

Regression analysis to predict total space required from mandibular first permanent molar

Umar Hussain^a, Ali Ayub^b, Afeef Umar Zia^c, Faizan Ul Hassan^d, Syed Suleman Shahe,
Ghulam Rasool^f

Abstract

Introduction: Space analysis is an essential tool for treating crowded cases in Orthodontics. Accurate method for space analysis can help the clinician to obtain optimal results.

Material and methods: The mesiodistal width of teeth was measured for 120 plaster models. The correlation between MW of mandibular first molar (Md-6) and total space required (TSR) in both jaws was assessed with Pearson correlation test. Regression equations for both genders and jaws between Md-6 and TSR were derived through linear regression. Independent samples t test was used for comparison of MW of Md-6 and TSR between genders for each jaw. Paired t test was applied for comparing the MW of predicted and actual TSR.

Results: The mean MW of all 10 permanent teeth in mandible for males (68.30 ± 4.41) was higher than females (66.44 ± 3.337) statistically ($P = .010$). Correlation between MW of Md-6 and TSR were higher in females (maxillary arch $r = 0.84$ and mandibular arch $r = 0.860$) than males (maxillary arch $r = 0.79$ and mandibular arch $r = 0.830$). In mandible 69.2% of the variations in TSR can be explained due to MW of Md-6 in the model. Similarly, in maxilla 65% of the variations in TSR can be explained due to MW of Md-6 in the model. Regression equations were derived for both arches and genders using Md-6 as an explanatory variable and TSR as a dependent variable.

Conclusions: Md-6 can be utilized as a predictor for TSR in both arches and genders.

Keywords: Mesiodistal widths; mandibular permanent first molar; regression equation; space analysis; total space required

Introduction

Crowding is the most common malocclusion especially in mixed dentition.^{1,2} Up to certain amount of crowding (1.6mm) especially in lower incisor region can resolve spontaneously during normal developmental process. Mechanism involved in the resolution of this slight mal-

alignment are increase in mandibular intercanine width, more labial path of eruption of permanent incisors as compared to their predecessors and creation of secondary spaces.³⁻⁵ Proper space analysis is usually needed if crowding in lower incisor area is more than 1.6mm.³

One of the essential component of diagnostic pathway for orthodontic patients during mixed dentition is proper space analysis with reliable and population specific method.^{6, 7} Estimation of actual width of unerupted dentition is pre-requisite to perceive and intercept the potential crowding and encourage adequate occlusal relationship through space maintenance, space regaining and guidance of occlusion.⁸⁻¹⁰ The existing of

^a Corresponding Author: BDS, FPCS, MS; Lecturer, Saidu College of Dentistry, Swat, Pakistan.

E-mail: drumarhussain@gmail.com

^b BDS, FPCS; Associate Professor, Orthodontics, HBS Medical and Dental college, Islamabad.

^c BDS, FPCS, M.Orth RCS Ed; Professor & Head of department Orthodontics, Margalla institute of Health Sciences, Pakistan.

^d BDS, FPCS; Assistant professor, Rehman College of Dentistry, Peshawar, Pakistan.

^e BDS, FPCS; Demonstrator, Khyber College of Dentistry, Peshawar, Pakistan.

^f BDS, MCPS, FPCS, MPHE; Dean and Principal of Rehman College of Dentistry, Peshawar, Pakistan.

crowding will help in decision making that which sort of interceptive care to be provided during mixed dentition.¹⁰

Ideal requirement of space analysis method are; easy and quick to perform in clinical setting, minimal intra and inter-examiner errors, do not need special instruments, do not pose risk to health of patients or clinician and should be specific for each arch.^{11, 12} In contemporary orthodontics three approaches are in practice to estimate the sizes of un-erupted teeth which are the use of regression equations, radiographs and combinations of both methods.^{13, 14} Especially Moyer's tables and Tanaka and Johnston equations are widely used.¹⁵ But applicability of these methods to other populations can result in either over or under estimation of actual widths of unerupted teeth.¹⁶ Radiographic method can be applied to estimate the sizes of unerupted teeth irrespective of population and gender which is based on a mathematical proportion to compensate for radiographic magnification.¹⁷ But radiographic method is associated with increased risk of radiation, requires sophisticated equipment and more time consuming.¹⁸

