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Original Article

Dentistry Section

Relationship of Anterior Alveolar Dimensions with Mandibular Divergence in Class I Malocclusion – A Cephalometric Study

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ABSTRACT

Introduction: One of the major limiting factors in retraction of proclined teeth is the width of the alveolus both in maxilla and mandible.

Aim: The objective of this study was to assess the maxillary and mandibular anterior alveolar dimensions and to correlate with mandibular divergence in Class I bi-dento-alveolar protrusion patients.

Materials and Methods: Pretreatment lateral cephalograms (n=88) were analysed using a composite analysis with cephalometric software. Both maxillary and mandibular anterior alveolar widths and heights were measured and correlated with mandibular divergence. One-way analysis (ANOVA) and Pearson correlation test were used to compare and establish the significance between groups.

Results: Segregation of the data based on variation in the bi-cortical widths and heights showed that lesser alveolar widths and greater alveolar heights were associated with the high angled subjects and greater alveolar widths and lesser heights were associated with low angled subjects.

Conclusion: Patients with hyperdivergent mandible exhibited thin anterior alveolar width and greater alveolar height whereas low angled subjects had wider alveolar width and lesser alveolar height. Orthodontic treatment plan for retraction of anterior teeth must be based on these differences caused by variations in mandibular divergence.

Keywords: Cortical limits, Iatrogenic sequelae, Retraction

INTRODUCTION

Maxillary and mandibular incisor axial inclination is altered in Class I bimaxillary protrusion patients. Retraction of these proclined incisors and positioning it within the bone is essential for function, stability and esthetics. Handelman highlighted the importance of respecting the cortical boundaries that exist in the anterior alveolus of the maxilla and mandible which govern the movement of incisors especially when orthodontic treatment requirements involve maximum retraction [1]. Hence, the anterior alveolar dimensions appear to set limits to orthodontic treatment and challenging these boundaries may accelerate iatrogenic sequelae viz. dehiscence, fenestrations and root resorption.

Studies have reported that mandibular divergence during growth might influence the dimensions of the alveolar bone in the anterior as well as posterior region of both maxilla and mandible [1,2]. The purpose of this study was to assess the anterior alveolar dimensions in Class I malocclusion patients.

The null hypothesis was that there is no significant correlation in anterior alveolar width and height with that of the mandibular divergence in Class I bi-dento-alveolar protrusion patients.

MATERIALS AND METHODS

This retrospective study was conducted using pretreatment cephalometric radiographs of 100 patients out of which only 88 patients including 41 females and 47 males were selected who underwent orthodontic treatment during the period 2009 to 2011 at the Department of Orthodontics and Dentofacial Orthopedics, Meenakshi Ammal Dental College and Hospital, Chennai, Tamilnadu and fulfilled the inclusion criteria.

The following inclusion criteria were utilized: Patients who were in the age group of 18 to 27 years, absence of systemic illness, no history of previous orthodontic treatment, presence of only minimal crowding (<4mm) in lower arch and well aligned upper arch (0mm crowding), a Class I skeletal pattern (ANB 2±2°) and Class I molar relation with bi-dento-alveolar protrusion who were indicated for orthodontic treatment involving extraction of first premolars.

The exclusion criteria were patients who had impacted canines, tooth size discrepancy, moderate to severe crowding.

The subjects were divided into three groups: Sella-Nasion to Mandibular Plane (SN-MP) Angle were measured and Frankfurt Mandibular Plane Angle (FMA) values were used to determine the mandibular divergence and group them as low (23.50±5.81°), average (33.17±3.33°) and high angled (40.84±2.41°) subjects accordingly [3,4].

