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Changes in mandibular position in treated Class II division 2 malocclusions in growing and non-growing subjects

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Objective: To determine changes in mandibular position after the treatment of patients presenting with Class II division 2 malocclusions and to test the null hypothesis that there is posterior displacement of the mandible in these patients, in comparison with a control group of Class II division 1 subjects.
Materials and methods: The assessed data consisted of pre- and post-treatment cephalometric radiographs of 77 subjects identified with Class II division 1 and Class II division 2 malocclusions matched according to age, gender and treatment duration. All completed fixed appliance orthodontic treatment. The changes in the position of point B, Pogonion and Articulare were determined at the end of treatment by superimposing the cephalometric radiographs on Sella-Nasion line at Sella. Thirteen cephalometric parameters including the distance between Basion and Articular (Ba-Art) were measured at each stage.
Results: In both groups, SNB angle, SNPog angle and Ba-Art distance showed no statistically significant changes. Pogonion was displaced significantly in a forward and downward direction in the growing group, with no significant differences identified between Class II division 1 and Class II division 2 subjects.
Conclusion: The null hypothesis that there is posterior displacement of the mandible in Class II division 2 malocclusion is rejected. The growth pattern of the mandible in both divisions of a Class II malocclusion after orthodontic treatment was found to be similar.
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Introduction

A Class II division 2 (Class II/2) malocclusion is characterised by excessive palatal inclination of the maxillary central incisors, often accompanied by a deep overbite and minimal overjet.[1] The anterior relationship has been assumed likely to cause displacement of the condyles posteriorly and superiorly in the glenoid fossae.[2-5]

Swann[2] estimated that one-third of Class II/2 malocclusion cases exhibited a posterior functional shift. Cleall and BeGole[6] also demonstrated that the intrusion of the upper incisors during treatment of a Class II/2 malocclusion would relieve the posterior mandibular displacement and aid in the correction of a distal occlusion.

However, contrary studies have favoured the view that the mandible is not posteriorly displaced in a Class II/2 malocclusion. Ingervall[7] reported that the distance between the retruded contact and the intercuspal positions was greater in children with a Class II/2 malocclusion compared with children possessing a normal occlusion. It was considered illogical that this distance should be greater than normal in a Class II/2 malocclusion if the mandible was displaced backwards. Gianelly et al.[8] found no evidence of abnormal condylar positioning in Class II cases with upright incisors and deep overbite compared with Class II cases without these features. This was consistent with the findings of Pullinger et al.,[9] who found no relationship between a deep overbite and condylar position.

It has been claimed that possible posterior mandibular displacement may have negative consequences on the temporomandibular joints by forcing the condyle

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against the posterior border of the disk and generating reciprocal clicking during function.[10-13] Nevertheless, the presence of a posterior mandibular displacement is considered favourable for the orthodontic management of a Class II/2 malocclusion, as maxillary incisor proclination and overbite reduction likely result in spontaneous forward repositioning of the mandible toward a Class I molar relationship.[14]

In addition to the possibility of mandibular posterior displacement, it is believed that the 'unlocking' of the mandible following proclination of maxillary incisors in Class II/2 malocclusions in growing subjects allowed the mandible to grow in a more anterior direction.[3,15-17]

Erickson and Hunter[3] identified that the amount of mandibular growth in treated Class II/2 malocclusion subjects was greater than in untreated subjects with a difference of 1.5 mm/year. Woods[18] found that incisal bite opening during the treatment of Class II/2 patients was associated with forward movement of B point without substantial enhancement of the forward position of Pogonion. It was explained that the reduction of the deep overbite led to dentoalveolar forward movement rather than skeletal change.

Accordingly, the purpose of the present study was to evaluate positional changes in the mandible that might occur after orthodontic treatment of growing and non-growing patients presenting with a Class II/2 malocclusion against a matched control group of Class II division 1 (Class II/1) subjects. The aim was to test the hypothesis that there is a posterior mandibular displacement in Class II/2 patients, the relief of which changes the expression of mandibular growth during orthodontic treatment.

Materials and methods

Ethical approval for the study was obtained from the Institution of Research Board, Jordan University of Science and Technology (JUST). The retrospective examination was based on pre- and post-treatment lateral cephalograms of 77 patients obtained from the files of patients treated in the Orthodontic Department at the Dental Teaching Center of JUST and in two private clinics.