Regression equations are widely studied for various populations. Some of them are based on prediction of widths of unerupted canine and premolars from lower incisors^{14, 16, 19} and predicted unerupted cuspids and bicuspid sizes from combined width of lower first permanent molar and lower incisors.^{20, 21}

This is the first kind of study which used only mandibular first permanent molar to predict the total space required (sum of mesiodistal width of all ten teeth from second premolar on one side to second premolar on other side). Lower mandibular first molar is erupting first among all permanent teeth usually at 5 years of age. So, this study can help in earliest diagnosis of potential crowding and provide opportunity to orthodontists to intercept early and optimize adequate occlusion with no or minimal need of orthodontic fixed appliances.

The objective of this study was to predict total space required from mesiodistal width of mandibular first permanent molar by regression analysis.

Material and Methods

This investigation was carried out on 120 study plaster models of orthodontic patients (half males and half females) at the Khyber College of Dentistry Peshawar, Pakistan from October 2019 to June 2020. The sample size was taken by arbitrary method. In this method the sample size is selected on basis of clinical judgment and average sample size used in previous related studies. In previous studies on space analysis about 100 cases are used.¹⁴ Ethical approval from college's ethical review committee was obtained (letter #1109-A-AD/PG/R/KCD). After explaining the benefits and aim of the study verbal informed consent was obtained from all participants. Patients in permanent dentition with all teeth fully erupted except third molars, no prior history of orthodontic treatment, no fracture or restoration in proximal surface of teeth and age 12 to 30 years were included. Participants with microdontia and macrodontia were excluded.

An electronic digitized caliper (Japan incorporation) with least of 0.01 mm was used to measure the maximum mesiodistal widths (MW) of teeth. Digital vernier with narrow tips was selected to facilitate access to interproximal space to record maximum MW of the teeth. Measurement was done by two consultant orthodontist having 2 years post-graduation experience. The mesiodistal crown widths were recorded by measuring the maximum distance between the contact points on proximal surfaces of teeth. Inter-examiner's reliability was assessed on 10 casts by using Pearson correlation test. Inter-examiner's reliability was almost perfect ($r=0.96$). Mesiodistal widths of 12 permanent teeth in mandible and 10 permanent teeth in maxilla along with gender were recorded.

Data entry were done in excel sheet (Microsoft 2013) and were imported into SPSS version 22.0(Chicago, Ill). Student t test was run for comparing of MW of mandibular permanent first molar and total space required in both arches between genders. Pearson's correlation test was used to determine correlation between MW of Md-6 and TSR in both arches. Simple linear regression was run using TSR as a dependent variable and MW of lower first permanent molar as an independent variable in both arches and for both males and females. Comparison of mesiodistal widths of actual tooth space available and predicted TSR in both arches and for both genders were done by applying paired t test. Scatterplots were made for maxilla and mandible between MW of mandibular first permanent molar and TSR to visualize the strength of correlation and outliers. For all analyses the significance level was $P \leq 0.05$ under two-sided hypothesis.

Results

The mean age was 21 ± 2.61 years with range from 12 to 30 years. The difference in MW of mandibular first molar ($P = .116$) and all 10 permanent teeth in maxilla ($P = 0.056$) were not different statistically. However, the mean MW of all 10 permanent teeth in mandible for males (68.30 ± 4.41) was higher than females (66.44 ± 3.337) statistically ($P = .010$). The details are given in Table I.

