Tooth Size and Arch Widths in Crowded Class I Malocclusion

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Abstract

Objective: To examine the extent to which maxillary arch width and tooth size contributes to dental crowding.

Methods: A cross-sectional study was conducted for six months after approval of synopsis by ERC of KMDC with 96 patients at department of orthodontics, Karachi Medical and Dental College, Karachi, Pakistan. Patients with age 13-21 years with maligned teeth, over-crowding, presence of all fully erupted permanent teeth and all angle classes were included, whereas patients with history of orthodontic treatment, presence of fractured restorations/crowns with tooth anomalies such as number, size, form and position as confirmed on clinical examination and craniofacial anomalies/syndromes were excluded. Maxillary crowding was calculated as the millimetre difference between arch perimeter and the sum of tooth widths of both second premolars. Arch perimeter was measured from the mesial aspect of the permanent first molar to its antimere with a brass wire. Intermolar arch width was calculated as distance from the central fossa of permanent maxillary first molar to its antimere. Data was analysed using SPSS 23.0. Prior to analysis assumptions were tested; an independent sample t-test was used to compare differences in crowded maxillary arch widths and spearman correlation was used to determine relationship between variables.

Results: Significant differences were obtained in anterior ($t_{(63)}$ = -2.547, p=0.047) and posterior tooth size ($t_{(63)}$= -2.218, p=0.030) in patients with mild, moderate and severe maxillary crowded arches and an inverse weak correlation was obtained against maxillary crowding and maxillary arch widths (ρ=-0.054) and maxillary crowding and anterior tooth (ρ= -0.201) and posterior tooth size (ρ= -0.353).

Conclusion: An inverse significant relation was found between crowding and tooth sizes & significantly different tooth sizes were observed in patients with mild, moderate and severe maxillary crowding.

Keywords: Malocclusion, crowding, tooth.

IRB: Approved by the Ethical and Scientific Review Committee, Karachi Medical and Dental College. Dated: 30th January 2019

Citation: Khan WA, Faisal SS, Hussain SS. Tooth Size and Arch Widths in Crowded Class I Malocclusion [Online]. Annals ASH KM&DC 2019;24:.

(ASH & KMDC 24(3):145;2019)

Introduction

Malocclusion is a condition where the maxilla and mandible are in off balance position to each other; the most prevalent cause of malocclusion includes dental crowding[1]. Dental crowding is the instability between tooth size and arch dimension[2]. This deprivation of space between arch width and teeth leads the teeth to dislocate and grow in an overlapping state[3]. The presence of crowding effects the quality of life of an individual. The problem associated with crowding includes poor oral hygienic problems, social interaction, chronic stress, bad breath, speech problems, wearing of teeth etc. Crowding is multifactorial and is interlinked with various factors. Dental arch widths, arch length, mesio-distal tooth dimensions, dental proportions, oral and perioral musculature, maxillary and mandibular body lengths and direction of jaw growth have been related to dental crowding[4]. Tooth size-arch length discrepancy (TSALD) is a well-defined means of assessing dental crowding[5]. It is very crucial to rule out the actual contributing factor for planning appropriate treatment strategy as well as achieving stable post-treatment results. Crowding acts as the key factor in curtailment of jaw size in growth of an individual[6]. It is observed that arch width of people with crowding are smaller compared

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Date of Submission: 27th March 2019
Date of Acceptance: 18th October 2019

