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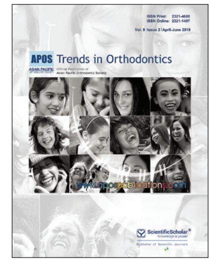

Original Article

Relationship of maxillary and mandibular effective base length, arch length and dental crowding in different vertical growth pattern

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ABSTRACT

Objectives: The objectives of the study were to assess, measure, and correlate the maxillary and mandibular effective base length, arch length to the amount of dental crowding in different vertical growth pattern patients.

Materials and Methods: Sample comprising 100 pre-treatment lateral cephalograms and study models (age group – 16–25 years) was randomly selected. The sample was divided into two groups, that is, clockwise (50) and anticlockwise (50) rotation based on the measurement of the gonial angle. The gonial angle and maxillary and mandibular effective lengths were measured on pre-treatment lateral cephalograms. Dental crowding and arch length were measured on the pre-treatment dental casts. Intergroup comparisons of effective base length, arch length, and crowding were performed with unpaired *t*-tests. Correlations between effective base length, arch length, and dental crowding were examined by means of Pearson's correlation coefficient ($P < 0.05$).

Results: Subjects with clockwise rotation significantly had more mandibular dental crowding and significantly decreased mandibular arch length compared to the anticlockwise group. An inverse correlation was found between maxillary and mandibular effective base length, arch length, and dental crowding while a positive correlation was found between maxillary and mandibular base length and arch length in both the groups.

Conclusion: Clockwise rotation of the mandible along with skeletal and dental factors such as decreased effective base lengths and arch length, respectively, constitutes an important factor leading to dental crowding.

Keywords: Mandibular rotations, Dental crowding, Maxillary and mandibular base lengths

INTRODUCTION

Anterior crowding is one of the most frequent types of malocclusions that motivates the patients to seek an orthodontic treatment. Dental crowding can be defined as a discrepancy between tooth size and arch size that results in malposition and/or rotation of teeth. Understanding the causes of crowding might be useful in formulating various treatment plans and in predicting future needs. Crowding is not merely a tooth arch size discrepancy but also a discrepancy among many variables. Many factors have been evaluated and found to be related to dental crowding such as genetics, environment, and clinical factors such as mesiodistal tooth diameter, dental arch width and length, and dental proportions.[1-9] Along with these dental factors, studies have shown that cephalometric features such as effective

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base length are also associated with a greater amount of dental crowding.[10-17] However, in the above-mentioned studies, none of the studies have taken different vertical growth pattern into consideration. Therefore, the novelty of our study was to correlate skeletal parameters, dental parameters, and dental crowding to different vertical growth patterns.

Complex growth patterns, that is, mandibular rotations also have been implicated as the cause of dental crowding. Studies have shown that extreme degrees of mandibular rotation could result in increased crowding and that crowding is also caused by a specific pattern of growth and type of skeletal pattern that is susceptible to crowding at the beginning of adolescence.[18] Besides, the changes in facial morphology brought about by growth or orthodontic treatment play an important role in the development of crowding in the lower dental arch.[19] Many studies have found correlation between crowding and direction of mandibular rotation.[10,11,20-26] Although the correlation between dental parameters such as dental crowding and arch length and skeletal parameters such as effective base length have been studied by many investigators, similarly, the growth pattern also has been related to crowding in literature, the correlation between these skeletal parameters and dental parameters to dental crowding in different jaw rotations has yet to be determined. Therefore, the purpose of this present study was to assess and correlate the skeletal and dental parameters in different vertical growth patterns.

MATERIALS AND METHODS

The sample was retrospectively selected from the files of the patients who had undergone treatment in our orthodontic department. The inclusion criteria were records of age group 16–25 years, permanent dentition, no sex discrimination, no previous orthodontic treatment with the absence of dental anomalies of number, size, and form. Hundred patients who satisfied the inclusion criteria were selected. The sample was divided into two groups according to the measurement of the gonial angle. Group 1, that is, clockwise rotation consisted of 50 subjects with the gonial angle ≥134° and Group 2, that is, anticlockwise rotation consisted of 50 with gonial angle ≤120°.[27] The comparison of age and gonial angle in different mandibular rotation is shown in [Table 1].

