the Journal of CONTEMPORARY DENTAL PRACTICE
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Regression Equations for Predicting the Size of Unerupted Canines and Premolars in an Iranian Population: A Pilot Study

Maryam Talebi, DDS, MS; Iman Parisay, DDS, MS; Ali Sarraf, DDS, MS; Fateme Mazhari, DDS, MS

Abstract

Aim: The aim of this pilot study was to evaluate equations for predicting the size of unerupted canines and premolars during the mixed dentition period in an Iranian population.

Methods and Materials: This cross-sectional analysis was performed on 106 subjects (52 girls, 54 boys, aged 13–15 years). Data were obtained from dental cast by making direct measurements of the maximum mesiodistal widths of all mandibular and maxillary incisors, canines, premolars, and first molars with an electronic digital sliding caliper, with an accuracy of ±0.02 mm and repeatability of ±0.01 mm. The results were statistically analyzed using Student t tests, Pearson product-moment coefficients, and ANOVA tests. Correlation coefficients (*r*) and error variance of estimates were determined using a significance level of $p<0.05$.

Results: No significant differences were found between the mesiodistal tooth widths of males and females in this Iranian population. The highest correlation was between the sum of the mesiodistal width of canines and premolars in the maxilla with the mesiodistal width of the mandibular first molars and maxillary central incisors ($r=0.742$). A moderate correlation was obtained in the mandible ($r=0.665$). Approximations were developed to predict the size of the unerupted canines and premolars in both jaws (in the maxilla, $Y = 0.740X + 14.271$, or the simplified formula, $Y = 3/4X + 14$; for the

mandibular arch, $Y = 0.658X + 16.353$, or the simplified formula, $Y = 2/3\ X + 16$).

Conclusion: The strongest correlation was found for the sum of the mesiodistal width of canines and premolars in the maxilla with the mesiodistal width of the mandibular first molars and maxillary central incisors in the maxillary analysis ($r=0.742$). A moderate correlation was found in the mandible for the sum of the mesiodistal width of canines and premolars with the mesiodistal width of the mandibular first molars and maxillary central incisors ($r=0.665$).

Clinical Significance: The simplified equations proposed for the maxillary arch ($Y = 3/4\ X + 14$) and for the mandibular arch ($Y = 2/3\ X + 16$) offer an easy and practical way to predict the size of unerupted canines and premolars in the maxillary and mandibular arches of Iranian children.

Keywords: Predictions, regression equation, mixed dentition

Citation: Talebi M, Parisay I, Sarraf A, Mazhari F. Regression equations for predicting the size of unerupted canines and premolars in an Iranian population: A pilot study. J Contemp Dent Pract [Internet], 2010 October; 11(5):033-040. Available from http://www.thejcdp.com/journal/view/volume11-issue5-talebi

Introduction

Predicting the size of unerupted teeth during the mixed dentition period is a critical factor in managing the developing occlusion of growing children. An accurate prediction can help determine whether the available space in the posterior segments is sufficient to allow the permanent teeth to erupt freely with good alignment in their respective arches.[1] Three prediction methods are typically used: direct measurement of the unerupted tooth size on radiographs,[2,3] calculations from prediction equations and tables,[4–6] and a combination of radiographic measurements and prediction tables.[2,7,8]

The Hixon and Oldfather[7] approach is considered to be the most accurate,[9,10] but it is complex and many find it difficult to use. The Tanaka and Johnston[5] prediction equations and table are also widely used.[11] However, they were developed for Caucasian North American children. Consequently, their use is questionable in other populations because tooth sizes vary significantly between and within different ethnic groups.[8,11,12] Moyers' regression scheme has achieved widespread clinical acceptance because of its simplicity and ease of application.[4] Since it was published, several simple linear regression equations have been proposed for populations of different ethnic origins,[11,13–16] with mixed dentition analyses varying among different racial and population groups.

Therefore, this study was designed to evaluate new equations for predicting the width of unerupted canines and premolars during the mixed dentition period in an Iranian population.

Methods and Materials

This pilot study was carried out on 106 subjects (52 girls, 54 boys, aged 13–15 years) selected randomly from among 1,400 students in the seven regional directories of the Mashhad (Iran) population. Informed consent was obtained prior to the investigation. The inclusion criteria used were complete permanent dentition with no caries, proximal restorations, attrition, or dental anomalies; all teeth fully erupted to the occlusal plan; no previous or ongoing orthodontic treatment; and no horizontal discrepancies such as cross bite or scissors bite.