to un-crowded arches[7]. Relationship between tooth sizes and dental crowding have been examined previously but seem to be conflicting[8]. The causes of presence of dental crowding remains contradictory. The major nuisance factor of dental crowding involves development of smaller jaw sizes without decrement of tooth sizes[9]. The relationship between arch dimensions and tooth size has always been a major of interest and investigated by researchers and determined before[9-10]. Crowding can be relieved by creating space either by extracting teeth or arch expansion. It is categorized as first-degree/mild, second-degree/moderate, third-degree/severe according to the severity and as primary, secondary and tertiary according to the aetiology. The decision of treatment planning is based on the aetiology of crowding either it is due to narrow arch width or large tooth size. It is very crucial to rule out the actual contributing factor in dental crowding for planning appropriate treatment strategy as well as achieving stable post-treatment results. Orthodontists make use of distinct techniques in order to treat dental crowding such as extraction of teeth, braces, retainers, dental veneers and invisalign. A research was carried out at Karachi Medical and Dental College in order to evaluate the factors contributing in dental crowding. The major objective of study was to examine the extent to which arch width & anterior and posterior tooth size contributes to maxillary dental crowding.This study will help orthodontist to establish an appropriate treatment plan for patients with maxillary crowding. Besides the patients satisfaction could be anticipated. This study generates interest for further research in this field by enabling researchers to look into and explore insights of factors contributing in dental crowding and put forward new plans and suggestions for future planning of orthodontic treatments.

Material and Methods

A cross-sectional study was conducted at the department of orthodontics, Karachi Medical and Dental College, Karachi, Pakistan. The study was put into action for six months after approval of synopsis by Ethical review committee of KMDC. Non-probability sampling technique was used. A non-probability consecutive sampling technique was used asample size of 96 patients were calculated using Raosoft calculator with margin of error 0.10 at confidence of interval 95%.

Patients' age ranging between 13-21 years with maligned teeth, over-crowding, presence of all fully erupted permanent teeth up to first molar and angle classes I, II, and III were included in the sample. The patients with previous history of orthodontic treatment, presence of any fractured restorations or crowns with tooth anomalies such as number, size, form and position as confirmed on clinical examination and craniofacial anomalies/syndromes like Down's syndrome, Pierre-Robbin Syndrome, cleft lip and palate were excluded.

The sample size included 76 females and 20 males (n=96). Each patient was examined by the researcher on the basis of history and clinical examination. Before examination a verbal informed consent was taken from the patients. The study was conducted only on maxillary crowding of patients. Impressions of maxillary arch width were taken from alginate and then poured in dental plaster for study cast. Measurements were performed on pre-treatment dental casts. Maxillary crowding was calculated as the difference between arch perimeter and the sum of tooth widths from the second premolar to the second premolar on the other side, in millimetres. The arch perimeter was measured from the mesial aspect of the permanent first molar to its antimere with a brass wire. Negative values obtained indicated crowding. Inter molar arch width was calculated as distance from the central fossa of permanent maxillary first molar to its antimere using Vernier calliper. All measurements were recorded on a predesigned proforma by the researcher.

Maxillary dental crowding was calculated as difference between arch perimeter (maxillary jaw measured from the mesial aspect of the permanent first molar to its antimere with a brass wire) and sum of tooth widths from the second premolar to the second premolar of opposite side in millimetres.

Maxillary dental crowding was considered when the difference obtained was negative value and greater than 2 mm as assessed on cast and measuring was done with the help of scale.

Maxillary arch width was calculated as distance between the central fossa of first permanent molar of right side to the central fossa of first permanent molar of left side in the maxillary arch. Anterior and posterior tooth size was taken as ratio of sum of mandibular and maxillary mesiodital tooth widths. Maxillary crowding measured in patients were divided into three categories where patients with crowding ≤3mm were categorized as mild crowding, patients with crowding ranging between >3mm and ≤6mm were categorized as moderate crowding whereas patients with crowding >6mm were categorized as severe crowding.

Data was analysed using SPSS 23.0. Mean and standard deviation was calculated for age, inter-molar arch width. Frequency and percentage was calculated for gender and crowding. Spearman Correlation analysis was used in order to determine the extent to which arch width and tooth size contributes in crowding. An independent sample t-test was run in order to determine the mean differences of maxillary arch widths, anterior and posterior tooth sizes between mild, moderate and severe maxillary crowded arches. P-value < 0.05 was taken as significant.

Results

The figure 1 gives a graphical representation of gender of participants of study. The study consisted of 79% female and 21% male participants. The mean age of females was 17.53 ± 2.98 years and of males was 17.55 ± 0.71 years.

