A Longitudinal Evaluation of the Skeletal Profile of Treated and Untreated Skeletal Class II Individuals

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Abstract: This study evaluated the changes in the skeletal profile of Class II subjects submitted to orthodontic treatment. The experimental group comprised the lateral cephalograms of 30 Brazilian subjects (17 female and 13 male subjects) obtained between the mean ages of 11.1 years (initial) and 15.1 years (final) and treated with cervical headgear and edgewise appliance. The control group comprised the lateral cephalograms of 30 Canadian individuals (13 females and 17 male individuals) at the ages of 6, 9, 12, 14, and 16 years from the Burlington Growth Study University of Toronto, Canada, who did not receive any kind of orthodontic treatment. The results demonstrated a reduction in the convexity of the skeletal profile of both groups. However, this change was only significant for the Canadian sample of 6- to 9-year olds ($P < .01$), whereas reduction was greater for the Brazilian group and was significant between the initial and final ages ($P < .01$). In the Canadian control group, the maxilla presented a tendency toward a forward displacement ($P < .01$), which was not observed in the experimental group ($P < .01$). The mandible presented a forward displacement in both groups; yet, only the Canadian group demonstrated a significant difference, which occurred between 9 and 16 years ($P \leq .01$). (*Angle Orthod* 2004;75:47–53.)

Key Words: Facial convexity, Skeletal Class II, Facial growth, Cervical headgear

INTRODUCTION

Skeletal Class II is a facial alteration that affects about 20% of the population. This type of discrepancy brings about modifications in the skeletal profile caused by maxillary protrusion, mandibular retrusion, or a combination of both.[1] One of the great challenges of orthodontics is to treat this malocclusion and provide proper esthetics and function to the patient. Therefore, the awareness on how growth occurs without any intervention is of great interest to the orthodontist because it may provide important information related to the timing and type of treatment.

Many studies have been carried out during recent decades in an attempt to evaluate the effect of certain appliances on the facial growth of Class II subjects. Some of the more notable ones were by Klein,[2] Mills et al,[3] Cangialosi et al,[4] Tulloch et al,[5,6] and others. Untreated control groups were usually included to determine the effects actually achieved by the treatment.

The aims of this study were to verify the changes in the skeletal profile of individuals with skeletal Class II malocclusion with no orthodontic therapy and to compare them with a group treated by means of a Kloehn headgear and edgewise appliance.

Facial growth

Brodie[7] studied records from the files of the Bolton Study and showed that the maxilla and mandible tend to be displaced downward and forward during the growth period. On the other hand, Bishara[8] and You et al[9] found no significant differences in mandibular growth between an untreated Class II group and a normal occlusion group. Lima[10] found differences between the periods of larger growth spurts of the maxilla and mandible. Nanda and Ghosh[11] revealed that a greater amount of growth occurred from 6 to 12 years for the female subjects and from 12 to 18 years for the male subjects. From 18 to 24 years, the amount of growth was less, but it was more for the male subjects. Lande[12] reported that the mandible tended to be more prognathic in relation to the cranial base, whereas the maxilla demonstrated few changes from 3 years to 18 years. The increase in mandibular prognathism usually occurred after 7 years of age and facial convexity most often demonstrated a reduction. Bhatia and Leighton[13] agree with these findings and also reported a reduction in facial convexity during growth. Baccetti et al,[14] Ngan et al,[15] and Gesch[16] all observed that signs of an occlusal and skeletal Class II pattern, such as a significant mandibular retrusion and a reduced

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total mandibular length, may be identified in the deciduous dentition and may persist into the mixed dentition.

According to Buschang et al,[17] the maxilla demonstrates a faster growth in cases with Class II malocclusion, whereas the mandible presents an acceleration in growth due to the growth spurt, which is normal in this age range. Pollard and Mamandras[18] studied a sample in the postpubertal period obtained from the files of the Burlington Growth Study and concluded that the mandible presented a 3 times larger anteroposterior growth than the maxilla.

Aydemir et al[19] showed that the ANB angle did not demonstrate any significant changes between 10 and 14 years. The greater amount of growth was observed between 12 and 14 years.

