Original Article

Facial Profile Changes in Early Class II Correction with Cervical Headgear

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ABSTRACT

Objective: To characterize the effects of early cervical headgear treatment on the facial profile of children in Class II division 1 malocclusion.

Materials and Methods: Forty children aged 9.1 (7.2–11.5) years with Class II division 1 malocclusion were treated using a cervical headgear appliance. The headgear consisted of a long outer bow bent upward 15° and a large expanded inner bow. Lateral cephalograms were taken before and after treatment, and the facial profile was estimated from the cephalograms. The results were compared to an age- and sex-matched normal cohort of 644 Finnish children.

Results: Class I molar relationship was achieved in all treated children. The treatment time was 1.6 (0.3–3.1) years on average. Compared to the controls, the treatment restricted the forward growth of maxillary A-point, and the SNA angle decreased 1.4° ± 1.2° per year ($P < .00001$). Decreased maxillary prognathism was associated with decreased facial convexity, g-sn-pg ($P = .02$), and the ANB ($P < .00001$) angles decreased compared to the controls. Upper lip protrusion (distance ls to sn-pg; $P < .00001$) was decreased, and the nasolabial angle (cm-sn-ls) widened despite the increased facial inclination of the upper incisors ($P = .0005$). The treatment significantly decreased the gap between the lips ($P = .0009$) in their relaxed position.

Conclusion: Cervical headgear treatment in Class II correction is associated with a decreased facial convexity caused by the restriction of forward growth of the maxillary A-point, while the rest of the facial profile, including the mandible, continue to grow forward at a normal rate.

KEY WORDS: Cephalometry; Face; Headgear; Orthodontic; Malocclusion; Angle Class II

INTRODUCTION

Class II malocclusion is often associated with a protrusive maxilla and upper lip together with a convex facial profile, which are considered esthetically unfavorable.[1] The malocclusion is not expected to correct itself during growth.[2,3] Although the major goal of the treatment is the correction of the malocclusion, the beneficial treatment effect on the facial profile also is appreciated.[4,5] It has been shown that, in general, a straight profile is preferred for men and a slightly convex profile is preferred for women.[6,7]

We have previously shown that a cervical headgear may be used to treat Class II division 1 malocclusion to a Class I molar relationship.[8,9] However, a phase 2 treatment is often needed to correct the remaining overjet or overbite.[3] Plausibly, inclusion of maxillary expansion is important for the success of the treatment.[8–12] According to the cephalometric skeletal and dental casts analysis, Class II correction with a cervical headgear is associated with a decreased facial prognathism, normal forward growth of mandible, a decreased facial convexity, an increased maxillary width, and an increased mandibular dental arch width.[8–10] However, the effects of headgear treatment on the soft tissue profile have not been previously reported.

In this study, we evaluated the effects of cervical headgear in the first phase of treatment of Class II division 1 malocclusion on skeletal and soft tissue profile in growing children.

MATERIALS AND METHODS

Patients

Facial skeletal and soft tissue profiles were studied retrospectively in the records of 40 consecutive

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Table 1. Cephalometric Soft Tissue Landmarks

Measure	Definition
g	Glabella: the most prominent point in the midsagittal plane of the forehead
n	Soft tissue nasion: the point of deepest concavity of the soft tissue contour of the root of the nose
pr	Pronasale: the most prominent or anterior point of the nose tip
cm	Columella: the most anterior point of the columella of the nose
sn	Subnasale: the point at which the lower border of the nose meets the outer contour of the upper lip
a	Soft tissue a-point: the deepest point on the upper lip determined by an imaginary line joining subnasale with the laberale superius
ls	Labrale superius: a point located at the maximum convexity of the vermilion border most prominent in the midsagittal plane
stms	Stomion superius: the lowermost point on the vermilion of the upper lip
stmi	Stomion inferius: the uppermost point on the vermilion of the lower lip
li	Labrale inferius: the most prominent point on the vermilion border of the lower lip in the midsagittal plane
b	Mentolabial sulcus: the point of greatest concavity in the midline between the lower lip and chin
pg	Sort tissue pogonion: the most anterior point on soft tissue chin

