Long-term maxillary behavior in treated skeletal Class II malocclusion

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Abstract

Aim: To evaluate the post-treatment and long-term anteroposterior and vertical maxillary changes from the use of Kloehn cervical headgear in treated skeletal Class II Division 1 malocclusion. **Methods:** Using a longitudinal prospective study design, 90 lateral radiographs of 30 treated patients (12 male gender and 18 female gender) were taken at the beginning of the treatment (mean age = 10 years and 9 month), at the end of the treatment (mean age = 14 years and 6 months), and in the post-retention phases (mean age = 26 years and 2 months). Lateral radiographs of 30 adults patients with Class II malocclusion, as control group (mean age = 24 years and 1 month) were compared with lateral radiographs of patients in the post-retention phase in order to quantify the cephalometric measurements (5 angular and 2 linear) representing the maxillary position in the anteroposterior and vertical direction. **Results:** Under the effect of treatment, forward displacement of the maxilla was redirected in a downwards and backwards direction. When the means of the female measurements were compared between the two groups, only ANB was greater in the control group. When the male measurements were compared, they presented a mean value of ANB greater in the control group, and the mean of SNPP greater in the treated group. **Conclusions:** In the post-retention phase, maxillary displacement reverted in a downward and forward direction, confirming the transitory effect of the extra-oral action on maxillary displacement.

Keywords: Skeletal class II malocclusion, maxillary displacement, cervical extra-oral traction, post-retention.

Introduction

The treatment of Class II malocclusion, a subject of great interest to orthodontists, uses various strategies, extra-oral forces being one whose benefits have been unanimously recognized[1]. It restricts anterior displacement of the maxilla and thus contributes to correction of the anteroposterior discrepancy between the maxilla and mandible[2-3].

Silas Kloehn[4] designed the Kloehn extra-oral device, used since 1947, and experimentally verified that traction retarded the forward displacement of the maxilla in patients with Class II malocclusion, and in some cases, moved the maxillary teeth in the distal direction. The best results have been obtained when treatment is applied during the growth spurt because while the anterior displacement of the maxilla is retained, the mandible is displaced in a forward direction until a favorable relationship with it was obtained.

Studies have shown that cervical traction used in the correction of Class II is effective in redirecting maxillary displacement downwards and backwards[5-6]. The maxillary permanent first molars are maintained or moved in the distal direction, so that the premolars, permanent canines and second molars are oriented in the same direction[7]. The most adequate period for evaluating these results is after the removal of retention. Thus, the efficacy of the therapy on the cranial and facial structures and the effects of late residual growth can be evaluated[8-10].

The aim of this study was to evaluate the post-treatment and long-term anteroposterior and vertical maxillary changes from the use of Kloehn cervical headgear in skeletal Class II Division 1 malocclusion, compared with untreated patients.

Material and methods

A selection was made of 30 teleradiographs of 30 untreated adult patients with Class II malocclusion, as the control group (CG) and 90 teleradiographs of 30 patients submitted to complete fixed corrective orthodontic treatment with the standard edgewise system and extra-oral cervical traction appliance (Kloehn), as the treated group at the Orthodontic Graduate Program Clinic of the Federal University of Rio de Janeiro, Brazil, at different time intervals: before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2). The research protocol was approved by the Ethics Committee, number CAAE 0045.0.239.000-09.

The treated group consisted of 30 individuals (18 females and 12 males, and the control group consisted of 30 individuals (17 females and 13 males with Class II malocclusion) (Table 1). At the beginning of treatment all patients in the treated group were in the pubertal growth spurt stage, according to the hand and wrist radiograph, with skeletal Class II malocclusion (ANB e"5 degrees) and angle SNGoGn d" 36 degrees.

The measurements obtained from the cephalometric tracings at T_0, T_1 and T_2 were organized in tables for evaluation and statistical analysis, with the angular measurements being taken to the nearest whole degree whenever there was a fraction involved. The changes in maxillary displacement were measured in relation to the base of the skull by means of angles BaSN, ANB, NSENA, NSENP and SNPP. Linear measurements were used to describe maxillary displacement: S'-ENA, which corresponded to the distance from the perpendicular to the Sela-Nasio line passing through point

S to point Anterior Nasal Spine. S'-ENP, determined by the distance from the perpendicular to Sela-Nasio line passing through point S to point Posterior Nasal Spine.

For each cephalometric measurement the mean and standard deviation at T_0, T_1 and T_2 time intervals was calculated The behavior of the measurements between the time intervals (T_0 x T_1) and (T_1 x T_2) was tested for significance using the paired Student's-t test, with significance level set at 5%.