Class II treatment

One aim of the Class II treatment was to achieve distal movement of the maxillary first permanent molars and incisors. Reestablishment of the occlusion allows a harmonious lower and forward movement of the maxilla and mandible.[20] The direction of the headgear pull may be cervical or low in individuals with reduced anterior facial height, high in patients with increased anterior facial height, or a combination of both.[21]

Klein[2] showed that the effects of the cervical headgear on the maxilla of Class II division 1 malocclusion patients were significant and favorable. Kirjavainen et al[22] reported an inhibition of anterior maxillary growth and lower and forward rotation of the palate with the cervical headgear and also stated that earlier treatment had more remarkable effects on maxillary growth. Haas[23] showed that subjects treated with a cervical headgear presented a backward movement of the maxillary with a backward and downward displacement of the maxilla, which is a favorable orthopedic effect. Poulton[24] and Firouz et al[25] studied patients treated with high-pull headgear and reported an inhibition of anterior maxillary growth. Mills et al[3] observed an improvement in the relationship of the maxilla and the mandible in patients treated with J hooks inserted at the area of the maxillary incisors. Cangialosi et al[4] found that there was an inhibition of anterior maxillary growth and the mandible presented forward and downward growth, effectively reducing the maxillomandibular discrepancy in individuals treated with fixed edgewise therapy combined with the headgear.

MATERIALS AND METHODS

This retrospective study was conducted using 2 different samples. The control group was obtained from the files of the Burlington Growth Study, Department of Orthodontics, Faculty of Dentistry, University of Toronto, Canada. Thirty individuals were selected (17 male and 13 female subjects), all presenting a skeletal Class II malocclusion with no orthodontic treatment. Lateral cephalograms were evaluated

at 6, 9, 12, 14, and 16 years of age. The sample was longitudinally evaluated at 4 study periods.

- T1: 6–9 years
- T2: 9–12 years
- T3: 12–14 years
- T4: 14–16 years

The experimental group comprised 30 Brazilian Caucasian individuals with skeletal Class II malocclusion (13 male and 17 female subjects) who underwent nonextraction orthodontic therapy with a cervical headgear and edgewise appliances at Porto Alegre, Brazil. The lateral cephalograms were evaluated before (mean age, 11.05 ± 1.66 years) and after treatment (mean age, 15.11 ± 1.63 years). This sample was obtained from the files of 2 orthodontists.

Lateral cephalograms of both samples were obtained according to Broadbent's technique and revealed a 9.84% magnification of the Canadian sample and 9.18% magnification of the Brazilian sample. Skeletal Class II was characterized by means of the ANB angle (≥5°) and the Unit difference (Co-Gn)–(Co-Sn) (20 mm), as suggested by Harvold and Vargervik.[26] Compliant patients with an indication for cervical headgear and orthodontic appliance were selected for inclusion in the Brazilian sample. The tracings of each lateral cephalogram were performed and digitized on the Dentofacial Planner Plus software.

The values obtained at 6, 9, 12, 14, and 16 years for the Canadian group were evaluated according to their variation. The pretreatment values of the Brazilian sample were compared with the posttreatment values.

The following linear and angular measurements were used to evaluate the maxilla, the mandible, and the maxillomandibular relationship.

1. Linear measurements (Figure 1):
   - Mandibular length (Co-Gn);
   - Maxillary length (Co-Sn);
   - Unit difference, (Co-Gn)–(Co-Sn);
   - Wits appraisal, distance between points A and B on the occlusal plane.
2. Angular measurements (Figure 2):
   - ANB;
   - SNA;
   - SNB;
   - Facial angle (Po.Or-N.Pog);
   - Angle of convexity (N.A-A.Pog).