Polyvinyl silicone impressions (Speedex, Coltène/Whaledent, Germany) were obtained from each subject. The impressions were poured in a type IV dental stone (Elite Rock, Italy) on the same day by an experienced dental laboratory. Data were obtained by measuring the dental casts of the study subjects. Measurements of the maximum mesiodistal widths of all mandibular and maxillary incisors, canines, premolars, and first molars (except upper lateral incisors) were made by a single investigator with an electronic digital sliding caliper (Guanglu, GB/T14899-94, China), with an accuracy of ±0.02 mm and repeatability of ±0.01 mm. To gain easier access to the interdental spaces, the measuring tips of the digital caliper were reshaped to reduce the diameter of the two tips.

Each tooth was measured twice. Intra-examiner reliability was predetermined at 0.2 mm.[8] When the two sets of measurements varied by 0.2 mm or less, the measurements were averaged; otherwise, a new set of measurements was made and the nearest three measurements were averaged.[8]

Using the sum of the mesiodistal widths of the mandibular first molars and maxillary central incisors as reference teeth, the following equation was used: $Y = ax + b$. The Y variable (dependent variable) refers to the predicted sum of the mesiodistal widths (mm) of the maxillary or mandibular permanent canines and premolars on both sides. The X variable (independent variable) refers to the sum of the mesiodistal width (mm) of the maxillary permanent central incisors plus the mesiodistal widths of the mandibular first permanent molars on both sides. The constant b is the Y intercept, and the constant a is the slope of the regression.

The Kolmogorov-Smirnov test was used to confirm the normality of the data. Pearson product-moment coefficients were used to estimate the correlation between the mesiodistal widths of canines and premolars in the maxilla and mandible with reference teeth (maxillary central incisors, maxillary first molars, mandibular incisors, and mandibular first molars). Student *t* tests were carried out to compare tooth sizes between the sexes and the right and left sides of the arches. Statistical calculations and analyses, including error variance of the estimates (MSE), correlation coefficients (r), coefficients of determination (r^2), and analysis of variance (ANOVA) of the regression equations were performed using the SPSS for Windows statistical computer package (SPSS 15.1 release software Inc., Chicago, Illinois, USA). Statistical significance was established at the $p<0.05$ level.

Results

By using the multivariable stepwise regression analysis, no significant differences were found between the mesiodistal tooth widths of males and females and between the left and right sides of both arches in this population (Table 1).

Table 2 shows the linear regression equations for all reference teeth. The highest correlation was between the sum of the mesiodistal widths of canines and premolars in the maxilla with the mesiodistal widths of the mandibular first molars and maxillary central incisors (r=0.742). A moderate correlation was obtained in the mandible (r=0.665).

Using the sum of the mesiodistal widths of the mandibular first molars and maxillary central incisors as reference teeth, the following equations were developed ($Y = ax + b$): for the maxilla, $Y = 0.740X + 14.271$ (simplified, $Y = 3/4X + 14$); for the mandible: $Y = 0.658X + 16.353$ (simplified, $Y = 2/3X + 16$) (Tables 2 and 3).

The differences (in mm) between the regression values of the actual sum of the permanent canine and the first and second premolars of Iranian subjects and those predicted from the Tanaka and Johnston[5] equations for same subjects for the upper and lower arches are presented in Table 4.

The scatter plots of the data show the presence of outlying values, the linearity of the relationship, and the width of 95 percent confidence bands around the regression line (Figures 1and 2).

The prediction error ΔY(–1.5±1.5 mm) was estimated as the sum of the mesiodistal widths of the canine and premolars on both sides in a dental arch using the simplified equations indicated (Figures 3 and 4). The prediction accuracy was higher in the maxilla than in the mandible. In 54.36 percent of subjects, the simplified equations overestimated the real size of the maxillary canines and premolars. In 54 percent of subjects, the mandibular canines and premolars were underestimated (Figures 3 and 4).

Table 1. Mean linear measurements (mm) for the canines and premolars by gender from the left and right sides of arches.

Teeth	Males	Females
Right mandibular canines	6.9083	6.6431
Left mandibular canines	6.8556	6.5938
Right maxillary canines	7.9067	7.6187
Left maxillary canines	7.8498	7.5873
Right mandibular first premolars	7.0807	7.0700
Left mandibular first premolars	7.0915	7.0335
Right maxillary first premolars	6.9961	7.0238
Left maxillary first premolars	7.1296	7.1158
Right mandibular second premolars	7.2007	7.1783
Left mandibular second premolars	7.1107	7.0892
Right maxillary second premolars	6.7531	6.7937
Left maxillary second premolars	6.7685	6.7790

Table 2. Regression parameters for prediction of sum of maxillary or mandibular canines and premolars.