healthy school children (20 boys and 20 girls) referred to the Health Center of Forssa, Finland, for treatment of a Class II division 1 malocclusion. The inclusion criteria were (1) Angle Class II division 1 malocclusion with at least an end-to-end Class II molar relationship and with an overjet more than 2 mm, (2) protrusive maxilla indicated in cephalometric analysis by the A-point position in the front of the nasion-pogonion line, (3) presence of pretreatment and posttreatment plaster models and lateral cephalograms, (4) aged 7 to 12 years at the date of referral, (5) generally healthy, and (6) good or at least moderate cooperation. The mean age of the children at the beginning of treatment was 9.1 $\pm$ 1.1 (range, 7.2–11.5) years and at the end of the treatment was 10.7 $\pm$ 1.1 (range, 8.6–13.1) years.

The control group was a cross-sectional cohort of 644 Finnish schoolchildren aged 6 to 15 years, of whom 362 were boys and 282 were girls.[13] The cephalograms were taken from all pupils of the Kaisaniemi and Aleksis Kivi elementary schools of Helsinki, Finland, between the years 1965 and 1968 using a cephalostat. The study population represented an unselected, geographic child population around the two elementary schools. The number of children in each 1-year age group ranged from 41 to 109.

The study protocol was approved by the Ethics Review Committee of the Hospital for Children and Adolescents, Helsinki University Hospital.

Methods

The children with Class II malocclusion were treated by the first author as previously described.[8–10] A Kloehn-type cervical headgear was used as the only treatment appliance during the study period. The headgear had a large inner bow and long rigid outer bow bent 15° upward. The inner bow of the headgear was expanded to be 10 mm larger than the distance between the maxillary first molar tubes and made parallel to the occlusal plane. The bow did not have contact with the anterior teeth, and the distance between the bow and anterior teeth was set at 3 mm. The cervical traction force was 500 g per side, and it was delivered to the subject through only the first molar tubes. The expansion of the inner bow and the amount of force used were controlled at 6- to 8-week intervals. The subjects were asked to wear the headgear 12 to 14 hours a day, in the evenings and at nights, and to keep a daily diary of their headgear wear. Cooperation was estimated using the diary notes as well as the signs of use in the device, including the tearing of the elastic band and the neck strap. The treatment results were recorded when a Class I molar relationship was achieved.

Cephalometric Landmarks and Reference Planes

To analyze the effects of the cervical headgear therapy on facial skeletal and soft tissue profile, lateral cephalograms were taken before and after treatment using a DC2 cephalostat (Cranex, Tuusula, Finland). The lips were in a relaxed position and teeth in occlusion. All cephalograms were traced and the landmarks digitized using special purpose software. The used skeletal landmarks were identified according to the criteria described by Bhatia and Leighton.[14] Soft tissue analysis by Legan and Burstone[15] was used with some modifications. The studied soft tissue landmarks are defined in Table 1, and all digitized landmarks are presented in Figure 1. Horizontal overjet and vertical overbites were determined from dental cast models taken before and after treatment.

Statistical Methods

Statistical analyses were performed with SPSS 12.0.1 (SPSS Inc, Chicago, Ill). The results of the children with Class II division 1 malocclusion were com-

