Mandibular changes in skeletal Class II patients treated with Kloehn cervical headgear

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This study evaluated the posttreatment and long-term anteroposterior and vertical mandibular changes in skeletal Class II Division 1 patients (ANB angle ≥ 5°) treated with Kloehn cervical headgear. The sample consisted of 40 patients (18 males, 22 females, average age 10.5 years at pretreatment [T1], 13.5 years at posttreatment [T2], and 23.5 years at postretention [T3]) treated with cervical traction with an expanded inner bow (4-8 mm) and a long outer bow bent upwards off the horizontal 10° to 20° in relation to the inner bow. The force applied averaged 450 g, and the recommended use of the appliance was 12 to 14 hours per day, with monthly adjustments. The Student t test was used for comparison between stages. Results showed that during treatment no significant change was found in the mandibular plane angle, but a significant decrease was detected at T3. Kloehn cervical headgear was efficient in the skeletal Class II correction. The superimposition of tracings suggests that much of the treatment effect occurs when the mandible is displaced forward. Skeletal Class II correction with Kloehn cervical headgear was found to be stable over the long term. (Am J Orthod Dentofacial Orthop 2003;124:83-90)

Although cervical headgear has been used for more than half a century, there are still controversies regarding its action. The most frequently debated aspects are the effect on the SNA angle, extrusion of the maxillary first molars, inclination of the palatal plane, and variation of the mandibular plane angle.

Studying the benefits of the treatment in guiding alveolar growth and tooth eruption during mixed dentition, Kloehn1 achieved Class II correction using cervical gear alone. In 1953, he2 stated that treatment during the mixed dentition must promote alveolar bone growth and tooth eruption, with limited use of appliances to minimize tissue destruction or loss and to produce a more stable result.

Most patients with Class II malocclusions have some sort of skeletal discrepancy. Growth modification and the optimal timing for treatment are factors of considerable clinical interest. The objectives of growth modification and Class II treatment are achievable by combining dentoalveolar and skeletal changes in growing patients. Facial growth in a child is usually irregular. Although the overall direction of growth is downward and forward, marked differences in rate and direction of growth are seen from one year to another.3

Studies have shown that cervical traction usually used to correct a Class II malocclusion is effective in redirecting maxillary growth inferiorly and posteriorly.4,5 Kloehn cervical headgear has been most frequently used in cases of skeletal maxillary protrusion with reduced vertical dimension, producing distal displacement of the maxilla and increasing the vertical dimension, because of extrusion of the molars, generating mandibular clockwise rotation.

Control of the vertical dimension is important in producing the maximum effective mandibular dimension in the anteroposterior direction. Because of this, many studies have examined the influence of cervical headgear on mandibular rotation during treatment.6-9 If the mandible rotates backward, increasing lower anterior face height, it will compromise the forward displacement of the mandible, making Class II correction more difficult.

The objective of this longitudinal study was to evaluate the posttreatment and long-term mandibular skeletal anteroposterior and vertical changes from the use of Kloehn cervical headgear with an expanded inner bow and a long outer bow bent upwards in correcting skeletal Class II malocclusion.

MATERIAL AND METHODS

The sample consisted of 40 patients (18 males, 22 females, average age 10.5 years at pretreatment [T1],
13.5 years at posttreatment [T2], and 23.5 years at postretention [T3]) treated with cervical traction with an expanded inner bow (4-8 mm) and a long outer bow bent upward from the horizontal 10° to 20° in relation to the inner bow (Fig 1). A total of 120 lateral cephalograms were obtained at T1, T2, and T3.

The patients were treated at our clinic in Brazil between 1975 and 1992 and selected consecutively from the records according to the following criteria: (1) skeletal Class II with ANB angle /H11350 5°, (2) no fixed appliance used until a Class I molar relationship was obtained, (3) nonextraction treatment, and (4) no Class II intermaxillary elastics.

Treatment began either in the late mixed dentition or at the beginning of the permanent dentition. The patients were treated with cervical headgear followed by cervical headgear and fixed appliances immediately. The mean treatment protocol was as follows: 12 months Kloehn cervical headgear, 22 months headgear and fixed appliances, 28 months maxillary Hawley retainers, 6 months headgear at night during retention with Hawley, and 8 years mandibular fixed retainer. This study was comparative, with observation of growth longitudinally at stages T1, T2, and T3.

