CEPHALOMETRIC FEATURES OF ANGLE CLASS III MALOCCLUSION WITH DIFFERENT DENTOALVEOLAR COMPENSATION (RETROSPECTIVE STUDY)

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Abstract

Introduction: *This study was to investigate dentoalveolar compensation in untreated skeletal Class III patients.*

Methods:*This retrospective study was conducted on 102 untreated Class III malocclusion patients. They were divided into group 1 (overjet<0mm, n=51) and group 2 (overjet ≥ 0mm, n=51). Twenty-six cephlometric readings were compared between the two groups. Correlation analysis was performed between the overjet with skeletal and dental measurements and Regression analysis was performed to determine the overjet.*

Results: *The results showed a significantly higher SNB, S-N-Pg, gonial angle and L1-NB mm in the negative overjet group. While, the ANB angle, angle of convexity, Wits appraisal, bony chin and U1-A-Pg mm were significantly higher in the positive overjet group. However, no statistically significant difference was found in the rest of the readings. Correlational analyses showed that the overjet has significant negative correlation with SNB, S-N-Pg, L1-Frankfort, gonialangles. On the other hand, it had significant positivecorrelation with ANB angle, angle of convexity, Wits appraisal, bony chin, L1-MP angle and U1-A-Pg mm. Nine regression equations for the overjet were calculated with the highest coeffcient of determination of 0.33.*

Conclusion: *Dentoalveolar compensation was seen in Class III cases with less skeletal discrepancy, lower mandibular prominence, larger bony chin, greater angle of convexity and smaller gonial angle. Moreover, the position of the maxillary and mandibular incisors on the basal bone, rather than their inclination, contributed in dentoalveolar compensation*

Keywords: *Class III malocclusion; dentoalveolar compensation; overjet.*

INTRODUCTION

Dentoalveolar compensatory mechanism can be defined as a system which attempts to maintain normal interarch relations with varying jaw relationships in all three planes of space.[1, 2] Complete occlusal compensation during facial and dental development enables a normal occlusion despite some skeletal variations, whereas incomplete compensatory guidance of tooth eruption results in malocclusion.[3]

Since Class III patients have various anteroposterior and vertical types. The upper and lower incisors demonstrate a diverse

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dentoalveolar compensation in order to maintain their occlusal function and adapt to the varying jaw relationships trying to achieve a normal relationship between dental arches.[4] Thus, Some Class III patients show normal incisor relationships, but others can have an edge to edge or a negative overjet, although having similar skeletal discrepancy.

Many authors postulated that dentoalveolar compensation varies according to various anteroposterior and vertical discrepancies.[5-8] Generally, Class III patients show proclination of maxillary incisors and retroclination of mandibular incisors which vary according to the severity of the dentoalveolar or skeletal discrepancy.[4, 9-13]

A complicating factor for the diagnosis and treatment of Class III malocclusion is its etiologic diversity. Its origin can be either skeletal or dentoalveolar. The skeletal manifestation can be due to mandibular prognathism, maxillary retrognathism, or a combination of both.[14-16]. Therefore, it is important to investigate the skeletal and dental factors that contribute to the dentoalveolar compensation in untreated Class III patients.

MATERIALS AND METHODS

In this retrospective study,the sample size for studying the dentoalveolar compensation in untreated skeletal Class III patients, with either positive or edge to edge or negative overjet, was estimated using MedCalc® software (version 14.8.1) [17] with a p-value of 0.05 and power of 80%. The correlation tested for was based on the results of Kim et al.[2] who reported a significant correlation at $p<0.001$ of 0.381. The estimated sample size was 102 subjects which were further divided into 2 equal groups (51 each).

Group1 included patients having a negative overjet, whilst patients with edge to edge or positive overjet were included in Group 2. The lateral cephalograms of those patients were collected from the diagnostic clinic archive of the Orthodontic department, Faculty of Dentistry, Alexandria University. The patients included in the study were aged between 15-30 years and were previously diagnosed clinically by two orthodontists as Angle Class III. However, patients who had previous orthodontic treatment as well as those who have craniofacial syndromes and/or functional shift were excluded.

