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Cephalometric evaluation of Class II malocclusion treatment with cervical headgear and mandibular fixed appliances

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SUMMARY The present study aimed to evaluate the cephalometric changes in Class II patients treated exclusively with cervical headgear (CHG) in the maxillary arch and fixed appliances in the mandibular arch as compared with a control group. The sample comprised 82 lateral cephalograms obtained pre- (T1) and post- (T2) treatment/observation of 41 subjects, divided into two groups: group 1—25 Class II division 1 patients (20 females and five males), with a mean pre-treatment age of 10.4 years, treated for a mean period of 2.5 years and group 2—16 Class II untreated subjects (12 females and four males), with a mean initial age of 9.9 years, followed for a mean period of 2.2 years. Treatment changes between the groups were compared by means of *t*-tests.

The results showed restriction of maxillary forward displacement and also a restriction in maxillary length growth, improvement in the maxillomandibular relationship, restriction of mandibular incisor vertical development, reduction in overjet and overbite, and improvement in molar relationship. It was concluded that this treatment protocol corrected the Class II malocclusion characteristics primarily through maxillary forward growth restriction.

Introduction

Many investigators have claimed that a Class II molar relationship occurs in a wide variety of skeletal and dental configurations. Some studies (Drehlich, 1948; Henry, 1957) have shown that the components of a Class II malocclusion can be categorized into four main groups: anterior position of the maxilla, anterior position of the maxillary teeth, mandibular skeletal retrusion in absolute size or relative position, and excessive or deficient vertical development. McNamara (1990) differentiated many more groups of Class II subjects, resulting from several combinations of skeletal and dentoalveolar components. If the contemplated treatment option includes correcting the component most deviated from normal, then several treatment strategies should be considered.

Class II malocclusion non-extraction treatment with fixed appliances and cervical headgear (CHG) usually includes fixed appliances and the use of an extraoral appliance (Baalack and Poulsen, 1966; Gandini *et al.*, 2001; Kim and Muhl, 2001; Haralabakis and Sifakakis, 2004). However, fixed appliances, especially if pre-adjusted, can cause unfavourable protrusion of the maxillary anterior teeth by inclination and angulation of the premolars, canines, and incisors (Bennett and McLaughlin, 1993). To overcome this unfavourable side-effect, CHG can be used exclusively on the maxillary teeth to correct the Class II anteroposterior discrepancy while the mandibular teeth are levelled and aligned with fixed appliances. Subsequently, when the anteroposterior discrepancy has been corrected, fixed appliances can be used in the maxillary arch.

Studies of Class II treatment with CHG combined with fixed appliances have shown inhibition of forward movement of the maxilla (Cangialosi *et al.*, 1988; Lima Filho *et al.*, 2003) and a postero-inferior redirection of its growth (Wieslander, 1974), anterior downward tipping of the palatal plane (Blueher, 1959; Gandini *et al.*, 2001; Lima Filho *et al.*, 2003), opening of the bite (Godt *et al.*, 2007) and an increase in anterior face height (Blueher, 1959), downward and backward rotation of the mandible and improvement of the maxillomandibular relationship (Gianelly and Valentini, 1976; Kim and Muhl, 2001; Haralabakis and Sifakakis, 2004), extrusion (Cangialosi *et al.*, 1988) and distalization of the maxillary first molars (Wieslander, 1974; Gandini *et al.*, 2001), distal tipping of the maxillary molars (Wieslander, 1974), and palatal tipping of the maxillary incisors (Graber, 1955). However, these studies have not specifically investigated the protocol of using only CHG in the maxillary arch and fixed appliances in the mandibular arch during the first stage of treatment, followed by fixed appliances in the maxillary arch in a second stage. Therefore, the objective of the current study was to investigate the treatment effects with this specific protocol.

Subjects and methods

The experimental group (group 1) was a retrospective sample of successfully treated Class II division 1 subjects, obtained from a private clinic at Cuiabá, Brazil, and treated by a single orthodontist (DVL). The group comprised 25 Class II division 1 patients (20 females and five males) with a pre-treatment mean age of 10.4 years [standard deviation (SD)=1.5]. These patients underwent orthodontic treatment with a maxillary CHG and fixed appliances in the mandibular arch during the

first stage of treatment, followed by maxillary fixed appliances when the molar Class II antero-posterior discrepancy had been corrected, after a mean treatment time of 2.5 years (SD=0.9). Eight patients displayed a full-cusp, six a three-quarter, and 11 a half-cusp Class II molar relationship. All permanent teeth up to the first molars were erupted at the pre-treatment stage, without agenesis or tooth anomalies.