The extraoral appliances used in this study were Kloehn cervical headgear (GAC International, Bohemia, NY, and Morelli Ortodontia, Sorocaba, São Paulo, Brazil), consisting of an inner bow soldered to an outer bow, with diameters measuring .045 and .071 in, respectively. The inner bow was bent mesial to the tubes of the first molar bands, to allow approximately 4 mm between the extraoral arch and the maxillary incisors, and was thus not in contact with the anterior teeth. The long outer bow extended to the tragus. Both ends of this arch were connected to a .75-in elastic, wrapped in a cervical pad (Summit Orthodontic, Monroe Falls, Ohio).

The force applied averaged 450 g, measured by calibrated dynamometer (Ohaus, Florham Park, NJ). It was recommended that the Kloehn appliance be worn 12 to 14 hours per day. The patients were seen monthly and received 3 types of adjustment: (1) the inner bow was maintained at a 4- to 8-mm expansion, (2) the outer bow was maintained at a 10° to 20° elevation to prevent distal tipping of the molars, and (3) the ends of the inner bow were adjusted to rotate the molars (aiding the anteroposterior correction).

The lateral cephalometric radiographs were taken according to standard procedure established at the First Workshop on Cephalometrics. The degree of image distortion was determined with a 100-mm correction ruler adapted to the patient, on the midsagittal plane. Kodak T-Mat (Eastman Kodak, Rochester, NY) film (20.3 × 25.4 cm) was used, placed at the left side of the cephalostat, to prevent image enlargement beyond 8% in relation to the structures.

Cephalometric tracings were made with a 0.5-mm lead pencil on transparent acetate sheets 20.3 × 25.4 cm × 0.003 in on a luminator. For bilateral structures (gonial angle, teeth) that did not superpose, the average of the 2 sides was considered. For incisors and molars, a template was made for each patient, obtained from the best quality radiograph from the 3 stages measured.

Cephalometric points were digitized (AccuGrid XNT A30BL, Numonics, Montgomeryville, Pa) and processed according to the ortho lateral regimen in Dentofacial Planner Plus software, version 2.5b (Dentofacial Software, Toronto, Ontario, Canada).

The angular measurements used were SNB, representing mandibular protrusion, and SN-GoGn, representing mandibular rotation.

To evaluate the reproducibility of this research in determining the cephalometric points, preliminary tests were performed by an author (R.M.A.L.F.) to check for errors in the method used. Eleven randomly chosen lateral cephalograms were digitized at predetermined intervals (minimum of 2 weeks apart) between the first

Fig 1. Lateral cephalogram of patient with Kloehn cervical headgear with outer bow bent upward.
and the second sessions. The largest error was 0.8°, and the smallest was 0.1°.

Our objective was to verify statistically significant differences between measurements taken at T1 and T2 and between measurements taken at T2 and T3.

Exploratory analyses of the data were performed by using standard descriptive statistics and box-plot graphics for the variables studied in phases T1, T2, and T3. The Student paired $t$ test was used to compare data and independent averages. The data were transferred from Dentofacial Planner Plus software to Minitab (version 11, Minitab, State College, Pa) to be analyzed.

**RESULTS**

A descriptive analysis initially was made considering patients’ sex (Table I). Results from the $t$ tests comparing patients according to sex in all time periods are shown in Table II. Table III shows the results of the descriptive statistics for the angular measurements of the entire sample.

A box-plot (Fig 2) illustrates the angular measurements obtained for the 40 patients at T1, T2, and T3.

The SNB angle showed average increases of 0.94° from T1 to T2 and 0.93° from T2 to T3 (Fig 3). A comparison of T1 with T2 and T2 with T3 showed statistically significant differences ($P = .012$ and $P = .0004$, respectively).

The GoGn-SN angle showed average reductions of 0.5° from T1 to T2 and 2.06° from T2 to T3 (Fig 4). Results of the $t$ tests showed a highly significant difference only when comparing T2 and T3 ($P = .0000$) (Table IV).

**DISCUSSION**

Comparing these results with those from other studies in the literature concerning extraoral appliances is difficult, not only because several types of appliances are used, but also because Class II malocclusion can be caused by numerous combinations of dental and skeletal relationships between the maxilla and the mandible.\(^{13}\) The age at the onset of treatment has also been suggested as a critical factor.

In this study, it was decided to start treatment in the late mixed dentition or at the beginning of permanent dentition, based on the belief that this period often coincides with the facial growth spurt. The cervical extraoral appliance was placed primarily to take advantage of this growth pattern and to allow observation of the changes from its use.

Brodie\(^{14}\) reported on Class II treatment during mixed dentition and proposed that growth itself should be used to create a more harmonious relationship between the jaws during this period. Terra\(^{15}\) suggested that treatment is simpler when the molar relation has already been corrected, rather than having to displace all maxillary teeth posteriorly as a unit (Fig 5). According to the author, this benefits not only the patient but also the orthodontist, because treatment time with a fixed appliance is reduced.