Regression Equation	X	Correlation Coefficient	Coefficient of Determination (r^2)	Coefficients		MSE	95% CI	Significance	ANOVA Test (F)
				a	b				
(maxilla) $y = aX + b$	Sum of mandibular incisors	0.642	0.41	1.002	20.793	2.402	0 ± 3.02	$p<0.001$	$F=69.304$
(maxilla) $y = aX + b$	Sum of maxillary central incisors	0.697	0.49	1.278	21.506	2.095	0 ± 2.82	$p<0.001$	$F=94.459$
(maxilla) $y = aX + b$	Sum of mandibular incisors and maxillary central incisors	0.680	0.46	0.589	19.962	2.156	0 ± 2.86	$p<0.001$	$F=86.752$
(maxilla) $y = aX + b$	Sum of maxillary centrals and mandibular first molars	0.742	0.55	0.740	14.271	1.951	0 ± 2.72	$p<0.001$	$F=124.043$
(maxilla) $y = aX + b$	Sum of mandibular and maxillary first molars	0.624	0.41	0.634	15.990	2.493	0 ± 3.07	$p<0.001$	$F=63.757$
(mandible) $y = aX + b$	Sum of mandibular first molars	0.607	0.37	1.011	19.798	2.448	0 ± 3.05	$p<0.001$	$F=57.704$
(mandible) $y = aX + b$	Sum of mandibular and maxillary first molars	0.646	0.42	0.647	13.066	2.266	0 ± 2.93	$p<0.001$	$F=70.063$
(mandible) $y = aX + b$	Sum of maxillary centrals and mandibular first molars	0.665	0.45	0.658	16.353	2.004	0 ± 2.76	$p<0.001$	$F=77.873$

MSE = Mean square of error; CI = Confidence interval;
a = Y intercept; b = Slope of the regression; y = Predicted sum of upper or lower canines and premolars

Table 3. Descriptive statistics of simplified regression equations for reference teeth.

Reference teeth	Min	Max	Sum	Mean	MSE	Std. Deviation	Residual
Sum of maxillary central incisors and mandibular first molars	-3.93	3.83	-10.76	-0.1045	1.962	1.39017	*Δy (maxilla)
Sum of upper maxillary central incisors and mandibular first molars	-3.30	3.96	2.21	0.221	2.005	1.40855	*Δy (mandible)

*$\Delta y = y_1 - y_2$; y_1 = Sum of canines and premolars; y_2 = Predicted sum of canines and premolars; $p<0.001$

Table 4. Descriptive statistics of Tanaka and Johnson regression equations in the maxilla and the mandible.

Residual	Min	Max	Sum	Mean	MSE	Std. Deviation
*Δy (maxilla)	–5.23	2.25	–117.28	–1.1612	3.70	1.54205
*Δy (mandible)	–4.95	2.65	–139.16	–1.3916	4.36	1.56720

*$\Delta y = y_1 - y_2$; y_1 = Sum of canines and premolars; y_2 = Predicted sum of canines and premolars; $p<0.001$

Discussion

It is documented that different racial and ethnic groups present variations in the mesiodistal widths of permanent teeth.[8,12,17–19] Thus, data collected from one ethnic group to predict the size of unerupted permanent teeth might not be applicable to another.[10,11,13,20] Variations in the results among different studies might be attributable to different sample sizes, methods of analysis, ethnic groups, and/or standard deviations.[21]

Data from the present study were used to generate statistically significant equations that could be used to predict unerupted canine and premolar widths in Iranian children (Table 2). For both sexes, the prediction of canines and premolars could be made from the sum of the mesiodistal widths of the mandibular incisors and first molars as reference teeth. The values obtained from regression equations provide good results, but many investigators prefer multiple linear regression equations over simple regression.

