DENTOALVEOLAR COMPENSATION IN VERTICAL SKELETAL DYSPLASIA IN AN EGYPTIAN SAMPLE

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ABSTRACT:

Introduction: *The Dentoalveolar compensatory mechanism is the changes that occur in the dentoalveolar complex in cases of skeletal discrepancies (anteroposterior, vertical, transverse) in order to maintain functional occlusion. In a patient with a deep bite or an open bite coinciding with an extreme vertical lower face deficiency or excess, surgical approach that requires presurgical dental decompensation might be considered. Alternatively, simpler non-surgical treatment options involve dentoalveolar compensation. The determination of which option is suitable for a patient must be based on the feasibility of dentoalveolar compensation which in turn will depend on severity of skeletal discrepancy. An accurate estimation of the limits of dentoalveolar compensation is therefore a key to successful treatment.*

Aim of the study: *To determine the extent of dentoalveolar compensation in various facial types and to investigate the influence of skeletal and dentoalveolar characteristics on overbites in long and short face individuals.*

Materials and methods: *Lateral cephalometric X-rays from the department of Orthodontics, Alexandria University were evaluated till we got 90 lateral cephalometric X-rays of three equal*

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groups: Long face, Average face and short face. 15 dentoalveolar measurements and 5 skeletal measurements were made on these Xrays. Comparison of linear, angular, area and ratio measurements were compared among the three study groups using ANOVA for normally distributed variables and Kruskal Wallis test for variables that were not normally distributed. Measurements that were significantly different among the three groups were further tested in comparison of pairs using Tukey post hoc test for normally distributed variables and Mann Whitney U test for variables that were not normally distributed. Comparison of overbite categories among the three groups was done using Wilcoxon signed ranks test. Non parametric correlation between study groups and categories of overbite was examined using Kendal tau b. Stepwise regression analysis was used to examine significant predictors of overbite in short, long faces separately and in the whole sample using all measured linear, area, angular and ratio measurements.

Results: The results of this study showed that there were significant differences between the three groups in nine linear variables which were: ramus length, mandibular body length, anterior cranial base length, mandibular alveolar depth, mandibular and maxillary incisor alveolar and basal heights, mandibular and maxillary dentoalveolar heights and overbite. The prevalence study of different categories of overbite in the three groups showed that in the short face group about two thirds of the patients had deepbite while in the long face group only four cases had an openbite and more than half of the patients had normal or deepbite. The multiple regression analysis showed that that there were two powerful predictors of overbite in the short face group which were the ratio between the mandibular molar dentoalveolar height and mandibular incisor alveolar and basal height and the interincisal angle. In the long face group only one powerful predictor of overbite was determined which was the SN-Mandibular plane angle.

Conclusions: *The role of dentoalveolar compensatory mechanism in the establishment of the overbite had been shown, but still its effect is limited beyond certain limits. In the short face group the combined effect of both the mandibular molar and incisor alveolar heights play an important role in maintaining the overbite. An overbite of 3mm can be achieved if the ratio didn't exceed 0.83.In the long face group the skeletal factors plays a more dominating role than dentoalveolar factors in controlling the overbite. Although the role of dentoalveolar compensation is more demonstrated in the long face group, its actual mechanism hadn't been determined exactly. An overbite of 3mm can be achieved if the SN-Mandibular Plane angle didn't exceed 39 degrees.*

INTRODUCTION

The human face has been the subject of study since man could first express himself. Facial proportion was discovered; there were standards set for balance and harmony of the face. Frakas [(1)] described the ideal face as vertically divided into equal thirds by horizontal lines that approximate the hairline, the bridge of the nose, the ala of the nose, the menton. In the ideally vertically proportioned face there is further subdivision of the lower one third of the face into an upper one third and a lower two thirds. These divisions of the face can be used by the clinician to help diagnose vertical dimension problems. Vertical malocclusions are multidimensional. Vertical malocclusions result from the interplay of many different etiological factors during the growth period. These factors include growth of the maxilla and the mandible. Thus, Vertical malocclusions can be divided into those that are dentoalveolar in origin and those that are predominately skeletal due to growth patterns of the jaws. In addition, functional factors can also modify the developing occlusion and can play significant role in the development of malocclusion in the vertical plane.[(2)]

Since the individual variability in the amount and the direction of the growth of both the mandible and the maxilla is large together with the multiple factors affecting development and growth. On the other hand, the coordination of the development of the upper and the lower jaws is not always perfect. Therefore, some mechanism is needed to coordinate the eruption and the position of the teeth relative to their jaw bases in order for a normal relationship between upper and lower dental arches to be achieved and maintained. The existence of such dentoalveolar adaptations had been demonstrated in individual case analyses and by statistical analyses. (3)

The mechanism was termed dentoalveolar compensatory mechanism and can be defined as a system which attempts to maintain normal inter-arch relations under varying jaw relationships in all three planes of space (anteroposterior, transverse, vertical).(4) Solow(4) stated that the efficiency of the dentoalveolar compensatory mechanism is obviously related to the development of malocclusion and malocclusions that reflect discrepancies in the jaw base relationships are not directly caused by the discrepancy in the jaw relationship. Rather, they may be considered due to the fact that discrepancy in the jaw base relationship was not compensated for, due to an insufficient or inoperative dentoalveolar compensatory mechanism.

Schudy(5) in his study of the growth increments and its relation to overbite stated that ‘One of the most baffling enigmas is the non variability of the vertical overbite throughout the aberrations of growth and development. How the vertical overbite can remain the same or change so little despite marked changes in facial proportions is hard to understand.

Subjects having long face had been described to have skeletal open bite. On the other hand, subjects having short face had been described to have skeletal open bite. This terminology had led to confusion in the literature since samples of persons suspected of having vertical problems have been chosen on the basis of overbite. Not surprisingly, these studies have yielded different results. Not all long face subjects have open bite and not all open bite patients are long faced and consequently not all short face subjects have deep bite and not all deep bite patients are short face. We usually overlook the dentoalveolar changes that take place in the anterior and posterior region to maintain functional occlusion.

