forensic Sci Crim Inves. 2017; 6(3). https:// doi.org/10.19080/JFSCI.2017.06.555695
- 2. Bommannavar S, Kulkarni M. Comparative study of age estimation using dentinal translucency by digital and conventional methods. J Forensic Dent Sci. 2015; 7(1):71. https://doi.org/10.4103/0975-1475.150323 PMid:25709325 PMCid:PMC4330624
- Acharya AB. A New Digital Approach for Measuring Dentin Translucency in Forensic Age Estimation. Am J Forensic Med Pathol. 2010 Jun; 31(2):133-7. https://doi. org/10.1097/PAF.0b013e3181cf328d PMid:20081523
- 4. Acharya AB. Forensic Dental Age Estimation by Measuring Root Dentin Translucency Area Using a New Digital Technique. J Forensic Sci. 2014 May; 59(3):763-8. https:// doi.org/10.1111/1556-4029.12385 PMid:24602092
- 5. Rai B. Age determination from dental root.

- Acharya AB, Vimi S. Effectiveness of Bang and Ramm's formulae in age assessment of Indians from dentin translucency length. Int J Legal Med. 2009 Nov 16; 123(6):483-8. https://doi.org/10.1007/s00414-009-0346-7 PMid:19370359
- Singhal A, Ramesh V, Balamurali P. A comparative analysis of root dentin transparency with known age. J Forensic Dent Sci. 2010 Jan; 2(1):18-21. https://doi.org/10.4103/0974-2948.71052 PMid:21189985 PMCid:PMC3009549
- Arora J, Talwar I, Sahni D, Rattan V. Secondary dentine as a sole parameter for age estimation: Comparison and reliability of qualitative and quantitative methods among North Western adult Indians. Egypt J Forensic Sci. 2016 Jun 1; 6(2):170-8. https://doi.org/10.1016/j.ejfs.2016.05.006
- 9. Singh N, Grover N, Puri N, Singh S, Arora S. Age estimation from physiological changes of teeth: A reliable age marker? J Forensic Dent Sci. 2014 May; 6(2):113-21. https://doi.org/10.4103/0975-1475.132541 PMid:25125919 PMCid:PMC4130013
- 10. Sabarad P, Kalburge J. Chronological age estimation using transparent root dentin: A stereomicroscopic study. J Adv Med Dent Sci Res. 2014; 2(2):23-32.
- Ackermann A, Steyn M. A test of the Lamendin method of age estimation in South African canines. Forensic Sci Int. 2014 Mar; 236:192.e1-192.e6. https://doi.org/10.1016/j. forsciint.2013.12.023 PMid:24445081
- 12. Kattappagari KK, Kommalapati RK, Katuri D, Murakonda RS, Chitturi RT, Reddy BVR. Age estimation by assessment of dentin translucency in single rooted permanent teeth. J Int oral Heal JIOH. 2014; 6(6):37-40.
- Chopra V, Thodasam G, Ahmad ZH, Singh S, Rajawat I, Gupta S. Conventional versus digital approach for measuring dentin translucency in forensic age estimation. J Nat Sci Biol Med. 2015; 6(1):139-43. https://doi.org/10.4103/0976-9668.149112 PMid:25810651 PMCid:PMC4367025
- 14. Puneeth KH, Nandini DB, Praveen SB, Selvamani M, Mandana D. A comparative study of efficacy of single rooted and double rooted teeth in age estimation using

dentin translucency. J Forensic Odontostomatol. 2016 Dec 1; 2(34):1-10.

- Gupta S, Chandra A, Agnihotri A, Gupta OP, Maurya N. Age estimation by dentin translucency measurement using digital method: An institutional study. J Forensic Dent Sci. 2017; 9(1):42.
- 16. Gopika MG, Sunayana Manipal, Dinesh T, Rajmohan M, Naveen P, et al. Digital measurement of dentinal translucency in correlation with age maturity- A fact or fiction? J Indian Acad Forensic Med. 2017; 39(3):266-270. https://doi.org/10.4103/0975-1475.114558 PMid:23960415 PMCid:PMC3746473
- Tandon A, Agarwal V, Arora V. Reliability of India-specific regression formula for age estimation of population in and around Bahadurgarh, Haryana (India). J Oral Biol Craniofacial Res. 2015 Sep; 5(3):193-7. https://doi. org/10.1016/j.jobcr.2015.06.013 PMid:26587381 PMCid: PMC4623884
- Singh S, Venkatapathy R, Balamurali P, Charles N, Suganya R. Digital approach for measuring dentin translucency in forensic age estimation. J Forensic Dent Sci. 2013; 5(1):47. https://doi.org/10.4103/0975-1475.114558 PMid:23960415 PMCid:PMC3746473
- Manipal S, E Na. Digital measurement of dentinal translucency in correlation with age maturity- A fact or fiction? *J Indian Acad Forensic Med.* 2017; 39(3):266 https:// doi.org/10.5958/0974-0848.2017.00051.3
- 20. Priyadarshini C, Puranik MP, Uma SR. Dental age estimation methods: A review. Int J Adv Heal Sci. 2015;
- Bommannavar S, Kulkarni M. Comparative study of age estimation using dentinal translucency by digital and conventional methods. J Forensic Dent Sci. 2015; 7(1):71-5. https://doi.org/10.4103/0975-1475.150323 PMid:25709325 PMCid:PMC4330624
- 22. Willems G. A review of the most commonly used dental age estimation techniques. J Forensic Odontostomatol. 2001; 19(1):9-17.

How to cite this article: Abhirami P. T. and Bose C. T. Root Dentin Translucency based Dental Age Estimation in Adults: A Systematic Review. J Forensic Dent Sci. 2021; 13(2):97-106.

Access this a	article online		
	Quick Response Code		
Website: www.jfds.org			