The lateral cephalograms were manually traced and cephalometric measurements were compared between the two groups.The cephalometric landmarks and planes are illustrated in Figure 1.

The following skeletal measurements were used in the study: SNA, SNB, ANB, S-N-Pg, Facial angle: N-Pg-FHP, Angle of convexity:N-A-Pg, Gonial angle:Ar-TGo-Me, Cranial base angle: Ar-S-N, SN-MP, SN-PP, FMA, PP-MP, Y Axis-FHP, Postero-anterior face height ratio(%): (S-Go/N-Me), Jarabak facial ratio(%): (ANS-Me/N-Me), Wits appraisal, Bony chin.The dental measurements used were;Interincisal angle: U1/L1, L1-MP angle, L1-FHP angle, L1-NB mm,L1-NB angle, U1-NA mm,U1-NA angle, U1-FHP angle and U1-A-Pg mm.

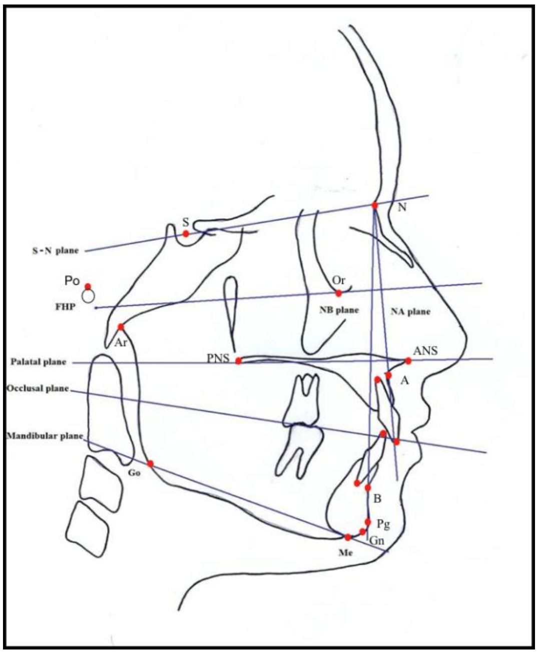

Fig.1: Lateral cephalogram landmarks and planes.

Statistical Analysis

Intra-examiner and inter-examiner reliability

Cephalometric land marks were taken by two orthodontists. All measurements were performed twice, with minimum 10 days apart, by the same examiner. A student t test was conducted on the paired measurements to quantify the reproducibility of the measurements for the inter-examiner and intra-examiner reliability testing. Method errors were calculated using Dahlberg's formula (Dahlberg 1940), SE = $\sqrt{(d^2/2n)}$, where d is the difference between measurements, and n is the number of pairs of measurements.

The student t test showed no statistically significant difference between the measurements. The method errors were 0.32 to 1.00 mm for linear measurements and 0.057 to 1.00 for angular measurements.

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0(Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Quantitative data were expressed using range (minimum and maximum), mean, median and standard deviation. Significance of the obtained results was judged at the 5% level.

The used tests were:

1 - Chi-square test

For categorical variables, to compare between different groups.

2 - Student t-test

For normally distributed quantitative variables, to compare between two studied groups.

3 - Mann Whitney test

For abnormally distributed quantitative variables, to compare between two studied groups.

4 - Spearman Coefficient

To correlate between two not normally distributed quantitative variables.

5 – Regression To detect the most independent factor for the overjet.

RESULTS

As regards the gender, the females were predominating the two groups (approximately 55% in group 1 and 59% in group 2). The age range was more or less the same in both groups (Median 19 years). (Table 1)

By comparing the skeletal readings in both groups, SNB, S-N-Pg and gonial angle were significantly higher in the negative overjet group than the positive overjet group. On the contrary, the positive overjet group showed significantly higher readings regarding the ANB, angle of convexity,Wits appraisal and the bony chin. Furthermore, there was no statistically significant difference in the rest of the angles including SNA, facial angle, cranial base angle, SN-MP and SN-PP, the PP-MP, FMA, Y-axis-Frankfort and the facial ratios among both groups (Table 2).

In terms of dental compensation, L1-NB mm was significantly more in the negative overjet group. Whilst, U1-A-Pg mm was significantly more in the positive overjet group. U1/L1, L1-MP, L1- Frankfort, L1-NB Angle, U1-NA Angle, U1-NA mm and U1-Frankfort did not differ significantly between both groups. (Table 3).

