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TABLE OF CONTENTS

[INTRODUCTION] [MATERIALS AND...] [RESULTS] [DISCUSSION] [CONCLUSION] [REFERENCES] [TABLES] [FIGURES]

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Longitudinal Study of Anteroposterior and Vertical Maxillary Changes in Skeletal Class II Patients Treated with Kloehn Cervical Headgear

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ABSTRACT

This is a study to evaluate the posttreatment and long-term anteroposterior and vertical maxillary changes in skeletal Class II Division 1 patients (ANB ≥5°) who had received Kloehn cervical headgear treatment. The sample consisted of 120 lateral cephalograms obtained at pretreatment (T_1), posttreatment (T_2), and postretention (T_3) phases of 40 patients (18 males and 22 females). The patients were of an average age of 10½ years in phase T_1, 13½ years in phase T_2, and 23½ years in phase T_3. They were treated with cervical traction and an expanded inner bow (4–8 mm) and a long outer bow bent upwards off the horizontal 10–20° in relation to the inner bow. After correction of the molar relationship on both sides, a conventional edgewise fixed appliance was used to complement the correction of the malocclusion. The onset of treatment was either at the late mixed dentition or at the beginning of the permanent dentition. The force applied for the 40 patients averaged 450 g and the recommended use of the appliance was 12–14 hours per day with monthly adjustments. F-Snedecor test was applied to the entire sample and multiple comparisons between phases were tested by the Bonferroni method. Results revealed that treatment had reduced maxillary protrusion, inclined the palatal plane with an increase in the SN-PP angle with reduction at long-term. In conclusion, Kloehn cervical headgear with elevated external bow and expanded inner bow was efficient in correcting the skeletal Class II in late mixed-early permanent dentition. Skeletal Class II correction with Kloehn cervical headgear was found to be very stable long term.

KEY WORDS: Skeletal Class II Division 1, Kloehn cervical headgear, Maxillary protrusion, Maxillary inclination, Long-term.

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INTRODUCTION Return to TOC

Initially, in the diagnosis and treatment planning of Class II malocclusions, special attention was placed on the anteroposterior relationship as indicated by the Angle classification of malocclusion.[1] It was not until the 1960s, partly because of the contributions of Schudy,[2] that the role of vertical dimension finally was recognized. Recent investigations suggest that Class II malocclusion is related to deficiency in the maxillary width.[3–7]

The objectives of growth modification and Class II treatment are possible by combining dentoalveolar and skeletal changes which depend on the individual's response to treatment and on the vertical dimension control and its effect on mandibular anteroposterior position.[8,9]

The Kloehn cervical headgear has been used since 1947 when Silas Kloehn revived the approach of treating Class II during mixed dentition.[10] Kloehn understood that during normal growth, the alveolar development and teeth move forward. If the orthodontist could interrupt this movement in Class II patients, the mandible could follow its normal growth until reaching a favorable relation to the maxilla. Kloehn advised that the outer face bow be long enough to extend well behind the first permanent molar attachment for the inner bow. He further recommended that the outer bow be bent upwards off of the horizontal plane, to prevent excessive tipping and extrusion of the molar teeth. With his protocol, an excellent control over the occlusal, palatal, and mandibular planes was achieved with little, if any, adverse effect on the vertical dimension, while accomplishing the intended improvement in anteroposterior dimension.[11]

Studies have shown that the cervical traction usually employed in the correction of Class II is effective in redirecting the maxillary growth inferiorly and posteriorly.[12,13] 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, generating mandibular clockwise rotation.

The objective of our longitudinal study was to evaluate the posttreatment and long-term maxillary skeletal anteroposterior and vertical changes from the use of Kloehn cervical headgear with an expanded inner bow and long outer bow bent upwards in skeletal Class II Division 1 malocclusion.

MATERIALS AND METHODS Return to TOC

The sample consisted of 120 lateral cephalograms obtained at pretreatment (T_1), posttreatment (T_2), and postretention (T_3) of 40 patients (18 males and 22 females). The patients were an average age of 10½ years in phase T_1; 13½ years in phase T_2, and 23½ years in phase T_3. They were treated with cervical traction with expanded inner bow (4–8 mm) and long outer bow bent upwards off the horizontal 10–20° in relation to the inner bow.