Table 1 reports the mean age, maxillary arch width, anterior and posterior tooth size of all participants of current study. The mean age of study participants was found to be 17.53 ± 3.01 years, arch width 43.44 ± 3.89 mm, anterior tooth size 78.26 ± 7.66 and posterior tooth size 91.26 ± 4.92 mm. The mean arch width was found to be 43.44 ± 3.89 mm, anterior tooth size 78.26 ± 7.66 mm and posterior tooth size 91.26 ± 4.92 mm.

The patients were divided into three maxillary crowding categories mild, moderate and severe. The higher frequency (n=40) of patients with severe crowded arches were witnessed in the study compared to those with mild (n=25) and moderate (n=31) crowded arches. The mean age of participants having mild crowded arches was 16.60 ± 0.64 years, moderate crowded arches 19.0 ± 0.44 years and severe crowded arches 16.98 ± 0.46 years.

Table 2 represents the descriptive statistics of maxillary arch width, anterior and posterior tooth size with respect to maxillary crowding categories. Greater maxillary arch widths were observed in patients with mild maxillary crowded arches compared to those with mild and moderate maxillary crowded arches; whereas minimum maxillary arch widths were observed in patients with severe maxillary crowded arches. The mean maxillary arch widths of patients with mild crowded arches was found to be 42.32 ± 4.53 mm, moderate crowded arches 43.9 ± 3.23 mm and severe crowded arches 43.75 ± 3.89 mm.

Patients tending towards severe maxillary crowded arches were likely to have greater anterior and posterior tooth sizes compared to those who had mild and moderate maxillary crowded arches.The mean anterior tooth size of patients with mild maxillary crowded arches was 74.80 ± 13.17 mm, moderate maxillary crowded arches 43.94 ± 3.23 mm and severe maxillary crowded arches 43.75 ± 3.89 mm whereas the mean posterior tooth size of patients with mild maxillary crowded arches was 90.25 ± 5.77 mm, moderate maxillary crowded arches 90.18 ± 5.62 mm and severe crowded maxillary arches 92.72 ± 3.24 mm.

Due to non-linear relation of variables spearman correlation was run in order to evaluate the type of relation maxillary crowding has with maxillary arch width and tooth sizes of patients. Negative weak correlations were obtained against maxillary crowding and maxillary arch width (ρ=-

0.054, p=0.601) and maxillary crowding and anterior (ρ=-0.201, p=0.50) and posterior tooth size (ρ=-0.353, p<0.001). Positive moderate correlation was depicted between anterior and posterior tooth sizes (ρ=0.584, p<0.001).

The mean differences between factors contributing in each category of dental crowding were tested against each other. An independent t test was run against mild and moderate maxillary crowded arches, mild and severe maxillary crowded arches and moderate and severe maxillary crowded arches; prior to analysis assumptions of independent t test were tested by the statistician (i.e. independence, normality of error terms and homogeneity of variances). The table 2, 3 and 4 report the statistics of independent t test of comparisons arch widths, anterior and posterior tooth sizes of patients with mild, moderate severe maxillary crowded arches.

The observation in each case was independently identically distributed as all sample participants of study were independent from each other, the normality of dependent variables for each group was tested using Shapiro Wilk test and the homogeneity of variances assumption was tested using Levene's test.

Shapiro Wilk showed that maxillary arch widths in moderate and severe maxillary crowded arches were normally distributed with p>0.05 but in case of mild maxillary crowded arches they were non normally distributed with p<0.05 however the anterior and posterior tooth sizes were found to be non-normally distributed in mild, moderate and severe crowded arches with p<0.05. Although the assumption of normality was failed but despite of violation of this assumption the t test was run because of its robust nature against violation of assumption of normality[11]. The Levene's test showed that the variances for maxillary arch widths and posterior tooth sizeof patients with mild and moderate maxillary crowding and mild and severe maxillary crowding were equal with p>0.05, but variances for anterior tooth size were not equal with p<0.05, whereas the variances for maxillary arch widths, posterior and anterior tooth size of patients with moderate and severe maxillary crowding were equal with p>0.05. In case of comparison between mild and moderate and severe and moderate maxillary crowding groups anterior tooth sizes assumption was violated despite of violation of homogeneity of variances assumption t-test was run as in cases of comparison of unequal sample sizes homogeneity of variances is often not attained[12].