Correlational analyses showed that the overjet has significant negative correlation with SNB, S-N-Pg, L1- Frankfort and gonial angles. On the other hand, it had positive significant correlation with ANB, angle of convexity, Wits appraisal, bony chin, L1-MP, and U1-A-Pg mm. (Table 4)

Regression analysis with the overjet as a dependent variable showed that Wits appraisal as the independent variable showing the highest coefficient of determination, 0.33 indicating that approximately 33% of the variation in the overjet could be explained by the Wits appraisal. Followed by the ANB as an independent variable showing 0.237 as a coefficient of determination, indicating approximately 24% of the variation in the overjet could be explained by the ANB values (Table 5).

Table (1): Comparison of the demographic data between the negative and positive overjet groups.

	Group 1 Overjet<0 mm (n=51)		Group 2 Overjet≥0 mm (n=51)		Test of sig.	p
	No.	%	No.	%		
Sex					χ^2= 0.160	0.689
Male	23	45.1	21	41.2		
Female	28	54.9	30	58.8		
Age (years)					t= 1.820	0.072
Min. – Max.	16.0 – 28.0		16.0 – 29.0			
Mean ± SD.	19.31 ± 2.10		20.33 ± 3.40			
Median	19.0		19.0			

χ^2: Chi square test: Student t-test
p: p-value for comparing between the two groups
Group 1: Patients having an overjet< 0 mm.
Group 2: Patients having an overjet ≥ 0 mm.

Table (2): Comparison of the skeletal measurements between the negative and positive overjet groups.

Skeletal measurements	Group 1 Overjet<0 mm (n=51)	Group 2 Overjet≥0 mm (n=51)	Test of sig.	*p*
SNA				
Min. – Max.	63.0 – 89.0	67.0 – 91.0		
Mean ± SD.	80.22 ± 5.31	79.89 ± 4.61	t=0.329	0.743
Median	81.0	79.0		
SNB				
Min. – Max.	74.0 – 91.0	69.0 – 90.0		
Mean ± SD.	83.08 ± 4.55	80.0 ± 4.84	t=3.310*	0.001*
Median	83.0	80.0		
ANB				
Min. – Max.	-13.0 – 3.0	-7.0 – 9.0		
Mean ± SD.	-2.82 ± 3.30	-0.07 ± 2.84	U=695.0*	<0.001*
Median	-3.0	0.0		
S-N-Pg				
Min. – Max.	73.0 – 92.0	70.0 – 91.0		
Mean ± SD.	83.14 ± 4.54	80.37 ± 5.09	t=2.892*	0.005*
Median	83.0	81.0		
Facial angle				
Min. – Max.	81.0 – 99.0	79.0 – 99.0		
Mean ± SD.	90.37 ± 4.40	89.51 ± 4.81	t=0.946	0.347
Median	91.0	90.0		
Angle of convexity				
Min. – Max.	-35.0 – 13.0	-10.0 – 20.0		
Mean ± SD.	-4.78 ± 8.72	0.43 ± 6.16	U=830.0*	0.002*
Median	-3.0	0.0		
Gonial angle				
Min. – Max.	106.0 – 143.0	114.0 – 149.0		
Mean ± SD.	131.39 ± 7.43	128.12 ± 6.90	t=2.306*	0.023*
Median	133.0	127.0		
Cranial base angle				
Min. – Max.	36.0 – 147.0	12.0 – 145.0		
Mean ± SD.	130.22 ± 15.50	130.04 ± 18.12	U=1263.0	0.802
Median	133.0	132.0		
SN-MP				
Min. – Max.	18.0 – 50.0	20.0 – 56.0		
Mean ± SD.	38.47 ± 6.78	38.53 ± 7.24	t=0.042	0.966
Median	39.0	39.0		
SN-PP				
Min. – Max.	0.0 – 30.0	-1.0 – 20.0		
Mean ± SD.	11.16 ± 5.19	9.67 ± 4.54	t=1.544	0.126
Median	12.0	10.0		

