Coronal pulp: An age biomarker – A cross-sectional radiographic study in children

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Abstract

Background: Age plays an important role in personal identification, treatment planning, forensic dentistry, and legal issues. It is one of the key identification tools for distinguishing one person from another and one population from another. An intraoral radiographic technique for age estimation is an easier approach. The widely accepted age estimation method in children is the Demirjian system. Tooth coronal index is another method that gained popularity for adult age estimation.

Aim: This study aims to estimate the tooth coronal index (TCI) of mandibular right and left second deciduous molar and its correlation with chronological age to derive a regression equation.

Settings and Design: The present study is a cross-sectional radiographical study which is conducted in AME's Dental College and Hospital, Raichur, Karnataka, India.

Materials and Methods: A total of 100 children aged 5–10 years were selected. Digital intraoral periapical radiographs were taken for right and left deciduous mandibular second molar. The length of the tooth crown and the coronal pulp cavity were measured. Statistical Analysis: Further, the data are subjected to student's unpaired *t*-test and ANOVA test for the statistical analysis and simple linear regression to derive the regression equation.

Results: TCI showed a statistically significant reduction with increasing age in both right and left mandibular deciduous second molar ($P \leq 0.05$), and the strength of the correlation is moderate ($r = -0.59$) if age is correlated with TCI using simple linear regression.

Conclusion: The tooth coronal index method is found as a simple, noninvasive, nondestructive and cost-effective method for age assessment in children.

Keywords: Age estimation, children, teeth, tooth coronal index

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INTRODUCTION

Age, gender, race, stature and other features of an individual are key identification tools for the forensic odontology that efficaciously distinguish one person from others and one populace from another.[1] Age estimation is an important requisite in the clinical practice, especially for growing patients. It is essential to decide the timing of the orthodontic treatment, to achieve a more stable outcome.

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Age estimation even has its application outside medical and dental sciences in certain issues for instance child marriages, inflating the number of child laborers and children trafficked for commercial and sexual exploitation. Teeth are unique forensic tool to aid in personal identification and age estimation as they are enormously durable, immune to putrefaction, fire and chemicals.[2]

Different skeletal, odontology, anthropologic and psychological methods allow an appropriate assessment of age in children of the growth stage. Age estimation employing teeth can be assessed by morphological, histological, biochemical and radiographic methods.[3] Among all, Demirjian system has gained extensive recognition in children.[4]

In 1925, Bodecker identified the secondary dentine apposition as being related to chronological age.[5] Ikeda *et al*. in 1985 developed tooth coronal index (TCI) for age estimation from radiographs taken on extracted teeth.[6] Furthermore, Drusini in 1993 followed the established technique of Ikeda *et al*. and verified the negative correlation between the TCI and the chronological age.[7] According to Babshet *et al*., radiographic evaluation of secondary dentin, conceivably the best noninvasive approach to estimate age from fully developed teeth in a living individual.[8]

Many studies are conducted in the adult population to derive a regressive formula for age estimation using the TCI method. However, no studies had been carried out in deciduous dentition using this method. Hence, the present study aims to estimate age from TCI of deciduous mandibular second molars using digital intraoral periapical radiograph of known age and gender. Furthermore, to develop regression equations those apply to the local population.

MATERIALS AND METHODS

The present study was conducted in the Department of Pedodontics and Preventive Dentistry, AME's Dental College and Hospital, Raichur, Karnataka, India, for a period of 3 months (August to October 2018) after obtaining the approval from the Ethical Committee of the institution (IEC-152/18-19).

Sample size determination

Based on the previous study,[9] taking alpha error as 0.05 and power as 95%, a total of 100 children (200 mandibular molars) who fit into the following inclusion criteria were included in the study.

Inclusion criteria

- Children age 5–10 years who are willing to participate in the study along with their parental consent
- Children having intact right mandibular deciduous second molar (85) and left mandibular deciduous second molar (75)
- Belonging to local area, i.e., Raichur District, Karnataka, India.

Individuals with the following conditions were excluded from the study:

- Children with missing any of the deciduous left and right mandibular second molar
- Absence of pathologies such as dental caries, periapical and periodontal pathologies
- Filled/prosthetically restored tooth
- Tooth with morphological abnormalities, attrition/abrasion
- Children having systemic diseases.

Study design and Selection of the participants

It was a cross-sectional study planned and conducted according to the STROBE guidelines. The samples were recruited based on gender-stratified probability sampling. Study participants were those children who reported to the department of pedodontics and preventive dentistry for their treatment needs.

