*Original Article*

# Stability of Class II, Division 1 Treatment with the Headgear-Activator Combination Followed by the Edgewise Appliance

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**Abstract:** This study assessed the stability of the headgear-activator combination treatment, followed by edgewise mechanotherapy, 5.75 years after treatment. The experimental group consisted of 23 patients who were evaluated during treatment and after treatment. Two compatible control groups consisting of 15 Class II, division 1 patients and 24 normal occlusion individuals were used. This enabled us to evaluate the changes during treatment and after treatment, respectively. Results showed that the anteroposterior dentoalveolar changes and the maxillary and the mandibular positions remained stable in the long term. However, there was a slight relapse of the maxillomandibular relationship probably because the maxilla resumed its normal development and the mandibular growth rate was smaller than in the control group. The overbite demonstrated a statistically significant relapse that was directly proportional to the amount of its correction. There were low but significant inverse correlations between the changes in Go-Gn during and after treatment. These included the uprighting of the maxillary incisors, labial tipping of the mandibular incisors, and the amount of molar relationship correction during treatment and their stability. Active retention time, length of posttreatment period, initial Class II malocclusion severity (ANB and Wits), and initial molar relationship did not present any correlation with molar relationship and overjet relapse. However, the initial overjet presented a low but statistically significant correlation with molar relationship relapse and overjet relapse. (*Angle Orthod* 2004;74:594–604.)

**Key Words:** Headgear-activator treatment stability; Treatment relapse

## INTRODUCTION

In general, Class II, division 1 malocclusion correction by the high-pull headgear-activator combination therapy produces restriction of the forward maxillary growth, inhibition of the mesial and vertical displacement of the maxillary teeth, improvement of the mandibular horizontal growth, differential eruption of the mandibular posterior teeth, condylar and glenoid fossa remodeling, and an improvement in muscle pattern.[1,2] These changes, however, can only be considered satisfactory if they remain stable.

Longitudinal studies have demonstrated that changes obtained during the active treatment period tend to relapse toward the initial malocclusion in the following posttreatment years.[3,4] The dentoskeletal relationship does not necessarily remain constant and spontaneously changes during facial growth.[3]

Literature on the stability of the effects yielded by the headgear combined with functional appliances is scarce. A shortcoming observed in the few studies on this subject was the absence of a control group of untreated subjects for analysis of the results.[5,6] Therefore, because stability is known to be the fundamental key to the successful outcome of orthodontic treatment, this study investigated the stability

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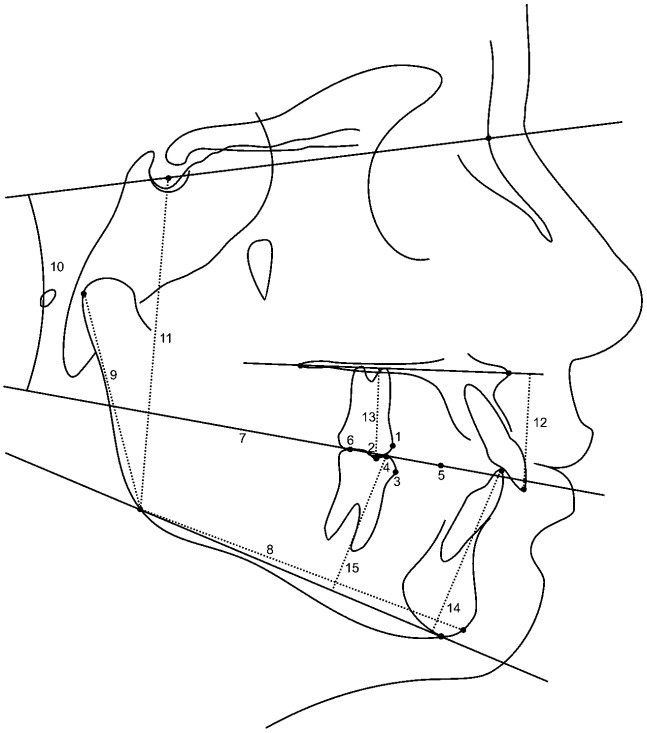