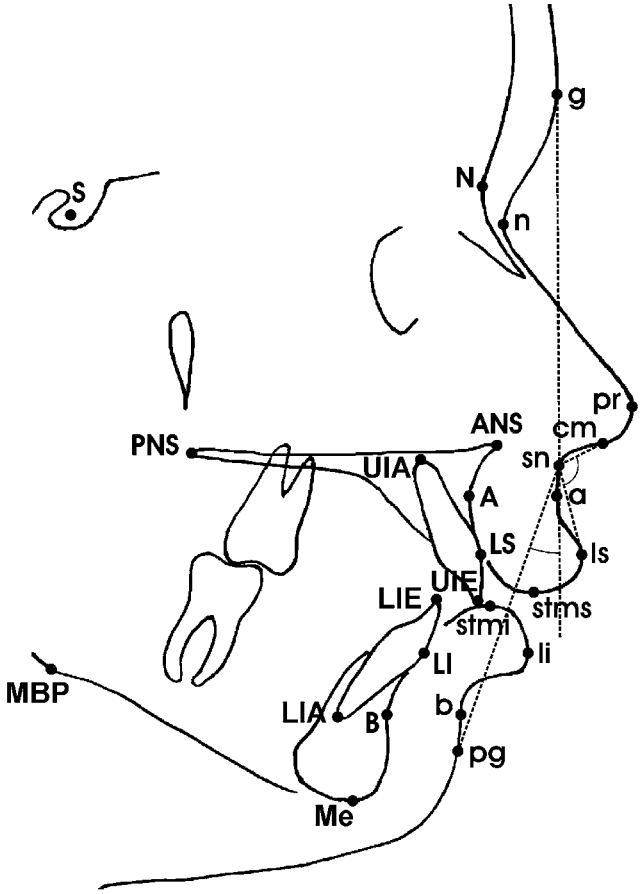


Figure 1. Used landmarks. Please see Table 1 for a description of the soft tissue landmarks.

pared to the calculated age- and sex-matched average of the normal cohort (Figures 3 and 4). The comparisons were performed using paired *t*-tests. Paired *t*-tests were also used to compare pretreatment and posttreatment measurements. $P < .05$ was considered statistically significant. The values are presented in the form of mean ± standard deviation.

Method Error

To estimate method error, serial pretreatment and posttreatment measurements were taken in five randomly selected children. The method error was estimated using Dahlberg's formula[16]:

$$ME = \sqrt{\frac{\sum d^2}{2n}},$$

where d is the difference between the first and second tracing measurements and n is the number of comparisons performed. The results are presented in Table 2. Existence of systematic method error was estimated by Forsberg's method.[17] The significance tests of the mean differences ($\bar{d}$) were calculated according to the formula

$$t = \frac{\bar{d}}{\sqrt{\frac{\sum d^2}{n \cdot (n-1)}}}.$$

If the t value was within the limits $-2.07 < t < 2.07$, the measurement was considered to be free of systematic error. None of the measurements presented with systematic error.

RESULTS

Class II division 1 malocclusion was corrected into a Class I molar relationship in all treated children. The mean treatment time was 1.6 ± 1.5 (range, 0.3–3.1) years. Thirty-two children had good cooperation, and 8 had moderate cooperation. Effects of the treatment on the facial skeletal widths have been published previously.[9] No significant differences were observed between the genders, and the measurements of boys and girls were combined. The pretreatment and posttreatment measurements are shown in Table 2. Phase 2 treatment was needed in 19 of 40 treated children, most often because of remaining overjet or overbite.

Changes in Maxilla, Mandible, and Incisors

The forward growth of the maxillary A-point was greatly restricted by the cervical headgear treatment, while the rest of the facial structures grew forward at a normal rate (Figures 2 and 3). At the beginning of the treatment, the SNA angle was 2.7° ± 3.1° wider than in the controls ($P < .0001$), but it was decreased 1.4° ± 1.2° per year more than in the controls ($P < .0001$). At the end of the treatment, the SNA angle did not differ between the groups.

Before the treatment, the palatal plane (NS-ANS-PNS) was inclined facially upward 1.8° ± 3.2° more than in the controls ($P = .001$) but rotated 0.9° ± 1.0° per year facially downward ($P < .0001$) during the treatment to become positioned as in the controls. Before the treatment, the palatal plane (ANS-PNS) was 2.1 ± 2.3 mm longer in children with Class II malocclusion compared to the controls ($P < .0001$). During the treatment, the growth of the palatal plane was 0.4 ± 1.2 mm per year slower than in the controls ($P = .05$), and at the end of the treatment, its length did not differ between the groups.