The patients were treated at the Lima Ortodontia Clinic in São José do Rio Preto, State of São Paulo, Brazil, between 1975 and 1992 and selected consecutively from the file records of our private patients. The following criteria were used: (1) present with a skeletal Class II Division 1 with an ANB ≥5°; (2) no fixed appliance was employed until Class I molar relationship was obtained; (3) all patients were treated nonextraction; and (4) absence of the use of Class II intermaxillary elastics. The onset of treatment was either at the late mixed dentition or at the beginning of the permanent dentition. Patients were treated using a cervical headgear (first period) and cervical headgear and fixed appliance (second period). These periods were performed without interruption characterizing treatment in one phase. The mean usage time of fixed and removable appliances during treatment and retention was 12 months (extraoral), 22 months (extraoral and fixed), 28 months (maxillary Hawley), 6 months (extraoral at night during retention) and 8 years (lower fixed retainer).

The extraoral appliance used in this study was Kloehn cervical headgear (GAC International Inc, Central Islip, New York, NY and Morelli™ Ortodontia Ltd, Sorocaba, São Paulo, Brazil), consisting of an inner bow soldered to an outer bow, with diameters measuring 0.045 and 0.071 inches. The inner bow was bent mesial to the first molar bands tubes, to allow a distance of approximately 4 mm between the extraoral arch and the upper incisors, therefore, not in contact with the anterior teeth. The long outer bow was extended to the tragus of the ear. Both ends of this arch were connected to a ¾-inch elastic strap 015-001, wrapped in a cervical pad 020-040, both from Summit Orthod. Co (Monroe Falls, Ohio).

The force applied for the 40 patients averaged 450 g, as measured by an adequately calibrated dynamometer (Ohaus Corp., Florham Park, NJ). It was recommended that the Kloehn appliance be worn 12–14 hours per day. The patients were seen monthly at which time attention was given to three areas of adjustment: (1) the inner bow was maintained at a 4–8 mm expansion; (2) the outer bow was maintained at a 10–20° elevation to prevent distal tipping of the molars; and (3) the ends of the inner bow were adjusted to rotate the molars (an adjustment aiding in the A-P correction) (Figure 1).

The lateral cephalometric X-rays were taken following the standard procedure established at the First Workshop on Cephalometrics.[14,15] The degree of image distortion was determined with a 100 mm correction ruler adapted to the patient on the midsagittal plane.

Cephalometric tracings were made with an ultraphan transparent acetate sheets, size 20.3 × 25.4 cm and 0.003 inch thickness, on a luminator using a Pentel 0.5 mm lead pencil. In bilateral structures (gonial angle, teeth) that did not superimpose, the average of the two sides was used.

Cephalometric points were digitized (Numonics Corp, model AccuGrid XNT A30BL, Montgomeryville, Pa), according to Ortho lateral regimen and processed in a Dentofacial Planner Plus software, version 2.5b—Copyright © 1984–2000—serial number PP2-D32-1275 (DentoFacial Software Inc, Toronto, Ontario, Canada). The measurement criteria used in the present investigation were SNA representing maxillary protrusion and SN-PP representing maxillary inclination.

To evaluate the reproducibility of the present study in determining the cephalometric points, preliminary essays were performed to check errors in the method employed. Eleven randomly chosen lateral cephalograms were digitized at predetermined intervals of a minimum of two weeks. The largest error was 0.8° and the smallest was 0.1°.

The hypotheses consisted of verifying through profile analysis,[16] the differences in the measurements taken at the pretreatment (T_1), posttreatment (T_2), and postretention (T_3) phases analyzing whether:

- H_{01}—are the profiles parallel?
- H_{02}—assuming the profiles are parallel, are the profiles coincident?
- H_{03}—assuming the profiles are coincident, are the profiles level?

The data were statistically analyzed by exploratory analyses for the variables studied in T_1, T_2, and T_3 phases. In the hypotheses H_{01} and H_{02}, Hotelling's T^2 test was used, considering gender. In H_{03}, F-Snedecor test was applied to the entire sample. The multiple comparisons between phases were tested by the Bonferroni method.[16]

RESULTS Return to TOC

A descriptive analysis initially was made considering the patients' sex (Table 1). No difference was encountered comparing sexes according Hotelling's T^2 test (H_{01} and H_{02}, Table 2). Because there were no statistically significant differences in SNA and SN-PP measurements in all phases, the H_{03} hypothesis was tested by F-Snedecor method considering the 40 patients (Table 2).