These dentoalveolar changes include incisors and molar dentoalveolar heights, proclination or retroclination of the maxillary and mandibular incisors and shape and the size of the sypmhysis and anterior maxillary alveolus.

Frost and associates[6] compared pretreatment cephalometric tracings in patients with good dentoalveolar proportions and that with skeletal open bite. They recorded increased distance between the tip of maxillary central incisor and palatal plane in skeletal open bite patients. Ellies and McNamara[7] recorded posterior maxillary and mandibular dentoalveolar hyperplasia in open bite group in class III patients. They also recorded significant greater amount of anterior maxillary dentoalveolar height which they explained as an adaptation to overcome the open bite condition by the over-eruption of the maxillary incisors.

Gavito et al[8] noticed an increase in all maxillary dentoalveolar heights both anterior and posterior in cases with open bite. They called that dentoalveolar hyperplasia. Karlsen published two papers[9, 10] where he studied two groups with high and low angles for 10 years. He recorded an increased dentoalveolar height of the incisors in both jaws in high angle group which indicated a compensatory mechanism. Ceylan and Eróz [11] investigated the relationship between the amount of overbite and the maxillary and mandibular morphology. They recorded that patients with open bite had narrower and longer mandibular symphysis whereas subjects with deep bite had the opposite characteristics.

In a study of the use of the open bite bionator to close the bite[12], no significant difference was found between the maxillary and the mandibular dentoalveolar heights as measured from the tip of the incisor to palatal plane and mandibular plane respectively.

On the other hand, Nahoum et al[13] and Lowe[14] recorded decreased anterior dentoalveolar heights (maxillary and mandibular) in open bite patients when compared to normal group. Nahoum also found that open bite patients demonstrated shorter dentoalveolar height of mandibular first molar and the dentoalveolar height of maxillary first molar was not affected

In a recent study by Kuitert et al [15] showed that the maxillary and mandibular molar heights were not related to over bite. They stated that in subjects with extremely large or small lower face heights, the anterior dentoalveolar dimensions were more important than the posterior ones and that the growth pattern didn’t determine the overbite to the same extent as in subjects with average lower vertical facial dimensions.

Schendel et al [16] in his study of patients with vertical maxillary excess found that in patients having open bite shorter maxillary molar dental height was found.

Fields et al [17] studied the skeletal and dental morphology of long, normal, and short face children and adults with particular emphasis on long faces. He concluded that both long faced adults and children had more intermaxillary space occupied by greater dentoalveolar component than normal children. On the other hand, short face subjects tended to have less dentoalveolar height than normal. But, there was no statistically significant difference between the two groups.

Janson et al [18] studied the maxillary and mandibular molars and incisors vertical dimension in 12 years children having excessive, normal, and short face height. They showed that all dentoalveolar heights were significantly greater in excess LAFH persons than in normal LAFH. In the short LAFH group, all dentoalveolar heights with exception of lower posterior dentoalveolar height were significantly shorter than normal LAFH group.

Martina et al[19] studied the relationship between the molar dentoalveolar heights and craniofacial morphology by means of multiple regression analysis. He found that the length of the anterior lower facial height had a positive influence on the amount of molar dentoalveolar height supporting a positive relationship between the dentoalveolar and craniofacial heights.

Conversely, Bjórk and Skeiller[3] in their longitudinal implant studies found that posterior rotational growth pattern was accompanied with reduced eruption of molar teeth which was interpreted as compensatory mechanism. These observations however were obtained from two long face subjects only.

In the study of Kuitert et al[15] the ratio between the maxillary molar dentoalveolar height and maxillary incisor alveolar and basal height and the ratio between the mandibular molar dentoalveolar height and mandibular incisor alveolar and basal height were analyzed. Results showed that in the maxilla, the proportion between molar and incisor dentoalveolar height was independent of the vertical facial pattern; didn't differ between the long face (LF) and short face (SF) individuals. In contrast, in the mandible, the ratio was significantly smaller in the LF subjects. That meant that, in the LF subjects, the vertical development of the mandibular incisor alveolar height exceeded the vertical development of the mandibular molars. They concluded that the vertical dentoalveolar dimensions of the maxilla were shaped independently from the patient skeletal vertical pattern, whereas the dentoalveolar compensatory mechanism acts in the mandible by enlarging the vertical size of the frontal basal and dentoalveolar heights in LF subjects, and conversely reduced it in the SF subjects.

In summary, the literature showed contradictory results regarding the dentoalveolar height in subjects with differing lower anterior face heights. The reason for the conflicting results reported may be due to different criteria used in sample selection. Some selected the sample according to the degree of overbite, others used skeletal characteristics. Few authors used clinical impression of long and short face.

Haskell(20) measured the amount of protruding chin area as a percentage of total mandibular alveolar and basal area in subjects with deep bite and open bite. He found that patients with open bite showed a smaller protruding chin area related to their total mandibular alveolar and basal area. This might indicate that in patients with open bite, the base of the symphysis might be narrowed.

Handelman(21) studied the anterior alveolus widths in both arches in different horizontal and vertical groups. He concluded that a thin alveolus may be encountered in any skeletal type, but was most frequently encountered in patients with long lower face height and severe bimaxillary protrusion. He also concluded that the palatal wall of the maxilla and the posterior cortex of the symphysis represented what he called ‘orthodontic walls’ or barriers to tooth movement. Thus, the width of the anterior alveolus can be used in determining if the borderline patient would be best treated via conventional orthodontics or a combined orthodontic surgical approach.

Beckmann et al (22) conducted a study to investigate the relationships between the lower face height and the structure of the frontal alveolar process and basal bone in the maxilla and the mandible in persons with normal overbite. With this approach the possible interaction between the long face syndrome and open bite was eliminated. The results showed that the long face subjects would generally have a larger area of the maxillary alveolar and basal bone with no significant deviation in its shape. Thus the scope of antero-posterior movements of the maxillary incisors would be larger. In the mandible a stronger relation between the symphysis and the lower face height was found. In long face individuals the symphysis appeared to be longer and narrower with no change in size. The shape only changed. This may limit the possibility of labiolingual movements of the mandibular incisors.