Group 2 (control) included 16 untreated subjects with a Class II division 1 malocclusion (12 females and four males), followed for a similar time period as group 1 (2.2 years, SD=0.7). Their mean initial age was 9.9 years (SD=0.4). The subjects in this group presented the same Class II malocclusion severity as group 1. This sample was obtained from the files of the Orthodontic Department at Bauru Dental School, University of São Paulo. The data on these subjects were collected some years previously when there were not the current ethical restrictions on human studies.

Treatment protocol

The treatment protocol used in group 1 consisted of CHG wear for 12 hours a day in the maxillary arch and concomitant use of fixed appliances in the mandibular arch. The CHG (GAC International Inc., Central Islip, New York, USA) had an expanded inner bow (between 4 and 6 mm) and a long outer bow (extended to the tragus of the ear) bent upwards 15 degrees from the horizontal in relation to the inner bow. After a Class I molar relationship had been obtained, maxillary fixed appliances were used in order to align the maxillary teeth and refine the occlusion. The maxillary CHG applied a force of 450 g per side. The patients used the CHG for an average period of 18 months.

The mandibular fixed appliances (TruStraight-Wire Classic Andrews, Ormco Co., Orange, California, USA, 0.022 × 0.028 inch) provided alignment of the teeth, correction of crowding by slight labial tipping, expansion or accomplishment of interproximal stripping, and levelling of the curve of Spee, using stainless steel wires from 0.014 to 0.019 × 0.025 inch. The second molars were included in the appliance as soon as they had completely erupted. In patients with a deep overbite, a bite plate was used full time to aid in its correction and to allow bonding of the mandibular incisors. The bite plane was used in 18 patients, for 3–5 months, and its use ceased just after the deep overbite correction.

Methods

Lateral cephalograms of the subjects were obtained at the pre- (T1) and post- (T2) treatment stages for group 1 and at compatible stages for group 2. Cephalometric tracings and landmark identification were performed on acetate paper by a single investigator (DVL) and then digitized (Numonics AccuGrid XNT, model A30TL.F, Numonics Corporation, Montgomeryville, Pennsylvania, USA). These data were then stored on a computer and analysed with the Dentofacial Planner 7.02 (Dentofacial Planner Software Inc., Toronto, Ontario, Canada).

The less usual cephalometric measurements are illustrated in Figures 1 and 2.

Error study

Twenty-four randomly selected radiographs were retraced, re-digitized, and re-measured after a 1 month interval from the first measurement, by the same examiner. The casual error was calculated according to the formula ($Se^2 = \sum d^2 / 2n$) (Dahlberg, 1940), and the systematic error was evaluated with dependent *t*-tests (Houston, 1983), at a significance of $P < 0.05$.

Statistical analysis

Means and SD for all variables at T1 and for the changes between the first and second stages of treatment (T2 − T1) were calculated and the groups were compared with *t*-tests ($P < 0.05$). These analyses were performed using Statistica software (Statistica for Windows 6.0; Statsoft, Tulsa, Oklahoma, USA).