Measurements were performed on pre-treatment dental casts and lateral cephalograms. All lateral cephalograms were taken on the same radiographic unit and traced by a single operator. Tracings were done on acetate sheets. Gonion (Go), condylion (Co), point A, and gnathion (Gn) were the cephalometric landmarks that were used in the study. The angular measurement used was Ar-Go-Me (gonial angle) [Figure 1] based on which it was divided into two groups while linear measurements used were Co-point A (maxillary effective base length) and Co-Gn (mandibular effective base length) [Figure 2].

Crowding was quantified in relation to the arch form that reflects the majority of teeth. After determining the imaginary arch, the amount of crowding was assessed using a millimetric scale by measuring the discrepancy between the mesiodistal width of the displaced tooth and space available in the arch between the contact points of adjacent teeth taking care to conform to the individual's arch form.[28] The dental casts were scanned using Epson Perfection V750 scanner and the arch length was measured as the perpendicular distance from the contact point between the permanent central incisors to a line joining the distal surfaces of the first permanent molars.[29]

Error study

A month after the first measurements, 40 pairs of dental casts (20 of each group) were remeasured. Furthermore, an inter- and intra-observer agreement was done between using intraclass correlation test.

Interexaminer reliability

It was seen that for maxillary crowding, there was almost a perfect agreement (96%), that is, a highly significant agreement ($P < 0.001$**) between Observer 1 and Observer 2 and for mandibular crowding an excellent agreement (94.3%), that is, highly significant agreement ($P < 0.001$**) was observed between Observer 1 and Observer 2.

Intraexaminer reliability

It was seen that for maxillary crowding, there was almost a perfect agreement (98.2%), that is, highly significant agreement ($P < 0.001$**) was observed between different

Table 1: Comparison of age (in years) and gonial angle (in degrees) in different mandibular rotations, respectively.

	Clockwise rotation Mean (SD)	Anticlock rotation Mean (SD)	Unpaired "*t*" test	*P* value, significance
Age	18.9 (2.71)	19.5 (2.75)	*t*=-1.17	*P*=0.245
Gonial angle	136 (2.44)	118 (2.23)	*t*=38.81	*P*<0.001**

P>0.05 – No significant difference, **P*<0.001 – Highly significant difference

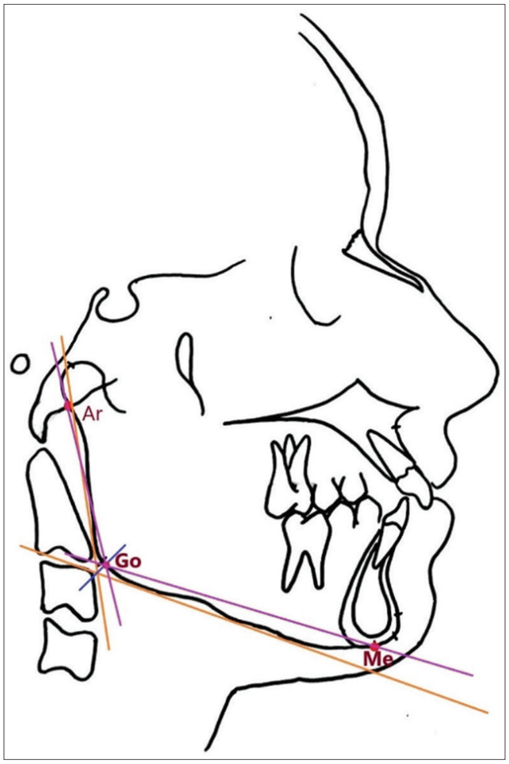

Figure 1: Lateral cephalogram showing the angular measurement – gonial angle (Ar-Go-Me).

