ORIGINAL ARTICLE

ASSOCIATION OF MAXILLARY AND MANDIBULAR BASE LENGTHS WITH DENTAL CROWDING IN DIFFERENT SKELETAL MALOCCLUSIONS

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Background: Dental crowding is the one of the most frequently encountered problem for an orthodontist. The relationship between crowding and various skeletal, dental and soft tissue parameters is important to establish and consider during the overall orthodontic treatment planning. This study aimed to determine the correlation of maxillary and mandibular base lengths with dental arch crowding in different malocclusions and to evaluate the gender dimorphism for these variables. **Methods:** A sample of 120 subjects divided into three skeletal malocclusions was further subdivided based on amount of mandibular arch crowding. Maxillary and mandibular base lengths and dental arch crowding were measured on pre-treatment lateral cephalograms and initial casts using vernier calliper respectively. Inter-group comparisons were assessed by univariate analysis of variance. Correlation between base lengths and dental crowding was assessed by Pearson's correlation ($p \leq 0.05$). **Results:** Statistically significant differences were found for maxillary (p=0.008) and mandibular base lengths (p=0.000) between different skeletal malocclusions. Mandibular base length was significantly larger in males (p=0.000). Mandibular crowding was highest in class-II and lowest in class-III (p=0.01). A significant but weak negative correlation was found between dental crowding and maxillary (r=-0.28, p=0.02) and mandibular (r=-0.20, p=0.02) base lengths, significant but moderate positive correlation between maxillary and mandibular base lengths (r=0.566, p=0.000) and between maxillary and mandibular crowding (r=0.408, p=0.000). **Conclusions:** Maxillary and mandibular base lengths are largest in skeletal class-II and class-III malocclusions respectively. Mandibular base length is larger in males as compared to females. An increase in amount of dental crowding is weakly associated with smaller skeletal base lengths.

Keywords: Dental crowding, Base lengths, skeletal malocclusions

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INTRODUCTION

Dental crowding is one of the most frequent chief complaints of patients seeking orthodontic treatment. It is identified as a disparity between tooth size and arch size that causes teeth to rotate, impact or otherwise to erupt in an improper position.[1] However, dental crowding is not only influenced by tooth and arch size discrepancy but a multitude of factors are responsible for its development and severity.[2,3] Various studies have been carried out in the past to identify the etiological and contributing factors of dental crowding, however it is still an ongoing subject of debate.[4–11] Although, it was established that dental crowding can be the result of changes in human evolutionary trends[12] as well as certain hereditary and environmental factors[13], the importance of investigating the various clinical characteristics that contribute to it should be emphasized during the overall orthodontic treatment planning.[8]

These factors could be of skeletal, dental or soft tissue in origin. These include tooth size, tooth shape, dental arch dimensions, oral and perioral musculature, mandibular and maxillary body lengths and direction of growth of the jaws etc.[1,2] Different treatment modalities have been employed in orthodontic correction of dental crowding such as extraction of permanent tooth, inter-proximal reduction of tooth size, arch expansion and growth modification.[9] Identification of the existing contributing factors of dental crowding will help us in employing appropriate treatment strategy as well as in achieving stable post-treatment results.[9,10]

Several studies have been carried out to examine the various skeletal, dental and soft tissue factors that may be related to dental arch crowding. Some studies reported the correlation of tooth size with dental crowding while others correlated arch dimensions. Lundstrom[11] in his study found that the dental crowding increases in individuals with large teeth or macrodontia. Mills[3] found that dental arches of individuals without crowding are wider than crowded arches. Harvold[14] determined the effect of soft tissues and found that the volume and position of tongue contributes to dental crowding.

The severity of dental crowding can also be influenced by various cephalometric variables; however few studies have investigated and emphasized their importance. Leighton and Hunter[15] in their study compared the skeletal morphology of individuals with and without crowding and found smaller mandibular body length in cases with crowding. Similarly, Sakuda and his associates[16] examined the relationship between skeletal morphology and dental crowding and found smaller mandibular body lengths in patients with crowding in permanent dentition. Moreover, Janson G *et al*[1] found that patients with class-II malocclusion with moderate to severe mandibular crowding have smaller skeletal base lengths than patients with slight mandibular crowding. However, none of these studies have investigated and compared these cephalometric variables in skeletal class-I, II and III malocclusions altogether. The primary aim of the present study is to determine the association of maxillary and mandibular skeletal base lengths with the amount of dental arch crowding in skeletal class-I, II and III malocclusions. The secondary goal is to compare the differences in length of these skeletal bases as well as amount of maxillary and mandibular arch crowding across the gender of subjects.