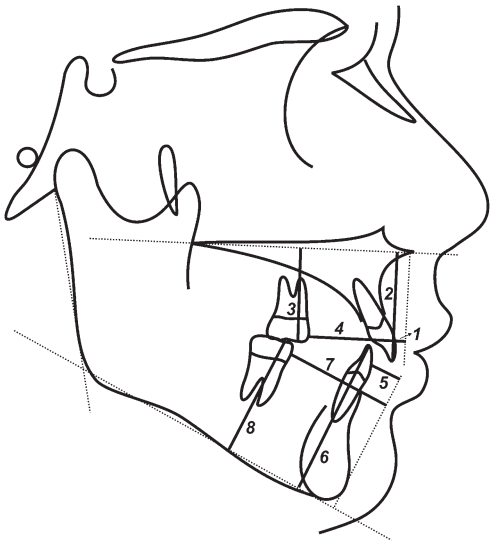

Figure 1 Linear variables related to the maxillary and mandibular teeth: 1. 1-ANSperp, linear distance from the more anterior point of the crown of the maxillary incisor to a line perpendicular to anterior nasal spine; 2. 1-PP, linear distance from the incisal edge of the central maxillary incisor to the palatal plane; 3. 6-PP, linear distance from the mesiobuccal cusp of the right maxillary molar to the palatal plane; 4. 6-ANSperp, linear distance from the mesial surface of the right maxillary molar to a line perpendicular to anterior nasal spine; 5. 1-Pperp, linear distance from the incisal edge of the central mandibular incisor to a line perpendicular to pogonion; 6. 1-GoMe, linear distance from the incisal edge of the central mandibular incisor to the mandibular plane Go–Me; 7. 6-Pperp, linear distance from the mesial surface of the right mandibular molar to a line perpendicular to pogonion; and 8. 6-GoMe, linear distance from the mesiobuccal cusp of the right mandibular molar to the mandibular plane Go–Me.

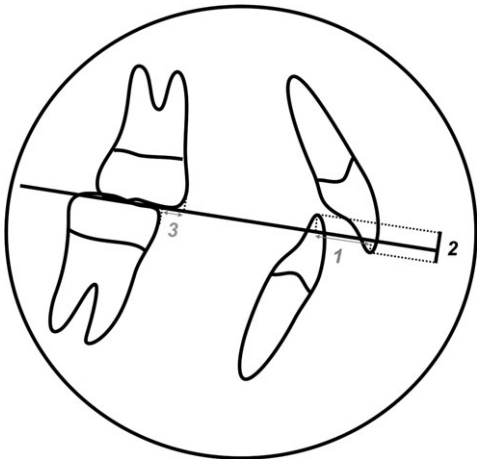

Figure 2 Variables related to dental relationships: 1. overjet, linear distance between the incisal edges of the maxillary and mandibular incisors, measured parallel to the functional occlusal plane (FOP); 2. overbite, linear distance between the incisal edges of the maxillary and mandibular incisors, measured perpendicular to the FOP; and 3. molar relationship, distance between the mesial surfaces of the maxillary and mandibular molars, measured parallel to the FOP.

Results

The results of error study are shown in Table 1. No statistically significant error was found, and any errors were considered acceptable and within normal range.

The groups were compatible regarding initial age and observation interval (Table 2). They also presented the same severity of Class II molar relationship, overjet, and overbite (Table 3). The growth pattern of the groups was also similar and compatible (Table 3). At T1, group 1 had a significantly more protruded maxilla, greater effective mandibular length, better Class II skeletal relationship, and a more convex facial profile than group 2. Lower anterior face, maxillary incisor and molar, and mandibular incisor dentoalveolar heights were also greater in group 1 (Table 3).

Treatment caused a significant retrusion of the maxilla and a reduction in effective maxillary length, which improved the Class II apical base discrepancy and reduced profile convexity as compared with group 2. There was a significant restriction of the vertical development of the mandibular incisors and a decrease in overjet, overbite, and Class II molar relationship (Table 4).

Discussion

Sample

Because an adequate number of patients to determine the treatment effects is indirectly proportional to the magnitude of the changes to be investigated (Tulloch *et al.*, 1990), a larger number of patients would have been preferable. However, because the treatment protocol used is not common and has not been previously reported, the number of subjects in group 1 can be considered satisfactory.

Group compatibility

In general, the subjects in group 1 had a more accentuated skeletal Class II than those group 2 subjects (Table 3). Therefore, the groups presented the same severity of Class II molar relationship, overjet, and overbite, and the growth pattern of the groups was similar and compatible (Table 3). Since the primary interests of the investigation were the treatment changes, it is unlikely that these differences would influence the results. There does not appear to be a difference in development between subjects with variations of skeletal Class II malocclusions (Tulloch *et al.*, 1990, 1997). Besides, the dental relationships were similar between the groups.