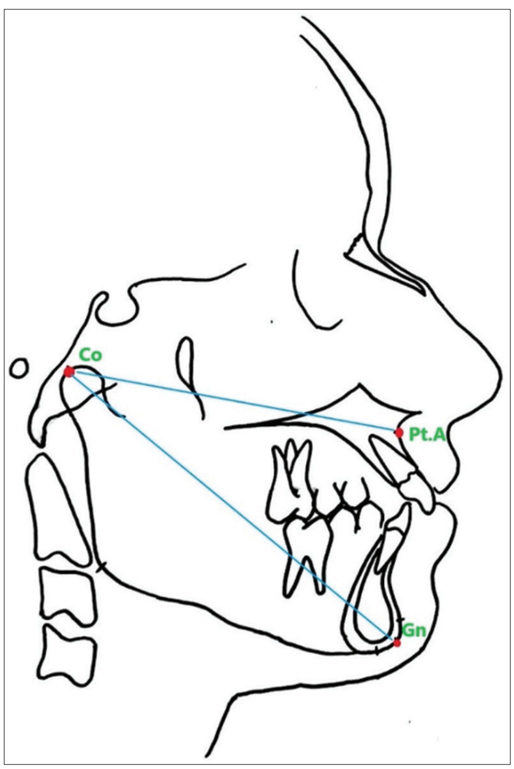

Figure 2: Lateral cephalogram showing linear measurements – maxillary effective base length (Co-Pt. A) and mandibular effective base lengths (Co-Gn).

time intervals and for mandibular crowding an excellent agreement (96.4%), that is, highly significant agreement ($P < 0.001$**) was observed between different time intervals.

Statistical analyses

Intergroup compatibility for age and gonial angle as well as the skeletal and dental variables was evaluated with unpaired *t*-tests, respectively. Correlation between maxillary and mandibular effective length, arch length, and dental crowding severity, that is, the intragroup correlation was investigated with the Pearson correlation coefficient.

RESULTS

The groups were compatible in terms of age distribution and gonial angle as shown in [Table 1]. Statistically significant differences were found in mandibular crowding ($P = 0.003$) and mandibular arch length ($P = 0.036$) between both the groups [Table 2]. However, there was no significant intergroup difference in the maxillary and mandibular effective base length, maxillary dental crowding, and maxillary arch length.

Significant weak to moderate inverse correlations were found between dental crowding and effective base lengths and a significant moderate to strong inverse correlations were found between dental crowding and arch length in both the groups. Weak to moderate positive correlations were found between effective base lengths and arch lengths in both the groups [Tables 3 and 4].

DISCUSSION

A review of the literature indicated numerous etiological factors of crowding.[3,18] Only few studies have evaluated the relationship between crowding and cephalometric measurements. It was the aim of this study to assess and correlate whether a relationship existed between crowding and skeletal and dental parameters in different mandibular rotations.

Sample selection and grouping

Sample size was derived to be 100 according to statistical analysis with the power of the study set at 80%. Group selection was done according to the severity of mandibular rotation, that is, Group 1 consisted subjects with clockwise rotation, that is, gonial angle ≥134° (mean – 136° ± 2.44°) and Group 2 consisted subjects with anticlockwise rotation, that is, gonial angle ≤ 120° (118° ± 2.23°).[26] However, in the previous studies, group selection was based according to the severity of mandibular crowding using 3 mm crowding for group assignment.[14-17] In the present study, along with dental crowding, even the different vertical growth pattern was also taken into consideration.

Table 2: Comparison between maxillary and mandibular effective lengths, arch length to the amount of dental crowding (all in mm) in different mandibular rotations, respectively.

	Clockwise rotation Mean (SD)	Anticlock rotation Mean (SD)	Unpaired "*t*" test	*P* value, significance
Effective maxillary length	85.7 (6.49)	87.2 (6.43)	$t=-1.161$	$P=0.249$
Effective mandibular length	111.06 (8.04)	112.6 (7.78)	$t=-1.011$	$P=0.315$
Maxillary dental crowding	3.92 (4.05)	3.05 (3.01)	$t=1.218$	$P=0.226$
Mandibular dental crowding	6.38 (3.0)	4.57 (2.95)	$t=3.035$	**$P=0.003$***
Maxillary arch length	24.04 (3.07)	23.24 (3.93)	$t=1.133$	$P=0.26$
Mandibular arch length	17.73 (2.36)	19.92 (1.95)	$t=-5.044$	**$P=0.036$***

$P>0.05$ – No significant difference, *$P<0.05$ – Significant difference, *$P=0.003$ – Significant difference suggesting increasing in mandibular crowding in clockwise group

Table 3: Correlation between maxillary and mandibular effective lengths, arch length to the amount of dental crowding (all in mm) in clockwise mandibular rotations, respectively.