MATERIAL AND METHODS

This cross sectional study was conducted by review of the data from all the available orthodontic records including files, dental casts and cephalometric radiographs of the Dental Section at the Aga Khan University Hospital, Karachi. The inclusion criteria included the presence of skeletal class-I, II or III malocclusion, age range of 13–25 years, fully erupted permanent teeth up to first molars and mandibular arch crowding of less than or greater than 3 mm. The exclusion criteria included any prior history of orthodontic treatment, fractured restorations or crowns, any tooth anomaly of number, size, form and position, premature exfoliation/extraction of primary teeth which may cause secondary crowding and any craniofacial anomalies/syndromes. This study included 120 subjects (38 males, 82 females) who were equally divided into skeletal class-I, II and III malocclusions (40 subjects each) on the basis of sagittal relationship of maxilla with the mandible. The sagittal relationship was determined on pre-treatment lateral cephalometric tracings by measuring ANB angle which was constructed by intersection of lines joining point N to point A and point N to point B (Figure-1). The ANB was set at 1–4°, >5° and <0° for skeletal class-I, II and III respectively. Each skeletal Class was further subdivided into two groups according to the severity of mandibular arch crowding. Subjects with mandibular arch crowding of <3mm were placed in group-1 and those with mandibular arch crowding of >3 mm were placed in group-2. Therefore, the total subjects distributed as skeletal class-I (20 subjects in each group), skeletal class-II (group-1: 18, group-2: 22 subjects), skeletal class-III (group-1: 27, group-2: 13 subjects).

The tooth size arch length discrepancy in the maxilla and mandible was calculated as the difference between space available and space required. Space available was measured on the dental casts by segmental method from the mesial aspect of first permanent molar to its antimere in millimeters with the help of a digital vernier caliper (0–150 mm ME00183, Dentaurum, Pforzheim, Germany) with an accuracy of 0.02 and reliability of 0.01 mm manufacturer's specification. The space required was calculated by measuring the mesiodistal width of each tooth from the second premolar to contralateral second premolar in millimeters by a single investigator. Crowding was recorded as positive value whereas spacing as a negative value. The maxillary and mandibular skeletal base lengths were measured on pretreatment lateral cephalograms which were traced manually over illuminator by the principal investigator according to the conventional method. The cephalometric landmarks were marked and maxillary and mandibular skeletal base lengths were subsequently measured as a linear measurement from Co to point A and Co to Gn in millimeters, respectively (Figure-2).

In order to rule out measurement error, 10 pairs of dental casts and 10 cephalograms were randomly selected and retraced by principal investigator for intra-examiner reliability. All the readings obtained were collected on the data collection form.

The data were analysed using SPSS-19 (Chicago Inc. USA). Univariate analysis of variance was applied to determine the difference in length of maxillary and mandibular bases between three skeletal malocclusion groups, between the two mandibular crowding groups and across the gender of subjects. Pearson's correlation was applied to evaluate the relationship of maxillary and mandibular base lengths with amount of dental crowding and to assess the intra-examiner reliability. The $p \leq 0.05$ was considered to be statistically significant.

RESULTS

The mean age of subjects in skeletal class I, II and III malocclusion was 16.6±3.6 years, 17.8±4.4 years and 17.3±3.8 years respectively. Each skeletal malocclusion group was found to be comparable in terms of age (Figure-3).

The difference in maxillary and mandibular base lengths among skeletal class-I, II and III malocclusion groups was statistically significant (Table-I and II). The maxillary base length was found to be largest in skeletal Class II and smallest in skeletal class-III (p=0.008). The mandibular base length was largest in skeletal class III and smallest in skeletal class-II (p=0.000). However, the difference in maxillary and mandibular base lengths between the two mandibular crowding groups of <3 mm and >3mm was found statistically insignificant (p=0.13) (Table-1 and 2).

Between the genders, there was statistically significant difference for the mandibular base length, being larger in males as compared to the females (Table-1 and 2).