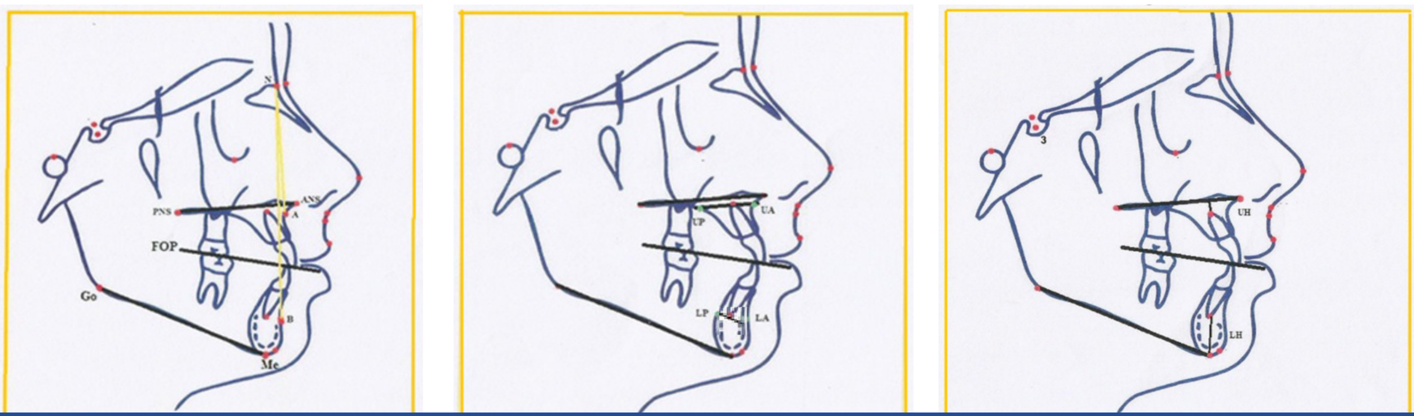
A composite cephalometric analysis including seven linear measurements and one angular measurement was compiled to measure the bi-cortical widths and heights in the maxilla and mandible. The Dolphin imaging cephalometric software (version 11.2) was employed to evaluate the data.

Tracing and measurement method: The maxilla, mandible and their respective incisal outlines were traced along with the palatal plane (ANS-PNS), mandibular plane (Go-Me) and the functional occlusal plane [Table/Fig-1a].

The following measurements were made which is shown in [Table/Fig-1b]:

1) A parallel line was constructed to the palatal plane which passed through the root apex of the maxillary incisor. In the maxillary outline, the anterior and posterior limits (UA point and UP point) were marked along the constructed parallel line.

2) A parallel line was constructed to the occlusal plane which passed through the root apex of the mandibular incisor. In the mandibular outline, the anterior and posterior limits (LA point and LP point) were marked along the constructed parallel line.



[Table/Fig-1a]: ANB, palatal plane and functional plane.**[Table/Fig-1b]:** Widths of maxillary and mandibular anterior alveolus. **[Table/Fig-1c]:** Anterior alveolar heights in maxilla and mandible.

3) Measurement of anterior maxillary alveolar boundary (UA') and posterior maxillary alveolar boundary (UP'): The distance (UA') was measured from U1 root to UA point along the parallel line previously constructed using the software. The measurement process was repeated to measure the posterior limit from U1 to UP point i.e. UP'.
4) The total maxillary alveolar width (UA'+UP') in the anterior region was also measured.
5) Measurement of anterior mandibular alveolar boundary (LA') and posterior mandibular alveolar boundary (LP'): The distance (LA') was measured from L1 root to LA point along the parallel line previously constructed using the software. The measurement process was repeated to measure the posterior limit from L1 to LP point i.e., LP'
6) The total mandibular alveolar width (LA'+LP') in the anterior region was also measured.
7) Maxillary anterior alveolar height (UH): The distance between U1 root apex to palatal plane was measured along the perpendicular line drawn from the palatal plane to U1 root [Table/Fig-1c].
8) Mandibular anterior alveolar height (LH): The distance between L1 root apex to mandibular plane was measured along the perpendicular line drawn from the mandibular plane to L1 root [Table/Fig-1c].

The mandibular plane angles (Sn-MP and FMA) were also measured which categorized the sample patients into average, low and high angle groups [Table/Fig-2].