Study error

For evaluation of the intraexaminer error, 8 randomly selected lateral cephalograms were retraced 7 days later and the points were digitized on Dentofacial Planner Plus software. These measurements were compared with the values obtained for the first measurement (Table 1).
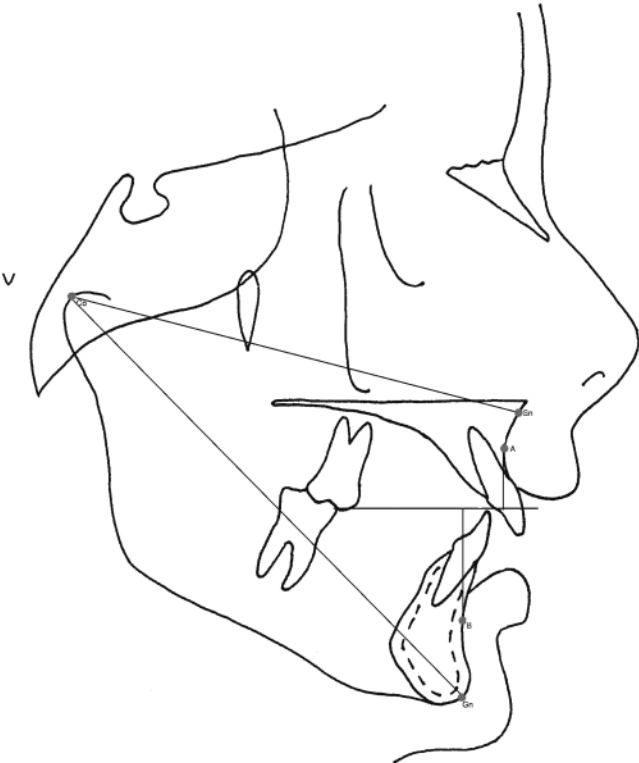
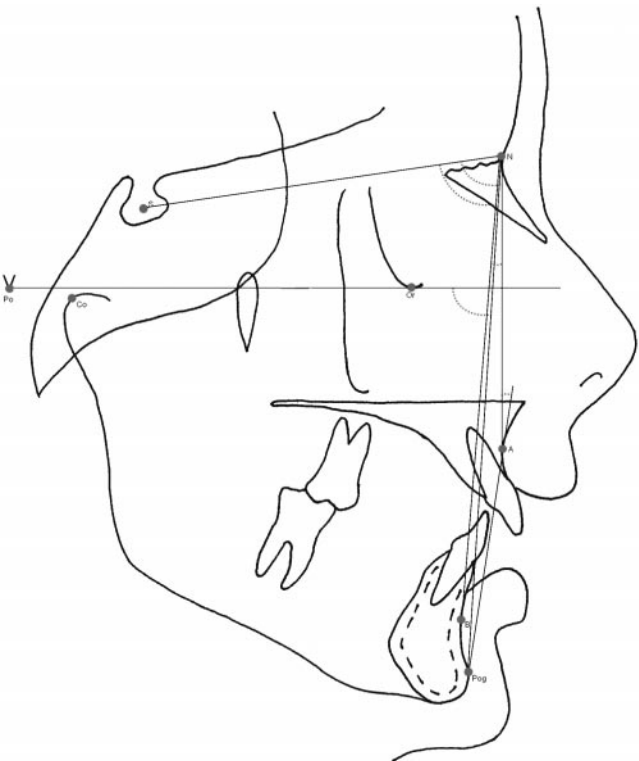**FIGURE 1.** Diagram illustrating the linear measurements.

TABLE 1. Comparison of the Values Obtained by the First Examiner from Two Evaluations, with a Seven-Day Interval

Measurement	First Measurement Mean	Second Measurement Mean	Difference	Agreement
ANB (°)	6.47	6.55	0.08	.98
SNA (°)	82.15	81.98	0.17	.99
SNB (°)	75.66	75.43	0.23	.99
Md length (mm)	109.45	110.07	0.62	.99
Mx length (mm)	90.26	90.18	0.08	.99
Unit Diff (mm)	19.21	19.91	0.70	.96
Wits (mm)	5.25	5.13	0.12	.97
Facial angle (°)	84.57	86.16	1.59	.98
Convexity angle (°)	12.47	12.81	0.34	.97

Statistical analysis

After data collection, the following statistical analyses were performed:

- Friedman nonparametric test was used for the Canadian sample.
- Student's *t*-test was used for the Brazilian group to compare the initial and final values.