The difference in amount of maxillary arch crowding among three skeletal malocclusions was found to be statistically insignificant (Table-3). However, the intergroup differences for the mandibular arch crowding between different skeletal malocclusions was found to be statistically significant being highest in skeletal Class-II and lowest in skeletal class-III (p=0.001) (Table-4). No statistically significant changes were observed for maxillary and mandibular arch crowding between the genders (Table-3 and 4). Moreover, our results showed a significant increase in maxillary arch crowding in moderate to severe mandibular crowding group (p=0.000) (Table 3)

The Pearson's correlation showed a significant but weak inverse correlation between the maxillary (r=-0.28, p=0.02) and mandibular (r= -0.20, p=0.02) base lengths with maxillary and mandibular crowding respectively. In addition, significant but moderate positive correlation was found between maxillary and mandibular base lengths (r=0.566, p=0.000) and between maxillary and mandibular crowding (r=0.408, p=0.000) (Table 5).

The intra-examiner reliability showed a strong correlation for maxillary base length (r=0.99), mandibular base length (r=0.97), mandibular crowding (r=0.97) and maxillary crowding(r=0.98).

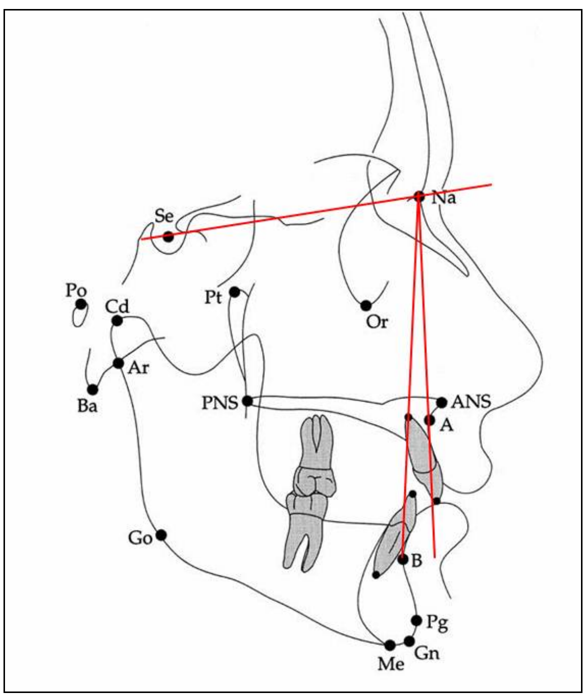

Figure-1: Measurement of ANB angle on Lateral Cephalogram

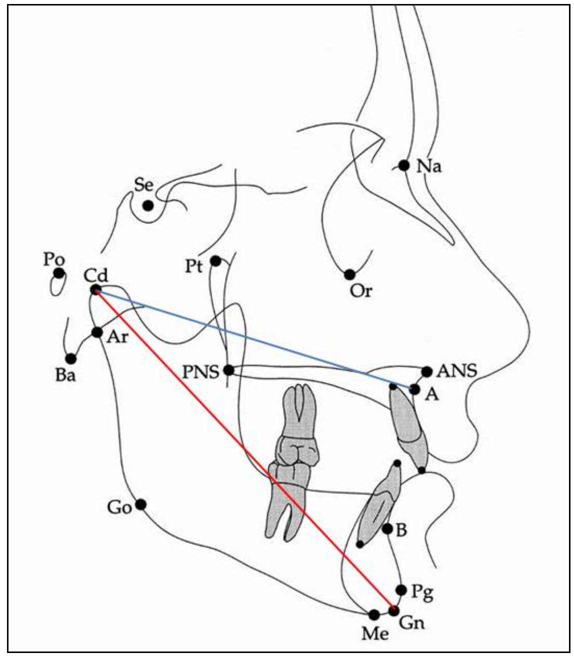

Figure-2: Measurement of maxillary (Co-A) and mandibular (Co-Gn) on Lateral Cephalogram

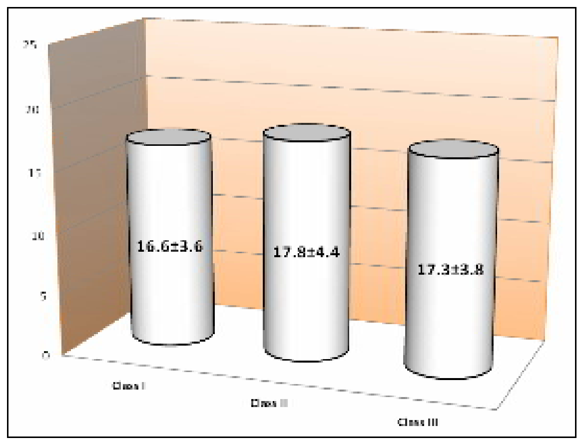

Figure-3: Mean age of the subjects in different skeletal malocclusions

Table-1: Comparison of maxillary base length between different skeletal malocclusions, among two mandibular crowding groups and across the gender