In another study, Beckmann et al(23) studied the relationships between the form and the size of the alveolar and basal bone in the anterior region of both jaws including area measurements and the overbite. They concluded that the size and the form of the sypmhysis were related to the overbite in such a way that subjects with deep bite generally showed a larger area, narrowing and elongation of the symphysis. In subjects with open bite, the reverse was found.

Beckmann et al(22) found that the inclination of the maxillary central incisor had more effect on overbite than the mandibulatr incisor. They stated that that the protrusion of the mandibular incisor seemed to be contradictory.

Kuitert et al(15) concluded that dentoalveolar compensatory mechanism acted mainly by vertical adaptation of the mandibular frontal alveolar process. Additional compensation could be gained in short face subjects by maxillary incisor protrusion, but in long face subjects, a corresponding maxillary incisor retrusion didn't occur which was considered unphysiologic. In the long face group, mandibular incisor retrusion had a minor compensatory role that they considered clinically irrelevant

MATERIALS AND METHODS

580 Pretreatment lateral cephalometric X-rays from the Orthodontic Department, Faculty of Dentistry, Alexandria University were screened till we got thirty (30) subjects with long face (LF), thirty (30) with average face (AvF), and thirty (30) with short face (SF). All lateral cephalometric X-rays were made by the same X-ray machine (60 Kv peak, 25-40 Milliamperes) to standardize the projection.

The inclusion criteria were: 1) Complete set of fully erupted permanent teeth (with the exception of the third molars). 2) At least one maxillary and one mandibular molar or premolar on both sides had occlusal contacts in centric occlusion. 3) Age range: Between 16 and 25.

The exclusion criteria were: 1) Previous orthodontic treatment. 2) Facial clefts or syndromes. 3) Periodontal diseases.

Identification of the three facial types:

The inclusion of the subjects of the sample into one of the three facial types was based on the evaluation of three parameters:

(1) The ratio of the posterior facial height to the anterior facial height.

(2) The inclination of the mandibular plane to the anterior cranial base (sella-nasion).

(3) The inclination of the mandibular plane to Frankfurt horizontal plane.

When two of the parameters identified the same facial type the subject was included into its respective group. If conflict between the three parameters occurred the subject was excluded from the sample.

The posterior face height was taken as the direct distance between the Sella (S) and the constructed Gonion (Go).The anterior face height was taken as the direct distance between the Nasion(Na) and the Menton(Me).

The mandibular plane was taken as the line connecting the constructed Gonion and the Menton.

Standards of the Alexandria University [24] were used for the identification of the three facial types and determination of the cut off points of the three groups was based on the first standard deviation.

Measurements:- (After Kuitert et al [15] and Beckmann et al [22, 23])

3) Measurements:

A) Dentoalveolar measurements:

1) MxMDH: Maxillary molar dentoalveolar height between mesiobuccal cusp of upper first molar and palate along long axis of molar.

2) **MdMDH:** Mandibular molar dentoalveoalar height between mesiobuccal cusp of mandibular first molar to mandibular plane along long axis of molar.

3) **MxIABH:** Distance between tip of most anterior maxillary incisor and intersection between bony hard palate and maxillary alveolar axis (maxillary alveolar axis rus from midpoint of alveolar meatus of maxillary central incisor through centerpoint of maxillary alveolus). **MxIABH** is measured parallel to maxillary alveolar axis.

4) **Maxillary alveolar depth (MxAD):** Distance between point A and intersection between line perpendicular to maxillary alveolar axis through point A and palatal border of maxillary frontal midsagittal alveolar bone.

5) **MxABA:** Area of anterior alveolar and basal midsagittal cross-section of maxilla. A line was drawn perpendicular to palatal plane intersecting point A and forming anterior border of maxillary basal area. From point A, a line was drawn parallel to nasal plane until intersection with dorsal contour of maxillary alveolar bone. The dorsal border of maxillary basal area was formed by a line running from this intersection until nasal plane. The area will be measured between these lines and between outer contour of maxillary alveolar bone below point A.

6) **MdIABH:** Distance between tip of most anterior mandibular incisor and intersection between lower border of symphysis and mandibular alveolar axis (the mandibular alveolar axis runs from midpoint of alveolar meatus of mandibular central incisor through center point of symphysis). **MdIABH** is measured parallel to maxillary alveolar axis.

7) **MdAD:** Distance between point B and intersection between a line perpendicular to the mandibular alveolar axis through point B and lingual border of the symphysis.

8) **MdABA:** Area of alveolar and basal midsagittal cross section of the mandible, area between outer contour of symphysis.

9) **Ratio between MxMDH and MxIABH**

10) **Ratio between MdMDH and MdIABH**

11) **Overjet (OJ):** Distance between most prominent maxillary and mandibular incisor edges parallel to occlusal plane in millemeters.

12) Overbite (OB): Distance between most prominent maxillary and mandibular incisor edges perpendicular to occlusal plane in millemeters.

13) Interincisal angle (upper incisor long axis to lower incisor long axis**)**

14) U1 to NA angle

15) L1 to NB angle

B) Skeletal measurements:

1) **ANB angle**
2) **Ramus height:** Ar_Go
3) **Corpus length:** Go_Me
4) **Na to S:** Distance in millemeters.
5) **ANS to PNS:** Distance in millemeters.

