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Age Estimation Using Monoradicular Teeth by comparing Pulp/Tooth Area Ratios between Bucco-lingual and Mesio-distal Periapical Radiographs

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ABSTRACT

Background: Age estimation is an integral tool in identification of the victims when visual identification is not possible. Secondary dentin deposition is a regular ageing process and can be utilized in dental age estimation when development and eruption parameters cannot be utilized.

Methods: In total, 38 monoradicular teeth of Nepalese subjects were assessed for tooth pulp ratio. Intraoral periapical radiographs of these teeth were taken, and pulp tooth ratio was calculated and dental age was estimated.

Results: The mean chronological age was 46.79 years and the mean estimated age was 44.32 years. The pulp/tooth area ratios calculated were in the range of 0.012 to 0.195, and 0.052 to 0.256 for mesio-distal and bucco-lingual planes respectively.

Conclusions: Pulp tooth ratio of maxillary lateral incisors and mandibular lateral incisors showed the highest correlation with values of 90% and 76% respectively. Mesio-distal assessment was more accurate in dental age estimation than bucco-lingual view.

Keywords: Age estimation by teeth; dental pulp; dental radiograph; pulp tooth ratio; secondary dentine

INTRODUCTION

Age estimation is an integral tool in identification of the deceased by contributing to their biological profile[1,2] whereas, in living individuals, it is considered in cases of immigration, child abuse, criminal prosecution and civil cases such as pension claims.[3,4]

Age estimation is based on the somatic changes taking place during growth and development of an individual, which are related to chronological age.[5] Tooth development and eruption is also considered a reliable age predictor,[6] as it shows less variability than other developmental features.[7,8] After dental development is ceased, some regressive changes in tooth occur. For instance, secondary dentin formation is a sign of ageing and results in decrease in size of the pulp cavity. This decrease in the size of pulp cavity can be utilized in age estimation.[9,10]

The primary aim of this study was to test published regression formulae of pulp/tooth ratio in a Nepalese population and the second aim was to compare the accuracy between the bucco-lingual and mesio-distal radiological views.

METHODS

This was a cross-sectional, observational study conducted in the University of Dundee, Scotland, UK in accordance with Helsinki Declaration. Monoradicular teeth of Nepalese subjects were collected in the Department of Dentistry, Tribhuvan University Teaching Hospital, Institute of Medicine, Kathmandu, Nepal. The study was conducted from June 2016 to Dec 2016. Ethical approval was taken from Institutional Review Committee (IRC), Institute of Medicine, Kathmandu, Nepal. Convenience sampling was used for this study. Only functional 38 mono-radicular teeth with fully formed roots, and with no clinical/radiographic evidence of caries or restorations were included. Exclusion criteria included teeth with decay, root canal treatment, presence of restorations, attrition, abrasion, erosion or trauma. Also multi-rooted teeth were excluded from this study. No two teeth were taken from the same individual. Each extracted tooth was stored separately in a plastic container, filled with an aqueous solution of 10% buffered formalin. To ensure anonymity each container was labelled with the tooth number, the patient's sex and age.

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Periapical radiographs were taken using a portable hand held dental x-ray device (NOMAD Pro2) combined with a digital sensor (Schick CDR) linked to a portable computer (Toshiba, core 15). To reduce differences in angulation, magnification and distortion radiographs were taken with the sensor placed parallel to the long axis of the tooth with the x-ray device held at the same distance (10 cm) for each exposure in bucco- lingual and mesio-distal views. The digital radiographs were orientated into an upright position and stored in JPEG format.

All the radiographs were imported to the Image J software (National Institute of Health) for analysis. The 'polygonal tool' was selected to draw at least 20 points on each tooth outline and at least 10 points for each pulp outline. After outlining the tooth, each image was zoomed in to check if any discrepancy was present in the selected outline and the actual outline of a tooth or pulp. If any discrepancy was observed, the outline was repeated using more points. Each area was measured inpixels using the 'measure tool' from the image J software. The ratio between tooth and pulp areas was then calculated for each tooth in both bucco-lingual and mesio-distal views. The pulp tooth ration was calculated by dividing pulp area by tooth area. Dental age was estimated using published regression formulae for each tooth type. The residual age was calculated by subtracting the estimated age from the actual age. Statistical analysis was carried outusing IBM SPSS 22.0 software and 0.05 was the statistical significance level.