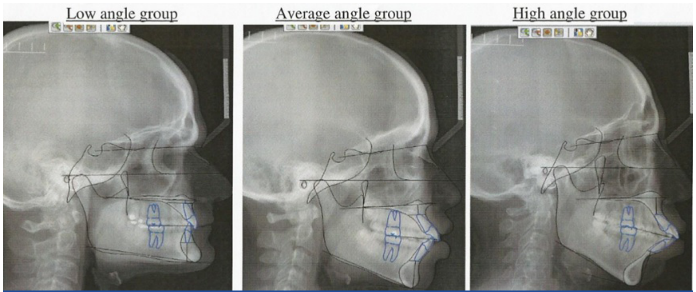
All the cephalometric measurements were carried out by three observers (O1, O2 and O3) to assess the reproducibility of the methodology and were repeated three times by all three observers at three weeks interval (P1, P2 and P3) to assess the consistency of method of measurement by each observer. The Dahlberg statistical analysis was performed for comparison.

STATISTICAL ANALYSIS

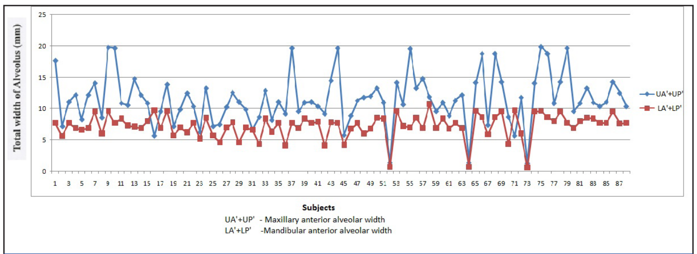
The data was subjected to the One–way analysis (ANOVA) for multiple comparisons and establishment of level of significance. Pearson correlation coefficient was calculated to correlate the relationship between mandibular divergence and alveolar dimensions.

RESULTS

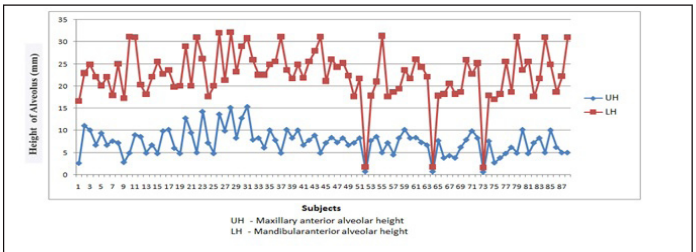
The alveolar widths and heights of all the 88 Class I subjects were measured and graphically represented [Table/Fig-3a,3b]. The maxillary and mandibular alveolar widths and alveolar heights of the low, average and high angled groups were also compared. The mean and standard deviation values of anterior alveolar width and height measurements were tabulated [Table/Fig-4a, 4b].



[Table/Fig-2]: Lateral cephalograms grouped based on mandibular divergence.



[Table/Fig-3a]: Total width of anterior alveolus in all 88 subjects.



[Table/Fig-3b]: Total height of alveolus in all 88 Class I subjects.

There were statistically significant differences in the total anterior alveolar widths of the maxilla and the mandible in all subjects assessed (UA'+UP' and LA'+LP'). However, there were no statistically significant differences observed between the anterior alveolar widths (UA' and LA') and posterior alveolar widths (UP' and LP') when assessed independently.

There were also statistically significant differences seen between the heights of the maxillary and mandibular alveolus (UH and LH) in all subjects.

Also the distribution of anterior alveolar widths and heights were categorized based on mandibular divergence which is shown in [Table/Fig-5a, 5b] respectively.

Three different magnitudes of bi-cortical widths and heights viz. low, average and high were isolated and it was then correlated with the mandibular plane angle of the respective subject which is shown in [Table/Fig-6]. It was found that divergence had significant correlation with the bi-cortical widths and heights. The correlation being, the lesser alveolar widths and greater alveolar heights were associated with the high angled subjects whereas the greater alveolar widths and lesser heights were associated with low angled subjects.