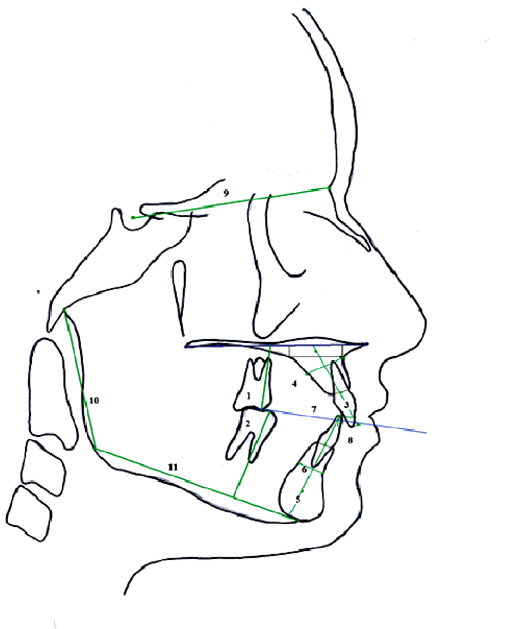

Figure 1: Linear measurements; 1=MxMDH, 2=MdMDH, 3=MxIABH, 4=MxAD, 5= MdIABH, 6=MdAD, 7=overjet, 8=overbite, 9=NA-S, 10=Ar-Go, 11= Go-Me

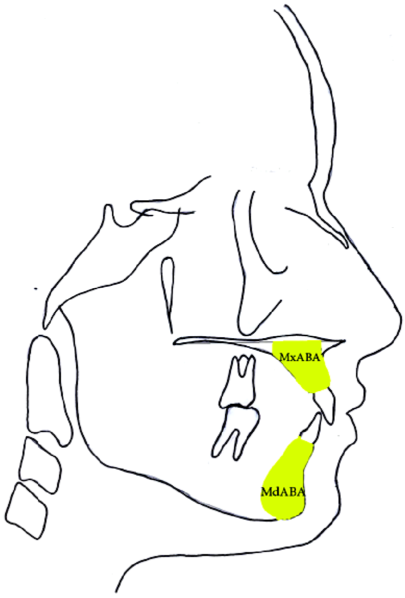

Figure 2: Area measurements

The 90 radiographs were traced using acetate paper and 0.35 mm graphite pencil. The tracings were scanned with actual size and data were inserted to the computer. Adobe photoshop CS3 program was used to make all linear, angular and area measurements.

Reliability of the study:

Reliability of landmark identification: Each landmark was identified by an investigator and checked for location by another investigator. When differences in landmark identification were found, the two investigators consulted with each other for final localization of the landmark.

Intra-examiner reliability: To minimize measurement error, all linear, angular and area measurements were repeated by the same investigator. The time between the two measurements was at least 2 weeks.

Reliability of measurements was examined using Bland Altman plots. Measurements whose plots contained zero between the upper and lower confidence limits were considered reliable.

Statistical Analyses:

Comparison of linear, angular, area and ratio measurements were compared among the three study groups using ANOVA for normally distributed variables and Kruskal Wallis test for variables that were not normally distributed. Measurements that were significantly different among the three groups were further tested in comparison of pairs using Tukey post hoc test for normally distributed variables and Mann Whitney U test for variables that were not normally distributed.

Comparison of overbite categories among the three groups was done using Wilcoxon signed ranks test. Non parametric correlation between study groups and categories of overbite was examined using Kendal tau b. Stepwise regression analysis was used to examine significant predictors of overbite in short, long faces separately and in the whole sample using all measured linear, area, angular and ratio measurements.

Significance was set at $P \leq 0.05$. Bar charts were used for graphical presentation. Statistical analysis was done using SPSS version 13.0.

In the prevalence study the different categories of overbite were considered as follows:

(1) Open bite group: Overbite smaller than -1 mm.

(2) End to end group: Overbite between -1 and + 1 mm.

(3) Normal overbite group: Overbite between +1 and +4 mm.

(4) Deep bite group: Overbite larger than +4 mm.

RESULTS

Reliability of the study:

Using Bland Altman plots to examine the reliability of linear, angular and area measurements, zero was included between the upper and lower confidence limits, denoting that there were no differences between measurements taken on the first and second times which indicates their reliability.

A) Descriptive statistics: Table I

Means and standard deviations were calculated for the three groups.

There were significant differences between the three groups in ramal length(Ar-Go) ($P < 0.0001$), mandibular body length (Go-Me)($P = 0.005$), mandibular alveolar depth (MdAD)($P = 0.005$), mandibular incisor alveolar and basal height (MdIABH)($P<0.0001$), mandibular molar dentoalveolar height (MdMDH) ($P=0.01$), Maxillary incisor alveolar and basal height (MxIABH) ($P<0.0001$), maxillary molar dentoalveolar height

(MxMDH) (P<0.0001), anterior cranial base length (Na-S) (P=0.002), and overbite (P<0.0001). No statistically significant difference between the three groups was found regarding both the maxillary (P=0.07) and mandibular (P=0.06) alveolar and basal areas.

Table I: Descriptive statistics for the three groups:

	Short face Group I Mean ± SD	Average face Group II Mean ± SD	Long face Group III Mean ± SD	Test P value
ANS-PNS	57.72 ± 4.08	58.36 ± 3.91	56.94 ± 4.47	0.87 0.42
Ar - Go	51.54 ± 5.36	48.38 ± 4.03	45.11 ± 3.77	15.72 <0.0001*
Go - Me	74.74 ± 4.06	75.74 ± 6.01	71.58 ± 4.71	5.66 0.005*
Na- S	74.63 ± 3.48	73.83 ± 3.57	71.46 ± 3.31	6.81 0.002*
MdAD	8.95 ± 1.37	7.99 ± 1.44	7.78 ± 1.46	5.68 0.005*
MdIABH	41.07 ± 5.23	42.82 ± 3.23	46.19 ± 3.56	12.06 <0.0001*
MdMDH	32.65 ± 3.10	33.17 ± 3.01	35.06 ± 3.64	4.53 0.01*
MxAD	12.49 ± 1.38	12.02 ± 1.85	11.95 ± 1.61	0.99 0.37
MxIABH	33.23 ± 3.60	33.92 ± 3.57	36.99 ± 3.67	9.18 <0.0001*
MxMDH	23.85 ± 2.52	25.46 ± 3.37	27.38 ± 3.27	9.92 <0.0001*
Overbite	4.88 ± 2.63	2.37 ± 2.72	1.64 ± 2.80	11.75 <0.0001*
Overjet	6.86 ± 3.74	5.39 ± 3.55	5.50 ± 3.94	3.24 0.20
MdABA	372.86 ± 50.47	342.70 ± 49.22	356.67 ± 48.99	2.78 0.07
MdMDH/MdIABH	0.78 ± 0.04	0.77 ± 0.06	0.76 ± 0.05	1.52 0.23
MxMdht/MxIABH	0.72 ± 0.06	0.75 ± 0.07	0.74 ± 0.07	1.71 0.19
ANB	4.05 ± 2.38	2.81 ± 2.64	3.46 ± 3.58	1.36 0.26
interincisal	124.57 ± 17.07	120.84 ± 12.29	120.99 ± 1.54	0.70 0.50
L1 to NB	26.59 ± 8.23	28.46 ± 8.57	29.76 ± 5.58	1.33 0.27
U1 to NA	24.95 ± 10.79	27.90 ± 9.80	25.84 ± 7.97	0.75 0.48