The records of the patients were selected from treatment lists according to the following criteria:

1. All patients were diagnosed with either a Class II/1 or Class II/2 malocclusion, according to the British Standards Institute Classification.[19]
2. There was contact between the maxillary and mandibular incisors in all cases diagnosed with Class II/2 malocclusion and at least a 70% deep overbite.
3. All patients had a similar ethnic background (Caucasian/Jordanians).
4. No congenitally missing or extracted permanent teeth.
5. No crowns or bridges.
6. Good quality pre- and post-treatment lateral cephalograms that had been taken using the same cephalometric machine and with the subject's posterior teeth in maximum intercuspation.
7. The entire treatment of each patient had been performed by the same clinician using a pre-adjusted edgewise orthodontic appliance (0.022 × 0.028 inch, Roth prescription).
8. The treatment did not include growth modification appliances or orthognathic surgery.
9. Patients did not have any craniofacial anomalies and/or medical conditions affecting skeletal growth.

The study sample was divided according to malocclusion characteristics into Class II/1 and Class II/2 groups. The sample was further divided into two age groups of growing (≤15years of age) and non-growing (≥18 years of age) subjects. The groups were matched for age, gender and treatment duration. The distribution of patients in the sample groups is shown in Table I.

All cephalometric films were taken using the standard Broadbent and Hofrath technique[20,21] and were manually traced by the same investigator (MAZ). No more than four lateral cephalograms were traced at any hour to reduce measurement error caused by operator fatigue.

Fifteen landmarks and four reference planes were identified for each cephalometric film either by inspection or construction, which allowed 13 parameters to be measured. The definitions of the landmark points are listed in Table II and shown in Figure 1. The definitions of the reference planes are listed in Table III and shown in Figure 2. The definitions of the measured parameters are listed in Table IV.

Table I. Distribution of patients according to diagnosis, gender and age, and the mean and standard deviation for age and treatment duration of all sample groups.

Parameter	Growing Class II/1 (N = 21; M:11, F:10)	Growing Class II/2 (N = 21; M:9, F:12)	Non-growing Class II/1 (N = 18; M:7, F:11)	Non-growing Class II/2 (N = 17; M:6, F:11)
Age (years) mean (SD)	12.12 (1.14)	12.62 (0.93)	24.61 (6.49)	20.88 (2.87)
Treatment duration (months) mean (SD)	26.14 (8.94)	24.10 (7.42)	27.56 (8.33)	27.12 (8.34)

Table II. Cephalometric landmarks.

The point	Definition
Sella	The center of the pituitary fossa of sphenoid bone.
Nasion	The most anterior point of the frontonasal suture.
Anterior nasal spine	The tip of the median anterior bony process of the maxilla.
Posterior nasal spine	The tip of the posterior nasal spine.
A point	A midline point located at the deepest point on the curve extending from Anterior nasal spine to Prosthion.
Incision superius	The tip of the crown of the most prominent upper incisor.
Apicale superius	Root apex of the most prominent upper incisor.
B point	The deepest point on the concavity at the anterior surface of the mandibular symphysis.
Incision inferius	The tip of the crown of the most prominent lower incisor.
Apicale inferius	Root apex of the most prominent lower incisor.
Pogonion	The most anterior point at the bony chin.
Menton	The most inferior point on the mandibular symphysis.
Gonion	The most inferior posterior point at the angle of the mandible.
Articulare	The intersection of the shadow of the undersurface of the basi-occiput with that of the posterior border of the neck of the mandible, with the teeth being in centric occlusion.
Basion	The most anterior point on the margin of the foramen magnum.

Table III. Reference planes.

The plane	Definition
SN plane	The horizontal line joining the Sella point with Nasion point.
Maxillary plane	The horizontal line joining the Anterior nasal spine with the Posterior nasal spine.
Mandibular plane	The horizontal line joining the Menton point with the Gonion point.
A-Pog line	The vertical line joining the A point with Pogonion point.

To assess mandibular position changes after treatment, the pre- and post-treatment tracings were superimposed on SN line at Sella. Using this superimposition, a line passing through Sella, 7 degrees to the SN line, was drawn to form a horizontal reference line. A line perpendicular to the horizontal reference line passing through Sella formed a vertical reference line.[22] The horizontal and vertical reference lines are shown in Figure 3. To determine the sagittal changes in B point after treatment, two perpendicular lines (one from pretreatment B point and one from post-treatment B point) were drawn to the horizontal reference line, as shown in Figure 3. The distance between the two lines represented the amount of sagittal treatment change at B point. The same procedure was used for Pogonion and Articulare points to enable the measurement of sagittal treatment changes at those sites. To determine the vertical changes at B point, two perpendicular lines (one from pretreatment B point and one from post-treatment B point) were drawn to the

vertical reference line, as shown in Figure 3. The distance between the two lines represented the amount of vertical displacement. Similar procedures were used for Pogonion to measure the amount of vertical displacement at the chin.