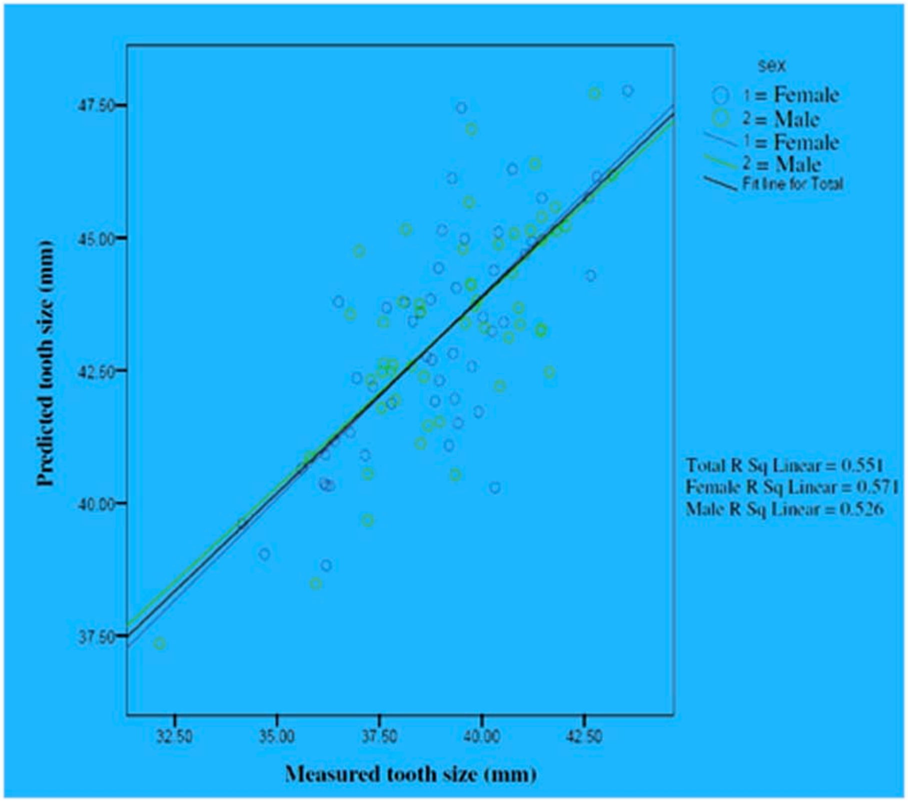

Figure 1. Actual versus predicted values of permanent canines and premolars (line represents perfect correlation between values) in maxilla.

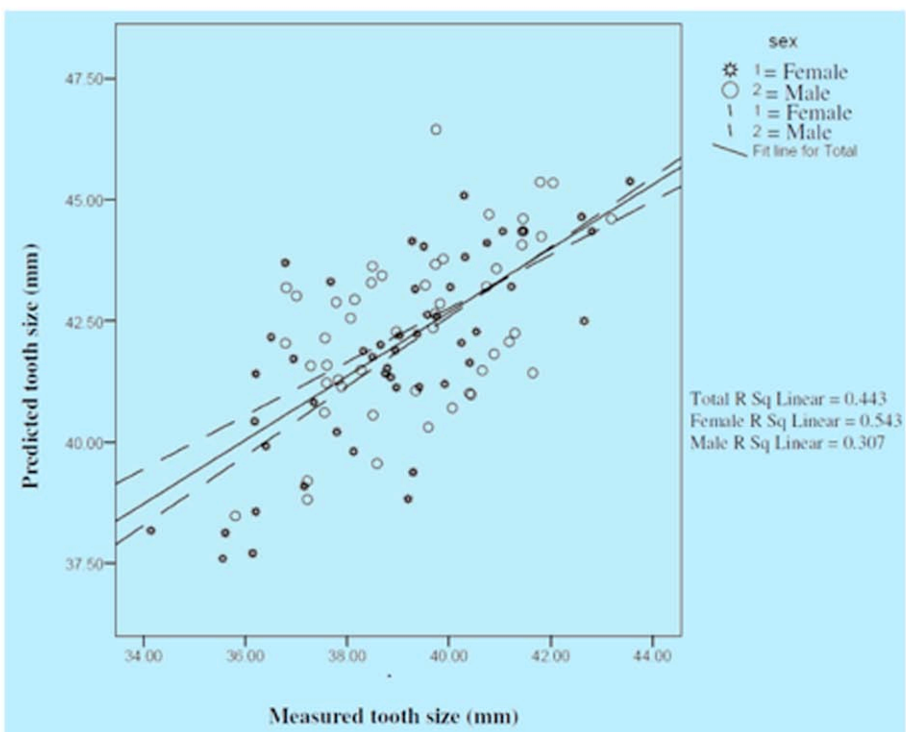

Figure 2. Actual vs. predicted values of permanent canines and premolars (line represents perfect correlation between values) in mandible.