Insignificant differences were obtained between means of maxillary arch width (t(54)=-1.567, p=0.123) and anterior (t(54)=-1.415, p=0.209) and posterior tooth sizes in mild and moderate maxillary crowded arches (t(54)=0.045, p=0.965) with p>0.05.

In comparison of mild and severe maxillary crowded arches insignificant result was obtained in maxillary arch width (t(63)=-1.351, p=0.182) of patients whereas significant differences were attained for anterior (t(63)= -2.547, p=0.047) and posterior tooth size (t(63)= -2.218, p=0.030) of patients.

Similarly insignificant results were obtained between means of maxillary arch widths (t(69)=0.230, p=0.819) of patients with moderate and severe maxillary crowding with p>0.05 whereas significant results were obtained between means of anterior tooth (t(69)= -2.423, p=0.018) and posterior tooth (t(69)= -2.398, p=0.019) sizes of patients with p<0.05.

Discussion

Dental crowding is the most frequent reason due to which people seek for orthodontic treatment. It is found to be associated with several factors which may include genetic inheritance, gender, age, previous orthodontic treatments, maxillary and mandibular jaw sizes, anterior and posterior tooth size

Table 1. Descriptive Statistic of age, arch, width, anterior & posterior tooth size

	Minimum	Maximum	Mean	Std. Deviation
Age	13.00	21.00	17.53	3.01
Arch Width	36.23	54.54	43.44	3.89
Anterior tooth Size	20.00	87.00	78.26	7.66
Posterior tooth Size	67.00	100.00	91.26	4.92

Table 2. Descriptive Statistic of arch width, anterior and posterior tooth size with respect to different crowding classes

	Mild Crowding (n=25)				Moderate Crowding (n=31)				Severe Crowding (n=40)			
	Minimum	Maximum	Mean	Std.Deviation	Minimum	Maximum	Mean	Std.Deviation	Minimum	Maximum	Mean	Std.iation
Arch Width	37.20	54.54	42.32	4.53	38.37	49.52	43.94	3.23	36.23	51.32	43.75	3.89
Anterior tooth Size	20.00	87.00	74.80	13.17	68.00	84.00	78.29	3.56	71.00	85.00	80.41	3.75
Posterior tooth Size	70.50	100.00	90.25	5.77	67.00	98.00	90.18	5.62	84.00	98.00	92.72	3.24

Table 3. Independent t-test for arch width, anterior and posterior tooth size between mild and moderate crowding

	Levene's Test for Equality of Variances			Independent Sample t test		
		F	p-value	t	df	p-value
Arch Width	Equal variances assumed	0.418	0.521	-1.567	54	0.123
	Equal variances not assumed			-1.512	42.065	0.138
Anterior tooth Size	Equal variances assumed	9.365	0.003	-1.415	54	0.163
	Equal variances not assumed			-1.287	26.838	0.209
Posterior tooth Size	Equal variances assumed	0.009	0.924	0.045	54	0.965
	Equal variances not assumed			0.044	50.932	0.965

Table 4. Independent t-test for arch width, anterior and posterior tooth size between mild and severe crowding

	Levene's Test for Equality of Variances			Independent Sample t test		
		F	p-value	t	df	p-value
Arch Width	Equal variances assumed	0.005	0.942	-1.351	63	0.182
	Equal variances not assumed			-1.304	45.320	0.199
Anterior tooth Size	Equal variances assumed	9.973	0.002	-2.547	63	0.013
	Equal variances not assumed			-2.080	26.451	0.047
Posterior tooth Size	Equal variances assumed	2.248	0.139	-2.218	63	0.030
	Equal variances not assumed			-1.962	33.612	0.058

Table 5. Independent t-test for arch width, anterior and posterior tooth size between moderate and severe crowding

