

## Cephalometric Characteristics of Growing Children with Class I, II and III Malocclusions

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**Abstract:** The aim of this cross-sectional study was to evaluate cephalometric characteristics of Saudi growing children with Class II and III malocclusions. **Methods:** The sample consisted of 135 Saudis (63 boys and 72 girls with a mean age of 12.4 years). The sample was selected from patients who were seeking orthodontic treatment at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia. The control group consisted of cephalometric records of 55 patients with normal occlusion (23 boys and 32 girls, mean age = 12.3). Comparisons of linear and angular measurements were performed using lateral cephalograms. **Results:** ANOVA for the total sample showed that there were no significant differences in the skeletal measurements between Class I, II and III malocclusions except in SNA, ANB, Wits, angle of convexity, maxillary length and total face height,  $p < 0.001$ . For boys, ANOVA showed similar results except that the total face height was not different and the maxillary/mandibular ration was significantly different,  $p \leq 0.002$ . For girls, ANOVA was only significant in SNA, ANB, Wits and angle of convexity,  $p < 0.001$ . There were significant differences between Class I, II and III in all dental readings except for the interincisal angle and SN to upper incisor angle. For boys' analysis, ANOVA showed that only upper incisor position and inclination and lower incisor inclination were significantly different. Dental measurements for the girls were significantly different amongst the three classes except for the interincisal angle, upper incisor to SN and NA angles. Soft Tissue Analysis showed that a significantly different readings between the three classes of malocclusions. However, in the boys reading the lower lip to E-plane was similar between the classes. For girls, only the reading for the soft tissue convexity was significantly different. **Conclusion:** maxillary deficiency and protrusion is the cause of Class II and III, respectively due to the differences in length of the maxilla. Maxillary incisors are proclined and protruded while the mandibular incisors are retroclined and retruded in Class III. Cephalometric characteristics differ between genders for all three classes of malocclusion.

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### 1. Introduction:

In orthodontics a comprehensive knowledge of the skeletal and dental components that contribute to a particular malocclusion is fundamental for these elements may influence the diagnosis and treatment plan. Both Class II and III malocclusions are subjects of interest and concern to the orthodontist in both research and clinical practice.

Class II malocclusion is more common than Class III malocclusion with a prevalence ranging between 5% and 29%.<sup>1-5</sup> In a Saudi sample, the prevalence of Class II was 12%.<sup>6</sup> Two thirds of the patients with Class II division 1 malocclusion were reported to have an associated significant skeletal discrepancy.<sup>5</sup>

The etiology of Class II and III malocclusions is an intriguing subject and there is still much to be elucidated and understood.<sup>7, 8</sup> There is considerable controversy as to the relative contributions of the size and position of the cranial base, the maxilla and the mandible.<sup>9-13</sup>

Several studies reported the dental and skeletal morphological features of Class II malocclusion subjects.<sup>14-18</sup> The maxilla was found to be more

protrusive and the mandible was normal in size and position in one study,<sup>18</sup> while in another study it was found that the maxilla was in a normal position in relation to the cranial base and the mandible was retrognathic.<sup>16</sup> Others showed that the skeletal pattern of Class II was due to a combination of maxillary protrusion and mandibular retrusion.<sup>17, 18</sup>

A number of studies attempted to evaluate mandibular size and growth changes; however, it is still ambiguous why in Class II the mandible becomes retrusive. It was suggested that shorter total and mandibular corpus lengths among Class II compared with Class I, where some reported greater growth in total mandibular length among Class I when compared to lass II, while others did not.<sup>19-23</sup>

In Class III, the appearance of a protruding mandible with reverse overlap of the anterior teeth is easy to identify. Dental class III malocclusion has no significant skeletal discrepancy whereas skeletal class III malocclusion is associated with a wide variety of underlying skeletal and dental patterns.<sup>24-26</sup>

The prevalence of class III malocclusion varies among different races and populations. The highest prevalence is among Asians and the lowest is in