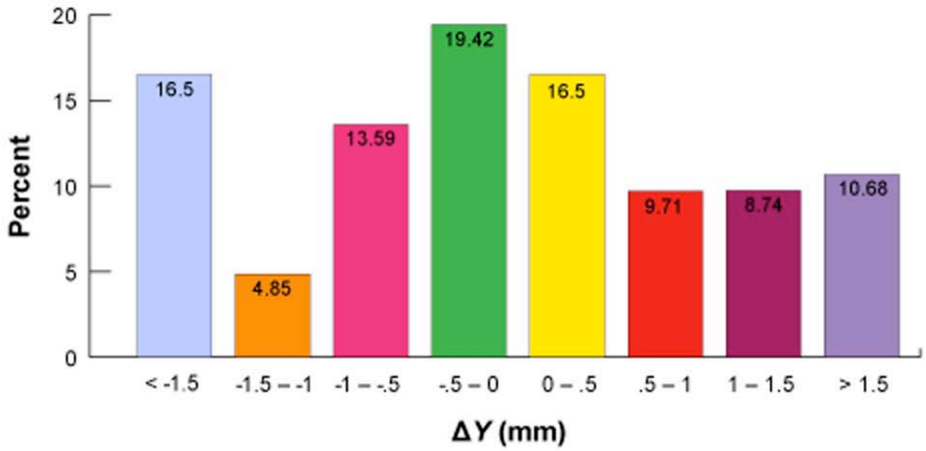

Figure 3. Prediction error (Δ*Y*) in maxilla (*Y* = 3/4*X* + 14).

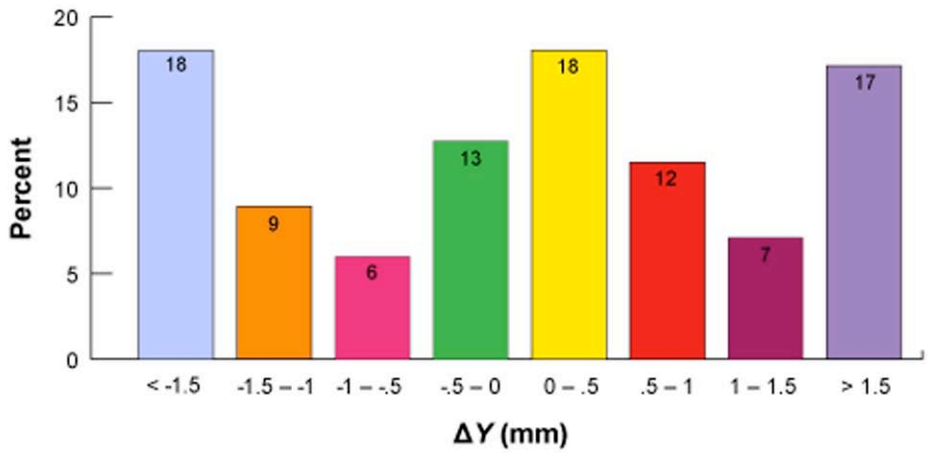

Figure 4. Prediction error (Δ*Y*) in mandible (*Y* = 2/3*X* + 16).

Because of the greater number of variables, multiple linear regression equations provide higher correlation, correlation coefficients, and improved accuracy.[14,22–26] However, these equations are complex and difficult to memorize, justifying the use of the simple equations adopted here.

A strong correlation was observed between the size of the permanent mandibular first molars and permanent maxillary central incisors and the size of canines and premolars in the maxilla (r=0.742). The coefficients of determination (r^2) in Table 1 indicate the predictive accuracy of regression equations for *Y* (the sum of mesiodistal widths of canines and premolars) based on the values of *X* (the corresponding sum of mesiodistal widths of maxillary central permanent incisors and mandibular first permanent molars). In the present study, the r^2 values were 55 percent and 45 percent for the sum of the maxillary and mandibular canines and premolars, respectively, and were determined from the sum of the maxillary central incisors and mandibular first molar widths. The *X* value of the maxillary regression equation seemed to determine *Y* better than that of the mandibular regression equation. Our r^2 results are larger than those obtained by Supanee et al.[26] or Jaroontham et al.,[16] but smaller than those determined by Yuen et al.,[13] Uysal et al.,[27] or Diagne et al.[28] These differences in the r^2 values of these studies might be attributable to the effects of different sample sizes, reference teeth, and ethnic mixes.