SNB and SNPog angles were measured for each patient and the difference between pre- and post-treatment angles determined the mandibular spacial changes throughout treatment.

The distance between Basion and Articulare points was measured and the difference between the pre- and post-treatment distances determined the amount of forward shift of the mandible generated during treatment.

Method error

To determine the method error, 10 lateral cephalometric films were retraced by the same investigator after at least a 10-day interval between tracings.

The method error was calculated using Dahlberg's formula.[23] The error ranged from 0.32º to 3.14º, from 0.11 mm to 0.4 mm and from 0.56% to 1.07% for angular, linear and proportional measurements, respectively.

Statistical analysis

A statistical analysis was performed using the Statistical Package for the Social Sciences computer software (SPSS 17.0, SPSS Inc., IL, USA). Means and standard deviations for all variables in the four groups were calculated. The significance of the angular and linear changes during treatment for all groups was determined using a one-sample student *t*-test. The difference in mandibular position between Class II/1 and Class II/2 groups was determined using the independent-sample student *t*-test. Statistical significance was predetermined at the $p \leq 0.05$ level.

Results

Non-growing subjects

The changes in cephalometric parameters that occurred during treatment of both non-growing groups with their statistical significance are shown in Table V. The changes in SNB angle, SNPog angle and Ba-Art distance for the groups were not statistically significant.

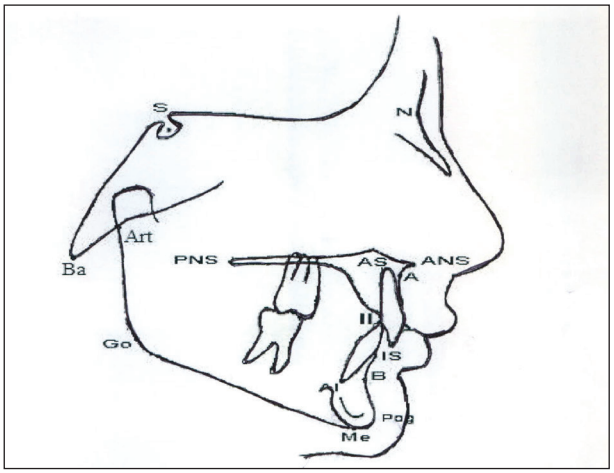

Figure 1. Cephalometric landmarks: S, Sella; N, Nasion; ANS, Anterior nasal spine; PNS, Posterior nasal spine; A, A point; IS, Incision superius; AS, Apicale superius; B, B point; II, Incision inferius; AI, Apicale inferius; Pog, Pogonion; Me, Menton; Go, Gonion; Art, Articulare; Ba, Basion.

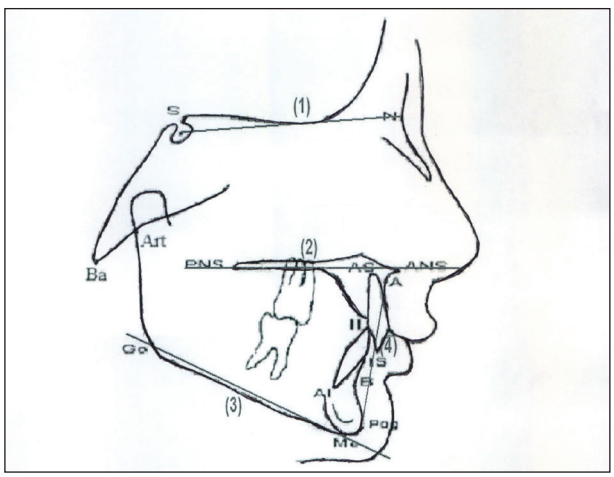

Figure 2. Reference planes:(1), SN plane; (2), Maxillary plane; (3), Mandibular plane; (4), A-Pog line.