Skeletal measurements	Group 1 Overjet<0 mm (n=51)	Group 2 Overjet≥0 mm (n=51)	Test of sig.	*p*
PP-MP				
Min. – Max.	11.0 – 44.0	12.0 – 42.0		
Mean ± SD.	28.33 ± 6.79	29.04 ± 6.73	t=0.527	0.599
Median	29.0	30.0		
FMA				
Min. – Max.	8.0 – 41.0	17.0 – 49.0		
Mean ± SD.	29.61 ± 7.42	29.33 ± 6.83	t=0.194	0.846
Median	30.0	30.0		
Y Axis - Frankfort				
Min. – Max.	31.0 – 70.0	32.0 – 72.0		
Mean ± SD.	58.18 ± 6.97	59.0 ± 7.23	U=1231.0	0.641
Median	59.0	59.0		
S-Go/N-Me %				
Min. – Max.	52.0 – 77.0	47.0 – 74.0		
Mean ± SD.	60.90 ± 5.49	60.65 ± 5.13	t=0.237	0.813
Median	60.0	61.0		
ANS-Me/ N-Me %				
Min. – Max.	44.0 – 65.0	51.0 – 69.0		
Mean ± SD.	56.67 ± 3.56	57.0 ± 3.36	t=0.993	0.323
Median	57.0	57.0		
Wits (mm)				
Min. – Max.	-22.0 – -2.0	-15.0 – 7.0		
Mean ± SD.	-11.63 ± 5.15	-6.22 ± 4.79	U=591.50*	<0.001*
Median	-12.0	-7.0		
Bony chin (mm)				
Min. – Max.	-4.0 – 10.0	-6.0 – 7.0		
Mean ± SD.	0.33 ± 2.36	1.06 ± 2.11	U=925.0*	0.010*
Median	0.0	1.0		

U: Mann Whitney test t: Student t-test
p: *p*-value for comparing between the two groups
*: Statistically significant at p ≤ 0.05
Group 1: Patients having an overjet< 0 mm.
Group 2: Patients having an overjet ≥ 0 mm.

Table (3): Comparison of the dental measurements between the negative and positive overjet groups.

Dental measurements	Group 1 Overjet<0 mm (n=51)	Group 2 Overjet ≥0 mm (n=51)	Test of sig.	*p*
U_1/L_1				
Min. – Max.	105.0 – 147.0	81.0 – 158.0		
Mean ± SD.	128.75 ± 11.10	125.69 ± 12.82	t=1.288	0.201
Median	128.0	127.0		
L_1- MP				
Min. – Max.	1.0 – 105.0	40.0 – 110.0		
Mean ± SD.	83.31 ± 14.74	87.0 ± 10.86	U=1109.0	0.200
Median	85.0	88.0		
L_1- Frankfort				
Min. – Max.	43.0 – 112.0	45.0 – 83.0		
Mean ± SD.	67.41 ± 10.78	64.0 ± 7.85	t=1.828	0.071
Median	66.0	65.0		
L1-NB Angle				
Min. – Max.	10.0 – 40.0	5.0 – 45.0		
Mean ± SD.	25.53 ± 7.23	25.57 ± 7.90	t=0.026	0.979
Median	25.0	24.0		
L1-NB (mm)				
Min. – Max.	-1.0 – 14.0	0.0 – 13.0		
Mean ± SD.	6.16 ± 3.0	5.14 ± 2.74	U=1009.0*	0.049*
Median	6.0	5.0		
U1-NA Angle				
Min. – Max.	12.0 – 50.0	10.0 – 45.0		
Mean ± SD.	29.24 ± 8.05	28.59 ± 7.30	U=1225.0	0.613
Median	29.0	29.0		
U1-NA (mm)				
Min. – Max.	0.0 – 23.0	1.0 – 37.0		
Mean ± SD.	7.02 ± 4.18	7.69 ± 5.50	U=1246.0	0.714
Median	7.0	7.0		
U1- Frankfort				
Min. – Max.	23.0 – 132.0	101.0 – 134.0		
Mean ± SD.	113.06 ± 18.94	117.74 ± 7.79	U=1190.0	0.459
Median	117.0	118.0		
U1 -A-Pg (mm)				
Min. – Max.	-1.0 – 20.0	1.0 – 16.0		
Mean ± SD.	4.67 ± 3.50	6.77 ± 3.38	U=3.253*	0.001*
Median	4.0	7.0		

U: Mann Whitney test   t: Student t-test

p: *p*-value for comparing between the two groups   *: Statistically significant at $p \leq 0.05$

Table (4): Correlation between overjet with skeletal measurements and dental measurements (n=102).