Caucasians. It has been reported in 13.0% of Japanese,<sup>27</sup> 14.5% of Chinese,<sup>28</sup> 19.0% of Korean<sup>29</sup> and 3% of Caucasian subjects.<sup>30</sup> However, the frequency of class III malocclusion in the Middle East is higher than in Caucasians but less than in Asians from the Far East. It varies from 5.1% to 10%<sup>31,32</sup> and in Saudi Arabians the occurrence of class III malocclusion is reported to be 9.4 %.<sup>33</sup>

Several studies have been conducted to determine the morphologic characteristics of craniofacial complex in patients with Class II and III malocclusions.<sup>10, 12, 31, 33-35</sup> It was demonstrated that Class III malocclusion is not a single diagnostic entity but can result from various combinations of skeletal and dentoalveolar components. In these studies, the cephalometric evaluation indicated that in most cases maxillary retrusion existed, while the mandible showed prognathism.<sup>10, 12, 33-35</sup> Only one study reported a normal mandibular position in Class III patients.<sup>31</sup>

In a number of reports, it was shown that patients with dental Class III relationship also present with skeletal Class III relationship as well.<sup>10, 33, 35</sup> From the dentoalveolar aspect, several studies showed protrusion of the maxillary incisors and retrusion of mandibular incisors,<sup>10, 12, 35</sup> except for the findings of Mouakeh, in which the retrusion of maxillary incisors was noted.<sup>31</sup>

In the assessment of vertical components in Class III patients, it was shown that there was an increase in the lower facial height in some studies,<sup>10, 12, 35</sup> while others showed a decrease of lower facial height in individuals with Class III malocclusion.<sup>31, 34</sup>

The determination of essence and the prevalence of the special components of the Class III malocclusion have special importance as facial beauty is affected most by this malocclusion compared to other discrepancies. The majority of researchers agree with the dentoalveolar pattern of this abnormality: the Class III relationship of molars, more anterior position of mandibular teeth and the decrease of overjet or negative overjet. However, the agreement on the possible skeletal pattern for this malocclusion is still a matter of controversy.

The purpose of this study was to describe and compare the skeletal and dental cephalometric characteristics of Class II and III malocclusions of Saudi growing children and to compare these cephalometric characteristics with normal Class I occlusion.

## 2. Materials and Methods

The sample of this cross-sectional study consisted of 135 Saudis (63 boys and 72 girls with a mean age of 12.4 years). The sample was selected from patients who were seeking orthodontic treatment

at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia.

Inclusion criteria were: 1) subjects are Saudi children, 2) Class II or III relationship of the second primary or first permanent molars, determined by clinical evaluation of each patient in centric relation to rule out functional shift or the presence of pseudo-Class III, 3) Between the ages of 6 and 14 years, 4) No previous orthodontic treatment and 5) No cleft lip or palate or other craniofacial syndromes.

An age matched control group consisted of cephalometric records of 55 patients (mean age = 12.3 years) with normal occlusion (23 boys and 32 girls) who also visited the Faculty of Dentistry during the same period as above. Inclusion criteria were: 1) minimal overbite and overjet, 2) straight to slightly convex profile, 3) primary molar relationship in neutro-occlusion or flush terminal plane, and (4) permanent Class I molar relationship.

Exclusion criteria for both groups were: 1) proximal dental caries, 2) missing teeth, 3) a history of significant medical illness, and 4) previous orthodontic or restorative treatment or the presence of stainless steel crowns.

Lateral cephalometric radiographs were taken in the natural head position with posterior teeth in maximum intercuspation. One investigator traced all cephalograms on acetate tracing papers and performed the measurements manually. Craniofacial structural relationships were divided into three categories (skeletal, dental and soft tissue) for analysis of the angular and linear measurements. Reliability in landmark location and resulting calculation of cephalometric measurements was determined. One investigator traced a sample of 20 random cephalometric radiographs twice at least 2 weeks. Differences between the first and second ratings were assessed and the intraclass correlation coefficient ranged from 0.87 to 0.94, suggesting that the measurements performed by the same investigator were reproducible and reliable. Cephalometric analyses were based on Steiner,<sup>36</sup> Down<sup>37</sup> McNamara,<sup>38</sup> Wits,<sup>39</sup> and Tweed<sup>40</sup>. The study was reviewed and approved by the Research Ethics Committee, Faculty of Dentistry, King Abdulaziz University.