Clockwise rotations		
Correlation variable	**Pearson "r" correlation coefficient**	***P* value, significance**
Maxillary dental crowding × Maxillary base length	r=−0.052 (Weak negative)	$P=0.720$
Mandibular dental crowding × Mandibular base length	r=−0.435 (Moderate negative)	**$P=0.003$***
Maxillary dental crowding × Maxillary arch length	r=−0.597 (Strong negative)	**$P<0.001$****
Mandibular dental crowding × Mandibular arch length	r=−0.334 (Moderate negative)	**$P=0.006$***
Maxillary base length × Maxillary arch length	r=0.078 (Weak positive)	$P=0.592$
Mandibular base length × Mandibular arch length	r=0.276 (Moderate positive)	**$P=0.037$***

$P>0.05$ – No significant correlation, *$P<0.05$ – Significant, *$P<0.001$ – Highly significant, *$P=0.003$ – Significant difference suggesting that mandibular base length and mandibular dental crowding are inversely proportional to each other in clockwise rotations

Age

Longitudinal studies consistently showed greater (up to 2 times) mandibular true rotation during childhood compared to adolescence. Most of true mandibular rotation during childhood occurs during the transition from the late primary to the early mixed dentitions.[30,31] Hence, in our study, the records of the subjects between the age groups ranging from 16 to 25 years were taken into consideration as most of the growth rotation is completed.

Method to measure crowding

Some studies have used the brass wire technique to measure dental crowding.[14-17] However, the method used in this study has been found to be preferable to using calipers and a brass wire to measure crowding, as the brass wire technique has shown to be less reliable, probably because of cumulative error or bias that arises from the need to measure every tooth rather than just the misaligned ones.[28,32] Furthermore, the intraobserver and interobserver agreement for dental crowding ranged from excellent to almost perfect agreement for both maxillary and mandibular arches in our present study.

Dental crowding

Our results were in agreement with Bjork implant studies that claimed that in extreme downward and backward rotation, the lower incisors become retroclined through their functional relationship with the upper incisors. The posterior teeth are not guided distally in their eruption, and crowding develops anteriorly.[20] Few studies have also found similar correlation between an increase in degree of mandibular dental crowding and high mandibular plane angles, they claimed that this was due to a particular type of skeleton that was susceptible to crowding and to a specific pattern of growth.[10,13]

Conversely, several other investigators have found no correlation between dental crowding and direction of mandibular growth and they believe that crowding is a local, independent, genetically determined discrepancy between tooth width and size of supporting bone.[22,23]

Table 4: Correlation between maxillary and mandibular effective lengths, arch length to the amount of dental crowding (all in mm) in anticlockwise mandibular rotations, respectively

Anticlockwise rotations		
Correlation variable	**Pearson "r" correlation coefficient**	***P* value, Significance**
Maxillary dental crowding × Maxillary base length	r=−0.210 (Weak negative)	*P*=0.144
Mandibular dental crowding × Mandibular base length	r=−0.463 (Moderate negative)	***P*=0.001***
Maxillary dental crowding × Maxillary arch length	r=−0.565 (Strong negative)	***P*<0.001****
Mandibular dental crowding × Mandibular arch length	r=−0.188 (Weak negative)	*P*=0.190
Maxillary base length × Maxillary arch length	r=0.269 (Moderate positive)	***P*=0.049***
Mandibular base length × Mandibular arch length	r=0.298 (Moderate positive)	***P*=0.035***

**P*=0.001 – Highly significant suggesting that mandibular dental crowding and mandibular base length are inversely proportional to each other in anticlockwise rotations

In our study, increased amount of crowding seen in clockwise rotators is due to greater amount of vertical space created between anterior teeth due to clockwise rotation, thereby requiring a greater amount of eruption of the anterior teeth to compensate for the vertical space created, therefore, greater amount of eruption decreases the likelihood of the contacts between the anterior teeth to be maintained and increases the risk of crowding.[24,25]

However, the most probable reason of dental crowding in clockwise rotators is due to the dentoalveolar compensation where the dental apparatus compensates for the extreme degree of jaw rotation, thereby maintaining the occlusal relationship by deteriorating the space condition and causing dental crowding.[33] This can be related to the genetic as well as environmental factors where the vertical growth pattern is due to the genetic component and the dental crowding is due the environmental factor, that is, the eruption of the teeth which tries to compensate for the extreme degree of vertical growth pattern. Moreover, the soft tissue also plays an important role, that is, the incisors retrocline when the mandible rotates posteriorly due probably to relatively greater lip than tongue pressure.[34]

This suggests that jaw rotation plays an important role and is one of the etiologic factors in the development of dental crowding.