	Overjet	
	r_s	*p*
SNA	-0.009	0.929
SNB	-0.279*	0.004
ANB	0.455*	<0.001
S-N-Pg	-0.272*	0.006
Facial angle	-0.124	0.214
Angle of convexity	0.380*	<0.001
Gonial angle	-0.257*	0.009
Cranial base angle	-0.053	0.600
SN-MP	-0.035	0.725
SN-PP	-0.153	0.124
PP-MP	0.039	0.698
FMA	-0.038	0.701
Y Axis - Frankfort	0.096	0.337
S-Go/N-Me %	0.071	0.476
ANS-Me/ N-Me %	0.082	0.411
Wits (mm)	0.549*	<0.001
Bony chin (mm)	0.238*	0.016
U1/L1	-0.181	0.069
L1- MP	0.240*	0.015
L1- Frankfort	-0.216*	0.029
L1-NB Angle	0.068	0.495
L1-NB (mm)	-0.133	0.181
U1-NA Angle	-0.050	0.621
U1-NA (mm)	0.093	0.352
U1- Frankfort	0.078	0.435
U1 -A-Pg (mm)	0.437*	<0.001

r_s: Spearman coefficient *: Statistically significant at $p \leq 0.05$

Table (5):Univariate Linear regression analysis for overjet(mm).

Dependent	Independents	R^2	Equation	*F*	*p*
Overjet	**SNB**	0.087	15.848-0.206***SNB**	9.484*	0.003*
	ANB	0.237	-0.202+0.498***ANB**	31.047*	<0.001*
	S-N-Pg	0.081	15.043-0.195* **S-N-Pg**	8.764*	0.004*
	Angle of convexity	0.170	-0.534+0.178* **Angle of convexity**	20.468*	<0.001*
	Gonial angle	0.039	11.157-0.093***Gonial angle**	4.087*	0.046*
	Wits (mm)	0.330	2.200+0.350* **Wits**	49.234*	<0.001*
	Bony chin (mm)	0.017	-1.060+0.199* **Bony chin**	1.740	0.190
	L1-NB (mm)	0.031	0.248-0.207* **L1-NB**	3.158	0.079
	U1-A-Pg (mm)	0.166	-3.157+0.391* **U1-A-Pg**	19.912*	<0.001*

F, *p*: *F* and *p*-values

R^2: Coefficient of determination

*: Statistically significant at $p \leq 0.05$

DISCUSSION

Although Class III is one of the rarest malocclusions in the Middle East, its treatment is one of the most difficult strategies. Surgery is needed in Class III more often than in other classes of malocclusion. The borderline between orthdontically treated and surgically treated cases is not really well defined. The study of the natural compensatory mechanism that yields a normal overjet might help in guiding the orthodontist to decide the best treatment plan regarding these cases.

The age of the chosen cases in this study was above fifteen years when most of the growth is finished. As regards the epidemiology of the cases, similar age range was taken in both groups. We took both females and males randomly in our sample and it was found that females were slightly higher than males.

By comparing the skeletal cephalometric readings between the negative and positive overjet groups it was found that the mandibular position evident by the SNB and S-N-Pg angles was significantly more protrusive in the negative overjet group with less dentoalveolar compensation. This explains that the whole mandible is protruded in position relative to the patient’s face giving the evident Class III features and subsequently, the decreased dentoalveolar compensation.

While, the position of the maxilla did not show any significant difference between the two groups, this maybe because the lower incisors do not have the same capacity of the upper incisor to incline because of the limited amount of bone available in the mandible meaning that the upper incisors have a higher chance of inclination to achieve dentoalveolar compensation. Relevant results were found by Emral et al.[18] showing a greater degree of upper incisors inclination in the maxillary retrusion group than in the mandibular protrusion group.