The same measurements were obtained for the non-treated group (control). The behavior of measurements was compared between the control and treated groups at time interval T_2 using non paired Student's-t test, with a level of significance of 5%.

Error of the method

Thirty cephalograms of 10 randomly selected patients were traced on two separate occasions, totaling 60 tracings. No significant difference was found using the paired t test. The degree of reliability of the measurements was calculated using the Dahlberg's[11] formula of method error. For the angular measurements the error of the method did not exceed 0.375 degrees and for linear measurements it did not exceed 0.345 mm.

Results

Table 2 shows the means, standard deviations of the angular and linear measurements at time intervals T_0, T_1 and T_2 of the treated and control groups and the p-values between T_0 x T_1, between T_1 x T_2 and between T_2 x CG. Table 3 shows the data obtained only in women, and Table 4 shows the reference values for men in the treated and control groups, with p-values.

When the genders in the control group were compared, the mean value of ANB was 2 degrees greater for the female gender ($p < .001$), while the mean value of S'ENA was 4.45 mm higher for the male gender ($p = .04$). In the treated group, between T_0 x T_1, the male gender presented mean values of NSENA and SNPP 2.5 degrees ($p = .003$) and 2.84 degrees ($p = .006$) greater, respectively, showing also mean value of ANB 2.34 degrees ($p < .001$) lower than the female gender. Between T_1 x T_2 ANB decreased in both genders, while NSENA and SNPP decreased 0.56 degrees ($p = .004$) and 0.73 degrees ($p = .01$) respectively, only in females (Tables 3 and 4).

When the means of the female measurements were compared between the two groups, only ANB was 5.80 degrees greater ($p < .001$) in the control group (Table 3).

Table 1 - Mean and standard deviation (sd) of ages (in years) at time intervals T_0, T_1 and T_2 for both genders in the treated and control groups.

		Treated group			Control group	
	N	T_0 Mean ± sd	T_1 Mean ± sd	T_2 Mean ± sd	N	Mean ± sd
Male	12	11.9 ± 1.33	15.8 ± 1.34	26.6 ± 3.10	13	23.56±5.59
Female	18	10.9 ± 1.22	14.6 ± 1.48	26.2 ± 4.78	17	24.43±3.62

Time intervals: before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2).

Table 2 - Mean and standard deviation (sd) of angular and linear measurements in the treated group (n = 30) at time intervals T_0, T_1 and T_2 and in the control group (n = 30).

	Treated group			Control group	P value		
	T_0 Mean ± sd	T_1 Mean ± sd	T_2 Mean ± sd	Mean ± sd	P T_0 x T_1	P T_0 x T_1	P T_2 x CG
BaSN (°)	132.63 ± 6.68	132.97 ± 6.18	132.80 ± 5.64	131.20 ±4.90	0.41 ns	.53 ns	.24 ns
ANB (°)	5.93 ± 1.25	3.43 ± 1.50	2.90 ± 1.53	7.46 ± 1.69	< .001	< . 001	<.001
NSENA (°)	36.70 ± 2.21	39.00 ± 2.75	38.67 ± 2.95	37.20 ± 2.36	< .001	.023	.08 ns
NSENP (°)	69.70 ± 2.62	71.77 ± 3.44	71.93 ± 3.27	70.50 ± 4.61	< .001	.54 ns	.17 ns
SNPP (°)	7.60 ± 3.08	10.07 ± 3.29	9.57 ± 3.69	7.36 ± 3.74	< .001	.01	.02
S'ENA (mm)	68.53 ± 3.70	69.20 ± 4.65	71.47 ± 4.53	72.40 ± 6.00	.19 ns	< .001	.050 ns
S'ENP (mm)	16.43 ± 2.58	15.13 ± 3.04	15.50 ± 3.07	16.26 ± 4.39	.002	.17 ns	.43 ns

Time intervals: before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2). p = 5% of significance.

Table 3 - Mean and standard deviation of angular and linear measurements for the female gender in the treated group (n = 18) at time intervals T_0, T_1 and T_2 and in the control group (n = 17).