**FIGURE 1.** Unusual cephalometric landmarks, planes, and measurements. 1. MSUFM (mesial surface of the maxillary first molar): the most anterior point on the maxillary first permanent molar crown; 2. MCUFM (mesial cusp of the maxillary first molar): the lowest point on the maxillary first permanent molar mesial cusp tip; 3. MSLFM (mesial surface of the mandibular first molar): the most anterior point on the mandibular first permanent molar crown; 4. MCLFM (mesial cusp of the mandibular first molar): the most superior point on the mandibular first permanent molar mesial cusp tip; 5. PMOC (premolar occlusal contact): first premolars or primary first molars intercuspation midpoint; 6. MOC (molar occlusal contact): first molars intercuspation midpoint; 7. Functional occlusal plane: a plane drawn through PMOC and MOC; 8. Go-Gn: distance between gonion and gnathion; 9. Co-Go: distance between condylion and gonion; 10. SN.FOP: angle formed between line SN and the functional occlusal plane; 11. S-Go: Distance between sella and gonion; 12. U1-PP: perpendicular distance between the incisal edge of the maxillary central incisor and palatal plane; 13. U6-PP: perpendicular distance between the mesiobuccal cusp of the maxillary first molar and the palatal plane; 14. L1-MP: perpendicular distance between the incisal edge of the mandibular central incisor and mandibular plane; 15. L6-MP: perpendicular distance between the mesiobuccal cusp of the mandibular first molar and mandibular plane.

of dentoskeletal changes 5.75 years after treatment with the headgear-activator combination, followed by the edgewise appliance, using control groups.

## MATERIALS AND METHODS

The samples were obtained from the files of the Orthodontic Department at Bauru Dental School and consisted of 147 lateral cephalometric head films of 62 patients who were divided into three groups.

### An experimental group

This group consisted of 23 Class II, division 1 malocclusion patients (nine male and 14 female patients; initial mean age 11.22 ± 1.47 years, range 9 to 14.83 years). These patients underwent an orthopedic treatment with the high-pull headgear-activator combination for a mean period of 10.6 months (SD = 3.9, range 4.8 to 15.6 months), followed by orthodontic treatment with fixed appliances for 1.61 years (SD = 0.63, range one to 3.6 years). Therefore, the complete treatment time was 2.49 years (SD = 0.76, range 1.4 to 4.9 years).

When fixed appliance treatment was initiated, the corrected anteroposterior long-term relationship was retained by five patients using the headgear-activator combination, nine patients using the headgear associated with Class II elastics, seven patients using only the headgear, and two not using any anteroposterior retention device. This active retention period lasted 1.21 years (SD = 0.23, range zero to 2.75 years). At the end of treatment, a Hawley plate was worn full time during the first six months and as night-time wear for the subsequent six months. A lingual 3 by 3 bonded retainer was installed and used for a mean period of three years or until the end of growth. Only cases with good results were included. Patients concluded treatment at a mean age of 13.71 years (SD = 1.37, range 10.40 to 17.41 years). As this research aimed to investigate treatment stability, the selected subjects had to have been out of treatment for three years, at least. As a result, the mean follow-up period was 5.75 years (SD = 1.71, range 3.16 to 9.58 years), and the mean age at the posttreatment stage was 19.46 years (SD = 2.05, range 17 to 26 years).

### Control group I

From the longitudinal growth study sample of the Orthodontic Department at Bauru Dental School, 15 subjects (eight male and seven female subjects) were selected. All subjects presented with a Class II, division 1 malocclusion and had never been orthodontically treated. The subjects in this group had an initial mean age of 10.91 years (SD = 0.73, range 9.83 to 12 years) and a final mean age of 13.59 years (SD = 1.61, range 10.83 to 16.25 years). The mean observation period was 2.68 years (SD = 0.53, range one to 5.50 years). This group was used to assess the changes during treatment.