No statistically significant difference between the three groups was found regarding both the ratio of mandibular molar dentoalveolar height to mandibular incisor alveolar and basal height (P=0.23) and maxillary molar dentoalveolar height to maxillary incisor alveolar and basal height (P=0.19). No statistically significant difference between the three groups was found regarding ANB, interincisal , L1 to NB and U1 to NA angles.

B) Pairwise comparison: Table II

Pairwise comparison was made for the statistically significant variables between the three groups to determine which group was significantly different from the other.

The three groups showed significant difference in ramal length from each other.Long face group showed a significantly smaller mandibular body length (Go-Me) than the short face group and average face group.

Short face group showed a statistically significant larger mandibular alveolar depth (MdAD) than the average face group and long face group.Long face group showed a significantly larger mandibular incisor alveolar and basal height (MdIABH) than short face group and average face group. Long face group showed a significantly larger mandibular molar dentoalveolar height (MdMDH) than short face group.

Long face group showed a significantly larger maxillary incisor alveolar and basal height (MxIABH) than short face group and average face group.Long face group showed a significantly larger maxillary molar dentoalveolar height than short face group and average face group.

Long face group showed a significantly smaller anterior cranial base length (Na-S) than short face group and average face group.

Short face group showed a significantly deeper overbite than average face group and long face group.

Table II: Pairwise comparison between significant variables:

Group	Compared to group	Ar-Go	Go-Me	MdAD	MdIABH	MdMDH	MxIABH	MxMDH	Na- S	Overbite
Group I	Group II	0.02*	0.72	0.03*	0.23	0.81	0.74	0.11	0.65	0.002*
	Group III	<0.0001*	0.04*	0.006*	<0.0001*	0.02*	<0.0001*	<0.0001*	0.002*	<0.0001*
GroupII	Group III	0.02*	0.005*	0.84	0.006*	0.07	0.004*	0.05*	0.03*	0.56

C) Prevalence of different types of overbite in different groups: Table III & Figure 3

The percentage of different types of overbite (openbite, end to end, normal, deep) was calculated in the three groups.In the Short face group, no cases of open bite existed, 2 cases had end to end bite (6.7%), 8 cases had normal overbite (26.7%) and 20 cases had deep bite (66.7 %).

In the Average face group, 3 cases with openbite existed (10%), 4 cases had end to end bite (13.3%), 14 cases had normal overbite (46.7%) and 9 cases had deepbite (30%).In the Long face group, 4 cases with openbite existed (13.3%), 10 cases had end to end bite (33.3%), 9 cases had normal overbite (30%) and 7 cases were diagnosed to have deepbite (23.3%).Wilcoxon signed ranks test showed significant (P<0.0001) difference in the distribution of different categories of overbite in different facial groups.Kendal tau b test showed significant (P<0.0001) inverse proportion of overbite (from openbite to deep bite) in facial groups (from short face to long face).

Table III: Prevalence of different types of overbite in different groups.

Overbite	Short face Group I N (%)	Average face Group II N (%)	Long face Group III N (%)	Total N (%)
Open bite	0	3 (10)	4 (13.3)	7 (7.8)
End to end	2 (6.7)	4 (13.3)	10 (33.3)	16 (17.8)
Normal overbite	8 (26.7)	14 (46.7)	9 (30)	31 (34.4)
Deep bite	20 (66.7)	9 (30)	7 (23.3)	36 (40)
Total	30 (100)	30 (100)	30 (100)	90 (100)
Chi square of Wilcoxon signed ranks test **P value**	16.72 <0.0001*			
Kendal tau b **P value**	-0.38 <0.0001*			

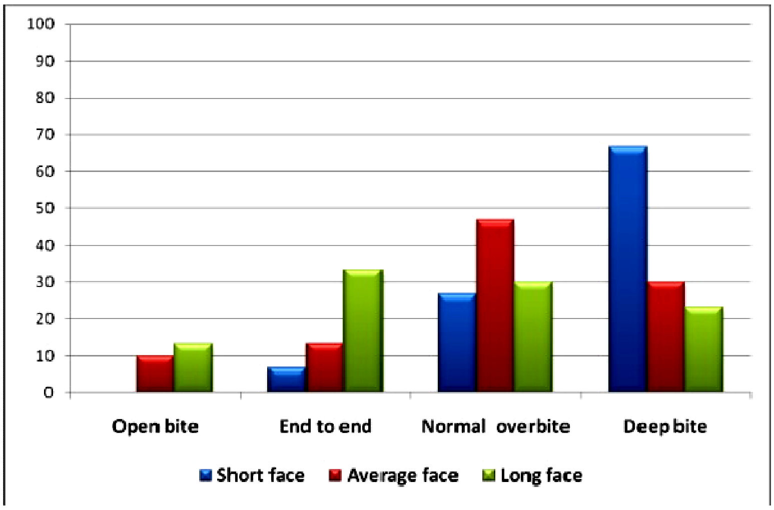

Figure 3: Graphical representation of the distribution of different categories of overbite in the three facial types.

D) Multiple linear stepwise regression analysis with the overbite as dependent variable in the whole sample: Table IV

Multiple stepwise linear regression analysis was performed with the overbite as dependent variable and all the other craniofacial and dentoalveolar variables as independent variables to detect the predictors of overbite in the whole sample.The results showed that L1 to NB, ANB, Ar-Go,MdMDH/MdIABH, MxMDH/MxIABH and interincisal angles act as predictors of overbite in descending order for the whole sample.