Levene's Test for Equality of Variances		Independent Sample t-test				
	F	p-value	t	df	p-value	
Arch Width	Equal variances assumed	0.997	0.322	.230	69	0.819
	Equal variances not assumed			.235	68.641	0.815
Anterior tooth size	Equal variances assumed	0.868	0.355	-2.423	69	0.018
	Equal variances not assumed			-2.439	66.141	0.017
Posterior tooth Size	Equal variances assumed	2.007	0.161	-2.398	69	0.019
	Equal variances not assumed			-2.248	45.168	0.029

etc. Several cephalometric variables impacts dental crowding and increases its severity[5]. Despite of several contributing factors of dental crowding the relationship between arch width and tooth sizes have always been a major of interest for orthodontists for treatment planning of crowded arches. The results of this relationship have been studied previously between crowded and un-crowded arches and are still found to be discrepant, and have created controversy leading to division of opinions of researchers[8]. Various etiological factors are found to be linked with dental crowding which are previously highlighted by researchers; Mitali etal[10] found relationship between dental morphology and dental crowding, However et al[7] in his study noticed arch dimension as a greater contributor to dental crowding than tooth size, Carter[14], Gilmore[15] and Randzic[16] found similar associations between arch dimensions and dental crowding, Hamid and Rahbar[17] found significant relationship between arch dimensions and crowding rather than to tooth size in a Pakistani sample and Sanin and Savara[18] evaluated 150 children and reported that children without crowding in the permanent dentition had larger anterior and posterior widths of the mandibular dental arch. Eduardo[8] made comparisons between crowded and non-crowded arches and focused only on upper MD tooth sizes and revealed significant differences in upper MD tooth size in crowded and non-crowded arches. Georgeta[19] highlighted various factors which contributes in cause of dental crowding and revealed the fact that dental crowding is related to age, dentition type, angle classes, corrective/surgical treatments and extraction of tooth. Khoja et al.[5] found association between crowding and maxillary and mandibular base lengths. Researchers have highlighted dental crowding in mandibular crowded arches but this study focuses dental crowding only in maxillary crowded arches.

The current study focused on the relationship between maxillary arch widths, anterior and posterior tooth sizes against maxillary crowded arches; it has also focused on comparisons between differences in mean maxillary arch widths and anterior and posterior tooth sizes against mild, moderate, severe maxillary crowded arches.

Greater frequencies of females were witnessed to seek for orthodontic treatment compared to males in Pakistan. Due to limited period, only 96 patients were included in the study out of which 26% of reported cases had mild maxillary crowding, 32% had moderate maxillary crowding & 42% had severe maxillary crowding. This depicts that greater proportion of individuals had severe maxillary crowding in Pakistan whereas in study by Georgeta et.al[19] greater proportion of individuals in Romania were found to have moderate (54%) & mild (28%) crowding and smaller proportion had severe crowding (18%).

In terms of gender, 26.3% of females and 25% of males had mild maxillary crowding, 27.6% of females and 50% of males had moderate maxillary crowding and 46.1% of females and 25% of males had severe maxillary crowding.

The study was limited to cases reporting in department of orthodontic of Karachi Medical and Dental College and was examined by the researcher him/herself. The results and conclusions of the study were based on Pakistani sample with maxillary crowded arches and having age between 13 to 21 years and didn't have any orthodontic treatment previously.

The study revealed significant differences in anterior and posterior tooth sizes between mild and severe as well as moderate and severe maxillary crowded arches. However, insignificant differences were found in anterior and posterior tooth sizes in mild and moderate maxillary crowded arches. The comparison of tooth sizes uncovers the fact that no major difference holds between anterior and posterior tooth sizes when an individual has mild or moderate maxillary crowding, though the findings depicted greater anterior and posterior tooth sizes in patients with severe maxillary crowding compared to patients with mild and moderate maxillary crowding. The comparisons of maxillary arch widths between mild, moderate and severe maxillary crowded

arches depicted insignificant mean differences between mild and moderate, mild and severe, moderate and severe maxillary crowded arches. An inverse relation was obtained for anterior and posterior tooth sizes and maxillary crowding. The study unfolds the fact that individuals with greater anterior and posterior tooth sizes had severe maxillary crowding but smaller maxillary arch widths and individuals with smaller anterior and posterior tooth sizes had mild and moderate maxillary crowding. The results of this study were supported by findings of Saman[13] and Poosti[20] found greater tooth sizes in crowded arches and smaller arch widths whereas insignificant relationships have been reported between tooth sizes and crowding in studies by Gilmore[15] and Randzic[16].