	Treated group			Control group			
	T_0 Mean ± sd	T_1 Mean ± sd	T_2 Mean ± sd	Mean ± sd	p T_0 x T_1	p T_1 x T_2	P T_2 x CG
BaSN (°)	131.11 ±5.08	131.67 ± 5.08	131.64 ± 4.69	131.94±5.22	.29 ns	.54 ns	.77 ns
ANB (°)	5.61 ± 1.14	3.0 ± 1.45	2.56 ± 1.42	8.35±1.22	< .001	.007	<.001
NSENA (°)	35.89 ± 2.11	38.06 ± 2.10	37.50 ± 1.94	36.94±2.46	< .001	.004	.46 ns
NSENP (°)	68.78 ± 2.36	71.44 ± 2.99	71.39 ± 3.05	70.05±5.58	< .001	.87 ns	.39 ns
SNPP (°)	6.44 ± 2.59	8.67 ± 2.11	7.94 ± 2.38	8.11±3.78	< .001	.01	.87 ns
S'ENA (mm)	68.78 ± 3.57	68.83 ± 3.41	70.78 ± 3.11	70.47±6.05	.91 ns	< .001	.85 ns
S'ENP (mm)	17.22 ± 2.31	15.28 ± 2.67	15.61 ± 3.01	15.52±5.10	< .001	.21 ns	.95 ns

Time intervals: before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2). p = 5% of significance.

Table 4 - Mean and standard deviation of angular and linear measurements for male gender in the treated group (n = 12) at time intervals T_0, T_1 and T_2 and in the control group (n = 13)..

	TG			CG	P value		
	T_0 Mean sd	T_1 Mean sd	T_2 Mean sd	Mean sd	p T_0 x T_1	p T_1 x T_2	P T_2 xGC
BaSN (°)	134.92 ± 8.27	134.92± 7.34	134.83± 6.52	130.23±4.47	1.0 ns	.83 ns	.06 ns
ANB (°)	6.42 ± 1.31	4.08 ± 1.37	3.42 ± 1.62	6.30±1.54	< .001	.02	<.001
NSENA (°)	37.92 ± 1.83	40.42 ± 3.08	40.42 ± 3.45	37.60±2.25	.003	1 n.s	.06 ns
NSENP (°)	71.08 ± 2.46	72.25 ± 4.11	72.75 ± 3.57	71.07±3.04	.19 ns	.29 ns	.21 ns
SNPP (°)	9.33 ± 3.02	12.17 ± 3.68	12.0 ± 4.04	6.38±3.59	.006	.50 ns	.001
S'ENA (mm)	68.17 ± 4.01	69.75 ± 6.21	72.50 ± 6.09	74.92±5.12	.12 ns	.001	.29 ns
S'ENP (mm)	15.25 ± 2.59	14.92 ± 3.65	15.33 ± 3.28	15.52±5.10	.60 ns	.47 ns	.95 ns

Time intervals: before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2). p = 5% of significance.

When the male measurements were compared, they presented a mean value of ANB 2.9 degrees (p <.001) greater in the control group, and the mean of SNPP 5.62 degrees greater in the treated group (p < .001) (Table 4).

Discussion

According to Kloehn[4], the growth spurt is essential for the correction of Class II malocclusion, while Kloehn's extra-oral appliance restricts forward displacement of the maxilla, and orients eruption of the posterior permanent teeth in a more distal direction.

As regards angle BaSN, no significant alteration in this angle was verified, both in the period corresponding to the use of the extra-oral appliance and in the post-retention phase (Tables 2, 3 and 4, Figure 1), suggesting that growth at the base of the skull is inherent to the individual, without the influence of any orthodontic mechanics[12].

In treated groups, between T_0 x T_1, a significant reduction in ANB, significant increase in SNPP and NSENA and inexpressive increase in S'ENA were observed (Table 2, Figures 1 and 2), and also when the genders were observed separately (Tables 3 and 4). As previously observed by other authors[1,13-14], the action of extra-oral force and orthodontic mechanics during the growth spurt promoted downward and backward displacement of the maxilla.