Table IV: Multiple stepwise linear regression analysis in the whole sample to predict overbite

Step	Predictor	R2	Change in R2	Beta
1	L1 to NB	0.14	0.15	-0.39
2	ANB	0.31	0.17	0.44
3	Ar-Go	0.36	0.06	0.25
4	MdMDH/MdIABH	0.42	0.06	-0.26
5	MxMdht/MxIABH	0.49	0.07	-0.28
6	Interincisal	0.60	0.11	0.61

E) Multiple linear stepwise regression analysis in the short face group:

Multiple stepwise linear regression analysis was made in the short face group. Table V) The results showed that the ratio between mandibular molar dentoalveolar height and mandibular incisor alveolar and basal height, intericisal angles, the ratio between the PFH to AFH, Go-Me and the U1 to NA angle are the predictors for overbite in the short face group. In the short face group matched values for the first three explanatory independent variables were calculated for different categories of the overbite from 0 to 5 mm. (Table VI)

Table V: Multiple stepwise linear regression analysis to predict overbite in short face.

Step	Predictor	R2	Change in R2	Beta
1	MdMDH/MdIABH	0.39	0.41	-0.64
2	Interincisal	0.68	0.29	0.54
3	PFH to AFH	0.74	0.07	0.27
4	Go - Me	0.79	0.05	0.25
5	U1 to NA	0.84	0.05	-0.51

Table VI: Matched values for MdMDH/MdIABH, interincisal angle and PFH/AFH in short face group in different categories of overbite:

Overbite (mm)	MdMDH/MdIABH	Interincisal angle	PFH/AFH
0	0.87	111.7	0.66
1	0.86	114.5	0.67
2	0.84	119.9	0.69
3	0.83	125.7	0.698

F) Multiple linear stepwise regression analysis in the long face group:

Multiple linear stepwise regression analysis was made in the long face group .The results showed that the SN to mandibular plane angle, overjet, the ratio of PFH/AFH and maxillary alveolar and basal area (MxABA) are the predictors of the overbite in the long face group. Table VII Matched values for SN mandibular plane angle and PFH to AFH in the long face group in different categories of overbite from -3 to 4 mm were calculated. (Table VIII)

Table VII: Multiple stepwise regression analysis to predict overbite in the long face.

Step	Predictor	R2	Change in R2	Beta
1	SN to MdPl	0.67	0.69	-0.83
2	Overjet	0.74	0.07	0.27
3	PFH to AFH	0.78	0.05	0.30
4	MxABA	0.81	0.04	0.20

Table VIII: Matched values for SN-Mandibular plane angle and PFH/AFH in long face group for different categories of overbite

Overbite	SN-Mand.Pl.	PFH/AFH
4	38	0.62
3	39	0.61
2	40.1	0.61
1	41.2	0.6
0	42.7	0.59
-1	45.75	0.58
-2	49.5	0.5
-3	53	0.47

DISCUSSION

In this study, the sample was classified using three parameters; The inclination of the mandibular plane to the anterior cranial base (sella-nasion), the inclination of the mandibular plane to Frankfurt horizontal plane and the ratio of the posterior facial height to the anterior facial height multiplied by 100.The use of these three parameters was to ascertain the classification of the sample into the three facial types. The study was conducted on female patients to exclude the effect of any sexual dimorphism on dentoalveolar or skeletal characteristics. Age of the sample ranged from 17-25 with a mean of 19 years and 8 months which exclude to a great extent the effect of any remaining growth on compensation of the overbite.

The results of the descriptive statistics between the three groups regarding linear, angular, ratio and area measurements showed that angular, ratio and area measurements had no significant differences between the three groups. On the other hand, nine linear measurements showed significant differences between the three groups. The long face group showed significantly smaller ramal length and mandibular body length than short face group which coincide with previous reports. [15]

Long face group showed a significantly smaller anterior cranial base length (Na-S) than short face group .The long face group showed significantly narrower mandibular alveolar depth than both average and short face subjects coinciding with both Handelman[21] and Kuitert et al[15]. The narrower symphysis associated with long face may offer a limitation for orthodontic movement of mandibular incisors to camouflage skeletal discrepancy.

The long face group showed significantly larger maxillary and mandibular molar dentoalveolar height than the short face group.

The results may indicate a limited effect of the molar height solely as compensation for vertical discrepancy. It seems that molar dentoalveolar height react to vertical growth pattern than affecting it.

The long face group had significantly larger maxillary and mandibular incisor alveolar and basal height (MxIABH, MdIABH) than the short face group. This might indicate a compensatory lengthening of the incisors with their bone to achieve normal overbite in long face groups.

There was no significant difference between the three groups regarding the maxillary alveolar depth. This might be explained that the vertical dentoalveolar development of the maxilla is shaped independently of the subject vertical skeletal pattern.

There was no significant difference in the ratio of molar dentoalveolar height to incisor alveolar and basal height in maxilla and mandible between the three groups. This indicates that both the maxillary and mandibular incisors and molars underwent proportional over or under development compensating for the vertical skeletal pattern.

There was no significant difference between the three groups in area measurements. This might be explained that in the mandible both the height and width increase leading to narrower and longer symphysis i.e. shape changed but with no variation in the size. On the other hand, in the maxilla the alveolar height increased but no significant change in width or area was recorded. This might indicates limited increase in alveolar height that no change in area occurred. The role of maxillary incisors in compensating for the vertical skeletal pattern seems to be limited compared to mandibular incisors.

The results of the prevalence study of different types of overbite in different facial types in the research sample showed that deep bites (23.3%) and normal overbite (30%) occurred in long face subjects. Surprisingly, the open bite occurred only in 4 cases (13.3%). This apparent disharmony between overbite and vertical skeletal excess showed the effect of natural dental compensation in long face subjects. End to end bite (6.7%) and normal overbite (26.7%) occurred in short face subjects. No cases with openbite were found in short face group.