An ANOVA of regression showed a highly significant relationship between the corresponding *X* and *Y* values used for developing the regression equations (p<0.001). The lower the MSE, the better is the prediction equation. The MSE values for the maxillary and mandibular arch equations developed in this analysis were 1.951 and 2.004, respectively, indicating greater accuracy of the new analysis in the maxilla and mandible than other results (Table

2). These findings, coupled with the r^2 values of the regressions, suggest that we can use this new analysis in an Iranian population with more accuracy than the other references used in this study (Table 2).

The prediction error (ΔY) of the simplified equations in the present study indicated that the maxillary analysis tended to overestimate the canine and premolar sizes. An ideal prediction method should result in no difference between the predicted and actual widths of permanent canines and premolars. However, prediction methods are not 100 percent precise and can overestimate or underestimate the actual size of unerupted teeth.[4,29] Overestimation, within 1 mm beyond the actual widths of the permanent canines and premolars on each side of the arch, seems to be better at preventing lack of space and should not seriously affect an extraction or nonextraction decision.[3,22,30] The prediction error in the maxillary equation was between –1 and +1 mm a greater percentage of the time (59.5 percent) than the prediction error in the mandibular equation (49 percent). Such results indicate that the prediction accuracy was higher in the maxilla than in the mandible when we used the sum of the maxillary centrals and mandibular first molars to predict the actual size of canines and premolars. This finding was similar to that reported by Paredes et al.[31]

This outcome was demonstrated in this study by the statistically significant differences seen between the means of actual mesiodistal widths of permanent canines and premolars of Iranian adolescents and those derived from the Tanaka and Johnston equations for subjects from northwestern European ancestry.[5] The Tanaka and Johnston[5] regression equations overestimated the mesiodistal widths of permanent canines and premolars ($\Delta y < 0$).

Current research, including the present study, supports the view that ethnic differences are likely to be important variables in tooth-size prediction equations. The prediction analyses (for the maxillary arch, $Y = 3/4X + 14$, and for the mandibular arch, $Y = 2/3X + 16$) based on the present study could be used in Iranian children. And additional investigations, with a larger sample size, are recommended to confirm the outcomes of this study.

Conclusion

The simplified equations proposed for the maxillary arch ($Y = 0.740X + 14.271$, or the simplied formula, $Y = 3/4X + 14$) and for the mandibular arch ($Y = 0.658X + 16.353$, or the simplified formula, $Y = 2/3X + 16$) are practical ways to predict the size of unerupted canines and premolars in the maxillary and mandibular arches for the Iranian children evaluated in this study. The mesiodistal linear measurements of the teeth in the maxillary arch (r=0.742) were more accurately predicted than those for the teeth in the mandibular arch (r=0.665).

Clinical Significance

The simplified equations proposed for the maxillary arch ($Y = 3/4X + 14$) and for the mandibular arch ($Y = 2/3X + 16$) provide an easy and practical way to predict the size of unerupted canines and premolars in the maxillary and mandibular arches of Iranian children.

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About the Authors

Maryam Talebi, DDS, MS

Dr. Talebi is an associate professor in the Department of Pedodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Iran. She received her master of science degree in pedodontics from the Mashhad Faculty of Dentistry in Mashhad, Iran, in 1996. Her research interests include prevention and space analysis in pediatric dentistry.

e-mail: talebim@mums.ac.ir

Iman Parisay, DDS (Corresponding Author)

Dr. Parisay is an assistant professor, Shahid Sadoghi University of Medical Sciences, Iran. His research interests include prevention and dental caries.

e-mail: parisay1851@mums.ac.ir

Ali Sarraf, DDS, MS

Dr. Sarraf is an assistant professor in the Department of Pedodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Iran. He received his master of science degree in pedodontics from the Mashhad Faculty of Dentistry in Mashhad, Iran, in 1999. His research interests include behavior management and prevention.

e-mail: sarrafA@mums.ac.ir

Fateme Mazhari, DDS, MS

Dr. Mazhari is an associate professor in the Department of Pedodontics, Faculty of Dentistry, Mashhad University of Medical Sciences, Iran. She received her master of science degree in pedodontics from the Mashhad Faculty of Dentistry in Mashhad, Iran, in 1997. Her research interests include dental material and space analysis in pediatric dentistry.

e-mail: MazhariF@mums.ac.ir

Acknowledgements

The authors wish to acknowledge the financial support of the vice president of the Research Center of Mashhad University of Medical Sciences.