In this investigation, all patients showed SNA angle reduction from T_1 to T_2 phase, for an average of 3.18° and an average increase of 0.74° from T_2 to T_3 (Figure 2A). Comparing T_1 with T_2 and T_1 with T_3 showed that the differences were highly significant, whereas comparing T_2 with T_3 showed no significant difference (Table 2).

There was an average increase of 1.7° in the SN-PP angle from phase T_1 to T_2 and an average decrease of 0.47° from T_2 to T_3 (Figure 2B). The difference was highly significant when comparing phases T_1 with T_2 and T_1 with T_3. In T_2 and T_3, the difference was not statistically significant.

DISCUSSION Return to TOC

The Kloehn extraoral appliance has been used for more than half a century and yet there are controversies regarding the changes resulting from its action. The most debated aspects are the effects on the behavior of SNA angle,[17] upper first molar extrusion,[18,19] anterior inclination of the palatal plane with a disproportional lowering of the maxilla,[20,21] and mandibular plane variation.[22]

Comparing the results of this extraoral appliance study with the results found in the literature is troublesome. This is because several types of appliances are employed and also because of the types of Class II malocclusion, which may come in numerous combinations of dental and skeletal relations between the maxilla and the mandible.[23] There is a great variation in the direction and the force of traction.[24] The inner bow may be used with or without expansion. Furthermore, in many studies headgear therapy has not been used alone but by adding fixed or functional appliances with or without tooth extractions. Forces above 450 g overcome the limits of dental movement. Yet they are enough to generate orthopedic effects on the midpalatal, intermaxillary, and maxillocranial suture lines, which are essential in the correction of skeletal Class II malocclusion.[25,26]

The age of onset of treatment is also a critical factor. In this study, it was decided to initiate treatment in the late mixed dentition or at the beginning of permanent dentition based on the belief that it often coincides with the facial growth spurt. Therefore, the cervical extraoral appliance was primarily placed with the intent of taking advantage of this growth pattern that would allow for observation of the changes exclusively because of its use.[27]

Approximately 12 months later, after correction of the molar relationship on both sides (Figure 3), a second stage of treatment was done. This phase consisted of a conventional edgewise fixed appliance to complement the correction of the malocclusion. As proposed by Haas and Gianelly, it must be emphasized that these two periods constitute just one phase of treatment, without interruption between them.[28,29]

In most cases, cervical traction was employed until the end of treatment to maintain the corrected Class I occlusion and control of the molars during upper incisor intrusion, torque, and retraction as needed in each particular case.

Of the 40 patients studied, 32 (80%) initiated treatment at the late mixed dentition and eight (20%) at the beginning of the permanent dentition. Satisfactory results were achieved in both groups. This is the reason why these two periods were not compared.

Analyzing treatments performed in one or two phases (beginning or late mixed dentition), Gianelly[30] questions what real benefits patients reap from orthodontic correction in two phases because most cases of Class II can be treated in just one phase. Such a treatment option is consistent with that used in the present study. Moreover, other benefits in Class II cases should be mentioned, such as cost-benefit relation, better acceptance of treatment by the patient, shorter treatment time with fixed appliances, and easier follow-up.

Treatment with cervical extraoral appliances requires compliance for a successful final result. Most orthodontists opt to treat patients during the mixed dentition mainly because they encounter a better degree of compliance.[31,32] Berg[33] found unsatisfactory cooperation in 9% of cases treated with the cervical extraoral appliance. Several studies have reported better acceptance among preadolescent patients,[34,35] especially those with good school records.[36] Others, however, found no relationship between age and compliance.[37] Clemmer and Hayes[38] reported better cooperation among female patients treated with extraoral appliances as compared with male patients. This is probably because of a higher motivation for dentofacial esthetics of the female patients. Regarding gender, in this study no difference was found. This shows that extraoral traction does not seem to be influenced by gender.[10,39,40]

The SNA angle describes the anteroposterior relation between the maxilla and the cranial base.[41] The inclusion of the SNA angle in the present study was because of the facility of identifying sella and nasion points and also because of stability during normal growth.[42] The downward and forward displacement of A point in relation to the cranial base occurs in the same proportion as the displacement of the nasion upward and forward.[42–44] Thus, any decrease in this angle may represent a reduction of maxillary protrusion.