In study by Howe et al[7] greater association was found between crowding and arch dimensions compared to tooth sizes similarly in current study association between maxillary crowding and maxillary arch widths was found to be weak and insignificant whereas association between anterior and posterior tooth size and maxillary crowding was found to be weak and significant. A significant positive moderate relationship between anterior and posterior tooth sizes was depicted. The results of this study are supported by results of studies put forward by Little[21], Hamid and Rahbar[17]. Dental crowding is caused by various different reasons which includes development or decrement in length of dental arch, maturation, aging of dentition etc[22,23].

It is recommended that orthodontists must take maxillary arch widths and tooth sizes of patients in consideration for treatment planning of patients with maxillary crowded arches. The current study results are reported in terms of sample of Pakistani patients the future studies in this area can be made with regard to comparison of sample of patients from distinct nationality. Future researches can be put into action in terms of relationship between anterior and posterior tooth sizes.

Conclusion

Crowding is the prime reason due to which individuals seek for orthodontic treatment. In light of current findings the study concludes that presence of maxillary crowding is related to jaw size, anterior and posterior tooth sizes. The curtailment of arch widths leads to greater tooth sizes due to which severity of maxillary crowding increases and vice versa.

Conflict of Interest

The authors of the study do not have any conflict of interest with findings of authors of previous studies.

References

1. Leighton BC. Aetiology of malocclusion of the teeth. Arch Dis Child 1991;66:1011-2. [DOI:10.1136/adc.66.9.1011].
2. Das PJ, Dkhar W, Pradhan A. An Evaluation of Dental Crowding in Relation to the Mesiodistal Crown Widths and Arch Dimensions in Southern Indian Population [Online]. J Clin Diagn Res 2017;11:10-3. Available from: https://jcdr.net/article_fulltext.asp?issn=0973-709x&year=2017&volume=11&issue=9&page=TC10&issn=0973-709x&id=10554. Accessed on: 28th August 2019.[DOI:10.7860/JCDR/2017/29642.10554].
3. Sadeghian S, EsnaashariN ghoreishi N. Relationship of dental crowding with mesiodistal crown diameters and arch dimension. Iran J Orthod 2014;1:133-8. Available from: https://www.magiran.com/paper/1505544/?lang=en. Accessed on: 2nd September 2019.
4. Ayesha Khoja, Mubassar Fida AS. Association of maxillary and mandibular base lengths with dental crowding in different skeletal malocclusions [Online]. J Ayub Med Coll Abbottabad 2014;26:428-33. Available from: http://jamc.ayubmed.edu.pk/index.php/jamc/article/view/1171. Accessed on: 28th August 2019.
5. Warren JJ, Bishara JE, Yonezu T. Tooth size-arch length relationships in the deciduous dentition: A comparison between contemporary and historical samples. Am J Orthod Dentofacial Orthop 2003;123:614-9.
6. Jahan H, HMZ. A dissertation on tooth size and arch dimension in uncrowded versus crowded Class I malocclusion [Online]. Bangladesh Journal of Orthodontics and Dentofacial Orthopedics 2011;2. Available from: https://www.banglajol.info/index.php/BJODFO/article/view/15995. Accessed

on: 28th August 2019. [DOI: https://doi.org/10.3329/bjodfo.v2i1.15995].

7. Howe RP, McNamara JA OK. An examination of dental crowding and its relationship to tooth size and arch dimension. Am J Orthod 1983;83:363-73.