Mean and standard deviation ( $\pm$ SD) for male and female subjects were calculated as one group and separately for all measurements. Analysis of variance (ANOVA) was performed to evaluate significant differences between each Class of malocclusion. When significant differences existed, post-hoc multiple comparisons were performed using the Bonferroni method to correct for type-I error. Unpaired sample t-tests were performed when appropriate. Statistical analysis was performed using

Statistical Package for the Social Sciences (IBM Corp. Released 2011. IBM SPSS Statistics for Mac, Version 20.0. Armonk, NY: IBM Corp).

### 3. Results:

There were no significant differences between the ages of Class I, II and III,  $p > 0.05$ . The means and standard deviations of the linear and angular measurements for the cephalometric variables for the whole group are presented in Table 1. Furthermore, the comparisons between Class I, II and III for boys and girls are presented separately in Tables 2 and 3, respectively.

#### Skeletal Analysis

ANOVA for the total sample showed that there were no significant differences in the skeletal measurements between Class I, II and III malocclusions except in SNA, ANB, Wits, angle of convexity, maxillary length and total face height,  $p < 0.001$  while the maxillary/mandibular ration approached but did not attain a significant value (Table 1). For boys, ANOVA showed similar results except that the total face height was not different and the maxillary / mandibular ration was significantly

different (Table 2). In the results of girls, ANOVA was only significant in SNA, ANB, Wits and angle of convexity,  $p < 0.001$  (Table 3).

#### Dental Analysis

Comparisons between dental measurements for the total sample showed that there were significant differences between Class I, II and III in all the readings except for the interincisal angle and SN to upper incisor angle, (Table 1).

For boys' analysis, ANOVA showed that only upper to incisor distance and angle and lower incisor to mandibular plane angle were significantly different (Table 2).

Dental measurements for the girls were significantly different amongst the three classes except for the interincisal angle, upper incisor to SN and NA angles (Table 3).

#### Soft Tissue Analysis

All readings were significantly different between the three classes of malocclusions (Table 1). However, in the boys reading the lower lip to E-plane was similar between the classes (Table 2). For girls, only the reading for the soft tissue convexity was significantly different (Table 3).

Table 1. Comparisons of cephalometric parameters between Class I, II and III (data is presented as mean  $\pm$ SD)

Cephalometric Parameter	Class I (n=55)	Class II (n=50)	Class III (n=30)	Significance (p-value)
<b>SKELETAL</b>				
Cranial base (mm)	62.77 (8.60)	63.56 (7.89)	62.55 (5.22)	NS
SNA (angle)	83.34 (4.24)	83.40 (5.07)	79.26 (4.36)	<0.001
SNB (angle)	80.43 (3.96)	80.15 (4.32)	80.67 (4.06)	NS
ANB (angle)	2.90 (1.11)	3.26 (3.28)	-1.39 (1.60)	<0.001
Wits (mm)	-1.19 (2.18)	-0.89 (4.18)	-5.63 (3.84)	<0.001
Occlusal plane – SN (angle)	15.25 (4.37)	15.38 (4.92)	15.10 (4.66)	NS
Mandibular Plane – SN (angle)	34.94 (6.06)	35.64 (6.65)	36.88 (4.82)	NS
Frankfort Mandibular plane (angle)	27.71 (5.94)	28.24 (6.56)	29.75 (5.97)	NS
Angle of Convexity	4.83 (3.09)	5.68 (7.41)	-4.38 (3.94)	<0.001
Pog – NB (angle)	1.41 (3.18)	1.75 (3.68)	2.84 (4.59)	NS
Y-axis	59.78 (4.16)	60.13 (4.53)	60.28 (4.56)	NS
Maxillary length (ANS-PNS) (mm)	46.26 (7.38)	46.06 (6.69)	44.86 (5.34)	NS
Maxillary length (Co-A) (mm)	76.24 (7.54)	76.57 (6.74)	73.29 (5.74)	0.001
Mandibular length (mm)	107.83 (14.55)	107.52(11.41)	110.10 (9.45)	NS
Maxillary / Mandibular Ration (mm)	-61.58 (13.91)	-61.47 (10.99)	-65.25 (9.89)	0.051
Gonial angle	127.32 (9.11)	127.32(9.27)	128.38 (7.71)	NS
Total face height (mm)	110.09 (9.84)	110.68(9.06)	112.62 (8.94)	<0.001
<b>DENTAL</b>				
Interincisal Angle	123.26 (11.38)	123.02(11.94)	126.73 (11.88)	NS
Upper 1 - SN (angle)	106.61 (16.31)	107.79(12.23)	108.73 (7.63)	NS
Upper 1 - NA (distance mm)	5.20 (2.98)	5.16 (3.40)	7.59 (3.11)	<0.001
Upper 1 - NA (angle)	25.12 (7.91)	25.13 (7.85)	29.46 (5.96)	0.001
Lower 1 - NB (distance mm)	6.22 (3.01)	6.38 (2.80)	5.36 (2.99)	0.016
Lower 1 - NB (angle)	28.72 (6.04)	28.60 (6.63)	25.22 (7.33)	0.002
Lower 1 – Frankfort Horizontal (angle)	58.95 (6.38)	58.96 (7.47)	62.59 (8.04)	0.003
Lower 1 – Mandibular Plane (angle)	93.34 (7.40)	92.80 (8.29)	87.66 (8.93)	<0.001
<b>SOFT TISSUE</b>				
Soft tissue convexity	132.25 (6.60)	131.18(7.26)	136.51 (6.23)	<0.001
Upper lip - E-plane (mm)	-3.26 (2.2)	-3.38 (3.21)	-4.71 (2.64)	0.025
Lower lip - E-plane (mm)	-0.80 (3.65)	-0.82 (3.62)	-1.00 (3.26)	NS