Long-term follow-up studies on skeletal Class II patients treated with cervical headgear are rare in the literature. Melsen[45] reported only temporary influence of cervical headgear on skeletal growth pattern and a recovery of expected amount of growth in the maxillary complex. In our present investigation, all patients showed SNA angle reduction from T_1 to T_2 phase of an average of 3.18° and an average increase of 0.74° from T_2 to T_3.

Some authors have interpreted the small differences in SNA reduction in several ways. Mills et al[17] observed a 1° reduction in this angle and concluded that the maxilla could not continue its normal growth. Contrary to this finding, Caldwell et al[46] registered an SNA angle decrease of 1.3° and he concluded that most of the change was in the teeth and dentoalveolar structures.

Gianelly[30] questioned whether distal displacement of point A is an orthopedic response or a dental change because the position of incisor roots also influences the position of point A. Mitchell and Kinder[47] demonstrated that point A can be repositioned 2 mm posteriorly when the upper incisor roots are moved towards the palate. On studying nontreated Class I patients, Riolo et al[48] found that the SNA angle had increased only 0.4° in males and 0.3° in females from 10 to 13 years of age.

In the present study, the patients used the cervical headgear only for an average period of one year. Clinical observation during this period showed displacement of the maxilla and upper incisors. During the phase with fixed appliance, displacement of these teeth and their influence on posterior displacement of point A were smaller. Treatment initiated during the mixed dentition using a high magnitude of force and long outer bow bent upward may have influenced the reduction of the SNA angle.

Riolo et al[48] found the SN-PP angle had increased only 0.4°, but this change was not clinically relevant. Focusing on the effects of Kloehn cervical headgear on the growth of maxillary bones, Cangialosi et al[49] registered a significant 1.03° increase of this angle. Hubbard et al[50] also registered an average increase of 1.6°. Other investigators have found similar results with approximate numbers.[20,51]

Of the 40 patients studied, 34 (85%) showed an increase of this angle from T_1 to T_2, and this probably resulted from repositioning the maxilla posteriorly and inferiorly by cervical traction. Furthermore, the distalizing forces to the upper molars cause them to erupt downward and backward, thus they inhibit the lowering of the posterior region of the maxilla, whereas the anterior region continues to move downward during growth.

To reiterate, as the maxillary molars are extruded by the Kloehn cervical headgear, forces of the occlusion from the lower dental arch dictated by the muscles of the mastication, prevent the inferior descent of the posterior maxilla (PNS), whereas the anterior part of the maxilla (ANS) demonstrates its expected inferior growth. Thus, PNS remain stable in the vertical plane; the decent of ANS translates into an anterior downward tipping of the palatal plane.

Some aspects such as initial time of treatment, patients' compliance and the use of cervical headgear until the end of treatment may have contributed to the SN-PP angle increase.

CONCLUSION Return to TOC

A successful correction of skeletal Class II with the use of cervical headgear is closely associated with the patient's age. Kloehn cervical headgear therapy with an elevated external bow and an expanded inner bow is a very useful appliance in correcting skeletal Class II in the late mixed-early permanent dentition because of the potential to displace the entire maxilla posteriorly, down and back, on the cranial base and to give a vastly improved anteroposterior jaw and dental relationship in the skeletal Class II patient.

In the posttreatment phase (T_2), there was a reduction of the maxillary protrusion and palatal plane tipping downwards, with an increase of the SN-PP angle. In the postretention phase (T_3), the molar and skeletal pattern relationships were kept stable and the SN-PP angle was reduced.