Treatment changes

Maxillary components. In group 1 patients, there was a restrictive effect on anterior maxillary growth and development due to the use of CHG. Treatment resulted in a significant reduction in maxillary anterior displacement and a reduction in effective maxillary length (Table 4). These effects on the maxilla are in agreement with several previous studies (Blueher, 1959; Wieslander, 1974; Cangialosi *et al.*, 1988; Cook *et al.*, 1994), when evaluating patients treated with CHG and fixed appliances in both dental arches.

Mandibular components. The CHG had no effect on mandibular anterior displacement, compared with the controls. This result corroborates previous findings in the literature (Baumrind *et al.*, 1981; Keeling *et al.*, 1998; Kim and Muhl, 2001). The effective mandibular length (Co–Gn) also was not affected by treatment as was expected with the use of CHG (Baumrind *et al.*, 1981; Keeling *et al.*, 1998; Kim and Muhl, 2001). Therefore, correction of the Class II malocclusion was obtained exclusively by the action of the appliances on the maxillary structures.

Maxillomandibular relationship. The Class II correction obtained is evidenced by the marked improvement of the maxillomandibular relationship (Table 4). This improvement resulted from restriction in maxillary anterior displacement and mandibular normal growth. Similar findings were found when CHG therapy was evaluated (Wieslander, 1974; Keeling *et al.*, 1998; Kim and Muhl, 2001). The decrease in facial convexity was similar to previous observations and consequent to maxillary anterior displacement restriction and normal mandibular growth (Blueher, 1959).

Vertical components. Wieslander (1974) and Cangialosi *et al.* (1988) stated that the use of CHG significantly increases face height in relation to a control group. Baumrind *et al.* (1981) observed that patients treated with CHG had an annual increase in anterior face height 1.5 times greater than that of a control group. The present study did not corroborate these results since the increase in face height was not significantly greater in relation to the control group.

Table 1 Casual and systematic errors between the first and second measurements.

Variables	First measurement, $n=24$		Second measurement, $n=24$		Dahlberg	P
	Mean	SD	Mean	SD		
Maxillary components						
SNA	81.48	4.08	81.89	4.84	1.77	0.501 ns
Co–A	81.93	5.16	82.16	4.64	1.38	0.635 ns
A–Nperp	0.01	2.76	−0.26	3.14	1.37	0.577 ns
Mandibular components						
SNB	76.41	3.42	7.79	4.14	1.21	0.376 ns
Co–Gn	100.78	5.87	100.89	5.98	1.13	0.783 ns
P–Nperp	−7.99	3.69	−8.1	4.19	1.91	0.877 ns
Maxillomandibular relationship						
ANB	5.07	2.02	5.11	1.96	0.8	0.877 ns
Wits	1.87	1.93	2.24	2.1	1.02	0.307 ns
NAP	9.76	5.85	9.79	5.23	1.63	0.947 ns
Vertical components						
FMA	26.96	3.47	27.19	4.03	1.06	0.536 ns
LAFH	59.88	5.62	59.83	6.14	0.9	0.876 ns
S–Go	65.98	4.9	65.87	5.56	1.49	0.826 ns
Maxillary teeth						
1-PP	114.14	6.38	114.82	7.03	1.86	0.304 ns
1-ANSperp	0.81	1.88	1.07	3.22	1.81	0.685 ns
1-PP	26.06	3.14	25.86	3.44	0.98	0.557 ns
6-PP	18.45	2.18	18.51	2.23	0.74	0.833 ns
6-ANSperp	29.92	2.64	29.03	3.28	1.87	0.175 ns
Mandibular teeth						
IMPA	98.81	4.74	98.07	4.19	1.4	0.130 ns
1-Pperp	−6.24	2.94	−6.62	2.53	1.1	0.338 ns
1-GoMe	36.45	3.29	36.49	3.24	0.61	0.839 ns
6-Pperp	−29.46	2.23	−28.89	2.3	0.96	0.085 ns
6-GoMe	27.28	3	27.21	3.12	0.49	0.677 ns
Dental relationships						
Overjet	4.19	1.34	4.68	1.65	0.94	0.134 ns
Overbite	2.84	1.1	3.05	1.43	0.75	0.438 ns
Molar	−0.56	1.98	−0.79	1.94	0.8	0.399 ns

Table 2 Inter-group comparison for initial age and observation interval (*t*-tests).

