

## Tooth coronal index biomarker for age estimation using digital panoramic radiography- A retrospective study

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### Abstract

**Background:** A study was carried out to analyze the efficacy and practical application for age estimation using digital panoramic radiograph to exploit image analysis to obtain metric measurement of morphologic parameters of permanent right and left mandibular 1<sup>st</sup> molar and 2<sup>nd</sup> premolar.

**Aim:** To know the significance of tooth coronal index with age and to select a tooth which is reliable for prediction of actual age.

**Objective:** To compare original age with the estimated age of right and left mandibular 1<sup>st</sup> molar and 2<sup>nd</sup> premolar.

**Materials and Methods:** The OPG of 100 subjects aged 20-50 years were selected for the study. The crown height and coronal pulp cavity height were measured of right and left quadrants of 1<sup>st</sup> molar and 2<sup>nd</sup> premolar and tooth coronal index was calculated and actual age compared with tooth coronal index of each tooth.

**Statistical Analysis Used:** Pearson correlation co-efficient was used to find the significance of the relationship between age and tooth coronal index. Regression analysis was used for predicting age using tooth coronal index for right and left 1<sup>st</sup> molar and 2<sup>nd</sup> premolar.

**Results:** Results revealed that there is no significant correlation between the estimated age and actual age and this study reveals that right mandibular 1<sup>st</sup> molar has more accuracy than other selected teeth.

**Conclusion:** Tooth coronal index has the potential to estimate age of an individual on dental radiographs.

**Keywords:** Age estimation, panoramic radiograph, Tooth coronal index, Pulp cavity height, Pulp/tooth ratio.

### Introduction

Age estimation is an important part of one's identification process in the discipline of forensic science. Declaration of age is not only important for legal, ethical issues, and death reports but also an essential for living persons to clarify criminal and civil liability and social issues.<sup>1</sup> Human teeth proved to be the most reliable biological marker in forensic science as they withstand death and sustain themselves for many thousands of years without changes.<sup>2,3</sup> In forensic odontology, dental tissues are used for estimation of chronological age of individuals for orthodontic treatment, pediatric, and legal issues.<sup>4</sup> Tooth development shows less variability than other developmental features and shows low variability in relation to chronological age.<sup>5</sup> Moreover, dental tissues are more resistant to thermal, chemical, and mechanical stimuli and are less affected by endocrine diseases or nutritional variations than other tissues. Therefore, teeth form a unique and suitable parameter for dental age estimation.<sup>6</sup> In adults morphologic, histological, and biochemical methods analyze various forms of tooth modification such as tooth wear, dentin transparency, tooth cementum annulation, racemization by aspartic acid, and apposition of secondary dentin. These methods require tooth extraction and are invasive for living individuals.<sup>6</sup> To overcome this limitation, noninvasive radiographic methods have been developed that are simple and require less

expertise. In adults various methods have been developed to calculate age from dental tissue and tooth morphology.<sup>7</sup> These methods are classified as: radiologic and morphologic methods. Morphologic methods are sub classified into clinical, histological, and biochemical examination. Radiographic methods are simple, nondestructive, requires comparatively less duration of time, and expertise than morphologic methods.<sup>6</sup> The present study was undertaken in the department of Oral Medicine and Radiology, Al-badar Dental College and Hospital, Gulbarga, Karnataka, India with the aim to know the significance of the tooth coronal index with the actual age and prediction of suitable tooth as a indicator for age.

### Materials and Methods

A total of 100 digital panoramic radiographs, obtained through our department computer using CARE STREAM SOFTWARE and were selected for the study from the archives of department based on the inclusion and exclusion criteria. The digital panoramic radiographs of 100 subjects of Gulbarga aged 20–70 years were analyzed.

### Inclusion criteria

Patients of both sexes aged between 20-70 years, having fully erupted mandibular right and left molar and second premolar with no defects were included in the study.

### Exclusion criteria

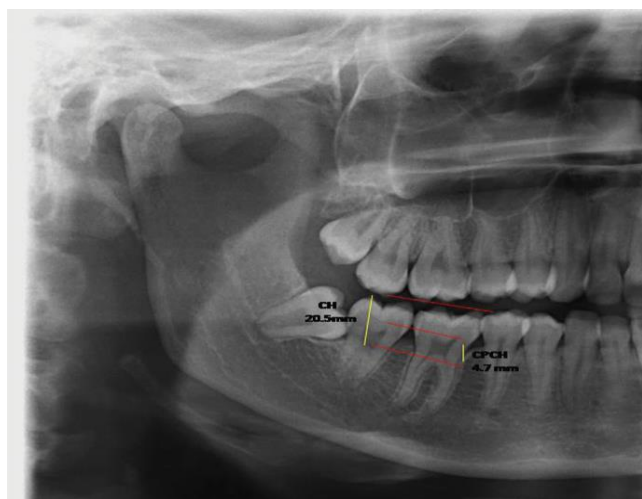
Digital panoramic radiographs with distorted image, carious/grossly decayed mandibular right and left second premolar, molars or periapical pathology, prosthesis, restored selected teeth, missing selected teeth, severely attrited or fractured selected teeth, rotated or maligned selected teeth, and teeth with any developmental anomalies were excluded from the study