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TABLES Return to TOC

TABLE 1. Descriptive Statistics of Measurements (in Degrees) Obtained in Pretreatment (T_1), Posttreatment (T_2), and Postretention (T_3) Phases of 22 Females (F) and 18 Males (M)

Measurement	Sex	Phase	$\bar{x}$	SD	Min	Q1	Median	Q3	Max
SNA	F	T_1	84.33	2.61	79.70	82.15	84.75	86.72	88.60
		T_2	81.01	3.01	74.40	78.82	80.70	83.40	85.70
		T_3	81.53	3.15	75.20	79.50	81.65	83.57	87.00
	M	T_1	82.29	3.25	76.10	80.00	82.05	85.02	86.90
		T_2	79.27	4.78	70.90	75.30	79.35	84.67	86.00
		T_3	80.28	3.41	75.10	77.27	80.45	83.10	85.40
SN–PP	F	T_1	6.15	3.15	−0.40	3.60	6.50	8.72	11.50
		T_2	8.18	3.44	1.80	5.72	8.30	10.42	14.90
		T_3	7.93	3.34	0.90	5.57	8.55	10.45	13.50
	M	T_1	6.03	3.14	0.30	3.45	6.15	3.45	8.52
		T_2	7.33	3.36	1.40	4.60	7.55	4.60	10.62
		T_3	6.60	2.86	1.80	4.05	6.85	4.05	8.75
SNA	F + M	T_1	83.41	3.06	76.10	80.75	84.10	85.85	88.60
		T_2	80.23	3.95	70.90	77.68	80.25	83.40	86.00
		T_3	80.97	3.29	75.10	78.33	81.40	83.38	87.00
SN–PP	F + M	T_1	6.10	3.11	−0.40	3.63	6.35	8.45	11.50
		T_2	7.80	3.39	1.40	4.93	7.80	10.58	14.90
		T_3	7.33	3.16	0.90	4.75	7.55	9.98	13.50

$\bar{x}$ indicates mean; SD, standard deviation; Min, minimum; Q1, first quartile; Q3, third quartile; and Max, maximum.

TABLE 2. Results of Hotelling's T^2, *F*-Test and *P* Values for the Hypotheses H_{01} and H_{02} (Sex) and H_{03} (Entire Sample), *t*-Test, *P* Values and Confidence Interval for Multiple Comparisons Between Pretreatment (T_1), Posttreatment (T_2), and Postretention (T_3) Phases

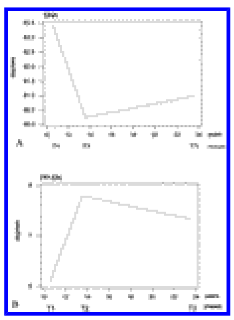
Measurement	H_{01}		H_{02}		H_{03}					
	T^2	P	T^2	P	F	P	Comparison	t	P	CI[a]
SNA	1.52	.49	3.48	.07	123.16	.000**	T_1–T_2	10.90	.000**	[2.37; 3.99]
							T_1–T_3	7.53	.000**	[1.54; 3.34]
							T_2–T_3	2.63	.01	
SN–PP	4.99	.10	0.65	.42	43.60	.000**	T_1–T_2	−5.47	.000**	[−2.56; −0.83]
							T_1–T_3	−4.28	.000**	[−2.03; −0.43]
							T_2–T_3	1.89	.07	

[a] CI, 95% confidence interval of Bonferroni.
** $P < .008$, highly significant difference.

FIGURES Return to TOC

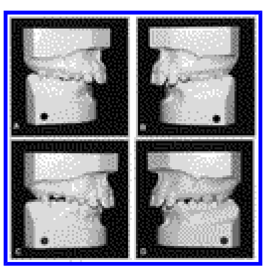
Click on thumbnail for full-sized image.

FIGURE 1. Photographs of lateral cephalograms (A and B) and intraoral photographs (C and D) of a patient with Kloehn cervical gear showing: (A) outer bow bent upward; (B) the same patient with the neck-band in place—note that the distal arms are pulled downward and backward which results in slight upward movement of anterior portion of the appliance; (C) inner bow expanded in relation to first molars, and (D) fitted to the molar tube.



Click on thumbnail for full-sized image.

FIGURE 2. Mean SNA (A) and SN-PP (B) measurements in pretreatment (T_1), posttreatment (T_2), and postretention (T_3) phases



Click on thumbnail for full-sized image.

FIGURE 3. Photographs of study models in pretreatment (A and B) and progressing (C and D) phases, right and left sides, showing correction of the molar relationship on both sides.

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