The greater skeletal discrepancy between the maxilla and mandible in the negative overjet group, evidenced by the more negative ANB angle and wits appraisal seems to be logic as dentoalveolar compensation cannot take place in extreme skeletal deviations. In total agreement with this study is Ishikawa et al. [7] stating "There must be limits in the sagittal jaw relationships where normal incisor relationships are obtained". Moreover similar results were found by Nahidh and Al-Monthaffar[19] who found that the skeletal discrepancy between the maxilla and the mandible is one of the most important parameters describing the dentoalveolar compensation in the sagittal relationship. In addition, Kim et al.[2] showed significantly more negative Wits appraisal values in the negative overjet groups than the positive overjet group.

More concave profiles diagnosed by a low angle of convexity showed decreased dentoalveolar compensation leading to a negative overjet.

In this study it was interesting to find that the bony chin indicating the actual distance between the pogonion and point B proved to be smaller in the negative overjet group (least dentoalveolar compensation). Meaning that in case of increased bony chin, a more concave Class III profile would be caused by the bony prominence of the chin with no effect on the incisor position. That is to say the bigger the bony chin, the more dentoalveolar compensation would be achieved.

Gonial angle was found to be larger in the negative overjet group, which is one of the characteristics of skeletal Class III cases.[20] It might be as the gonial angle increases the confinement of the mandible in the maxilla decreases and thus the mandible is free to move forward resulting in negative overjet.

As regards the dental findings, it was found that the more distal the position of the upper incisor in addition to the more mesial position of the lower incisor, indicated by the distances between upper incisor to A-Pg and Lower incisor to NB respectively, yielded a negative overjet group that proper compensation could not be reached. Our paper partially agreed with Ceylan et al.[21] who found that the incisor position and in addition the incisor axial inclination were significantly different between the two groups with the maxillary and mandibular incisors more labially inclined in the positive overjet group. In addition to the results of Hernández-Sayago et al.[11] who found that both the lower incisor position and inclination are important factors in achieving proper dentoalveolar compensations.

However in this study, although a weak positive correlation was found between the lower incisor inclination and the overjet, the Inclination of the maxillary and mandibular incisors was not significantly different between the two groups that was contradicted by Kim et al.[2] who reported that the more the proclination of the maxillary incisors the more positive overjet can be achieved and also by Ishikawa et al.[6] who stated that mandibular incisor retroclination contribute in a positive overjet. This difference might be because the overjet is dependent on the actual position of the incisal edge of the crown regardless of its inclination.

Positive correlation existed between the overjet and the skeletal discrepancy (ANB and Wits appraisal) which potentiates that the main factor responsible for the difference in dentoalveolar compensation between the two groups is the skeletal discrepancy between the maxilla and mandible.

Negative correlation was found between the overjet and mandibular position (SNB, S-N-Pg angles) supporting the concept of the more mesial the mandibular position the more negative the overjet. In addition, negative correlation between the overjetand the gonial angle was found indicating the greater the gonial angle the more difficult dentoalveolar compensation can take place.

Using regression analysis, the skeletal discrepancy between the maxilla and mandible measured by Wits appraisal and ANB angle proved to be the highest coefficients of determination for the overjet. Similar results were found by Stellzig-Eisenhauer, Lux and Schuster [22] who found that the Wits appraisal was the most decisive parameter for the classification of adult Class III patients.

To sum up, in the treatment of Class III patients, full attention should be given to the skeletal and dental features that have significant effect on the dentoalveolar compensation. The angles proving to forcibly impact the dentoalveolar compensation could be warning signs that these cases will be difficult to be treated orthodontically and they might need surgery.

CONCLUSION

- Dentoalveolar compensation was observed in Class III cases with more mesial position of maxillary incisors and more distal position of the mandibular insicors.
- Dentoalveolar compensation was noticed in Class III cases with less skeletal discrepancy, lower mandibular prominence, larger bony chin, greater

angle of convexity and smaller gonial angle.

- The overjet has significant negative correlation with mandibular position, L1-Frankfort and gonial angles. On the other hand, it had significant positive correlation with skeletal discrepancy between the maxilla and mandible, angle of convexity, bony chin, L1-MP and U1-A-Pg mm.

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