Effective base length

Our study showed no significant difference between maxillary and mandibular effective base lengths between both the groups. Furthermore, it was found that both maxillary and mandibular dental crowding were inversely correlated to maxillary and mandibular effective base lengths, respectively, in both the groups. Our results were similar to the previous studies with unspecified malocclusion in which they found that subjects with crowding in mixed and permanent dentition had significantly smaller mandibular body length.[10-12] Similarly, it was seen that in some studies with specified malocclusion, where they compared Class I and Class II facial pattern patients with and without anterior crowding and found that the patients with incisor crowding showed a shorter maxillary and mandibular length.[13-16] Conversely, Montasser and Taha did not find any correlation between maxillary and mandibular effective base lengths and dental crowding in Class I orthodontic cases.[17] This suggests that subjects with shorter effective base length have a greater likelihood of crowding and effective base length is independent of the direction of mandibular rotation.

Arch length

Our results are similar to the various other studies where they observed significant differences in arch lengths between the crowded and non-crowded, moreover, the crowded arches had smaller arch length than non-crowded groups.[3-5] However, in the above-mentioned studies, the growth rotation was not taken into consideration.

In our study, dental crowding was inversely correlated to arch length, that is, decrease in arch length in clockwise group was due to increase in crowding and vice versa. The probable cause of decrease in arch length is the eruption path of the mandibular teeth which is in upward and somewhat forward direction, and the normal internal rotation of the mandible carries the jaw upward in front and tends to upright the incisors. Because the internal jaw rotation tends to upright the incisors, the molars migrate further mesially during growth than do the incisors, and this migration is reflected as decrease in arch length that normally occurs.[29,35]

Furthermore, as clockwise rotators are weak musculated, more decrease in arch length may be observed due to mesial drift, in which posterior teeth have a tendency to mesially migrate overtime compared to anticlockwise rotators.

Functional factors

Functional factors also have an influence on the position of the teeth and normal pattern of skeletal growth, on the other hand, obstruction of the upper airway, resulting in mouth breathing, changes the pattern of craniofacial growth causing malocclusion. In majority of studies, the authors established a relation between mouth breathing and the development of dental crowding mainly seen in clockwise rotators. The malocclusions described include a distal occlusion, anterior open bite, increase overjet, posterior crossbite, crowding and average incisors inclination disturbances, and displacement of contact points leading to crowding. Moreover, the lowered tongue posture seen in mouth breathers leads to narrow arches, thereby leading to crowding and malocclusion. These clinical conditions become more complicated in the late mixed and permanent dentition if mouth breathing continues to persist.[29,36,37]

This study shows association between the clockwise rotation of the mandible and the amount of mandibular anterior crowding. The current results suggest that besides dental factors and skeletal factors such as effective base lengths, the different vertical growth pattern is also an important factor in dental crowding. Therefore, this has to be taken into consideration during treatment planning and retention.

CONCLUSION

- Dental crowding is correlated to different vertical growth pattern. In our study, the crowding was significantly increased in clockwise group.
- Mandibular arch length was significantly decreased in the clockwise group than the anticlockwise group while there was no significant difference in the maxillary arch length between both the groups.
- Dental crowding was found to be inversely correlated to arch length in both the groups, that is, if dental crowding increases, arch length decreases, and vice versa.
- There was no significant difference between effective maxillary and mandibular base length between both the groups, suggesting that the effective base lengths are independent of the jaw rotation.
- Effective maxillary and mandibular base lengths were inversely correlated to dental crowding, that is, subjects with smaller effective base lengths are mostly likely to have dental crowding.
- Effective maxillary and mandibular base lengths were found to be directly correlated to arch length in both the groups.

Limitation of the study

- Angles Classes I, II, and III malocclusions were not taken into consideration.
- Longitudinal data are not available.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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