Parameter	Mean (±S.D.)	95% Confidence Interval for Mean	
		Lower bound	Upper bound
UP'	6.46 ± 2.6	5.76	7.17
UA'	4.62 ± 1.0	4.33	4.92
UA'+UP'	11.22 ± 2.9*	10.43	12.01
LP'	4.67 ± 1.2	4.34	5.00
LA'	2.90 ± 1.0	2.61	3.18
LA'+LP'	7.57 ± 1.7*	7.10	8.04

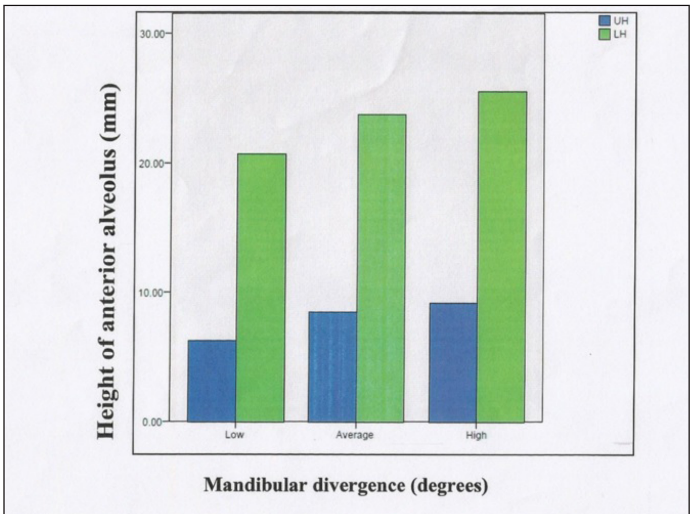
[Table/Fig-4a]: Mean and standard deviations for the maxillary and mandibular alveolar width measurements.
(*p<0.05, in One-way analysis (ANOVA); UP'- posterior maxillary alveolar boundary, UA'- anterior maxillary alveolar boundary, UA'+UP'- total maxillary alveolar width, LP'-posterior mandibular alveolar boundary, LA'-anterior mandibular alveolar boundary, LA'+LP'-total mandibular alveolar width).

Parameter	Mean (±S.D.)	95% Confidence Interval for Mean	
		Lower bound	Upper bound
UH	8.24 ± 2.7*	7.48	8.99
LH	23.67 ± 3.7*	22.65	24.69

[Table/Fig-4b]: Mean and standard deviations for the maxillary and mandibular alveolar height measurements.
(*p<0.05 in One-way analysis (ANOVA); UH-maxillary anterior alveolar height and LH-mandibular anterior alveolar height).

Variable	Low (n = 30)	Average (n = 30)	High (n = 28)
SN-MP	23.50 ± 5.81	33.17 ± 3.33	40.84 ± 2.41
UP'	7.94 ± 2.82†	6.55 ± 2.13	5.31 ± 2.91
UA'	4.83 ± 0.90	4.51 ± 1.21	4.71 ± 1.00
UA'+UP'	12.77 ± 3.33†	11.28 ± 2.40	10.08 ± 3.23
LP'	5.31 ± 1.10	4.51 ± 1.39	4.46 ± 0.75
LA'	3.64 ± 1.46*†	2.88 ± 0.97	2.44 ± 0.55
LA'+LP'	8.95 ± 1.69*†	7.44 ± 1.79	6.90 ± 1.10

[Table/Fig-5a]: Distribution of width of anterior alveolus based on mandibular divergence.
* p<0.05 for comparison with average group in One-way analysis (ANOVA).
†p<0.05 for comparison of low and high angled groups in One-way analysis (ANOVA).
(SN-MP-mandibular plane angle, UP'-posterior maxillary alveolar boundary, UA'-anterior maxillary alveolar boundary, UA'+UP'-total maxillary alveolar width, LP'-posterior mandibular alveolar boundary, LA'-anterior mandibular alveolar boundary, LA'+LP'-total mandibular alveolar width).