Procedure and measurements

Radiovisiography (Intra OS 70 Blue X, 70kvp, 7Ma, with 200 ms exposure time) of both left and right sides were taken for the children who met the inclusion criteria. Two radiographs were taken in every child for clinical needs following the ALARA principle. In the meantime, the biological age and gender of the child were noted.

Measuring lines include two vertical lines were drawn on all radiographs with a fully visible pulp cavity which includes crown height (CH) and coronal pulp cavity height (CPCH). Tooth coronal index (TCI) was then calculated for each tooth as follows:

$$TCI = CPCH \times 100/CH.$$

Measuring lines [Figure 1]:

- Reference line is the line that connects the mesial and distal cemento-enamel junction and divides the tooth into crown and root
- CH is the maximum perpendicular distance from the cervical line to the tip of the highest cusp of the tooth
- Pulp height is the distance from the cervical line to the coronal tip of the pulp chamber generally from the mesial pulp horn as the mesial pulp horn is higher.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences software version 19 (SPSS Inc., Chicago, IL, USA). Descriptive statistics such as mean, median, standard deviation and the percentage were used. A comparison of mean values was carried out using a student's unpaired *t*-test for two groups and ANOVA for more than two groups. Pearson correlation was done to detect the association between the two continuous variables. Simple linear regression was carried out by regressing the TCI score against age for a different tooth for boys, girls and combined samples. $P < 0.05$ was considered statistically significant.

RESULTS

Out of 100 participants, boys represent 45%, whereas girls were 55%, with a mean age of 7.31 ± 1.63 years [Table 1]. Mean TCI was found to be 39.296 ± 4.01 for 75and 39.356 ± 3.97 for 85, respectively [Table 2]. When TCI of the right and left teeth were compared with age, there was a reduction of TCI as the age progresses, which is the high statistical significance ($P = 0.001$) [Table 3]. As the mean TCI score of the right and left tooth were compared based on gender, there was no statistically significant difference ($P = 0.417$) [Table 4]. A negative correlation exists between TCI of both 75, 85 and age in all studied subjects which are represented in Table 5. The correlation is more in females than males ($r^a = 0.602$-0.591) for left second molars and more in males than females for right second molar ($r^a = 0.594$-0.584), respectively. Regression analysis used for TCI to determine the age is demonstrated in Table 6. The regression equations for the determination of age (Y) using the TCI score of 75and 85 are:

$$Y \text{ (Combined sexes)} = 16.853–0.243 \times_1 \text{ Combined sexes}$$

$$Y \text{ (Boy)} = 17.162–0.249 \times_1 \text{ Boys}$$

$$Y \text{ (Girl)} = 16.503–0.235 \times_1 \text{ Girls}$$

X_1 is the TCI score of 75.

$$Y \text{ (Combined sexes)} = 16.810–0.241 \times_2 \text{ Combined sexes}$$

$$Y \text{ (Boy)} = 17.524–0.257 \times_2 \text{ Boys}$$

$$Y \text{ (Girl)} = 16.140–0.226 \times_2 \text{ Girls}$$

X_2 is the TCI score of 85.

Scatter plot for age and TCI of 75 and 85 for combined gender, boys and girls are shown in Figures 2-7.

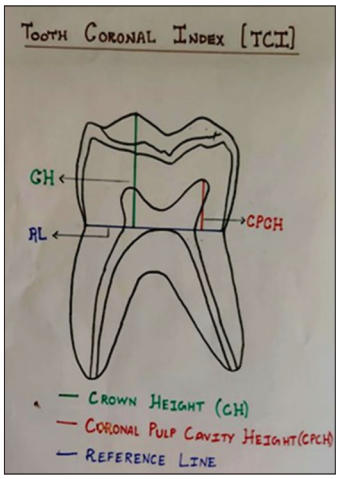

Figure 1: Tooth coronal index measuring lines

DISCUSSION

To the best of our knowledge, current research is the only work that studied the TCI of the deciduous tooth for age estimation. The applicability of TCI in forensic sciences has previously established in the adult population.[9,10] In the present study, the radiographic method was employed as, it is a noninvasive, economic, simple and time-saving method. Digital radiography has various advantages over conventional techniques, such as instant image viewing, reduced radiation exposure, enhanced image quality and reusable plate. Digital radiography is more feasible and cost-effective, and the resolution of an image is also higher compared to orthopantomogram.