Variables (in years)	Group 1 (experimental), $n=25$		Group 2 (control), $n=16$		P
	Mean	SD	Mean	SD	
Initial age	10.4	1.5	9.9	0.4	0.162 ns
Observation interval	2.5	0.9	2.2	0.7	0.220 ns

SD, standard deviation; ns, not statistically significant.

The growth pattern was not significantly altered during CHG therapy in the present study, in agreement with some previous investigations (Boecler *et al.*, 1989; Burke and Jacobson, 1992). Kim and Muhl (2001) found opposite results during treatment, but after removal of the appliances the growth pattern returned to previous values (Ricketts, 1960).

Maxillary and mandibular teeth. The treatment changes for the maxillary incisors and molars were not significantly different from normal growth changes (Table 4). The absence of significant changes related to the maxillary incisors can be partially explained by the relatively good pre-treatment linear and angular position of these teeth. It is known that one of the main characteristics of a Class II division 1 malocclusion is the greater protrusion and labial inclination of the maxillary incisors, which was not found in the present group 1. This may be because the Class II malocclusion was not so severe, and the pre-treatment incisors were not severely proclined.

Molar vertical treatment changes were similar to normal growth, in spite of the use of the CHG, agreeing with some previous reports (Klöehn, 1947, 1961; Gandini *et al.*, 2001), but contray to other investigations (Ricketts, 1960; Cangialosi *et al.*, 1988). Cangialosi *et al.* (1988) used a coordinate system to study dental changes and documented a significant 2.8 mm vertical movement of the maxillary first molar over 2.8 years. However, they did not consider the effects of full appliance treatment and Class II elastics when interpreting their results. They also did not compare the vertical change with an untreated group. Brown (1978) found that extrusion of the maxillary first molars was significantly greater in a CHG group than in a control group. However, it is not clear

Table 3 Inter-group cephalometric comparison pre-treatment (*t*-tests).

Variables	Group 1 (experimental), *n* = 25		Group 2 (control), *n* = 16		*P*
	Mean	SD	Mean	SD	
Maxillary components					
SNA	82.83	3.13	80.68	3.49	0.047*
Co–A	84.47	6.47	81.36	4.40	0.100 ns
A–Nperp	1.64	3.34	−0.60	2.61	0.028*
Mandibular components					
SNB	77.04	3.02	76.18	3.36	0.400 ns
Co–Gn	104.48	7.40	99.36	4.92	0.019*
P–Nperp	−6.32	5.48	−7.63	3.02	0.388 ns
Maxillomandibular relationship					
ANB	5.79	1.42	4.48	1.79	0.013*
Wits	3.06	2.04	1.51	2.03	0.022*
NAP	11.23	3.87	8.27	4.90	0.038*
Vertical components					
FMA	29.03	4.19	26.71	2.76	0.057 ns
LAFH	62.94	4.29	58.17	4.30	0.001**
S–Go	65.36	5.04	63.94	3.94	0.346 ns
Maxillary teeth					
1-PP	111.96	6.92	113.50	6.75	0.486 ns
1-ANSperp	0.14	3.29	1.35	2.52	0.218 ns
1-PP	27.22	2.13	25.27	2.12	0.006**
6-PP	20.09	1.80	18.08	1.70	0.001**
6-ANSperp	28.99	2.75	29.90	2.76	0.312 ns
Mandibular teeth					
IMPA	96.08	5.82	95.24	8.24	0.705 ns
1-Pperp	−8.40	3.58	−7.64	2.84	0.475 ns
1-GoMe	38.82	3.13	35.74	2.36	0.001**
6-Pperp	−30.85	2.33	−31.42	2.20	0.441 ns
6-GoMe	27.46	2.87	26.08	2.33	0.116 ns
Dental relationships					
Overjet	5.31	1.75	4.15	2.01	0.059 ns
Overbite	3.74	1.64	3.40	1.57	0.518 ns
Molar	−2.15	1.26	−1.85	1.26	0.461 ns

SD, standard deviation; ns, not statistically significant.
*$P < 0.05$; **$P < 0.01$, ***$P < 0.001$.

Table 4 Comparison of inter-group treatment changes (*t*-tests).