### Radiographic measurements

All 100 panoramic radiographs were subjected to radiographic measurements. They were measured using CARE STREAM SOFTWARE. All the measurements were recorded in millimeters.

### Measurement of TCI

To ensure the accuracy of the technique used for measuring TCI the detailed reference points used were, cervical line that connect two landmarks to be measured, the mesial and distal cementoenamel junction points, and divides the tooth into crown and root. Crown height is the maximum perpendicular distance from the cervical line to the tip of the highest cusp of teeth. While coronal pulp cavity height is the distance from the cervical line to the coronal tip of the pulp chamber. The height of the crown (coronal height [CH]) and the height of the coronal pulp cavity (coronal pulp cavity height [CPCH]) was digitally measured using CARE STREAM SOFTWARE on the computer screen. With this measurement, the coronal tooth cavity index was calculated for each tooth with the help of following formula, as suggested by Ikeda et al.<sup>8</sup>  $TCI = (CPCH \times 100)/CH$



**Fig. 1:** Panoramic image showing measurements on right mandibular second premolar to calculate TCI

### Statistical analysis

The calculated data were entered in a Microsoft Excel spreadsheet. Statistical analysis was done using the statistical analysis software, statistical package for the Social Science, Version 23. A Regression analysis were performed comparing the original age and calculated age, using the approach of Bland and Altman.<sup>20</sup> Pearson's correlation coefficient was applied between the actual age and TCI of mandibular right and left molar and second premolar. P value  $\leq 0.05$  was considered statistically significant.

### Results

The study involved 100 subjects of which 55 were males and 45 were females with mean real age of  $30.5 \pm 8.6$ . The mean value of TCI mandibular right and left 1<sup>st</sup> molar was  $25.3 \pm 6.8$  and  $23.8 \pm 6.7$  respectively. The mean value of TCI mandibular right and left 2<sup>nd</sup> premolar was  $20.9 \pm 4.9$  and  $21.3 \pm 5.6$  respectively [Table 1].

The t value of mandibular right 1st molar is 3.97 and  $R^2 = 0.138$  which shows  $p < 0.001$  which is statistically not significant. The t value of mandibular left 1st molar is 2.345 and  $R^2 = 0.053$  which shows  $p = 0.000$  which is also statistically not significant. The standard error of estimate of mandibular right and left 1st molar was 7.97 and 8.36 respectively. The t value of mandibular right and left 2nd premolar was 1.666 and 0.608,  $R^2$  value is 0.027 and 0.004, and standard error of estimate was 8.477 and 8.579 respectively which p value was statistically was not significant [Table 2].

Table 3 and Table 4 shows the regression analysis done on female and male. The t value in female on tooth mandibular right and left 1<sup>st</sup> molar was 4.64 and 3.782,  $R^2$  value was 0.362 and 0.273, standard error of estimate was 6.07 and 6.485 which showed p value statistically not significant. The t value in female on tooth mandibular right and left 2<sup>nd</sup> premolar was 2.412 and 0.786,  $R^2$  value was 0.133 and 0.016, standard error of estimate was 7.086 and 7.548, p value was 0.021 and 0.437 which was statistically not significant [Table 3]. The t value of in male of mandibular right and left 1<sup>st</sup> molar was 2.130 and 0.719, p value was 0.000 and 0.009,  $R^2$  value was 0.073 and 0.009, standard error of estimate was 8.761 and 9.057, which showed result statistically not significant. The t value of male on tooth mandibular right and left 2<sup>nd</sup> premolar was 0.148 and 0.303, p value was 0.883 and 0.763,  $R^2$  value was 0.000 and 0.002, standard error of estimate was 9.096 and 9.090 which also showed result statistically not significant [Table 4].