UH – Anterior alveolar height in maxilla, LH- Anterior alveolar height in mandible

[Table/Fig-5b]: Distribution of height of anterior alveolus based on mandibular divergence.

DISCUSSION

It has been established in literature by several other studies that the anatomic limits set by the cortical plates of the anterior alveolus at the level of the incisor apices may be regarded as "orthodontic walls"which limit the orthodontic tooth movement [1,5,6]. It has been reported that even though the alveolar bone at the incisor mid-root level as well as the marginal level undergoes remodeling, the assumption was that the bone at the level of the root apex does not remodel [6]. To validate the concept, the purpose of this study was to determine quantitatively, the width and height of the anterior alveolus in both skeletal and dentoalveolar Class I individuals. This would determine a clinical insight to the amount of tooth movement possible within these boundaries.

Handelman studied the anterior alveolar width in all the three groups of patients including Class I, II and III malocclusions with differing mandibular divergence and reported that narrower alveolar width existed in Class II high angle and Class III individuals [1].

Class I malocclusions with bi-dento-alveolar protrusion generally warrants the extraction of bicuspids in both maxillary and mandibular region and followed by anterior retraction. This demands bodily movement of incisors to a greater magnitude within the alveolar bone. However extraction pattern and the magnitude of anterior retraction in Class II as well as Class III malocclusion differ when compared to Class I bimaxillary protrusion. Hence, our study focused on investigating merely Class I skeletal and dento-alveolar situations which were indicated for maximum incisor retraction.

The age group considered in this study (18 to 27 years) represented a very stable period where the influence of growth is less and the permanent dentition is beyond the variability seen during the period of mixed dentition [7,8]. In most of the individuals with Class I bi-dento-alveolar excess, the skeletal discrepancy is so significant that in these cases, mere orthodontic tooth movement alone is limited. Lack of assessment of these limits could result in extensive tooth movement that could invade the cortical plates and perforate it, resulting in the occurrence of iatrogenic sequelae such as root resorption, gingival dehiscence and fenestration.

Studies have reported a higher incidence of root resorption in patients who had narrow maxillary alveolar bone width after lingualization of the anterior teeth [1,5,9]. Probable reason could be the presence of dense cortical plate on the labial and lingual surfaces near the apical region of the incisors which cannot accommodate greater magnitude of labiolingual tooth movement [10,11].

Mirabella et al., has shown that the alveolar widths in the anterior segment differ based on the three different mandibular divergences such as low, average and high angle cases [12]. To corroborate whether the mandibular divergence has any influence in the anterior alveolar width, subjects in our study were divided into low, average and high mandibular divergence groups.

Mandibular divergence and anterior alveolar width: Bjork has reported seven structural signs of mandibular growth rotation which influences the mandibular divergence [2]. Low angled patients are characterized by pronounced apposition of bone at the anterior part of the mandible and below the symphysis. It has also reported that a narrow shaped symphysis is mainly associated with a posterior rotation of the mandible in high angle subjects [13].Variations in growth pattern resulting in mandibular growth rotations cause the mandible to shift either in a forward or backward direction. Furthermore, it has been demonstrated that the apparent constancy of downward and forward facial growth is a result of rotations combined with remodeling [2]. Remodeling will occur at the mandibular border in an attempt to maintain the original MP-SN angle. Extremely high MP-SN angles have been theorized to result from relatively small amounts of vertical ramal as well as condylar growth producing backward rotation [2]. In these cases, the

Parameter	Upper alveolar width	Lower alveolar width	Upper alveolar height	Lower alveolar height
Low angle	-0.786**	-0.741**	0.519†	0.597†
Average angle	-0.474	0.252	0.402	-0.219
High angle	-0.672*	-0.657*	0.493†	0.559†

[Table/Fig-6]: Pearson correlation between alveolar width and mandibular divergence.
** signifies strong negative linear relationship
* signifies moderate negative linear relationship
† signifies moderate positive linear relationship.

mandibular anterior teeth supra-erupts to achieve an incisal stop thereby increasing the alveolar height compromising the alveolar width. As compensation, the maxillary anterior teeth also extrude to achieve incisal contact resulting in thinning the anterior alveolar width.