Table 2. Comparisons of cephalometric parameters between Class I, II and III for boys (data is presented as mean  $\pm$ SD)

Cephalometric Parameter	Class I (n=23)	Class II (n=21)	Class III (n=19)	Significance (p-value)
<b>SKELETAL</b>				
Cranial base (mm)	61.52 (10.81)	63.94 (8.07)	63.70 (4.33)	NS
SNA (angle)	82.43 (3.93)	82.64 (4.95)	79.48 (4.65)	<0.001
SNB (angle)	79.56 (3.56)	80.06 (4.25)	81.18 (4.07)	NS
ANB (angle)	2.87 (1.20)	2.58 (3.52)	-1.69 (1.83)	<0.001
Wits (mm)	-1.25 (2.37)	-2.05 (4.67)	-7.18 (3.83)	<0.001
Occlusal plane – SN (angle)	16.02 (4.06)	16.09 (4.66)	16.03 (5.15)	NS
Mandibular Plane – SN (angle)	36.79 (4.94)	36.59 (5.91)	37.51 (5.43)	NS
Frankfort Mandibular plane (angle)	28.71 (5.73)	28.86 (6.62)	30.05 (6.98)	NS
Angle of Convexity	5.06 (2.91)	4.32 (7.65)	-4.89 (4.44)	<0.001
Pog – NB (angle)	1.14 (2.67)	1.75 (3.64)	2.92 (5.12)	NS
Y-axis	60.04 (4.11)	60.08 (5.04)	60.08 (5.24)	NS
Maxillary length (ANS-PNS) (mm)	48.23 (9.72)	47.73 (8.38)	45.69 (6.14)	NS
Maxillary length (Co-A) (mm)	76.66 (6.28)	77.21 (6.52)	73.80 (6.10)	0.002
Mandibular length (mm)	107.95 (9.38)	109.82(9.13)	113.41 (9.46)	NS
Maxillary / Mandibular Ration (mm)	-59.71 (10.27)	-62.09(10.23)	-67.71 (11.12)	0.014
Gonial angle	129.77 (9.27)	128.68(9.17)	128.03 (8.06)	NS
Total face height (mm)	113.74 (9.85)	114.32(8.28)	116.38 (8.04)	NS
<b>DENTAL</b>				
Interincisal Angle	120.09 (9.75)	122.15(9.73)	124.86 (10.05)	NS
Upper I - SN (angle)	109.40 (7.17)	108.64(7.25)	108.87 (8.05)	NS
Upper I - NA (distance mm)	6.28 (3.47)	6.01 (3.64)	8.17 (3.32)	<0.001
Upper I - NA (angle)	26.97 (8.11)	26.00 (7.51)	29.37 (5.22)	0.004
Lower I - NB (distance mm)	7.36 (3.62)	6.87 (3.00)	6.23 (3.03)	NS
Lower I - NB (angle)	30.08 (5.58)	29.28 (5.38)	27.47 (5.58)	NS
Lower I – Frankfort Horizontal (angle)	57.57 (4.60)	58.53 (6.08)	61.18 (6.25)	NS
Lower I – Mandibular Plane (angle)	93.27 (6.74)	92.62 (7.42)	88.77 (8.30)	0.02
<b>SOFT TISSUE</b>				
Soft tissue convexity	132.54 (6.78)	131.40(7.31)	135.72 (5.87)	<0.001
Upper lip - E-plane (mm)	-2.31 (2.27)	-3.26 (2.75)	-5.08 (2.49)	0.001
Lower lip - E-plane (mm)	1.00 (3.21)	0.09 (3.20)	-0.62 (3.29)	NS