RESULTS

The ANB measurement decreased from a mean of 6.84° to 5.21° from 6 years to 16 years in the Canadian individuals. The first period (6–9 years) showed a statistically significant difference (Table 2). On average, the Brazilian group demonstrated a greater reduction in the ANB angle (from 5.99° to 3.34°) from 11 to 16 years (Table 5). The difference between the mandibular and maxillary lengths increased in the Canadian sample from 14.36 to 24.25 mm (Table 2), whereas in the Brazilian group it increased from 19.82 to 26.51 mm (Table 5).

The Canadian sample demonstrated a mean Wits analysis value of 1.31 mm at 6 years of age. There was a nonsignificant reduction at 12 years (1.17 mm) followed by a progressive and significant increase up to 14 years (1.63 mm), with stability thereafter up to 16 years (1.65 mm) (Table 2). The Brazilian group demonstrated a mean decrease from 4.07 to 1.41 mm (Table 5). The Brazilian group revealed a greater mean reduction in the convexity angle, from 10.96° to 4.62°, from 11 to 16 years (Table 5), whereas the Canadian subjects demonstrated a decrease from 11.62° to 9.57° in the same period (Table 2).

The Canadian sample presented a mean SNA angle of 82.96° at 6 years, which increased to 83.59° at 16 years but with no statistical significance (Table 3). The SNA angle of the Brazilian group demonstrated a significant reduction between the initial and final periods (from 82.44° to 80.14°) (Table 5). The maxillary length (Co-Sn) for the Canadian individuals increased significantly (from 82.43 mm at 6

FIGURE 2. Diagram illustrating the angular measurements.

TABLE 2. Means, Standard Deviations, and Nonparametric Friedman Test Comparing the Measurements of Maxillomandibular Relationship of Canadian Individuals at 6, 9, 12, 14, and 16 Years of Age (N = 30)[a]

Age (y)	ANB			(Co-Gn)–(Co-Sn) (Unit Diff)			Wits			N-A-Pog (Convexity Angle)		
	Mean	Standard Deviation	P	Mean	Standard Deviation	P	Mean	Standard Deviation	P	Mean	Standard Deviation	P
6	6.84 A[b]	1.28	.001	14.36 A	2.94	.001	1.31 AB	1.85	.026	15.47 A	3.42	.001
9	5.64 B	1.53		18.05 B	2.97		0.75 A	2.23		11.75 B	4.04	
12	5.50 B	1.41		20.32 C	3.15		1.17 AB	1.91		11.56 B	4.06	
14	5.40 B	1.45		22.22 D	3.54		1.63 B	2.04		10.86 C	4.31	
16	5.21 B	1.41		24.25 E	4.12		1.65 B	2.3		9.57 D	3.99	

[a] Source: Burlington Growth Study.
[b] Means followed by different letters are significantly different from each other.

TABLE 3. Means, Standard Deviations, and Nonparametric Friedman Test Comparing the Maxillary Measurements of the Canadian Individuals at 6, 9, 12, 14, and 16 Years of Age (N = 30)[a]

Age (y)	SNA			Co-Sn		
	Mean	Standard Deviation	P	Mean	Standard Deviation	P
6	82.96 B[b]	3.63	.001	82.43 A	3.95	.001
9	82.09 A	3.43		86.49 B	3.82	
12	83.09 B	3.32		91.45 C	3.79	
14	83.11 B	3.5		95.35 D	4	
16	83.59 B	3.39		97.60 E	5.16	

[a] Source: Burlington Growth Study.
[b] Means followed by different letters are significantly different from each other.

years to 97.60 mm at 16 years). In the Brazilian sample, this measurement increased from 89.30 to 92.44 mm.

The Canadian sample demonstrated a significant increase in SNB angle from 11 to 16 years of age (from 77.22° to 78.39°) (Table 4). The Brazilian sample did not demonstrate any significant differences between the initial and final SNB (Table 5). The mandibular length (Co-Gn) of the Canadian sample presented a significant increase in this measurement at all study periods (from 96.79 mm at 6 years to 121.86 mm at 16 years), with a mean length of 111.78 mm at 12 years (Table 4). The Brazilian sample demonstrated a similar pattern, with a significant increase in the mandibular length between the initial and final ages (Table 5). The Canadian sample demonstrated a significant increase in the

facial angle from 6 years to 14 years (from 83.15° to 86.86°), with no statistical difference from 14 to 16 years (from 86.86° to 87.26°) (Table 4). On the Brazilian subjects, this measurement also demonstrated a significant increase between the initial and final ages, namely, from 85.30° to 86.41° (Table 5).