Pearson correlation coefficient between MW of Md-6 and TSR were higher in female gender (maxillary arch $r = 0.840$ and mandibular arch $r = 0.860$) than male gender (maxillary $r = 0.79$ and Mandibular arch $r = 0.830$). Overall coefficient of correlation for both arches was almost similar. All correlation were very highly statistically significant ($P < 0.001$). (Table II)

All adjusted R^2 are more than 60% with statistical significance showing the fitting of model. In mandible 69.2% of the variations in TSR can be explained due to MW of

mandibular first molar in the model. Similarly in maxilla 65% of the variations in TSR can be explained due to MW of mandibular first molar in the model. Regression equations, adjusted R^2 , and P-value for prediction of TSR (dependent variable) from mandibular first permanent molar (independent variable) for overall and both genders in maxillary as well as mandibular arches are given in Table III. Table IV shows that no statistically significant difference was found between predicted and actual total MWs of second bicuspids from one side to contralateral side ($P > 0.05$). The scatter graphs for maxillary as well as mandibular arch show straight line with few outliers showing high strength of correlation. Regression equations and co-efficient of determination (r^2) are also shown in these plots (Figure 1 and Figure 2).

Table I: Comparison of MW of teeth for mandibular permanent first molar, TSR in mandible and maxilla between genders

Tooth group	Gender	Mean	95% CI	P-Value*
MW of mandibular first molar	Male (n=60)	11.4 \pm 0.869	-.056, 0.51	.116
	Female (n=60)	11.18 \pm 0.68		
Total space required-maxilla	Male (n=60)	77.29 \pm 3.78	-0.03,	.056
	Female (n=60)	75.95 \pm 3.80	2.71	
Total space required-mandible	Male (n=60)	68.30 \pm 4.41	.451,	.010
	Female (n=60)	66.44 \pm 3.337	3.28	

*Independent sample t test

Table II: Correlation between MW of mandibular permanent first molar TSR in both arches

Correlation Coefficient (r)	TSR in maxilla			TSR in mandible		
	Male	Female	Overall	Male	Female	Overall
Mandibular First molar	0.81*	0.84*	0.82*	0.80*	0.86*	0.83*

*Pearson correlation test; * $P < 0.001$

Table III: Results for linear regression of Mn-6with TSR for overall and both arches

Independent variable (TSR*)	Gender	Regression equation	Adj R ²	P-value
Mandibular arch	Males	TSR=3.83×Md-6**+24.4	.634	< 0.001
	Females	TSR=4.38×Md-6+17.84	.752	0.001
	Overall	TSR=4.05×Md-6+21.6	.692	0.001
Maxillary arch	Males	TSR=3.53×Md-6+37.01	.65	< 0.001
	Females	TSR=4.64×Md-6+24.04	.73	0.001
	Overall	TSR=4×Md-6+31.4	.674	0.001

*Total Space required, **Md-6; mandibular first molar

Table IV: Comparison of predicted and actual total mesiodistal widths of second premolar to second premolar

Arch	Gender	Actual TMWP-P** Mean ± SD	Predicted TMWP-P Mean ± SD	t-statistics*	P-value
Mandible	Male	68.11±4.41	68.16±3.73	.408	.684
	Female	66.44±3.34	66.44±2.67	-.181	.857
	Both	67.37±4.01	67.32±3.34	.250	.803
Maxilla	Male	77.29±3.78	77.39±3.15	.789	.433
	Female	75.95±3.80	76.16±2.7	-.743	.460
	Both	76.62±3.15	76.6±3.15	0.071	.943

*paired t test, ** total mesiodistal widths of second premolar to second premolar