According to the SNB angle, the position of the mandible was 1.3° ± 2.9° ($P = .008$) more advanced before and 1.3° ± 3.6° ($P = .02$) after the treatment than in the controls. The forward growth rate of the mandible was comparable between the two groups ($P = .51$).

In children with a Class II malocclusion, the upper incisors were 2.3° ± 6.5° ($P = .03$) more facially in-

Table 2. Pretreatment and Posttreatment Values and Changes and Method Errors[a]

	Pretreatment		Posttreatment				
	x̄	SD	x̄	SD	Change/y	SD	ME
Maxilla							
SNA, °	82.8θ****	3.1	80.9	3.4	−1.0↓****	0.7	0.3
NS-line–palatal-line, °	4.9↓**	3.3	6.7	3.3	0.9θ****	0.6	0.6
ANS-PNS, mm	46.8θ****	2.2	48.3	3.3	0.7↓*	0.9	0.6
Mandible							
SNB, °	78.0θ**	2.9	78.8θ*	3.2	0.4	0.9	0.3
Convexity							
ANB, °	4.9θ****	1.5	2.2	1.7	−1.3↓****	0.8	0.2
g-sn-pg, °	14.3	5.0	13.4	5.1	−0.5↓*	1.4	0.3
Nose							
n-pr, mm	36.1↓**	3.8	38.9	3.4	1.3	1.3	0.6
pr-sn, mm	15.3	1.7	16.3	1.9	0.4	0.6	0.4
Lips							
cm-sn-ls, °	103.9↓***	9.5	105.6	8.6	0.6	3.4	2.0
a-A, mm	12.9θ**	1.9	14.0θ****	1.7	0.6	0.9	0.6
ls-LS, mm	12.9θ****	1.8	13.0θ****	2.1	0.0	0.6	0.7
ls-sn-pg line, mm	5.7θ****	1.7	4.6	1.8	−0.5↓****	0.6	0.3
stms-stmi, mm	3.5	4.1	1.1↓****	1.9	−1.3↓***	2.3	0.2
li-LI, mm	14.2θ***	2.5	14.0θ****	2.2	−0.1	0.8	0.4
li-sn-pg line, mm	4.0θ*	2.0	3.9	1.8	0.0	0.6	0.3
b-li-pg line, mm	4.2	1.4	4.5	1.5	0.1	0.5	0.2
b-B, mm	9.6θ**	1.3	10.2θ**	1.5	0.3	0.7	0.2
Incisors							
NS line-UI, °	104.7θ*	6.6	108.3θ****	6.7	2.1θ***	2.8	1.0
Palatal line-UI, °	109.6	6.1	115.1θ****	6.1	3.0θ****	2.9	0.9
Mandibular line-LI, °	97.9	6.3	96.7	6.0	−0.6	2.7	0.8

[a] Superscript at the end of a number indicates if value is longer (θ) or shorter (↓) than in the controls and whether it differs from the controls. ME indicates method error.

* $P < .05$; ** $P < .01$; *** $P < .001$; **** $P < .0001$.