The mean value of actual age and estimated age of mandibular right 1<sup>st</sup> molar in males were  $31.7 \pm 9.0$  and  $30.18 \pm 3.24$  and on left mandibular 1<sup>st</sup> molar it was  $31.7 \pm 9.0$  and

30.27 ± 2.00 The mean value of actual age and estimated age in males of tooth mandibular right 2<sup>nd</sup> premolar was 31.7 ± 9.0 and 30.57 ± 1.42 and on mandibular left 2<sup>nd</sup> premolar it was 31.7 ± 9.0 and 30.56 ± 0.54. All the teeth showed statistically nit significant result.[table 5] The mean value of actual age and estimated age in females on mandibular right 1<sup>st</sup> molar showed 28.6 ± 7.5 and 30.3 ± 3.0 and on left mandibular 1<sup>st</sup> molar it was 28.6 ± 7.5 and 30.4 ± 1.9. The t value of actual age and estimated age in females on tooth mandibular right 2<sup>nd</sup> premolar showed 28.6 ± 7.5 and 30.0 ± 1.3 and on left mandibular 2<sup>nd</sup> premolar it was 28.8 ± 7.5 and

30.3 ± 0.4 which showed statistically not significant result [Table 5].

Over all result of the actual age and estimated age on mandibular right 1<sup>st</sup> molar was 30.5 ± 8.6 and 30.21±3.12 and on left mandibular 1<sup>st</sup> molar was 30.5 ± 8.6 and 30.31 ± 1.94. The actual age and estimated age in all individuals on mandibular right 2<sup>nd</sup> premolar was 30.5 ± 8.6 and 30.33 ± 1.39 and on mandibular left 2<sup>nd</sup> premolar it was 30.5 ± 8.6 and 30.45 ± 0.52. All the results showed statistically not significant result.

**Table 1:** Descriptive of various parameters

Parameter	Male		Female		Overall	
	Mean	SD	Mean	SD	Mean	SD
Age	31.7	9.0	28.6	7.5	30.5	8.6
TCI (RM)	25.2	7.0	25.4	6.5	25.3	6.8
TCI (RPM)	21.8	5.1	19.7	4.5	20.9	4.9
TCI(LM)	23.7	6.9	24.1	6.4	23.8	6.7
TCI (LPM)	22.6	5.9	19.4	4.7	21.3	5.6

**Table 2:** Regression Analysis for age estimation [overall]

Tooth	Parameter	Coefficient	SE	t value	P value	R square	SE of Estimate	Regression equation
RM	Constant	18.596	3.093	6.013	<0.001**	0.138	7.97	Y = 18.59 +0.46*X
	TCI	0.469	0.118	3.967	<0.001**			
RPM	Constant	24.468	3.703	6.608	<0.001**	0.027	8.477	Y = 24.468+0.28*X
	TCI	0.286	0.172	1.660	0.100			
LM	Constant	23.409	3.118	7.509	0.000	0.053	8.36	Y = 23.40 + 0.29*X
	TCI	0.295	0.126	2.345	0.021			
LPM	Constant	28.465	3.375	8.434	0.000	0.004	8.579	Y = 28.46 + 0.093*X
	TCI	0.093	0.153	0.608	0.545			

The above table shows that Right Molar has 13.6% accuracy, Right Premolar has 2.7% accuracy, Left molar has 5.3% accuracy and Left premolar has 0.4% accuracy in age estimation

**Table 3:** Regression analysis for age estimation (Female)

Tooth	Parameter	Coefficient	SE	t value	P value	Rsquare	SE of Estimate	Regression equation
RM	Constant	10.796	3.943	2.738	.009	0.362	6.07	Y = 10.796+0.70*X
	TCI	.700	.151	4.643	.000			
RPM	Constant	16.667	5.053	3.299	.002	0.133	7.086	Y = 16.66 +0.60*X
	TCI	.603	.250	2.412	.021			
LM	Constant	13.892	4.009	3.465	.001	0.273	6.485	Y = 13.89 + 0.609*X
	TCI	.609	.161	3.782	.001			
LPM	Constant	24.641	5.116	4.816	.000	.016	7.548	Y = 24.64 +0.201*X
	TCI	.201	.256	.786	.437			

The above table shows that Right Molar has 36.2% accuracy, Right Premolar has 13.3% accuracy, Left molar has 27.3% accuracy and Left premolar has 1.6% accuracy in age estimation

**Table 4:** Regression analysis for age estimation (Male)

Tooth	Parameter	Coefficient	SE	t value	P value	Rsquare	SE of Estimate	Regression equation
RM	Constant	23.02	4.235	5.436	.000	0.073	8.761	Y = 23.02 +0.34*X
	TCI	.345	.162	2.130	.037			
RPM	Constant	30.966	5.209	5.944	.000	0.000	9.096	Y = 30.96 +0.035*X
	TCI	.035	.233	.148	.883			
LM	Constant	28.792	4.232	6.804	.000	0.009	9.057	Y = 28.79 + 0.124*X
	TCI	.124	.172	.719	.475			
LPM	Constant	33.100	4.707	7.031	.000	.002	9.090	Y = 33.1 +(-0.061)*X
	TCI	-.061	.202	-.303	.763			

The above table shows that Right Molar has 7.3% accuracy, Right Premolar has 0% accuracy, Left molar has 0.9% accuracy and Left premolar has 0.2% accuracy in age estimation.