Analysis of the patients in the sample shows that greater growth (observed by the anterior and inferior displacement of the mandible) occurred in the treatment period T1 to T2 (Fig 6).

The results of our study demonstrate that, although cervical traction was used, the SNB angles of our patients followed the normal anteroposterior growth that was expected in the mandible, in accordance with Moyers et al.\(^{13}\) who studied craniofacial growth in untreated patients.

Haas\(^{16}\) noted that virtually all Class II Division 2 and most Class II Division 1 patients had mandibular functional retrusion. In the first group, this was due to lingual inclination of the maxillary central incisors; in the latter, to constriction of the maxillary dental arch.
especially between the canines. This author emphasized that, in these patients, it is important to expand the maxillary arch to obtain a permanent orthopedic effect on the maxilla, thus releasing the mandible to move anteriorly. According to the author, by expanding the maxillary arch, it is possible to create excellent conditions for the mandible to grow to full extent, helping to correct the Class II malocclusion.

Recent studies suggest that Class II malocclusion is related to deficiency in maxillary width. Wen-dling\textsuperscript{22} reported that rapid maxillary expansion can favor spontaneous correction of some Class II malocclusions. This procedure favors forward positioning of the mandible during the retention period (6-12 months postexpansion) in moderate Class II patients.

The 40 patients of this group had skeletal Class II malocclusions. All were treated with cervical gear with the inner bow expanded laterally. This might account for the behavior of the SNB angle, promoting forward mandibular displacement, probably due to the slow maxillary expansion by the inner bow of the cervical gear, as demonstrated by Kirjavainen et al.\textsuperscript{23}

| Table III. Descriptive statistics of measurements (in degrees) obtained from 40 patients during pretreatment (T1), posttreatment (T2), and postretention (T3) phases |
|----------------|-------------|----------|----------|----------|----------|----------|----------|----------|
| Measurement   | Phase      | Mean     | SD       | Min      | Q1       | Median   | Q3       | Max      |
| SNB           | T1         | 76.74    | 2.74     | 71.10    | 74.80    | 77.15    | 78.83    | 81.10    |
|               | T2         | 77.68    | 3.44     | 70.20    | 75.75    | 77.90    | 80.08    | 83.70    |
|               | T3         | 78.61    | 3.09     | 72.20    | 76.60    | 79.15    | 80.78    | 84.10    |
| SN-GoGn       | T1         | 31.09    | 4.56     | 18.70    | 28.25    | 31.40    | 35.18    | 37.30    |
|               | T2         | 30.59    | 5.40     | 18.10    | 27.12    | 31.15    | 34.23    | 40.70    |
|               | T3         | 28.53    | 5.42     | 15.60    | 24.63    | 30.40    | 31.95    | 36.50    |

SD, standard deviation; Min, minimum; Q1, first quartile; Q3, third quartile; Max, maximum.

Fig 2. Box-plot of angular measurements for 40 patients obtained during pretreatment (T1), posttreatment (T2), and postretention (T3) phases.

Fig 3. Mean SNB angle measurements during pretreatment (T1), posttreatment (T2), and postretention (T3) phases.

Fig 4. Mean GoGn-SN angle measurements during pretreatment (T1), posttreatment (T2), and postretention (T3) phases.
The results of this study are supported by those of Cook et al.\textsuperscript{24} and Kirjavainen et al.,\textsuperscript{23} in which cervical headgear with an expanded inner bow was used. Our findings suggest that the expansion of the maxillary arch allows the anterior displacement of the mandible. Expansion of the inner bow appears to be essential for the success of the procedure.

Our results indicate that the cervical headgear did not alter the inclination of the mandibular plane during treatment. In long-term follow-up, however, a decrease in the mandibular plane angle was noted as growth continued. In the posttreatment period, the behavior of this angle was similar to that in untreated patients, as reported by Riolo et al.\textsuperscript{24}

Many researchers have stated that the mandible rotates backwards and the mandibular plane angle increases with the use of cervical headgear.\textsuperscript{26-30} Boatwright,\textsuperscript{31} however, reported that the angle of this plane decreases with cervical headgear. Other authors have found no change in that angle resulting from this treatment.\textsuperscript{24,32,33}

Table IV. Student paired $t$ test comparing mean differences between pretreatment and posttreatment phases (T2-T1) and posttreatment and postretention phases (T3-T2) for analyzed measurements

<table>
<thead>
<tr>
<th>Measurement</th>
<th>MD</th>
<th>SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2-T1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNB</td>
<td>0.94</td>
<td>1.70</td>
<td>.0012**</td>
</tr>
<tr>
<td>SN-GoGn</td>
<td>−0.50</td>
<td>2.18</td>
<td>.15</td>
</tr>
<tr>
<td>T3-T2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNB</td>
<td>0.93</td>
<td>1.53</td>
<td>.0004**</td>
</tr>
<tr>
<td>SN-GoGn</td>
<td>−2.05</td>
<td>1.96</td>
<td>.0000**</td>
</tr>
</tbody>
</table>

MD, mean differences; SD, standard deviation. *$P < .05$, significant. **$P < .001$, highly significant.