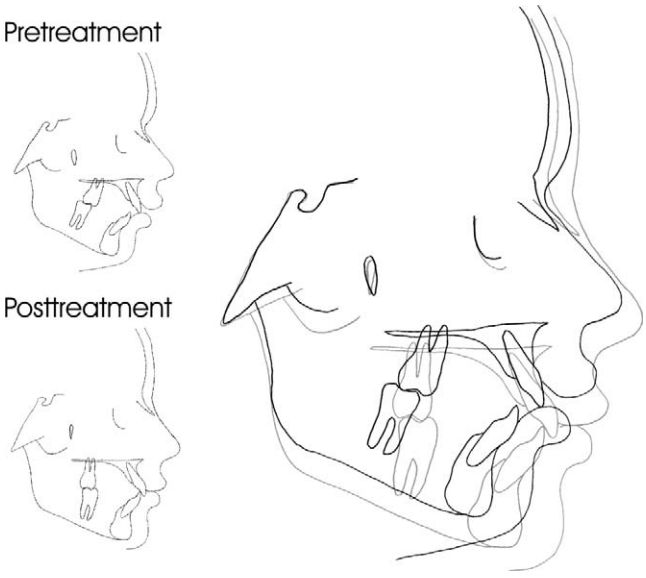
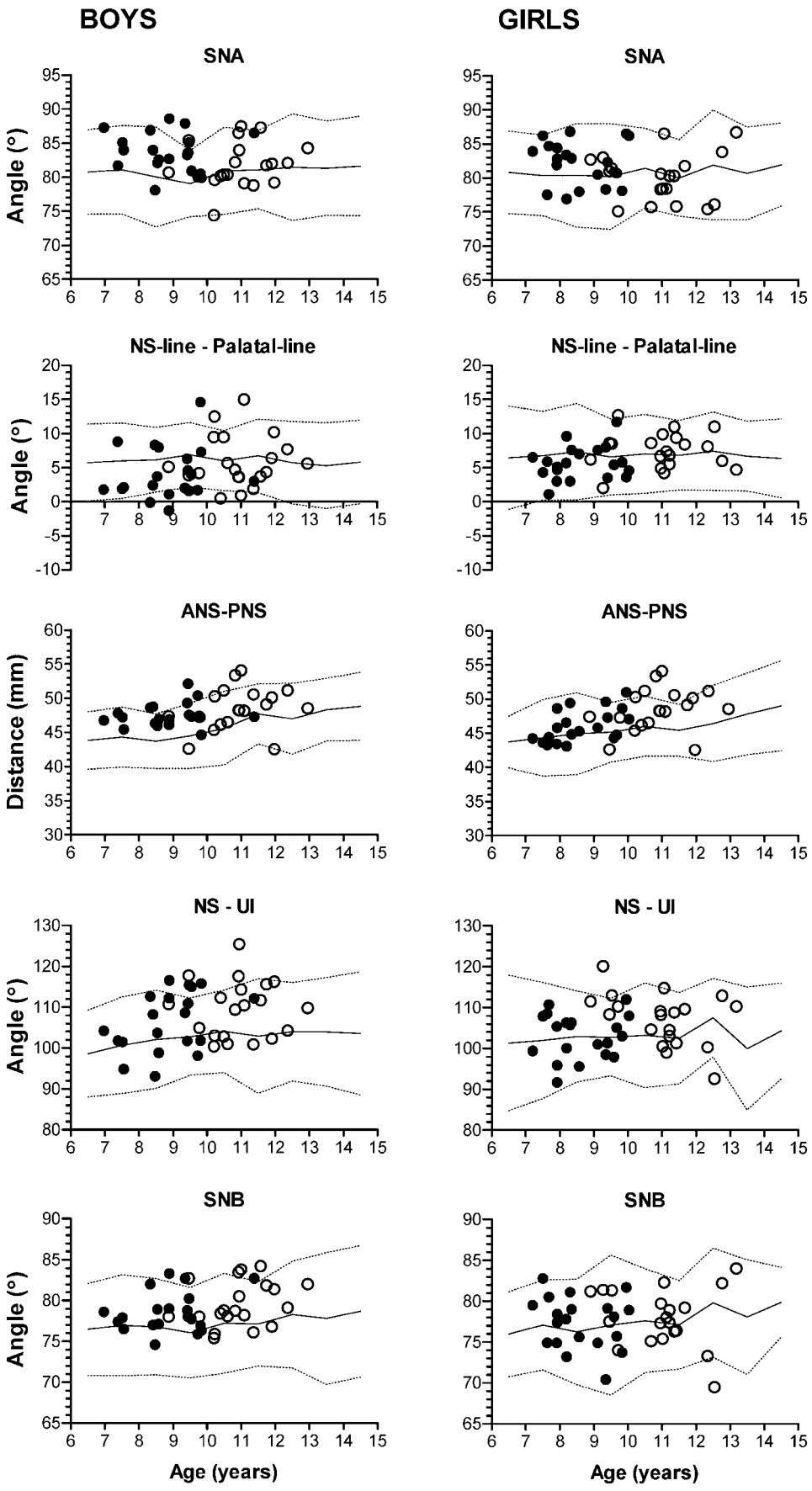