Maxillary Length		Mandibular Arch Crowding (Mean & SD)		*p*-value
Skeletal Class	Gender	<3mm	>3mm	
Class I	Male	96.6±4.39	91.5±5.22	0.13 (b/w mandibular crowding groups) **0.008*** (b/w skeletal malocclusions) 0.07 (across gender)
	Female	90.8±5.65	89.1±4.10	
Class II	Male	96.0±6.68	94.0±7.52	
	Female	90.6±7.23	95.3±5.56	
Class III	Male	91.5±4.82	87.1±10.8	
	Female	90.5±6.11	87.1±6.12	

N=120, Univariate analysis of variance, $p \leq 0.05$*

Table-2: Comparison of mandibular base length between different skeletal malocclusions, among two mandibular crowding groups and across the gender

Mandibular Length		Mandibular Arch Crowding (Mean & SD)		*p*-value
Skeletal Class	Gender	<3mm	>3mm	
Class I	Male	123.2±3.56	118.4±7.80	0.88 (b/w mandibular crowding groups) **0.00*** (b/w skeletal malocclusions) **0.00*** (across gender)
	Female	113.8±.05	117.6±4.03	
Class II	Male	121.0±4.96	117.8±10.0	
	Female	110.4±9.78	116.8±8.09	
Class III	Male	130.5±11.0	128.8±7.36	
	Female	121.4±7.22	119.5±8.24	

N=120, Univariate analysis of variance, $p\leq 0.05$*

Table-3: Comparison of amount of maxillary crowding between different skeletal malocclusions, two mandibular crowding groups and across the gender of subjects

Maxillary Crowding		Mandibular Arch Crowding (Mean & SD)		*p*-value
Skeletal Class	Gender	< 3mm	>3mm	
Class I	Male	1.30±3.56	5.07±2.99	**0.00*** (b/w mandibular crowding groups) .323 (b/w skeletal malocclusions) .277 (across gender)
	Female	-0.81±4.07	4.51±4.75	
Class II	Male	2.87±3.11	6.78±8.07	
	Female	1.55±4.00	1.34±4.31	
Class III	Male	-0.83±4.24	7.83±5.76	
	Female	2.35±5.03	7.68±6.01	

N=120, Univariate analysis of variance, $p\leq 0.05$*, +=crowding; - =spacing

Table-4: Comparison of amount of mandibular crowding between different skeletal malocclusions and across the gender of subjects

Mandibular crowding	Skeletal Class (Mean & SD)			*p*-value
Gender	**Class I**	**Class II**	**Class III**	**0.001*** (b/w skeletal malocclusions) 0.44 (across gender)
Male	3.80±3.23	6.59±5.49	1.87±5.12	
Femal	4.39±3.33	4.47±3.87	1.46±4.87	

N=120, Univariate analysis of variance, $p\leq 0.05$*

Table-5: Correlation of maxillary and mandibular base lengths with maxillary and mandibular crowding

Variable	r-value	*p*-value
Maxillary length×maxillary crowding	-0.285**	0.002
Mandibular length×mandibular crowding	-0.201*	0.028
Maxillary length×mandibular crowding	0.566**	0.000
Maxillary crowding×mandibular crowding	0.408**	0.000

N=120, Pearson's correlation, Correlation is significant at 0.05*, Correlation is significant at 0.01**.

DISCUSSION

One of the main goals of this study was to determine an association of maxillary and mandibular base lengths with the severity of dental crowding among different skeletal malocclusions. The findings of this study do not indicate any statistically significant differences in the mean values of maxillary and mandibular base lengths between the mild mandibular crowding group and moderate to severe mandibular crowding group. However, the results of correlation analysis indicated a weak inverse correlation between dental crowding and maxillary and mandibular base lengths. Janson G *et al*[1] in their study with similar objective but restricted only to skeletal Class II malocclusion found statistically significant mean values for maxillary and mandibular base lengths between the two mandibular crowding groups.