Our study results showed that the width of the anterior alveolus measured in the maxilla and mandible varied widely within each Class I individuals. Further grouping based on mandibular divergence showed decreased maxillary and mandibular alveolar bone width in the high mandibular divergence group when compared to average and low angle groups.

The width of the external symphysis increases in size as the facial types varies from a high angled to a low angled pattern. This finding was also supported by Haskell who measured the amount of protruding chin and found that patients with open bite (who were generally high angled individuals) showed a small protruding chin area [14]. Hylander proposed that the symphysis is necessary to mitigate shear stress distributed through the mandible as a result of a 'balancing' posterior bite [15]. The reduction of protruding chin in open bite cases may be due to the loss of incisal bite stress in mastication. This could be a possible reason for thinning of alveolar bone in relation to the anterior mandible in high mandibular divergence individuals as evident in our study.

Low mandibular divergence patients on the other hand, have thicker anterior alveolar widths. Gracco et al., reported that the distance between the apex and the internal surface of the vestibular cortex is more in low angled than in high angled subjects [16]. It was also reported that extreme and extensive development of perioral and masticatory musculature was observed in low angled individuals [17-19]. It has been demonstrated that the temporal muscle may have less prominent relation with the morphology of the mandible as when compared to the masseter and diagastric muscles and electromyographic study by Hiroshi et al., reported that masseter muscle activity is significantly longer in low angle individuals [20, 21]. Hence, the cortical bone thickness in these individuals is much thicker and could be attributed to this extreme muscular activity. Our study confirms this association. This correlation between masticatory muscle orientations, thickness, bite force and dento-skeletal morphology has been described previously [22].

Clinical significance of alveolar width: As the width of the cortical bone in high angled patients is thin, it is necessary to retract the incisors without any torque loss and have to be positioned well within the cancellous bone to prevent iatrogenic effects. In low angled subjects apparently the thicker anterior alveolus allows the orthodontist to freely move the incisors without any fear of untoward effects caused by limited bone width.

Mandibular divergence and Alveolar height: The results in this study showed that the height of the anterior alveolus in the maxilla and mandible was significantly greater in the high angled individuals when compared to low angled individuals. This is the result of dental compensation along with vertical elongation of the alveolus which has been reported earlier [23-25]. Whereas low angled subjects had a reduced alveolar height which could be probably due to forward rotation of the mandible lacking vertical anterior alveolar bone remodeling with compensated excess ramal growth. Hence, these patients present with deep bite and reduced lower facial height, even with average skeletal base.

Clinical significance of the alveolar height: Even though the alveolar height may not have a direct influence in retraction of incisors, due to the limitation in conventional orthodontic procedure, treatment options such as corticotomy might be beneficial in high angled individuals less traumatizing to the teeth as well as the alveolar bone. Corticotomy would enable setting back of the anterior teeth en-masse along with the alveolar housing thereby preventing iatrogenic sequelae like root resorption and dehiscence associated with orthodontic retraction thus helping to maintain the position of the incisor roots well within the cancellous bone.

LIMITATION

This study had certain limitations such as only pretreatment alveolar dimensions was evaluated and compared in different mandibular divergence patients. Further studies can be performed by comparing both pre and post-operative records on these subjects to evaluate the response of alveolar width and height to the orthodontic mechanics.

CONCLUSION

The null hypothesis was rejected. Our results showed a positive correlation between anterior alveolar widths and heights with the mandibular divergence. In high angled patients, overall decrease in alveolar width both in maxilla and mandible was observed whereas it was increased in low angled individuals. The maxillary and mandibular anterior alveolar heights were greater in high angled individuals and least in low angle individuals. Clinician should consider the anterior alveolar boundary while treating patients with Class I bi-maxillary protrusion with high mandibular divergence and choose alternative treatment plan such as corticotomy, surgical setback to prevent irreversible iatrogenic sequelae.