DISCUSSION

Methodology

The orthodontic treatment for the Brazilian sample comprised a cervical headgear and an orthodontic edgewise appliance. This kind of treatment was selected because it is the most frequently used technique for correction of the Class II malocclusion.[2–6,22–25]

The Canadian sample presented a longer period of evaluation than the Brazilian sample. The former was analyzed from 6 years to 16 years and the latter from 11.05 to 15.11 years. Therefore, if both samples are compared, the variation between 12 and 16 years should be added to the variation between 11 and 12 years of the Canadian sample. For this, the value of the variation between 9 years and 12 years was divided by 3.

Maxillomandibular relationship

The ANB measurement of the Canadian individuals were in agreement with those of Lande,[12] Bhatia and Leighton,[13] and Baccetti et al,[14] who reported a reduction in the ANB

TABLE 4. Means, Standard Deviations, and Nonparametric Friedman Test Comparing the Mandibular Measurements of the Canadian Individuals at 6, 9, 12, 14, and 16 Years of Age (N = 30)[a]

Age (y)	SNB			Co-Gn			N.Pog-Po.Or (Facial Angle)		
	Mean	Standard Deviation	P	Mean	Standard Deviation	P	Mean	Standard Deviation	P
6	76.14 A[b]	3.22	.001	96.79 A	4.77	.001	83.15 A	3.38	.001
9	76.46 A	2.79		104.54 B	5.26		84.91 B	3.48	
12	77.59 B	2.98		111.78 C	5.42		85.94 C	3.15	
14	77.72 BC	2.81		117.58 D	5.63		86.86 D	3.21	
16	78.39 C	3.29		121.86 E	6.88		87.26 D	3.12	

[a] Source: Burlington Growth Study.
[b] Means followed by different letters are significantly different from each other.

TABLE 5. Means, Standard Deviations, and Student's *t*-Test Comparing the Measurements Analyzed on the Brazilian Individuals at the Initial and Final Stages (N = 30)

Measurement	Mean	Standard Deviation	P
ANB			
Initial	5.99	1.19	.001*
Final	3.34	2.26	
SNA			
Initial	82.44	3.07	.001*
Final	80.14	4.07	
SNB			
Initial	76.45	3.25	.286
Final	76.81	3.98	
Co-Gn (Md length)			
Initial	109.11	4.74	.001*
Final	118.94	5.38	
Co-Sn (Mx length)			
Initial	89.30	4.21	.001*
Final	92.44	4.48	
(Co-Gn)–(Co-Sn) (Unit Diff)			
Initial	19.82	3.48	.001*
Final	26.51	4.82	
Wits			
Initial	4.07	2.21	.001*
Final	1.41	2.95	
Facial angle			
Initial	85.30	3.48	.020*
Final	86.41	3.07	
Convexity angle			
Initial	10.96	3.42	.001*
Final	4.62	5.61	

angle from childhood up to adolescence, which, however, is not enough to correct the Class II malocclusion. Aydemir et al[19] and Gesch[16] also reported that the maxilla and the mandible demonstrate anterior growth with no alterations in this angle from 10 to 14 years. According to Tweed,[27] identification of a Class II malocclusion requires an ANB angle greater than 4.5°. Therefore, only in the Brazilian group was the alteration in the ANB measurement yielded by the cervical headgear usually enough to achieve a Class I relationship. Cangialosi et al[4] observed a significant reduction in this angle in 43 Class II patients treated in a similar manner. The treatment effect was evident when evaluating the difference between the mandibular and maxillary lengths. In the Canadian sample it increases 9.89 mm, whereas in the Brazilian group it increases just 6.69 mm.

Jacobson,[28] when suggesting the use of the Wits analysis, reported that identification of a Class I relationship requires this measurement to be −1 mm for male subjects and 0 mm for female subjects. The Canadian sample demonstrated a progressive and significant increase after 12 years. The opposite was observed for the Brazilian sample, ie, the initial values were higher than the final values, which means that there was an improvement.