One of the biases from child to child is the change in angulation of the radiographic cone instigating elongation or shortening of the image. To avoid this, a radiograph was made using a parallel technique using an Extended

Table 1: Distribution of children according to age

Age (in years)	*n* (%)	Boys, *n* (%)	Girls, *n* (%)	Minimum	Maximum	Median	Mean±SD[a]
5	17 (17.0)	8 (17.8)	9 (16.4)	5	10	7.00	7.31±1.63
6	18 (18.0)	6 (13.3)	12 (21.8)				
7	20 (20.0)	9 (20.0)	11 (55.0)				
8	20 (20.0)	9 (20.0)	11 (20.0)				
9	12 (12.0)	5 (11.1)	7 (12.7)				
10	13 (12.0)	8 (17.8)	5 (9.1)				
Total	100 (100.0)	45 (100.0)	55 (100.)				

SD: Standard deviation

Cone Paralleling Instrument (XCP Holder) (Dentsply). Furthermore, the second primary molar was selected, as in children aged between 5 and 10 years, the first primary molar will be in various stages of resorption and second molars are the tooth that remains in the oral cavity for a longer period. Measurements were taken using the dental imaging software. The use of an index (TCI) instead of absolute values reduces possible errors from different scales of X-ray photos.[9,11] Measurements were carried out by a single calibrated observer to exclude the interobserver variability. In this study, the TCI was calculated using the mandibular teeth as mandibular radiographs will have more clarity than the maxillary tooth because of its palatal root.[9]

Table 2: Tooth coronal index score of deciduous mandibular left (75) and mandibular right (85) second molar

Tooth	Mean±SD	Minimum	Maximum	Median
75	39.296±4.01	24.615	45.312	40.473
85	39.356±3.97	24.000	45.312	40.149

SD: Standard deviation

Table 3: Comparison of tooth - coronal index of the right and left teeth with age

Age (in years)	*n* (%)	Mean±SD		ANOVA
		TCI Score (75)	TCI Score (85)	
5	17 (17.0)	42.528±2.31	42.495±2.27	*P*=0.001**
6	18 (18.0)	40.594±2.63	40.625±2.73	
7	20 (20.0)	40.434±2.17	40.484±2.20	
8	20 (20.0)	38.753±2.86	38.800±2.75	
9	12 (12.0)	36.915±4.70	37.131±4.62	
10	13 (12.0)	34.555±4.98	34.666±5.07	

P<0.05 is considered significant. SD: Standard deviation, TCI: Tooth Coronal Index, **P*<0.01 is Highly statistical Significant

Table 4: Comparison of Tooth Coronal Index of the right and left teeth between gender

Gender	*n* (%)	Mean±SD		Student *t*-test
		TCI Score (75)	TCI Score (85)	
Boys	45 (45.0)	38.934±4.07	39.074±3.96	*P*=0.417
Girls	55 (55.0)	39.592±3.97	39.586±4.01	

SD: Standard deviation, TCI: Tooth Coronal Index

Current work revealed a significant reduction of the coronal pulp chamber height with age which is per studies by Drusini, Drusini, Zadinska *et al*. and Karkhanis *et al*. and Nagammai *et al*.[7,12-16] Evaluation of tooth coronal index is an indirect assessment of secondary dentin deposition. Secondary dentin begins to form once when the tooth crown is fully formed. This secondary dentin is deposited by odontoblasts lining the pulp chamber continuously throughout life since this is laid down at the pulpal end, there will be a reduction of pulp cavity with age.

Furthermore, this study revealed that there is no difference in TCI with gender which states that gender of an individual has no significant influence on age estimation so that gender-specific formulae are not needed for age estimation in the specimens of unknown sex. In contrast to our findings, studies done by Agematsu *et al*., Igbigbi and Nyirenda, Singal *et al*. mentioned that gender had a significant influence on the TCI values.[17-19] They attributed these differences to the effect of estrogen on the formation of secondary dentin. Hietala *et al*. and Jukić *et al*. reported the existence of an estrogen receptor in odontoblast of human pulp tissues.[20,21] Besides, Yokose *et al*. reported that estrogen deficiency promotes the substrate synthesis of odontoblast.[22] This information suggests that estrogen exerts a strong influence on the formation of secondary dentin.