REFERENCES

[1] Handelman CS. The anterior alveolus: its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. *Angle Orthod*. 1996; 66(2):95-110.

[2] Bjork A. Prediction of mandibular growth. *Am J Orthod*. 1969; 55(6):585-99.

[3] Sassoni V. A roentgenograghic cephalometric analysis of cephalofacial dental relationships. *Am J Orthod*. 1958; 41:433-63.

[4] Tweed CH. The Frankfort-Mandibular plane angle in orthodontic diagnosis , classification, treatment planning and prognosis. *Am J Orthod and Oral Surg*. 1946; 32:175-320.

[5] Hoeve AT, Mulie RM. The effect of antero-postero incisor repositioning on the palatal cortex as studied with lamingraphy. *J Clin Orthod*. 1976;10: 804-22.

[6] Edwards JG. A study of the anterior portion of the palate as it relates to orthodontic therapy. *Am J Orthod*. 1976; 69:249-73.

[7] Altemus. A comparison of cephalofacial relationships. *Angle Orthod*. 1960;30(4):223-40.

[8] Brodie AG. The growth pattern of the human head from the third month to the eight year of life. *Am J Anat*. 1941; 68:209-62.

[9] Wehrbein H, Fuhrmann AW. Periodontal conditions after facial root tipping and palatal root torque of incisors. *Am J Orthod Dentofacial Orthop*. 1994; 455-62.

[10] Alexander D, Vardimon. Cortical bone remodeling/tooth movement ratio during maxillary incisor retraction with tip versus torque movements. *Am J Orthod Dentofacial Orthop.* 1998; 114:520-29.

[11] Ahn HW, Moon SC, Baek SH. Morphometric evaluation of changes in the alveolar bone and roots of the maxillary anterior teeth before and after en masse retraction using cone-beam computed tomography. *Angle Orthod*. 2013; 83:212–21.

[12] Mirabella AD, Artun J. Risk factors for apical root resorption of maxillary anterior teeth in adult orthodontic patients. *Am J Orthod Dentofacial Orthop*. 1995;108:48-55.

[13] Roy S. Jaw morphology and facial types. *Journal of Orofacial Research*. 2012;2(3):131-38.

[14] Haskell BS. The human chin and its relationship to mandibular morphology. *Angle Orthod*. 1979; 49:153-66.

[15] Hylander WL. The human mandible –lever or link. *Am J Phys Anthrop*. 1975; 43:2.

[16] Gracco A, Luca L, Bongiorno MC, Siciliani G. Computed tomography evaluation of mandibular incisor bony support in untreated patients. *Am J Orthod Dentofacial Orthop.* 2010; 138(2):179-87.

[17] Sassouni V. A classification of facial types. *Am J Orthod*. 1969;55(2):109-23.

[18] Ingervall B, Janson T. The value of clinical lip strength measurements. *Am J Orthod.* 1981; 80:496-507.

[19] Proffit WR, Fields HW. Occlusal forces in normal and long-face children. *J Dent Res*. 1983; 62:571-74.

[20] Latif A. An electromyographic study of the temporalis muscle in normal persons during selected positions and movements of the mandible. *Am J Orthod*. 1957;43:577-91.

[21] Ueda HM. Masticatory muscle activity in children and adults with different facial types. *Am J Orthod Dentofacial Orthop*. 2000;118:63-68.

[22] Sharma NS, Shrivastav SS. Relationship among types of growth patterns, buccolingual molar inclination and cortical bone thickness of the mandible: a CT scan study. *J Ind Orthod Soc*. 2012;46(2):59-64.

[23] Solow B. The dentoalveolar compensatory mechanism: background and clinical implications. *Brit J Orthod*. 1980; 7:145-61.

[24] Enlow DH. The morphological and morphogenetic basis for craniofacial form and pattern. *Angle Orthod*. 1971; 41(3):161-88.

[25] Chung CJ. Morphological characteristics of the symphyseal region in adult skeletal Class III crossbite and openbite malocclusions. *Angle Orthod*. 2008;78(1):38-43.

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