RESULTS

The teeth collected for this study were 100 in number. 38 met the inclusion criteria. Ages were banded as follows and the number of samples are in parentheses: 10-19 years (n=7), 20-29years (n=6), 40-49 years (n=5), 50-59 years (n=10), 60-69 years (n=3), 70-79 years (n=4), 80-89years (n=2) and100-110 years (n=1). There were 6 Maxillary lateral incisors, 1 Mandibular central incisors, 1 Maxillary central incisors, 2 Maxillary canines, 4 Mandibular canines, 7 Mandibular lateral Incisors, 8 Mandibular right 1st premolars, 7 Mandibular right 2nd Premolars, 1 Mandibular left 1stpremolars and 1 Mandibular Left 2nd Premolar. The mean chronological age was 46.79 years and the mean estimated age was 44.32 years as seen in table 1 to 5.

Table 1. Distribution of teeth, Chronological age and Estimated age of Mandibular Lateral Incisor (Man LI).

Tooth Type	Actual age (years)	Estimated Age (years)	Residual age (years)	% Age prediction
Man LI	41	37.99	3.01	76
Man LI	78	67.27	10.73	
Man LI	86	72.35	13.65	
Man LI	75	64.24	10.76	
Man LI	102	74	28	
Man LI	75	66.61	8.39	
Man LI	45	41.44	3.56	

Table 2. Distribution of teeth, Chronological age and Estimated age of Mandibular Right 1st Premolar (Man Rt1st PM).

Tooth Type	Actual age (years)	Estimated Age (years)	Residual age (years)	% Age prediction
Man Rt1st PM	55	55.6	-0.6	41
Man Rt1st PM	70	60.92	9.08	
Man Rt1st PM	58	45.78	12.22	
Man Rt1st PM	86	59.47	26.53	
Man Rt1st PM	23	22.78	0.22	
Man Rt1st PM	13	22.96	-9.96	
Man R1st PM	14	27.92	-13.92	
Man R1st PM	21	20.02	0.98	

Table 3. Distribution of teeth, Chronological age and Estimated age of Mandibular Right 2nd Premolar (MR Rt 2nd PM).

Tooth Type	Actual age (years)	Estimated Age (years)	Residual age (years)	% Age prediction
Man Rt 2nd PM	51	42.6	8.4	35
Man Rt 2nd PM	54	45.43	8.57	
Man Rt 2nd PM	28	30.67	-2.67	
Man Rt 2nd PM	20	21.56	-1.56	
Man Rt 2nd PM	16	31.11	-15.11	
Man Rt 2nd PM	20	33.2	-13.2	
Man Rt 2nd PM	20	22.94	-2.94	

Table 4. Distribution of teeth, Chronological age and Estimated age of Maxillary Lateral Incisor (MLI).

Tooth Type	Actual age (years)	Estimated Age (years)	Residual age (years)	% Age prediction
MLI	48	48.97	-0.97	90
MLI	55	42.5	12.5	
MLI	55	48.49	6.51	
MLI	68	60.08	7.92	
MLI	16	13.47	2.53	
MLI	68	56.49	11.51	

The intra- and inter-observer agreement was tested by using two-way random effects test. The obtained values for intra-observer agreement and inter-observer agreement were 0.911 and 0.841 respectively.

The regression formulae were used in mesio-distal area and R2 values of 0.76, 0.41, 0.35, 0.9 and 0.66 were calculated for maxillary lateral incisor, mandibular right 1st premolar, mandibular right 2nd premolar, maxillary lateral incisor and mandibular canine respectively. The correlation of the regression models for the Mandibular central incisor, Mandibular left 1st premolar, Mandibular left 2nd premolar, Maxillary canine and Maxillary central incisor could not be tested statistically due the insufficient number of samples present.

Table 5. Comparison of Bucco-Lingual and Mesio-Distal pulp tooth ratio.

	(B-L Pulp/ Tooth Ratio)	(M-D Pulp/ Tooth Ratio)
r^2	0.445	0.559
Std. Error of the Estimate in years (all teeth)	19	16
Regression formula (all teeth)	92.991-515.49*R	94.885-291.72*R
SE of estimate in years (25 years and older)	13	11
Regression formula (25 years and older)	93.358 – 419.632*R	81.383-129.861*R

A comparison of mesio-distal pulp/tooth area ratio to bucco-lingual pulp/tooth area ratio was undertaken to assess if the current regression formulae had validity for this view. The results indicated that mesio-distal measurement was better than the bucco-lingual measurement (Table 5).

As there are no published regression formulae for bucco-lingual area, no age estimations could be calculated from this data set. Global regression formula for the data set which could be used on teeth from a Nepalese population were calculated for two samples: the whole data set and for teeth aged 25 years and older. Results show r2 value of 0.445 and 0.559 for bucco-lingual area and mesio-distal area respectively (Table 5).