Turkkahraman and Sayin[2] reported a significant but weak inverse correlation between dental crowding and maxillary and mandibular base lengths in skeletal Class-I malocclusion. Our results are in concordance with their study as well as other previous studies[1,15,16] which provide compelling evidence that severity of dental crowding increases with retrognathic jaws or short bony bases and vice versa.

When maxillary and mandibular base lengths were compared between the different skeletal malocclusions, our data suggest statistically significant differences for their mean values. It was observed that maxillary base length was largest in skeletal class-II and smallest in skeletal class-III whereas mandibular base length was found to be largest in skeletal class-III and smallest in skeletal class-II. Similarly, Dhopatkar *et al*[17] in their study found maxilla and mandible to be longest in skeletal class-II and III respectively.

Baccetti *et al*[18] in their study on gender differences in class-III malocclusion found a significant degree of gender dimorphism in subjects aged 13 years and above for maxillary and mandibular base lengths along with other craniofacial structures. Male subjects with class-III malocclusion presented with a significantly larger linear dimensions of the maxilla (Co-PtA), mandible (Co-Gn) and anterior facial heights when compared to female subjects. Although, our study results also showed greater linear dimensions for both maxillary (Co-A) and mandibular (Co-Gn) base lengths in males aged 13–25 years among all skeletal malocclusions, this increase was found to be significant only for mandibular base length. Another longitudinal study of Ursi *et al*[19] on sexual dimorphism on craniofacial growth observed greater linear measurements for mid-facial (Co-A) and mandibular length (Co-Gn) in males as compared to females at all ages but significant changes were observed after 14 years. Our results are in correspondence with the aforementioned studies however, unlike those studies, the cross-sectional sampling technique used in our study doesn't give supporting evidence for growth changes of the maxillary and mandibular base lengths across genders at different chronological ages.

When maxillary crowding was compared between the two mandibular crowding groups, our results showed increase in mean values for maxillary crowding in moderate to severe mandibular crowding group. In addition, there is a positive correlation between maxillary and mandibular crowding. Since, the maxillary and mandibular base lengths are positively correlated with each other; the increase in dental crowding in maxilla will lead to increase in crowding in mandible and vice versa. These results are in agreement with the results of study conducted by Janson G *et al*.[1]

In addition, insignificant differences for maxillary and mandibular crowding were found across the gender. Numerous studies[20–24] in the past have investigated the gender differences for dental crowding. Dorris JM *et al*[20] did not find any significant differences for dental crowding between gender of subjects and therefore their results affirm these findings. Besides, our study results are inconsistent with other studies which found a greater degree of dental crowding in females than males.[21–23]

Several studies[25,26] have been conducted to determine the tooth size discrepancies between different malocclusions. Mihovil Sitrujic *et al*[22] found mandibular tooth size excess in Angle Class-III malocclusion and maxillary tooth size excess in Angle Class-II malocclusion. In our study, when the amounts of maxillary and mandibular arch crowding were compared between the three skeletal malocclusions, the difference in the mean values for mandibular arch crowding changed significantly, being highest in skeletal Class-II and lowest in skeletal Class-III. On the basis of these finding, it can be interpreted that subjects with skeletal Class-II had an increased mandibular arch crowding due to their smallest mandibular base length whereas, subjects with skeletal Class-III had comparatively decreased amount of mandibular arch crowding due to their largest mandibular base length.

In light of all the findings, it is suggested that in addition to the several other contributing factors of dental crowding as investigated in the literature, the maxillary and mandibular skeletal base lengths may also play a role. Therefore, during the selection of a suitable treatment strategy in patients presenting with varying severity of dental crowding, this factor should also be taken into consideration.

CONCLUSIONS

Maxillary and mandibular base lengths are different in skeletal class-I, II and III malocclusions. Maxillary base length is largest and mandibular base length is smallest in skeletal class-II and vice versa in skeletal class-III malocclusion. Mandibular base length is larger in males as compared to females. The amount of mandibular arch crowding is highest in skeletal class-II and the lowest in skeletal class-III malocclusion. There is no sexual dimorphism for amount of maxillary and mandibular arch crowding.

Increase in severity of dental arch crowding is weakly associated with maxillary and mandibular base lengths. However, there is a moderate positive correlation between maxillary and mandibular base lengths and between maxillary and mandibular crowding.

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