8. Bernabe E, Flores-Mir C. Dental Morphology & Crowding: A Multivariate. Angle Orthod 2006; 76:20-5.

9. Hussain SS, Ashraf B, Khan SQ. Relationship of Dental Crowding To Tooth Size and Arch Dimensions in Class I Normal & Class I Malocclusion Sample [Online]. Pakistan Oral and Dental Journal 2014;34:660-5. Available from: http://podj.com.pk/archive/Dec_2014/PODJ-18.pdf. Accessed on: 28th August 2019.

10. Bora M, Chokotiya H, Banthia A, Sharma M, Majumder P. Dental Crowding and Its Relationship To Dental Morphology in an Ethnic Population. IJOCR 2014;3(1):63-7.

11. Posten H. The Robustness of the Two-Sample T-test over the Pearson System [Onlne]. J Stat Comput Simul 1978;6:295-311. Available from: https://www.tandfonline.com/doi/abs/10.1080/00949657808810197. Accessed on: 28th August 2019. [DOI: https://doi.org/10.1080/00949657808810197.].

12. Guiard V, Rasch D. The Robustness of two sample tests for Means A Reply on von Eye's Comment [Online]. Psychology Science 2004;46:549-53. Available from: https://pdfs.semanticscholar.org/a73f/9e36ead6aad26107cd5f168c1271225e222a.pdf. Accessed on: 28th August 2019.

13. Faruqui S, Fida M, Shaikh A. Comparison of tooth and arch dimensions in dental crowding and spacing [Online]. Pakistan Orthodontic Journal 2012;4:48-55. Available from: https://www.poj.org.pk/index.php/poj/article/view/65. Accessed on: 28th August 2019.

14. Carter GA, McNamara JA. Longitudinal dental arch changes in adults. Am J Orthod Dentofacial Orthop 1998; 114:88-99.

15. Gilmore CA, Little RM. Mandibular incisor dimensions and crowding. Am J Orthod 1984;86:493-502.

16. Randzic D. Dental crowding and its relationship to mesiodistal crown diameters and arch dimension. Am J Orthod Dentofacial Orthop 1988;94:50-56.

17. Hamid MW, Rahbar MI. Dental crowding and its relationship to tooth size and arch dimensions [Online]. Pakistan Oral and Dent Journal 2005; 25:47-52. Available from: https://pdfs.semanticscholar.org/83db/a62d9a3317bdffd7acf72ca7b946ee25c199.pdf. Accessed on: 28th August 2019.

18. Sanin C, Savara BS. Factors that affect the alignment of the mandibular incisors. Am J Orthod 1973; 64:248-257.

19. Zegan G, Dascalu CG, MavruRB, Anistoroaei D. Necessity factors and predictors of dental crowding treatment [Online]. Orthodontics 2015;5:200-206. Available from: https://www.researchgate.net/profile/Georgeta_Zegan/publication/284727954_NECESSITY_FACTORS_AND_PREDICTORS_OF_DENTAL_CROWDING_TREATMENT/links/565855cd08aeafc2aac2cfad/NECESSITY-FACTORS-AND-PREDICTORS-OF-DENTAL-CROWDING-TREATMENT.pdf. Accessed on: 28th August 2019.

20. Poosti M, Jalali T. Tooth size and arch dimension in uncrowded versus crowded class I malocclusions. J Contemp Dent Pract 2007;8:45-52.

21. Little RM, Wallen TR, Riedel RA. Stability and relapse of mandibular anterior alignment - First premolar extraction cases treated by traditional edgewise orthodontics. Am J Orthod 1981; 80:349-365.

22. Shah AA, Eleock C, Brook AH. Incisor crown shape and crowding. Am J Orthod Dentofacial Orthop 2003; 123:562-567.

23. Mimoza Selmani, Julijana Gjorgova. Relationship among Lower Arch Length, Arch Width and Arch Perimeter in Crowding and Non-Crowding Groups [Online]. Balkan Journal of Dental Medicine 2015; 19:8-12. Available from: http://balkandentaljournal.com/relationship-among-lower-arch-length-arch-width-and-arch-perimeter-in-crowding-and-non-crowding-groups/. Accessed on: 28th August 2019.