Table 5: Correlation of age with Tooth Coronal Index score of deciduous mandibular left and right second molar

Tooth	Combined		Males		Females	
	R[a]	*P*	*R*	*P*	*R*	*P*
Deciduous mandibular left second molar (75)	−0.599	0.01*	−0.591	0.01*	−0.602	0.01*
Deciduous mandibular right second molar (85)	−0.590	0.01*	−0.594	0.01*	−0.584	0.01*

[a]*R* – Pearson's correlation coefficient. **P*<0.05 is considered significant

Table 6: Equation predicting age (Y) from proportion of tooth coronal index by side and tooth position for boys, girls and sexes combined

Tooth	Combined		Males		Females	
	R[a]	*P*	*R*	*P*	*R*	*P*
Deciduous second molars	*n*	Intercept	Slope	*r*	r^2	SEE
Combined sexes						
Left side (75)	100	16.853	−0.243	0.599	0.359	1.308
Right side (85)	100	16.810	−0.241	0.590	0.348	1.319
Boys						
Left side (75)	45	17.162	−0.249	0.591	0.350	1.398
Right side (85)	45	17.524	−0.257	0.594	0.353	1.394
Girls						
Left side (75)	55	16.503	−0.235	0.602	0.362	1.252
Right side (85)	55	16.140	−0.226	0.584	0.341	1.272

[a]*R* – Pearson's correlation coefficient. *r*: Coefficient of correlation, r^2: Coefficient of determination, SEE: Standard error of estimate

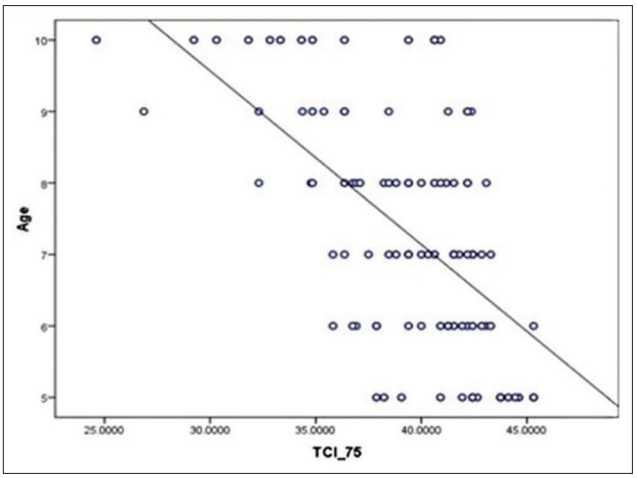

Figure 2: Scatter plot for age and TCI of 75 (combined gender)

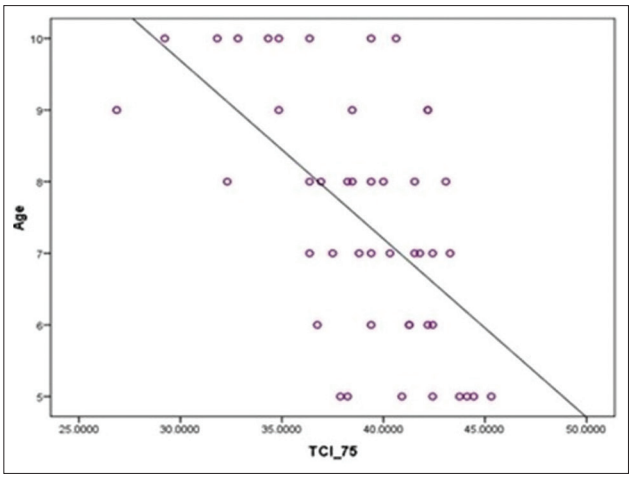

Figure 3: Scatter plot for age and TCI of 75 (boys)

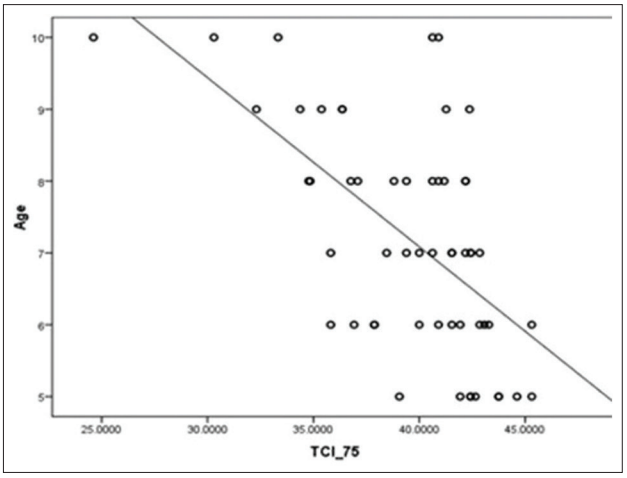

Figure 4: Scatter plot for age and TCI of 75 (girls)