Wilcoxon signed ranks test showed significant difference in the distribution of different categories of overbite in different facial groups. Kendal tau b test showed significant inverse proportion of overbite (from openbite to deep bite) in facial groups (from short face to long face). This suggests that although, dentoalveolar compensation mechanism had been detected, still its effect is limited and it is affected by different factors that should be considered.

The results of the multiple stepwise linear regression analysis in the whole sample revealed that three angular measurements acted as predictors of overbite; L1 to NB , interincisal angle, and ANB. It seems that incisor inclination especially mandibular incisors had an important effect on the overbite. As the mandibular incisor inclination (L1 to NB) decreases the overbite deepened which indicate that incisor retrusion had bite deepening effect. The increase of the interincisal angle resulted in deepening of the bite. It seems logical enough that decrease in mandibular incisor inclination and increase in the interincisal angle acted as predictors of overbite. Whether this was accompanied with change in maxillary incisor inclination which was insignificant or no change at all seem to be unclear. As the ANB angle increased the overbite deepened. This indicated that overbite can be related to the anteroposterior skeletal discrepancy as indicated by ANB angle. Class II patients had a greater tendency towards deepbite and class III patients had greater tendency towards openbite.

The only linear measurement that acted as predictor for the overbite was the ramal length (Ar-Go). By the increase in the ramal length the overbite deepens. This correlation between a skeletal measurement and overbite seems to be interesting(16, 23). It was reported in previous studies a correlation between skeletal facial type and ramal length, whereas, short face subjects tend to have longer ramal length. As these studies implied, that short face subjects tend to have deeper bite then it seems logical to get the ramal length as a predictor of overbite.

On the other hand , as the long face subjects tend to have shorter ramal length as had been stated before, then it follows that long face subjects should have higher proportion of openbite or end to end. This wasn't true as almost half (16 cases) of the long face subjects tend to have normal and deepbite. This might imply that various non-cephalomtetric variables could affect the overbite in long face subjects.

Both the ratio of the maxillary and mandibular molars dentoalveolar heights to maxillary and mandibular incisors alveolar and basal heights respectively acted as predictors of overbite. As the ratio increases the bite decreases and vice versa. Change in the ratio can occur either by change in the molar or incisor dentoalveolar height or both. But, since neither of the molar or incisor dentoalveolar height showed significant value in the regression analysis, it seems that the changes occur in both heights in a proportional manner.

Multiple stepwise regression analysis was performed to determine the predictors of the overbite in the short face group separately.

The results showed that the ratio between the mandibular molar dentoalveolar height and mandibular incisor alveolar and basal height, the interincisal angle, the ratio between the PFH to AFH, Go-Me and the U1 to Na angle are the predictors for overbite in the short face group in descending order. The regression model in the short face group explains about 87% of the overbite variance.

The first two predictors showed the highest impact on the overbite. The ratio between the mandibular molar and incisor dentoalveolar height explains about 41% of the variance of the overbite while the interincisal angle explains about 29 % of the variance of the overbite. The ratio of PFH/AFH explains only 7% of the variance of the overbite.

As the mandibular ratio decreases the bite deepens. The decrease in the ration can be affected by either under-eruption of the mandibular molars or over-eruption of the incisors or both. The change seems to be proportional between both heights which ascertain what was stated above of the combined importance of both mandibular incisors and molars in establishing the overbite. In the maxilla, the proportion between the molar and incisor dentoalveolar height seems to be shaped independently of the vertical facial pattern.

The other explanatory variable that was detected in the short face group is the interincisal angle. As the angle increases the bite deepens. This coincides with Bjórk [25] who stated that one of the criteria that can be used to predict a forward rotator patient is obtuse interincisal angle.

The increase in the interincisal angle can be achieved by retroclination of either the maxillary or mandibular incisors or both. Although, compensatory changes achieved by maxillary incisors retroclination had been detected as it acted as a predictor of the overbite in the short face group, it seems that most of the change in the interincisal angle is achieved by combined mandibular incisor retroclination together with retroclination of the maxillary incisors.

This can be explained that the change of the maxillary incisor inclination contributes to only 5 % of the variance of the overbite in the short while the mandibular incisor inclination was found to explain about 15% of the variance of the overbite in the whole sample. This indicates their mutual contribution in achievement of the overbite. This result should be further investigated to detect the actual contribution of each of the maxillary and mandibular incisors inclination in achievement of the overbite as the change in R2 is not that high for each of them separately to be regarded as a predicotor.

Matched values for these two predictors were calculated in the short face group for different categories of overbite from 0 to 5mm.It was found that an overbite of at least 3mm could be achieved if the mandibular molar to incisor ratio was at least 0.83. Likewise, the interincisal angle shouldn't exceed 126 to obtain an overbite of 3 mm.

The average mandibular ratio in the short face group was 0.78 which will predispose to an overbite of 5mm while the average interincisal angle was 124.5 which will predispose to a normal overbite. This implies that most of the short face cases would have developed deep bite if it wasn't for the dentolalveolar compensatory mechanism. It also emphasizes the role of the mandibular molar and incisor dentoalveolar height as the primary compensatory mechanism in the short face group while the change in the interincisal angle seems to have a secondary role.

Matched values for the ratio of PFH to AFH in the short face group showed that for an overbite of 3 mm to be achieved the ratio shouldn't exceed 0.7.

Multiple stepwise regression analysis was performed to determine the predictors of the overbite in the long face group separately.

The results showed that the SN to mandibular plane angle, overjet, the ratio of PFH/AFH and maxillary alveolar and basal area (MxABA) are the predictors of the overbite in the long face group. The regression model in the long face explains about 85% of the overbite variance.

The change in the SN to Mandibular plane angle contributed to about 69% of the variance of the overbite. The other predictors shoed minor contribution to the establishment of the overbite in the long face group.

The presence of only one strong predictor in the long face group may indicate the presence of other non-cephalomtric factor that may have an impact on overbite. This may point out the importance of the presence of the tongue as an obstacle preventing the dentoalveolar compensation (26, 27) and muscular imbalance in excessive vertical skeletal development. (28)

Moreover, it could be assumed that the dentoalveolar compensatory mechanism is limited in the long face and that there is a point beyond which no further compensation occurred.