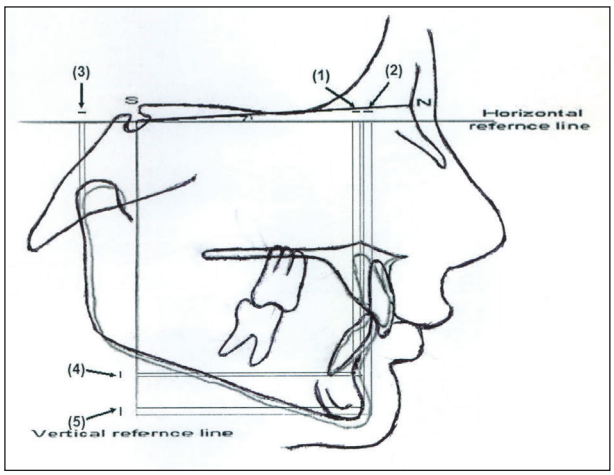

Figure 3. Sagittal and Vertical changes in B, Pogonion, and Articulare points: (1), Sagittal change in B point; (2), Sagittal change in Pogonion point; (3), Sagittal change in Articulare point; (4), Vertical change in B point; (5), Vertical change in Pogonion point.

The linear measurements that represent average changes in mandibular position for both groups and their statistical significance are shown in Table VI. No significant changes were detected in any parameter in either group except for the sagittal position of Articulare in the Class II/2 group. Articulare showed a statistically significant forward displacement after treatment. For all linear measurements, there were no significant differences between the Class II/1 and Class II/2 groups.

Growing subjects

The changes in cephalometric parameters that occurred during the treatment of both growing groups and their statistical significance are shown in Table VII. The changes in SNB angle, SNPog angle and Ba-Art distance were not statistically significant.

The linear measurements that represented average changes in mandibular position after treatment for both groups and their statistical significance are shown

Table IV. Definitions of cephalometric parameters.

The parameter	Definition
SNA	Angle formed by intersection of Sella-Nasion and Nasion-A point.
SNB	Angle formed by intersection of Sella-Nasion and Nasion-B point.
ANB	Angle formed by intersection of Nasion-B point and Nasion-A point.
SNPog	Angle formed by intersection of Sella-Nasion and Nasion-Pogonion point.
UI-Maxilla	Angle formed by intersection of long axis of maxillary incisor and Maxillary plane.
LI-Mandible	Angle formed by intersection of long axis of mandibular incisors and mandibular plane.
MM angle	Angle formed by intersection of maxillary and mandibular plane.
Overjet	The horizontal distance between the labial surface of lower incisor and the labial surface of upper incisor.
Overbite	The vertical distance between the Incision superius and Incision inferius.
Li to A-Pog line	Horizontal distance from mandibular incisor tip to A-Pog line.
Ba-Ar distance	The linear distance from the Basion point to Articulare point.
Anterior face height ratio	The ratio between Anterior nasal spine-Menton to Nasion-Menton.
Posterior-Anterior face height ratio	The ratio between Sella-Gonion to Nasion-Menton.

Table V. Changes in cephalometric parameters that occurred during treatment for both non-growing (NG) groups with their statistical significance.

	NG Class II/1		NG Class II/2	
Measurement	Treatment change	Significance	Treatment change	Significance
SNA (°)	-0.19 (1.85)	0.661	-0.85 (2.81)	0.228
SNB (°)	-0.08 (0.67)	0.604	0.09 (2.02)	0.859
ANB (°)	-0.11 (1.86)	0.803	-0.94 (1.86)	0.053
SNPog (°)	-0.11 (0.72)	0.521	0.24 (1.52)	0.533
MM (°)	0.81 (1.84)	0.081	1.21 (2.49)	0.064
Anterior face height ratio	0.59 (1.50)	0.111	0.61 (1.14)	0.044*
Posterior-Anterior face height ratio	-0.41 (1.65)	0.304	-0.48 (2.08)	0.356
Ba-Art Distance (mm)	0.11 (0.63)	0.466	0.21 (0.90)	0.361
UI-Max (°)	-9.89 (7.24)	0.000	13.82 (8.83)	0.000
LI-Mand (°)	0.94 (7.14)	0.582	8.88 (6.47)	0.000
LI/A-Pog (mm)	-0.72 (2.22)	0.185	2.97 (2.52)	0.000
Overjet (mm)	-3.75 (1.78)	0.000	-0.59 (1.62)	0.154
Overbite (mm)	-2.64 (1.55)	0.000	-3.09 (1.59)	0.000

Minus sign indicates decrease in angular, linear or proportional measurements.

in Table VIII. Significant vertical changes occurred in the position of point B in both groups. Nevertheless, the sagittal change of this point was significant in the Class II/1 group only. The position of Pogonion point showed significant sagittal and vertical changes in both groups. For all linear measurements, there were no significant differences between Class II/1 and Class II/2 groups.