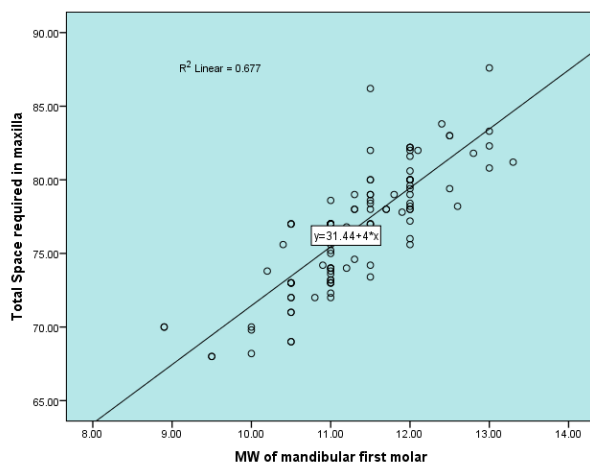


Figure 1: Scatter plot of TSR with mandibular permanent first molar in maxilla

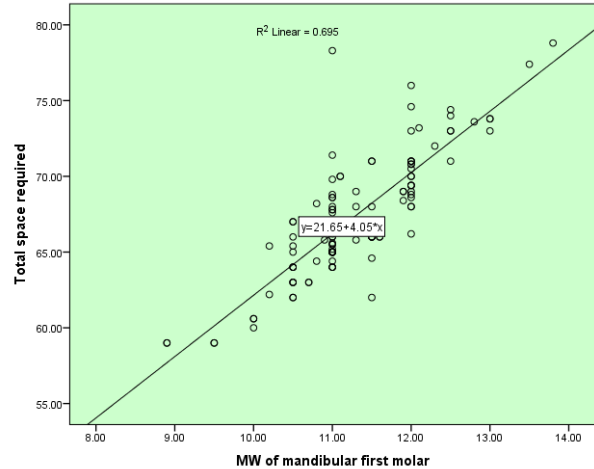


Figure 2: Scatter plot of TSR with mandibular permanent first molar in mandible

Discussion

This investigation was carried out to derive regression formulae to predict total space required from lower first permanent molar. Our findings showed that there is high correlation between TSR and MW of lower first permanent molar ($r=0.81$ for maxilla and $r=0.83$ for mandible). According to our results in 69.2% TSR can be predicted MW of mandibular first permanent molar for mandible and 65% for maxilla. We derived regression equations for both genders and arch. Our regression models were statistically significant and with high adjusted R².

No reliable method is available to predict the MWs of permanent dentition from primary teeth due to low co-efficient of determination ($r^2=0.36$).²² And there is also greater variability in leeway space which range from negative value to positive. Lo and Moyers²³ reported that the normal leeway space is 2.60 mm (half on each arch side) in upper arch and 6.20 mm in lower arch. Horowitz and Hixon²⁴ found that only in 4% to 36% participants primary teeth predict the sizes of their permanent successors.

The other factor which should be considered during space analysis is the change in arch perimeter while occlusion undergo transition from primary to mixed and finally to permanent dentition. Literature showed that

arch perimeter decreases during transition from primary to permanent dentition. Moorees²⁵ reported that arch perimeter decreases 2 to 3 mm during this transition. DeKock²⁶ found 10% loss in arch perimeter for boys and 9% for girls while dentition undergoes development.

So due to the two above factors i.e., less value of primary teeth in prediction and no increase arch perimeter the earliest possible prediction from Md-6 will be supportive in diagnosis of crowded dentitions. So, we conducted this study to derive regression equations based on mandibular first permanent molar which usually erupt at age 5.

Our study showed that there were no statistically significant differences in MW of teeth among genders. But the MW of mandibular first molar was larger in males than females statistically. Many studies found variations between male and female tooth widths^{19, 27-29} but others did find sex differences.³⁰⁻³² This shows that racial and population variations are present for mesiodistal dimension of teeth.

Studies showed that the mere use of lower incisors in the prediction of the mesio-distal dimensions of unerupted teeth is not valid.^{19, 21} Some studies used combined widths of mandibular first molar along with lower incisors to predict the sizes of unerupted cuspids and bicuspid.^{20, 21} This endorsed the notion of more importance of lower first permanent molar in prediction of teeth sizes. In this study we have formulated the prediction total mesiodistal widths in both sexes and dental arches from Md-6 for estimating the TSR. In this study the correlation is much higher (ranges from 0.810 to 0.830). As far our knowledge is concerned no study had been reported using only Md-6 for prediction of MW of unerupted teeth.

However, this is single center and small sample size study, so further studies are needed on large samples sizes to determine the accuracy of these derived regression equations. Other limitations can be the non-availability of mandibular first permanent molar in many patients due to dental caries or

malformed structure due to molar-incisor hypoplasia and Amelogenesis imperfecta.

Conclusions

Within the limitations of this study, the conclusion can be drawn that mandibular first permanent molar can be used to determine total space required by using regression equations.

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