Matched values for SN to mandibular plane angle showed that for an overbite of 3mm to be achieved the SN –Mand. Pl angle shouldn't exceed 39 degrees.The average SN to Mandibular plane angle of the sample was found to be 41.5 degrees which will predispose to an edge to edge bite or an overbite of 1 mm. This coincides with the result found that the majority of the long face group had edge to edge bite in which the edge to edge bite was considered to range from -1 to 1 mm.

Thus, we can conclude that in the long face group the skeletal factors had the greater impact on the establishment of the overbite with minor contribution of dentoalveolar factors which are either inoperable or combined factors might be acting in such a way that no significant role of each had been detected.

CONCLUSIONS

1) The role of dentoalveolar compensatory mechanism in the establishment of the overbite had been shown, but still its effect is limited beyond certain limits.
2) In the short face group the combined effect of both the mandibular molar and incisor alveolar heights play an important role in maintaining the overbite.

   An overbite of 3mm can be achieved if the ratio didn't exceed 0.83.
3) In the long face group the skeletal factors plays a more dominating role than dentoalveolar factors in controlling the overbite. Although the role of dentoalveolar compensation is more demonstrated in the long face group, its actual mechanism hadn't been determined exactly.

An overbite of 3mm can be achieved if the SN-Mand. Pl. angle didn't exceed 39 degrees.

REFERENCES

1) Frakas LG. Anthropometry of the head and face in medicine. NewYork NY, Elsevier science, 1981.
2) Skeiller V. Cephalometric analysis in the treatment of overbite. Trans Eur. Orthod. Soc. 1967; 147-57 .Quoted from Nielsen IL. Vertical malocclusions: etiology, development, diagnosis and some aspects of treatment. Angle Orthod.1991; 61(4); 247-260.

3) Bjórk A, Skeiller V. Facial development and tooth eruption. An implant study at the age of puberty. Am J Orthod.1972; 62:339-383.

4) Solow B. Dentoalveolar compensatory mechanism: Background and clinical implications. Br J Orthod.1980; 7:145-161.

5) Schudy FF. Vertical growth versus anteroposterior growth as related to function and treatment. Angle Orthod.1964; 34(2):75-93.

6) Frost DE, Fonesca RJ,Turvey TA, Hall DJ. Cephalometric and surgical orthodontic correction of apertognathia. Am J Orthod.1980;78(6):657-669.

7) Ellis E, McNamara JA. Components of adult class III openbite malocclusion. Am J Orthod.1984; 86(4):277-289.

8) Gravito GL, Wallen TR, Little RM, et al. Anterior openbite malocclusion: a longitudinal 10 years postretention evaluation of orthodontically treated patients. Angle Orthod.1985; 87(3):75-186.

9) Karlsen A. Association between facial height development and mandibular growth rotation in low and high Mp-SN angle faces. Longitudinal study. Angle Orthod.1997; 67(2):103-110.

10) Karlsen AT. Craniofacial growth differences between low and high MP-SN angle males: A longitudinal study. Angle Orthod.1995; 65(5):341-350.

11) Ceylan I, Eroz UB. The effects of overbite on the maxillary and mandibular morphology. Angle Othod.2001; 71:110-115.

12) Weinbach JR, Smith RJ. Cephalometric changes during treatment with openite bionator. Am J Orthod Dentofac Orthop.1992; 107:367-374.

13) Nahoum HI, Horowirz SL, Benedict EA. Varieties of anterior openbite. Am J Orthod.1972; 61(5):486-492.

14) Lowe AA. Correlation between orofacial muscle activity and craniofacial morphology in a sample of control and anterior openbite subjects. Am J Orthod.1980; 78(1):89-98.

15) Kuitert R, Beckmann S, Van loenen M, et al.Dentoalveolar compensation in subjects with vertical skeletal dysplasia. Am J Orthod Dentofac Orthop.2006; 129:649-657.

16) Schendel SA, Eisenfeld J, Bell WH, et al.The long face syndrome: Vertical maxillary excess. Am J Orthod.176; 70(4):398-408.

17) Fields HW, Proffit WR, Nixon WL, et al. Facial pattern differences in long faced children and adults. Am J Orthod.1984; 85(3):217-223.

18) Janson GRP, Metaxas A. Variation in maxillary and mandibualr incisor and molar vertical dimension in 12 years old subjects with excess, normal and short lower anterior face height. Am J Orthod.1994; 106(4):409-418.

19) Martina R, Farella M, Tagliaferri R, et al. The relationship between molar dentoalveolar and craniofacial heights. Angle Orthod.2004; 25(6):974-979.

20) Haskell BS. The human chin and its relationship to mandibular morphology. Angle Orthod.1979; 49(3):153-166.

21) Handelmann CS. The anterior alveolus: Its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequel. Angle Orthod.1996; 66(2):95-110.

22) Beckmann SH, Kuitert RB, Anderson BP, et al.Alveolar and skeletal dimensions associated with lower face height. Am J Orthod Dentofac Orthop.1998; 113:498-506.

23) Beckmann SH, Kuitert RB, Anderson BP, et al. Alveolar and skeletal dimensions associated with overbite. Am J Orthod Dentofac Orthop. 1998; 113:443-452.

24) Aboul-Azm SF, Enany N M, Fahmy MA, et al. The Alexandria Analysis:Radiographic cephalometric standards for Egyptian adults. Alex. Dent J.1984;9(1):1-8.

25) Bjórk A. Prediction of the mandibular growth rotation. Am J orthod. 1969; 55:585-599.

26) Straub WJ. Malfunction of the tongue Part II. The abnormal swallowing habits: Its causes, effects, and results in relation to orthodontic treatment and speech therapy. Am J Orthod.1961:47; 596-617.

27) Subtelny JD, Sakuda M. Openbite: Diagnosis and treatment. Am J Orthod. 1964:50; 337-358.

28) Satiroglu F, Arun T. Comparative data on facial morphology and muscle thickness using ultrasonography. Eur J Orthod.2005; 27:562-567.