Figure 2. Typical change in the facial profile during the headgear treatment of Class II malocclusion. Pretreatment cephalometric drawing of an 8.0-year-old girl is presented superimposed by a posttreatment drawing at 11.0 years of age. Cranial base structures are used for superimposition.

clined (NS-UI) than in the controls. This inclination was increased by 1.6° ± 2.6° per year ($P = .0005$), and at the end of the treatment, the upper incisors were 5.5° ± 7.5° ($P < .0001$) more facially inclined than in the controls. Instead, there was no inclination of the lower incisors (mandibular line–LI), which stayed at a similar position to the controls throughout the treatment period. Horizontal overjet decreased from 5.0 ± 2.0 mm to 3.5 ± 1.4 mm ($P < .0001$) on average. Vertical overbite was unaffected by the treatment.

Facial Convexity and Profile

Inhibition of forward growth of the maxillary A-point together with normal forward growth of other facial structures decreased facial convexity (Figure 4). However, this decrease was more evident on the skeletal than soft tissue profile. At the beginning of the treatment, the ANB angle was 1.4° ± 1.5° ($P < .0001$) wider in the children with Class II malocclusion than in the controls. During the treatment, the ANB angle decreased by 1.5° ± 0.8° per year ($P < .0001$) more than in the controls, and the angle was similar between the