Between T_0 x T_1, the mean value of angles NSENA and
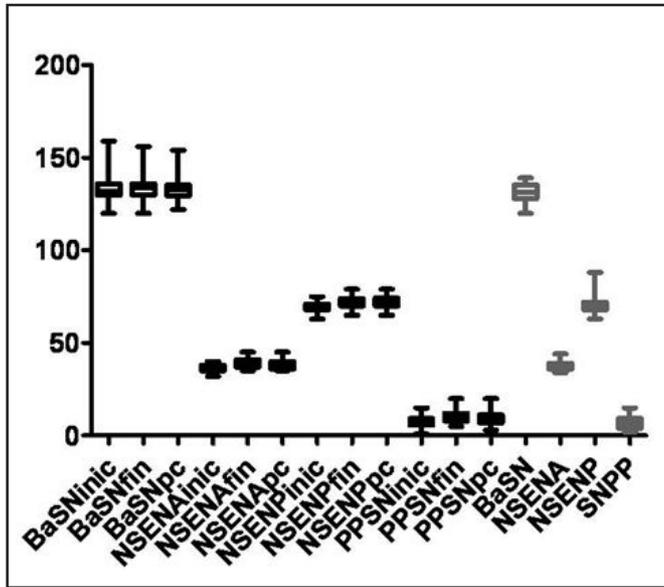
Fig. 1 - Values of BaSN, NSENA, NSENP and SNPP angles in the treated group at the time intervals before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2) and in the control group.
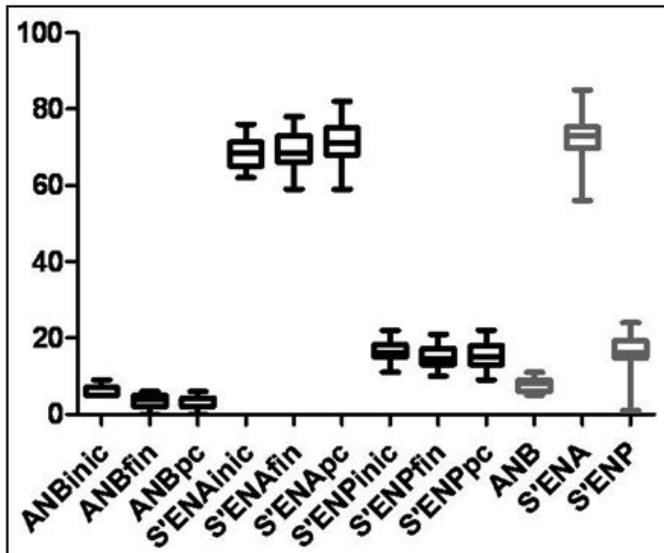
Fig. 2. Values of ANB value and of the linear measurements S'ENA and S'ENP in the treated group at the time intervals before treatment (T_0), at the end of treatment (T_1) and with a minimum of 5 years post-retention (T_2) and in the control group.

SNPP diminished and that of S'-ENA increased significantly, suggesting that growth was not altered but redirected.[15-19] A similar result was observed when the genders were analyzed separately (Tables 3 and 4). The results of this research confirm previous conclusions[1,14,20-21] that the reduction in facial convexity is a common effect of mechanics in Class II malocclusion.

The increase in NSENP and reduction in S'-ENP means (Table 2, Figures 1 and 2) were probably due to displacement of the posterior nasal spine in the posterior direction, by bone apposition at the tuberosity[13,22]. When the means of the female and male groups were analyzed separately (Table 3 and 4), angle NSENP did not increase significantly in the latter group (Table 4). That is to say, there was no relevant change in point ENP, either in the vertical or horizontal

direction in relation to the base of the skull, a phenomenon mentioned as being due to extrusion of the molars during the use of extra-oral mechanics, making it impossible for point ENP to be lowered[19,23-24].

Between T_1xT_2, the significant reduction in angle ANB resulted from residual mandibular growth, since no orthodontic mechanics were being applied. The means of angles NSENA (except in male gender) and SNPP diminished and that of S'ENA increased significantly, the influence of cervical traction on the maxillary growth pattern being temporary (Tables 2, 3 and 4, Figures 1 and 2)[25].

No significant changes were observed in the mean of NSENP and S'-ENP due to the posterior nasal spine being maintained in a stable position both in the vertical and horizontal directions (Tables 2, 3 and 4, Figures 1 and 2), as there was balance of the masticatory muscles and occlusal forces[25]. In addition, the growth in the posterior region of the maxilla had been expressed in the anterior region with the more forward positioning of point ENA[26-27].

When the treated group was compared with the control group at T_2, no significant difference between the groups was observed as regards growth at the base of the skull. In addition, the maxilla was no longer protruded in the control group, since there was no significant difference with regard to the measurements NSENA, NSENP, S'ENA and S'ENP (Tables 2, 3 and 4, Figures 1 and 2). This was observed by Bishara et al.[28], when they pointed out that Class II is not a result of excessive growth of the maxilla, but it is basically due to excessive retrusion of the mandible. Hunter et al.[29] had confirmed that the maxilla is normally well related to the base of the skull in Class II malocclusion.

The skeletal difference between the maxilla and mandible (ANB) was significantly greater in the control group. The maxilla was observed to be ahead of the mandible, suggesting that all the growth that occurred from childhood to the adult phase was genetically determined, and that Class II malocclusion is not self-corrected in growing patients[30-31].

Angle SNPP was significantly greater in the treated than in the control group, due to the effect of Kloehn's extra-oral mechanics on the maxilla[21-22].

It may be concluded that during orthodontic treatment combined with the use of Kloehn's extra-oral appliance, displacement of the maxilla was directed downwards and backwards. In the post-retention phase, however, maxillary displacement was reverted in a downward and forward direction, confirming the transitory effect of the extra-oral action on maxillary displacement.

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