Variables	Group 1 (experimental), *n* = 25		Group 2 (control), *n* = 16		*P*
	Mean	SD	Mean	SD	
Maxillary components					
SNA	−2.21	2.06	1.15	2.45	0.000***
Co–A	−0.22	4.09	3.89	2.11	0.000***
A–Nperp	−2.17	2.30	1.09	2.44	0.000***
Mandibular components					
SNB	0.14	1.73	0.44	1.64	0.580 ns
Co–Gn	3.95	5.52	4.41	2.56	0.755 ns
P–Nperp	−0.22	4.17	0.80	2.99	0.398 ns
Maxillomandibular relationship					
ANB	−2.36	1.75	0.75	2.01	0.000***
Wits	−2.70	2.47	1.69	3.08	0.000***
NAP	−5.20	3.50	1.27	4.22	0.000***
Vertical components					
FMA	0.46	3.06	−0.94	2.10	0.114 ns
LAFH	2.50	2.85	1.59	1.91	0.286 ns
S–Go	3.97	4.25	3.40	2.75	0.639 ns
Maxillary teeth					
1-PP	0.34	6.75	0.39	4.97	0.979 ns
1-ANSperp	0.07	2.37	−0.25	1.65	0.638 ns
1-PP	1.07	1.56	0.74	1.47	0.501 ns
6-PP	1.74	1.93	1.41	1.28	0.554 ns
6-ANSperp	0.12	2.83	−0.07	2.04	0.813 ns
Mandibular teeth					
IMPA	0.89	5.54	−0.03	5.36	0.597 ns
1-Pperp	−0.28	2.65	0.06	1.28	0.630 ns
1-GoMe	0.27	1.63	1.48	0.88	0.010*
6-Pperp	0.42	1.92	1.09	1.91	0.279 ns
6-GoMe	1.41	1.63	0.85	1.55	0.282 ns
Dental relationships					
Overjet	−2.19	1.69	0.56	1.58	0.000***
Overbite	−1.75	1.73	0.80	1.01	0.000***
Molar	3.51	1.93	0.42	1.26	0.000***

as to whether or not other appliances were used in association with the headgear. The dentoalveolar effects of the CHG, inhibiting the mesial movement of maxillary molars, or distalizing them, has already been demonstrated (Wieslander, 1974; Baumrind *et al.*, 1981 Altug-Atac and Erdem, 2007). However, the lack of change in molar position could be related to the use of the CHG for only 12 hours a day.

The mandibular fixed appliance did not significantly influence the vertical and sagittal position of the mandibular molars, but significantly restricted vertical development of the mandibular incisors, without significant protrusion or proclination. The same results were found by Cook *et al.* (1994) when evaluating CHG used with a mandibular utility arch in growing patients.

Dental relationships. The overjet, overbite, and molar relationship improved significantly with treatment, confirming other reports (Ghafari *et al.*, 1998; Kim and Muhl, 2001). Correction of the overbite involved restriction of the normal vertical development of the mandibular incisors with a reversed curve of Spee in the mandibular archwire (Cook *et al.*, 1994) and a bite plate in 18 deep overbite subjects.

Clinical considerations. Evaluating the present results, it was verified that the treatment protocol provided an effective correction of the Class II division 1 malocclusion, by improvement of the overbite, overjet, molar, and maxillomandibular relationships. Other factors that contributed to the correction were the restriction of maxillary forward displacement and normal mandibular growth.

The CHG can be considered contraindicated in the treatment of Class II malocclusions since it depends on patient compliance (Cole, 2002). Compliance is more easily achieved with part-time wear, primarily while sleeping (Cole, 2002), and this was obtained in the present study with the use of the CHG for only 12 hours a day.

The cephalometric changes of this treatment are not very different from other protocols using CHG, providing excellent cephalometric results. This treatment restricts

vertical development of the mandibular incisors, which helps correction in deep overbite subjects. A further advantage is the short period of use of maxillary fixed appliances, possibly reducing root resorption of the maxillary teeth.

Conclusions

Based on the present results, it can be concluded that the treatment protocol used had the following effects in the experimental group:

1. Restriction of maxillary forward displacement and also restriction of effective maxillary length growth.
2. Improvement in the maxillomandibular relationship.
3. Restriction of mandibular incisor vertical development.
4. Reduction in overjet and overbite and improvement in molar relationship.

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