Discussion

The aim of the present study was to compare the vertical and sagittal mandibular positional changes after treatment of Class II/2 malocclusion to assess whether there was mandibular posterior displacement in Class II/2 malocclusion cases and to determine how mandibular growth was expressed during orthodontic treatment in comparison with a Class II/1 control group.

The sample consisted of 77 patients with a Class II incisor relationship subjected to orthodontic treatment via a pre-adjusted edgewise orthodontic appliance. All cases of Class II/2 malocclusion initially had contact between the maxillary and mandibular incisors, as it was assumed that the mandible would not be posteriorly trapped by retroclined upper incisors if there was an overjet.[24]

Table VI. The linear measurements that represent average changes in the mandibular position for both non-growing (NG) groups with their statistical significance.

	NG Class II/1		NG Class II/2		Difference between the two groups	
Measurement	Treatment change	Significance	Treatment change	Significance	Mean difference	Significance
Sagittal movement of B point (mm)	-0.75 (1.55)	0.057	-0.12 (2.35)	0.839	-0.63	0.352
Vertical movement of B point (mm)	-0.64 (3.99)	0.505	0.37 (3.20)	0.642	-1.01	0.418
Sagittal movement of Pogonion point (mm)	-0.15 (1.21)	0.599	0.26 (1.99)	0.592	-0.42	0.456
Vertical movement of Pogonion point (mm)	-1.06 (4.91)	0.374	0.71 (3.94)	0.471	-1.76	0.252
Sagittal movement of Articulare point (mm)	0.36 (0.89)	0.103	0.93 (1.39)	0.014	-0.57	0.158

Minus sign indicates backward movement in sagittal plane or upward movement in vertical plane.

Table VII. Changes in cephalometric parameters that occurred during treatment for both growing (G) groups with their statistical significance.

	G Class II/1		G Class II/2	
Measurement	Treatment change	Significance	Treatment change	Significance
SNA (°)	-1.02 (0.31)	0.004	-1.07 (2.91)	0.107
SNB (°)	0.05 (1.58)	0.892	0.21 (1.98)	0.625
ANB (°)	-1.02 (1.59)	0.008	-1.29 (1.91)	0.006
SNPog (°)	0.36 (1.36)	0.243	0.50 (1.74)	0.203
MM (°)	-0.33 (1.90)	0.431	0.14 (1.36)	0.636
Anterior face height ratio	-0.32 (1.70)	0.392	0.67 (2.49)	0.233
Posterior-Anterior face height ratio	0.94 (1.78)	0.026	1.23 (2.64)	0.046
Ba-Art Distance (mm)	0.05 (0.27)	0.428	0.21 (0.96)	0.317
UI-Max (°)	-8.14 (9.28)	0.001	11.67 (7.60)	0.000
LI-Mand (°)	4.86 (8.40)	0.015	9.02 (6.42)	0.000
LI/A-Pog (mm)	0.24 (2.17)	0.620	2.02 (1.80)	0.000
Overjet (mm)	-5.02 (2.70)	0.000	-0.52 (1.26)	0.071
Overbite (mm)	-3.64 (1.37)	0.000	-3.74 (1.83)	0.000

Minus sign indicates decrease in angular, linear or proportional measurements.

Table VIII. The linear measurements that represent average changes in the mandibular position after treatment for both growing (G) groups with their statistical significance.

	G ClassII/1		G Class II/2		Difference between the two groups	
Measurement	Treatment change	Significance	Treatment change	Significance	Mean difference	Significance
Sagittal movement of B point (mm)	1.36 (2.25)	0.012	0.95 (2.43)	0.087	0.41	0.578
Vertical movement of B point (mm)	4.55 (3.54)	0.000	3.24 (4.32)	0.003	1.31	0.289
Sagittal movement of Pogonion point (mm)	1.81 (2.15)	0.001	1.69 (2.95)	0.016	0.12	0.882
Vertical movement of Pogonion point (mm)	5.71 (3.86)	0.000	4.90 (4.10)	0.000	0.81	0.514
Sagittal movement of Articulare point (mm)	-0.60 (1.89)	0.164	-0.17 (1.88)	0.689	-0.43	0.465

Minus sign indicates backward movement in sagittal plane or upward movement in vertical plane.