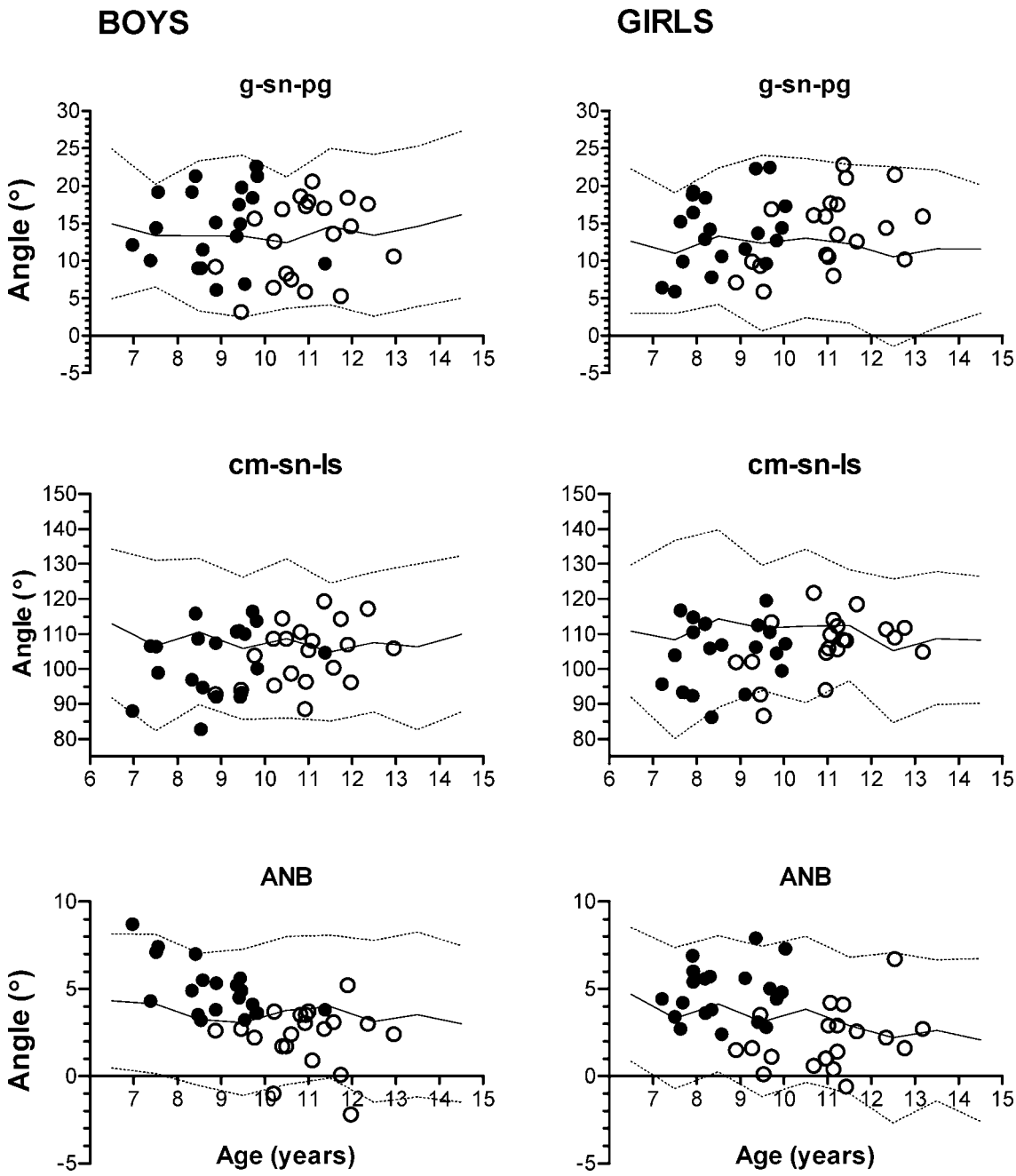


Figure 4. Changes in facial profile in the children with Class II malocclusion. Pretreatment (solid) and posttreatment (open) measures are plotted against normal mean with ±2 standard deviation values.

groups at the end of the treatment. Similarly, the facial convexity angle (g-sn-pg) decreased by 0.7° ± 1.8° per year ($P = .02$) more in the treated children compared to the controls, but the g-sn-pg angle did not differ significantly between the groups before or after the treatment (Table 2).

Lips

The children with Class II malocclusion had prominent lips. Before the treatment, the upper lip thicknesses (ls-LS) were 1.8 ± 1.8 mm ($P < .0001$), the lower lip thicknesses (li-LI) 1.7 ± 2.6 mm ($P = .0002$),

←

Figure 3. Changes in maxilla and mandible. Pretreatment (solid) and posttreatment (open) measures are plotted against normal mean with ±2 standard deviation values.

a-A 0.9 ± 1.7 mm ($P = .002$), and b-B 0.6 ± 1.2 mm ($P = .008$) longer than in the controls. After treatment, the upper lip thicknesses remained 1.9 ± 2.1 mm ($P < .0001$), lower lip thickness 1.5 ± 2.1 mm ($P < .0001$), a-A 1.5 ± 1.7 mm ($P < .0001$), and b-B 0.7 ± 1.5 mm ($P = .005$) longer than in the controls, respectively. The treatment did not significantly affect any of these lip thicknesses (Table 2).

The gap between the lips (stms-stmi) was similar between the groups before the treatment. In the treated children, the gap was decreased by 1.4 ± 2.5 mm per year ($P = .0009$) more than in the controls, and at the end of the treatment, the gap between the lips was 2.4 ± 2.5 mm ($P < .0001$) closer to each other than in the controls. Before the treatment, the nasolabial angle (cm-sn-ls) was 5.8° ± 9.8° ($P = .0006$) smaller in the treated children compared to the controls, but this difference disappeared during the treatment. Still, the difference in the annual change did not differ significantly between the groups.

Before the treatment, upper (ls–sn-pg) and lower (li–sn-pg) lips protruded by 1.5 ± 1.6 mm ($P < .0001$) and 0.7 ± 2.0 mm ($P = .03$) in the children with Class II malocclusion compared to the controls. Upper lip protrusion was decreased by 0.6 ± 0.8 mm ($P < .0001$) more than in the controls, such that there were no differences in upper or lower lip protrusion between the groups after the treatment. The rate of annual growth of lower lip protrusion remained similar to controls. The depth of chin recess (b–li-pg) did not differ between the groups and was unaffected by the treatment.