Table 3. Comparisons of cephalometric parameters between Class I, II and III for girls (data is presented as mean  $\pm$ SD)

Cephalometric Parameter	Class I (n=32)	Class II (n=29)	Class III (n=11)	Significance (p-value)
<b>SKELETAL</b>				
Cranial base (mm)	63.68 (6.62)	63.24 (7.77)	60.56 (6.19)	NS
SNA (angle)	83.99 (4.38)	84.07 (5.12)	78.89 (3.99)	<0.001
SNB (angle)	81.06 (4.38)	80.23 (4.40)	79.79 (4.08)	NS
ANB (angle)	2.92 (1.06)	3.84(2.96)	-0.88 (0.95)	<0.001
Wits (mm)	-1.14 (2.06)	0.12(3.41)	-2.96 (1.96)	<0.001
Occlusal plane – SN (angle)	14.69 (4.57)	14.77 (5.09)	13.51 (3.28)	NS
Mandibular Plane – SN (angle)	33.61 (6.51)	34.81(7.17)	35.81 (3.51)	NS
Frankfort Mandibular plane (angle)	26.98 (6.08)	27.70(6.51)	29.24 (3.92)	NS
Angle of Convexity	4.67 (3.26)	6.87 (7.02)	-3.49 (2.86)	<0.001
Pog – NB (angle)	1.61 (3.53)	1.75 (3.74)	2.71 (3.72)	NS
Y-axis	59.59 (2.5)	60.17 (4.07)	60.64 (3.28)	NS
Maxillary length (ANS-PNS) (mm)	44.83 (4.77)	44.59 (4.32)	43.41 (3.32)	NS
Maxillary length (Co-A) (mm)	75.96 (8.41)	76.01 (6.91)	72.40 (5.22)	NS
Mandibular length (mm)	107.75 (17.50)	105.52(12.82)	104.40 (6.46)	NS
Maxillary / Mandibular Ration (mm)	-62.92 (16.06)	-60.92(11.66)	-60.99 (5.41)	NS
Gonial angle	125.56 (8.72)	126.13(9.26)	128.99 (7.39)	NS
Total face height (mm)	107.47 (9.10)	107.04(15.34)	106.12 (6.51)	NS
<b>DENTAL</b>				
Interincisal Angle	125.54 (12.06)	123.78(13.61)	129.95 (14.47)	NS
Upper I - SN (angle)	104.60 (20.41)	107.04(15.34)	108.50 (7.23)	NS
Upper I - NA (distance mm)	4.42 (2.34)	4.42 (3.01)	6.58 (2.53)	0.019
Upper I - NA (angle)	23.79 (7.63)	24.28 (8.12)	29.61 (7.34)	NS
Lower I - NB (distance mm)	5.40 (2.18)	5.96 (2.57)	3.85 (2.31)	<0.001
Lower I - NB (angle)	27.74 (6.24)	28.00 (7.54)	21.34 (8.57)	0.001
Lower I – Frankfort Horizontal (angle)	59.95 (7.31)	59.33 (8.52)	65.01 (10.34)	0.014
Lower I – Mandibular Plane (angle)	93.07 (7.93)	92.96 (9.03)	85.75 (10.05)	0.007
<b>SOFT TISSUE</b>				
Soft tissue convexity	132.04 (6.57)	130.98(7.27)	137.89 (6.88)	<0.001
Upper lip - E-plane (mm)	-3.93 (3.00)	-3.49 (3.59)	-4.08 (2.88)	NS
Lower lip - E-plane (mm)	-2.09 (3.44)	-1.62 (3.79)	-1.65 (3.27)	NS