Cases treated via growth modification therapy or with combined orthodontic and surgical management were excluded from the sample. Growth modification therapy may possibly influence mandibular position by altering muscular balance in the region, although past studies have stated that different treatment modalities report comparable overall treatment outcomes.[3,25]

To differentiate between treatment outcome and growth effect, the study sample was further divided into two age groups comprising growing and non-growing subjects. Noticeable significant changes in mandibular position after orthodontic treatment of the non-growing Class II/2 group would indicate a posterior mandibular displacement, as growth had likely ceased to a negligible level. The growing groups were used to determine the pattern of mandibular growth during orthodontic treatment. It has been reported that treatment outcomes vary according to patient age[26] and gender,[3] and so Class II/1 and Class II/2 subjects in each age group were matched according to age, gender and treatment duration.

To determine the treatment changes in the mandible, three landmarks (B point, Pogonion point, and Articulare) were selected to represent the mandible. B point and Pogonion are located at the anterior border of the mandible, with the former representing the alveolar process while the latter represents the mandibular base. Condylion is a common landmark to represent the posterior border of the mandible, but its difficult identification when the patient closes in centric occlusion justifies the use of Articulare as a reliable substitute.[27]

In the present study, the changes in the position of B point, Pogonion, and Articulare were investigated by superimposing pre- and post-treatment cephalograms on the S-N line at Sella. Houston et al.[28] found that this line underwent little change during growth or remodelling after six years of age following the fusion of the spheno-ethmoidal synchondrosis. It was suggested that superimposition on the S-N line with registration at Sella usually provided a reliable account of overall facial growth. From the S-N line, horizontal and vertical reference lines were drawn. The horizontal reference line was drawn 7 degrees at the S-N line to simulate natural head position.[22]

Angular measurement changes in SNB and SNPog are likely to represent treatment alterations in mandibular position. Both study groups revealed statistically insignificant changes in these angles. This was in support of Combrink et al.,[29] who illustrated an insignificant change in SNB angle after non-extraction edgewise treatment of growing Class II patients, and Binda et al.,[26] who reported similar results for growing Class II/2 subjects. However, additional studies have illustrated significant changes in SNB and SNPog angles after fixed orthodontic treatment of Class II/2 patients.[3,6]

The distance between Ba-Ar is constant and reportedly does not change with growth, which makes it a positive indicator of forward mandibular change.[30] Rickets et al.[17] reported the expected posterior growth shift of Basion to be approximately 1.0 mm/year, with a similar amount of posterior repositioning of the mandible represented by Articulare to maintain a constant distance between Basion and Articulare. Coben[31] reported that Articulare possessed stability similar to that of Basion. Forward positioning of the mandible could therefore be expected to result in an increase in the Ba-Art distance, provided that the patients did

not protrude their mandibles during radiography. No significant changes in this distance were identified in either of the study groups. This provided a strong indication that a forward mandibular shift did not occur in any group.

Pogonion point showed statistically significant displacement in a forward and downward direction in the groups of growing Class II patients. This was considered a normal finding and characteristic of mandibular growth.[32,33] The observation is supported by many previous studies, which found that Pogonion continued to alter with growth.[34-36]

The insignificant change in the sagittal displacement of B point may be explained by the relationship between B point position and surface remodelling associated with orthodontic tooth movement.[37] In the present study, the mandibular incisors were more proclined during orthodontic treatment of Class II/2 subjects, which suggested that surface bone remodelling would displace B point slightly backward and negate some of the normal forward change at this point. Moreover, previous studies have shown that, differentially, more mandibular change tended to occur at Pogonion than at point B.[34,37]

The experimental comparison of all linear measurements between Class II/1 and Class II/2 growing subjects showed no statistically significant difference in mandibular position between the groups. Therefore, it may be assumed that the growth pattern of the mandible during orthodontic treatment of both divisions of Class II malocclusion does not significantly differ. A comparison between non-growing groups showed no statistically significant difference in all linear measurements of treatment changes that describe mandibular position. This suggests that mandibular position was not altered during treatment in either group.

The present study would be strengthened if growth changes in the treated Class II/2 malocclusion group were compared with those of an untreated Class II/2 malocclusion group. However, current guidelines[38] for clinical orthodontics state that diagnostic radiation exposure should be limited and justifiable, and it is therefore unethical to expose patients to unnecessary radiation for research purposes.

Conclusions

1. There was no difference in the position of the mandible after orthodontic treatment of both divisions of Class II malocclusion, suggesting that there was no posterior displacement of the mandible in Class II/2 cases.
2. The growth pattern of the mandible in Class II/2 cases after orthodontic treatment did not differ significantly from the mandibular growth pattern in Class II/1 cases.

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