When advocating the convexity angle, which evaluates the skeletal profile, Downs[29] reported that it should be 0° in flat profiles and positive in cases with convex profiles, characterizing the Class II malocclusion. Both samples demonstrated a very significant reduction. This result is in agreement with the outcomes observed by Lande[12] and Bhatia and Leighton.[13] Klein[2] observed a mean decrease in the convexity angle of subjects treated with the cervical headgear. Cangialosi et al[4] reported a significant decrease in this measurement with a similar therapy. The Brazilian group revealed a greater mean reduction in the convexity angle.

Maxillary alterations

The results found in the Canadian sample for the SNA angle agree with the findings of Lande,[12] who reported that the maxilla demonstrates few changes during growth. Haas[23] stated that during growth the A point, nasion, and anterior nasal spine points present an anterior displacement of similar intensity in untreated Class II subjects. Concerning the Brazilian sample, the significant reduction found in the SNA angle is supported by the findings of Klein,[2] Kirjavainen et al,[22] and Cangialosi et al.[4]

The maxillary length (Co-Sn) increased 7.8 mm in the Canadian individuals and 3.14 mm in the Brazilian individuals from 11 to 16 years, probably due to the effect of the cervical headgear.

Mandibular alterations

When the SNB angle for the Canadian and Brazilian samples at 11 years were compared, both groups presented an SNB angle less than 80°, indicating a mandibular deficiency in both groups. These data are in agreement with those of Ngan et al,[15] who reported that individuals with Class II malocclusion demonstrated a significantly greater mandibular retrognathism from 7 years to 14 years of age. However, when both samples were compared, similar alterations were observed in this measurement with an increase of 0.4° in the Brazilian subjects and 0.8° in the Canadian subjects. The increase may have been greater in the Canadian sample because of a slight counterclockwise rotation of the mandible, which may have been masked in the treated group. Pollard and Mamandras[18] evaluated the growth changes in 39 untreated male individuals with skeletal Class II malocclusion, from 16 to 20 years, and concluded that the mandible presented 3 times more anteroposterior growth than the maxilla during this final growth period.

Comparison of the 2 samples at 11 and 16 years demonstrated an increase in mandibular length of 12.49 mm for the Canadian individuals and 9.83 mm for the Brazilian individuals. According to Carter,[30] mandibular growth

among male individuals occurs later than for the female individuals, and according to Nanda and Ghosh,[11] this growth is more remarkable up to 12 years of age. The smaller increase in mandibular length observed for the Brazilian sample may be explained by the higher proportion of female individuals in the sample (56.7%, compared with 43.3% in the Canadian group).

Both samples presented changes in the facial angle similar to those in the SNB angle and presented a facial angle close to the standard suggested by Downs for the final evaluation. From 11 to 16 years, the facial angle for Canadian individuals increased 1.65°, and for the Brazilian individuals it increased 1.1°. This smaller increase in the Brazilian facial angle may also be explained by the larger number of female individuals.

The results of this study demonstrated that both samples presented a reduction in the convexity of the skeletal profile. This reduction was greater for the Brazilian group, which was treated using a cervical headgear and a fixed appliance, generally leading to correction of the Class II malocclusion. On the other hand, in the Canadian individuals the reduction was usually not enough to correct the malocclusion, therefore suggesting that Class II malocclusion does not present spontaneous correction.

CONCLUSIONS

The convexity of the skeletal profile presented a significant reduction between 6 years and 9 years in the Canadian individuals, however, with no statistically significant differences from 9 years to 16 years. The maxilla presented a tendency toward a forward displacement but with no significant difference at 16 years. The mandible presented a tendency toward a forward displacement with significant differences from 9 years to 16 years.

The convexity of the skeletal profile of the treated Brazilian subjects presented a significant reduction. The maxilla did not demonstrate forward displacement and significant reductions were observed in the values of all measurements that evaluate it. The mandible demonstrated forward displacement but with no statistical difference between the initial and final periods.

ACKNOWLEDGMENTS

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