DISCUSSION

Multi-rooted teeth were excluded from this study due to the high potential measurement error due to overlapping of roots. The type of dentin may vary in cases of attrition; abrasion, erosion, caries and any trauma to the tooth resulting in tertiary dentinogenesis.[11] This may give erroneous results. Therefore, teeth with attrition, caries or restoration were also excluded from our study. Teeth were chosen from either the left- or right-hand side based on availability. This was based on the findings that there are no significant differences between left and right permanent teeth.[12]

Periapical images of a single extracted tooth show more detail instead of inserted in the dental socket. It also overcomes the inadequacies such as accuracy of patient positioning and positioning of the tongue.[13] The advantage of using tooth pulp ratio is to reduce the effect of any variation in the magnification or angulations of the radiographs.[14]

In this study, maxillary lateral incisors showed the highest correlation of 90% (Table 4). The results obtained from the present study for lateral incisors are in agreement with Cameriere et al.[14] which showed correlation of 82% in maxillary lateral incisor. Similarly, Zaher et al.[15] compared maxillary lateral incisor to maxillary central incisor and concluded that maxillary lateral incisor shows better representation of age. Similarly, Babshet et al.[16] conducted a linear measurement-based study, which established maxillary lateral incisors to have the highest correlation with age compared to canines and premolars.

In this study, mandibular lateral incisors showed second highest correlation of 76 % (Table 1), which is a good level for age estimation using pulp tooth ratio. Bosmans et al.[17] in 2005 showed that pulp tooth ratio of mandibular lateral incisors showed highest correlation with the chronological age, in their sample. However, in this study, the findings for mandibular lateral incisors were not in agreement with those of Cameriere et al.[14] They showed that the standard estimate error increased to 10.90 years in comparison to maxillary lateral incisors, which gave standard estimate error of only 6.64 years. The suitability of mandibular incisors in our study can be correlated to the fact that lower incisors have the lowest morphological diversity.[18]

According to the study by Babshet et al.[16] age estimation using mandibular canines had a low correlation. This may be due to relatively slow and irregularly paced dentinal deposition in an Indian population. Similar results were obtained by Jeevan et al.[19] where the study demonstrated that lower canine showed maximum variation in age prediction which was in accordance with Cameriere's findings.[20] This study also showed lower correlation for mandibular canines, and this can be attributed to slower and irregular dentinal deposition in a Nepalese population which is anthropometrically similar to the Indian population.[21] When compared to premolars in our study, mandibular canines showed better correlation which is in agreement with findings of Cameriere's et al.[22]

In this study, the lowest correlation was obtained for premolars. The lower first premolar yielded a correlation

of 41% (Table 2) and lower second premolar of 35% (Table 3), in contrast to 76% of correlation obtained for mandibular lateral incisors. These findings were in agreement with the findings of Star et al.[23] who obtained correlation of pulp tooth ration in premolars of 0.48 in comparison to that of mandibular incisors (0.64). The lower correlation in our study can also be explained due to smaller sample size of premolars. Moreover, age estimation is least reliable when a single premolar is analysed.[22]

The age estimation obtained from mesio-distal measurements were more accurate (56%) than the bucco-lingual measurements (44%) seen in Table 5. This may be explained by the pattern of secondary dentin formation. Schroeder et al.[24] concluded that the root canal gets constricted mesiodistally initially, and only in the later stage gets restricted in bucco-lingual direction.

Our results indicated limited applicability of pulp tooth ration in mandibular canine and premolars, as the age estimations were far away from the real chronological age. We noted two biases using these formulas: underestimation of older individuals and overestimation of younger individuals. The regression formulas used in the study were not suitable for individuals under 20 years of age and over 85 years of age as it was fabricated for a particular age range.

Sex was not considered as a parameter in dental age estimation using pulp tooth ratio in this study. There is still some debate about the dimorphism of secondary dentine apposition as various authors suggested pulpal changes occur faster in males than in females.[16, 25-27] The influence of sex in pulp tooth ratio should be considered in future studies with larger sample size

A radiograph is a two-dimensional image of a three-dimensional tooth and a 3D visualization would help in achieving more accurate results in comparison to radiographs.[28] This can be taken into consideration by directing future studies using computed tomography.

Along with ethnicity, other environmental factors like nutrition, disease, occupation or any adverse habits can alter the course of human development.[29] The effect of these multiple factors in dental maturation cannot be excluded. These factors were also not considered during sample collection of our study, and requires consideration in future.

CONCLUSIONS

Correlation of age estimation using pulp tooth ratio of maxillary lateral incisors and mandibular lateral incisors were the highest, with values of 90% and 76% respectively. Due to small numbers of teeth it was necessary to develop a global score rather than one for individual teeth. This has a low regression model r2 and is unlikely to be of any benefit compared to other population formulae. The more common mesio-distal measurement and assessment was more accurate than the bucco-lingual views.

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