#### 4. Discussion

The differential diagnosis of skeletal pattern and the dental classification of malocclusion are important factors in planning the orthodontic treatment. Class III malocclusion is considered one of the most complex and difficult orthodontic problems to diagnose and treat. The prevalence of this type of malocclusion ranges between 0.2 in white populations to almost 12% in Chinese and Japanese population.<sup>31</sup> The possibility of diagnosis in very early stages of skeletal disharmony that are common in Class III children can play a substantial role in improving early treatment of these patients. This study was aimed to identifying cephalometric characteristics of Class III malocclusion and differentiate those of patients with Class I occlusion.

In this study, 110 lateral cephalograms including 55 cephalograms of patients with Class III malocclusion as case group and 55 cephalograms of Class I occlusion as control group were compared. It is believed that individuals with Class III malocclusion may have combinations of dentoalveolar and skeletal components. Diagnosis and consideration of the various components is essential in treating the underlying cause of the discrepancy appropriately.

According to previous studies,<sup>10, 26, 34, 35, 41</sup>

In this study, it was interesting to note that, in boys, there were no significant differences in the maxillary or mandibular lengths between Class I and III (Table 2). In contrast, the maxillary length in girls was significantly shorter in Class III compared to Class I (Table 3), even though in both boys and girls the SNA angle was significantly less, indicating that the maxillary position is retruded. Furthermore, it was interesting to find that there were no differences in the cephalometric reading in boys for the dental pattern except the lower incisor inclination where it was significantly retroclined in Class III. This was not the case in girls where there were significant differences in almost all the dental measurements (Table 3).

All parameters used to evaluate mandibular skeletal position did not reveal mandibular prognathism in Class III group. These results are not in agreement with earlier reports.<sup>10, 12, 33, 42</sup> However, it was in concert with Mouakeh,<sup>31</sup> who did not find significant difference between mandibular skeletal position in Class I and Class III cases. This could be due to the fact that the growth of lower jaw may have not been completed. Furthermore, this finding indicates that a combination between maxillary length and mandibular position rather than mandibular length could be the main cause of the Class III pattern in the current study.

From two parameters used to evaluate the mandibular dentoalveolar position, the angle between lower incisor and mandibular plane (IMPA) showed retrusion of lower incisors in Class III group compared to control group. Previous researches have also reported the lower incisors retrusion.<sup>10, 12, 34, 42</sup> On the other hand, maxillary dentoalveolar position showed protrusion of upper incisors, which is in accordance with the results of other reports,<sup>12, 35</sup> but in disagreement with one study that showed upper incisors retrusion.<sup>31</sup> This may be due to the age of the study samples in which dental compensations had not occurred yet.

The current findings did not demonstrate a difference in the facial height between Class III and I. Some studies showed increase of the lower facial height,<sup>10, 12, 35</sup> while others did not.<sup>31, 34</sup>

An interesting finding in the present study was the great prevalence of maxillary skeletal retrusion. Delaire et al, showed that forward positioning of the maxilla could be achieved with reverse headgear, if treatment is begun at an early age.<sup>43</sup> The best current data suggest that successful forward repositioning of the maxilla can be accomplished before age 8, but after that orthodontic tooth movement usually prevails skeletal change.<sup>44, 45</sup>

The current results are not in concert with previous reports in which Class III subjects showed significant different characteristics to Class I.<sup>28, 31, 34, 41</sup> This could be due to the fact that in the current study both genders were analyzed separately.

#### Conclusion

In comparison with Class I individuals it can be concluded that 1) maxillary deficiency and protrusion is the cause of Class II and III, respectively. This could be attributed to the decreased or increased length of the maxilla, 2) the maxillary incisors are proclined and protruded in Class III. 3) mandibular incisors are retroclined and retruded in Class III, and 7) different cephalometric characteristics exists between gender.

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