Nose

The children with Class II malocclusions had a 1.6 ± 3.6 mm ($P = .006$) shorter nose length (n-pr) than the controls before the treatment. After the treatment, this difference disappeared, although there was not a significant change in the annual growth rate between the groups. Nose depth (pr-sn) was similar between the groups and was unaffected by the treatment.

DISCUSSION

We have shown that the early cervical headgear treatment of Class II malocclusion has favorable esthetic effects on the facial profile. Skeletal and soft tissue facial convexities were significantly decreased when the protrusive forward growth of the maxilla was restricted by the treatment. The rest of the facial structures grew forward during the treatment at the same rate as in the controls. The treatment was associated with a facially downward rotation of the maxillary palate together with an increase in nose length. Upper incisors became more facially inclined, although the nasolabial angle decreased, indicating some decrease in upper lip protrusion.

Class II malocclusion was associated with a larger skeletal facial convexity than observed in the normal controls. All of the treated children had a protrusive maxilla and a large SNA angle. However, this large skeletal convexity was not as evident in the soft tissue profile, and the g-sn-pg angle did not differ significantly from the controls before or after the treatment, although the angle decreased more than in the controls during the treatment period. Thus, it seems that soft tissue masks part of the skeletal discrepancy and skeletal effects of the treatment.

The treatment had the most prominent effect on the forward growth of the maxillary A-point (Figure 2). The SNA angle was markedly decreased, indicating that the maxillary A-point stayed horizontal virtually at the same place without any forward movement while the rest of the facial profile grew forward at the same rate as in the controls. This restriction of forward movement of the maxillary A-point led to a significant reduction of maxillary prognathism.

Class II malocclusion may be related to mandibular retrognathism.[1,18] The children with Class II division 1 malocclusion in this study did not have a retrognathic mandible; in fact, they had an even larger SNB than the controls did both before and after the treatment. The treatment did not affect this angle, indicating that the mandible grew forward at a normal rate.

Length and thickness of the lips are important elements of a facial profile. The relaxed lip position became more closed with the treatment. Lip protrusion has been shown to be largely affected by the inclination of the incisors.[19] Despite clear and significant inclinations of the upper incisors, the nasolabial angle increased with the treatment, indicating that the upper lip became more upright. The explanation of this inclination remained unexplained. However, similar results have been reported previously with the cervical headgear therapy used in the same way as in this study.[20] The adjustment of the inner bow to be 3 mm in front of the incisors was likely to prevent the inner bow and lip from exerting pressure on the teeth, thus allowing the labial inclination of upper incisors. The prominent restriction of forward growth of the maxillary alveolar process supposedly overcame the effect of inclination on the upper lip position. The children with Class II malocclusion had thicker and more protruded upper and lower lips than the controls did. The treatment did not have a significant effect on the thickness or the protrusion of the lips. The decrease in the distance from ls to the sn-pg line is suggested to be caused mainly by the straightening of the facial profile rather than the retraction of the upper lip.

In the children with Class II malocclusion, the palatal

plane (ANS-PNS) was inclined facially upward compared with the controls before the treatment. This inclination is suggested to cause an upward cant of the nose with a short nose length.[21] Children with Class II malocclusion had a shorter nose length than the controls at the beginning of the treatment. This difference disappeared during the treatment at the same time as a facially downward rotation of the palatal plane occurred. The depth of the nose did not differ from the controls. This is in accordance with the previous data the suggest growth of the nose depth is independent of the underlying skeletal growth.[19] In our previous study, we have shown that skeletal nose width is increased with the use of headgear treatment.[9] This may lead to a more prominent appearance of the nose.

CONCLUSIONS

- Class II division 1 malocclusion may be treated to a Class I molar relationship by cervical headgear used as the only appliance.
- The headgear treatment was accompanied by decreased skeletal and soft tissue convexity.
- The upper and lower lips became closer to each other with the treatment as in their relaxed position.
- Class II malocclusion was associated with prominent and thick upper and lower lips. The treatment caused facial inclination of the upper incisors, but despite this, the nasolabial angle increased and upper lip became more upright.

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