The results of this study are supported by those of Cook et al.\textsuperscript{24} and Kirjavainen et al.\textsuperscript{23} in which cervical headgear with an expanded inner bow was used. Our findings suggest that the expansion of the maxillary arch allows the anterior displacement of the mandible. Expansion of the inner bow appears to be essential for the success of the procedure.

Baumrind et al.\textsuperscript{34} and Cangialosi et al.\textsuperscript{35} demonstrated mandibular rotation documented by cephalometric measurements. Both studies, however, differed in the kind of treatment and on the use of Class II intermaxillary elastics. Therefore, it is uncertain whether the results from their investigations were due to cervical headgear, other appliances, or Class II mechanics.

The most important posttreatment mandibular changes in our study show that the SN-GoGn angle did not demonstrate significant change between T1 and T2 ($P = .15$), contrary to the findings of several studies.\textsuperscript{26,28,29,36,37} According to these authors, the increase of this angle, resulting from cervical headgear, is caused by extrusion of the maxillary molars inducing mandibular rotation, thus producing an excessive increase in lower facial anterior height.

Using cervical traction extraoral appliances with a short outer bow, Brown\textsuperscript{37} found an increase of vertical dimension due to molar extrusion, causing clockwise rotation of the mandible. On the other hand, Cook et al.,\textsuperscript{24} using a long outer bow extending to the tragus of the ear, reported maxillary molar extrusion, with no opening of the mandibular plane angle, even in dolichocephalic patients.

Merrifield and Cross\textsuperscript{27} and Root\textsuperscript{38} have condemned the prolonged use of Kloehn cervical headgear in growing patients, believing that this appliance causes interference on the mandibular plane. However, the results of our study support Kloehn’s\textsuperscript{1} method of treatment with a long outer bow, reaching the tragus of the ear or well behind the first permanent molars. Kloehn recommended that the outer bow be bent upward, thus preventing excessive molar inclination. With this procedure, there was excellent control of the
mandibular plane, with minimum adverse effects on the vertical dimension during Class II correction. In our study, condylar growth might have kept the mandibular plane angle constant from T1 to T2 by compensating for the extrusion or the alveolar growth in the molar region, according to the findings of Schudy. Analysis of the vertical component demonstrated that the effects of cervical headgear have not interfered in the antero-

Fig 6. Superimposition of tracings from 4 patients in pretreatment (T1), posttreatment (T2), and postretention (T3) phases, showing greatest amount of growth in period from T1 to T2.
posterior mandibular position, as shown by measurements of the SNB angle.

Baumrind et al. noted that patients treated with cervical headgear had an annual increase in anterior face height 1.5 times greater than that of a control group. The authors noticed significant increases in the height of the ramus of the mandible, compared with the control group. This kept the mandibular plane angle relatively unaltered, with an anterior face increase. In addition, according to Boecler et al. and Hubbard et al., in patients with normal and hypodivergent face patterns, there is apparently enough vertical growth in the condylar region to compensate the extrusive vector from cervical headgear. This appliance has been used in large groups of growing patients without a resulting increase in the mandibular plane angle.

Klein related maxillary molar extrusion to negative rotation of the mandible. Brown noted these findings when comparing the effects of cervical and occipital traction on the maxillary and mandibular molars and on the mandible. He also observed that the maxillary molars erupted significantly more in the group that received cervical traction. On the other hand, the mandibular molars extruded significantly more in the group treated with occipital traction. In Brown’s study, it was also reported that the position of the maxillary and mandibular molars seems to be relevant to the mandibular response to rotation (Fig 7). These facts clearly explain the results of our study regarding the behavior of the mandibular plane angle, which did not change with our method of treatment.

CONCLUSIONS

Our results show that during treatment no significant change occurred in the mandibular plane angle, but a significant decrease was detected at postretention. The mandible showed normal growth and attained a favorable relationship to the maxilla. Kloehn cervical headgear was efficient in correcting the skeletal Class II relationship. Most of the correction occurred as a result of anteriorly directed mandibular growth. Class II correction with Kloehn cervical headgear was found to be stable during the postretention period.

REFERENCES

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