**Table 5:** Comparison of actual age with estimated age by various tooth

**A. Male**

Parameter	Actual age		Estimated age		P value
	Mean	SD	Mean	SD	
RM	31.7	9.0	30.18	3.24	0.885 NS
RPM	31.7	9.0	30.57	1.42	0.271 NS
LM	31.7	9.0	30.27	2.00	0.276 NS
LPM	31.7	9.0	30.56	0.54	0.281 NS

NS- Not significant (p>0.05)

There is no statistically significant difference present in the estimated age and the Actual age in male.

**B. Female**

Parameter	Actual age		Estimated age		P value
	Mean	SD	Mean	SD	
RM	28.6	7.5	30.3	3.0	0.089 NS
RPM	28.6	7.5	30.0	1.3	0.212 NS
LM	28.6	7.5	30.4	1.9	0.094 NS
LPM	28.6	7.5	30.3	0.4	0.154 NS

NS- Not significant (p>0.05)

There is no statistically significant difference present in the estimated age and the Actual age in female.

**C. Overall**

Parameter	Actual age		Estimated age		P value
	Mean	SD	Mean	SD	
RM	30.5	8.6	30.21	3.12	0.767 NS
RPM	30.5	8.6	30.33	1.39	0.890 NS
LM	30.5	8.6	30.31	1.94	0.867 NS
LPM	30.5	8.6	30.45	0.52	0.995 NS

NS- Not significant (p>0.05)

There is no statistically significant difference present in the estimated age and the Actual age.

## Discussion

Identification of the person is the first basis of any forensic investigation. Dental radiographs of adult teeth are rarely used in age estimation. This study measures the morphometric values of pulp on digital panoramic radiographs for the mandibular 2nd pm and 1st molar of the right and left quadrant, there by calculating TCI for each tooth. The present study is based on the nondestructive method suggested by Ikeda et al<sup>8</sup> found high correlation that the extent of pulp cavity is visible in premolars and molars in panoramic radiographs as shown by Drusini and El Morsi.<sup>9,10</sup>

Radiographic measurements are more accurate and have good reproducibility in comparison to other techniques Juneja M<sup>11</sup> and Saxena S.<sup>12</sup> More precise age estimation method, TCI was introduced by Ikeda et al,<sup>8</sup> several studies in literature have measured TCI of mandibular teeth on panoramic radiographs and correlated it with chronologic age.<sup>11</sup>

The study results are in agreement with the study results done by Drusini et al,<sup>9</sup> Zadinska et al<sup>13</sup> Shrestha et al.<sup>4</sup> Khattab et al.<sup>14</sup> And Karkhanis et al,<sup>15</sup> that there is no sex difference in TCI.

The present study shows 13.6% accuracy in right 1st molar and 2.7 % accuracy in right 2nd premolar which is less compared to study of Gotmare et al.<sup>16</sup> Which shows 63% accuracy in right 1<sup>st</sup> molar and 56% accuracy in right 2nd premolar and study of Veera et al,<sup>6</sup> which shows very high accuracy for both right molar and premolar which is 97% and 98% respectively. The present study has better result then the study of Nagi S et al.<sup>17</sup> and Jain S et al,<sup>18</sup> Which shows 9.2% and 2.2% accuracy in right 1st molar respectively.

The present study showed that the coefficient of correlation between actual age and predicted age were found to be high in right mandibular 1st molars similar to those of Ikeda et al.<sup>8</sup> Gotmare et al.<sup>16</sup> and came in accordance with the studies of Igbibi and Nyrindra<sup>19</sup> and Veera<sup>6</sup> Moreover in our study correlation was high for Right 1st molar compared to left 1st molar and right and left 2nd premolar indicating right mandibular as a more reliable indicator for dental age. The result of the present study is applicable to the limited sample size and similar groups.

## Conclusion

In this study TCI showed strong negative correlation with actual age. In age estimation studies, dental attrition is a factor, which must be acknowledged. Future studies on different population, in different geographical locations, on

other teeth should be conducted and should also take into account various environmental, racial, genetic, and cultural factors.

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None.

## Conflict of Interest

None.

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