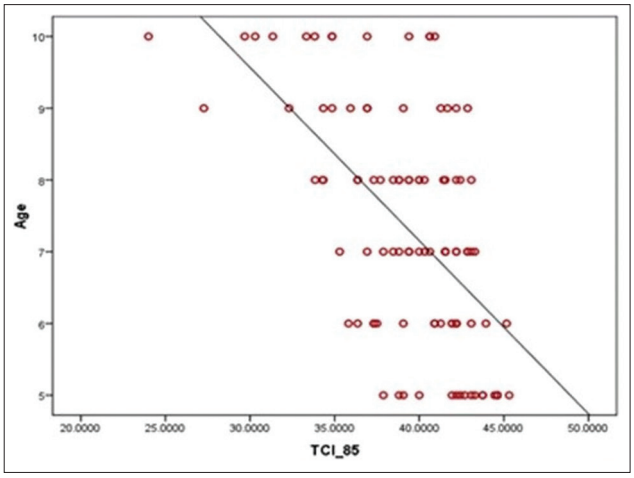

Figure 5: Scatter plot for age and TCI of 85 (combined gender)

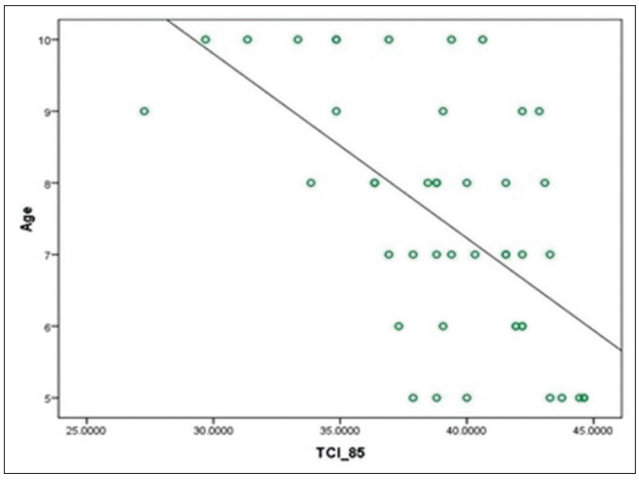

Figure 6: Scatter plot for age and TCI of 85 (boys)

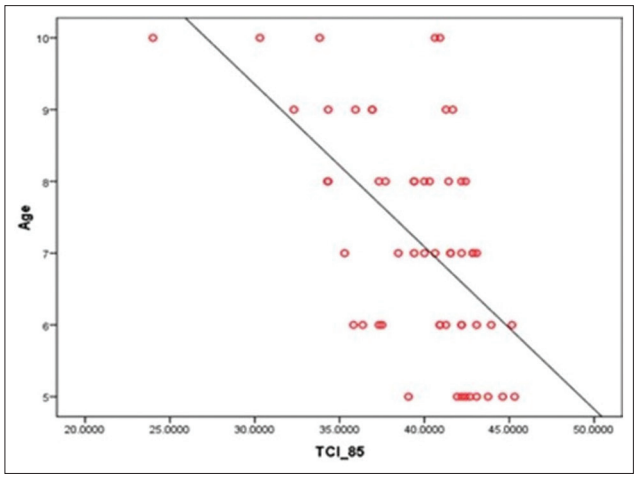

Figure 7: Scatter plot for age and TCI of 85 (girls)

Moreover, this study also demonstrated that there is no significant difference between right and left sides TCI which shows any primary molar tooth can be used as an age estimation tool irrespective of side. The strength of the correlation found in this study is moderate ($r = -0.59$) when compared with other studies on permanent dentition which has a high correlation (Drusini [$r = 0.92$]). This may be due to relatively less age gap among samples of the

present work as the age ranged from 5 to 10 years, with a mean age of 7.31 ± 1.63 years, while other studies were done on adults whose age ranges from 20 to 70 years. Moreover, Philippas have reported that aging had a greater effect on the formation of secondary dentin.[23]

The limitations of the present study are that it was conducted on a specific population with limited sample; therefore, further studies should be carried out on different populations, in different geographical locations, with larger sample sizes including other teeth for better knowledge about this age estimation method in children. Moreover, also, this equation cannot be used in teeth with dental caries because of the loss of tooth material that leads to improper measurements. Recent literature shows that TCI is compared with Cameriere's method and Olze's method and was found to be of limited use in age estimation.[24,25] Hence, there is a need for further studies to be carried out to compare the TCI with other age estimation methods in deciduous dentition.

CONCLUSION

Tooth coronal index method is found as a simple, noninvasive, nondestructive, cost-effective method for age assessment in children. The present study concluded that

- The TCI values concurrently decreased with development progression in children and adolescents
- Gender did not influence the TCI values.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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