### Control group II

To distinguish the posttreatment changes from those of normal growth, 24 subjects (12 male and 12 female subjects) were selected. All presented a normal occlusion. Their initial mean age was 14.54 years (SD = 0.71, range 12.41 to 15.66 years) and the final mean age was 19.33 years (SD = 0.98, range 17.33 to 22.66 years), compatible to the experimental group ages at the end of treatment and

**TABLE 1.** Unusual Cephalometric Landmarks and Measurements

| |
|---|
| PgnPerp (pogonion perpendicular line): a line drawn perpendicular to the Go-Me plane from pogonion |
| ANSPerp (anterior nasal spine perpendicular line): a line drawn perpendicular to the palatal plane from ANS |
| Pt (pterygoid): point located in the intersection of the upper and posterior walls of the pterygomaxillary fissure |
| CS (center of skull): point located on the intersection of lines Ba-N and Pt-Gn |
| U1-ANSperp: distance between the most anterior point of the maxillary central incisor crown and the anterior nasal spine perpendicular. Values posterior to this line were considered negative, whereas values anterior to it were regarded as positive |
| U6-ANSperp: distance between the mesial surface of the maxillary first molar and the anterior nasal spine perpendicular. It determines the sagittal position of the maxillary first molar in relation to the maxilla. Negative values were assigned to measurements behind the reference line. Therefore, a mesial molar movement was indicated by a decrease in the absolute values of this variable |
| L1-Pgnperp: distance between the most anterior point of the mandibular central incisor crown and pogonion perpendicular. It determines the sagittal position of the mandibular central incisor in relation to the mandible, and its increase indicates incisor protrusion |
| L6-Pgnperp: distance between the mesial surface of the mandibular first molar and pogonion perpendicular. It determines the sagittal position of the mandibular first molar in relation to the mandible. Negative values were assigned to measurements behind the reference line. Therefore, a mesial molar movement was indicated by a decrease in the absolute values of this variable |
| Overjet: distance from the incisal edge of the mandibular incisor to the incisal edge of the maxillary incisor, as measured parallel to the functional occlusal plane |
| Overbite: distance from the incisal edge of the mandibular incisor to the incisal edge of the maxillary incisor, as measured perpendicular to the functional occlusal plane |
| Molar relationship: horizontal distance of the perpendicular projections of the maxillary and mandibular first molars mesial surfaces on the functional occlusal plane. Positive values were attributed when the mandibular molars were mesial to the maxillary |

at the posttreatment stage, respectively. The mean observation period was 4.79 years (SD = 1.32, range 2.75 to 7.91 years). This group was also selected from the longitudinal growth study sample mentioned above.

## MATERIALS AND METHODS

The anatomic tracing and the location of dentoskeletal landmarks were manually carried out by a single investigator and digitized (Numonics AccuGrid XNT, model A30TL.F—Numonics Corporation, Montgomeryville, Pa) (Figure 1; Table 1). These data were then stored on a 166 Pentium II computer and analyzed with Dentofacial Planner 7.2 (Dentofacial Planner Software Inc., Toronto, Ontario, Canada). This software also corrected the magnification factor of the radiographic images that was 8.65% for the experimental group and 6% for control groups I and II.

### Error study

Twenty radiographs were randomly selected, retraced, redigitized, and remeasured by the same examiner after a 10-day interval. Student's paired *t*-test was used to evaluate the systematic error, for $P < .05$. Casual errors were calculated according to Dahlberg's formula:[7] $Se^2 = \Sigma d^2/2n$, where d is the difference between duplicate measurements and n is the number of double measurements.

### Statistical analyses

Independent *t*-test was used to evaluate the compatibility between experimental group and control group I before treatment and between experimental group and control group II at the end of treatment, as well as the intergroup treatment (experimental × control group I) and posttreatment (experimental × control group II) changes (Tables 2 through 5).

Pearson's correlation coefficient was used to investigate the relationship of the posttreatment changes with the treatment changes. Relations between the active retention time, length of posttreatment period, initial Class II malocclusion severity (ANB and Wits), initial molar relationship and overjet, with molar relationship and overjet relapses were also investigated. Results were considered to be statistically significant for $P < .05$.

## RESULTS

Only one variable (U1-PP) demonstrated a systematic error, no variable showed a casual error greater than two degrees or two mm, and just six variables were above one degree or one mm. Tables 2 and 3 show the results of the compatibility *t*-test between the experimental and control groups I and II before and after treatment, respectively. Table 4 shows the results of the *t*-test between changes obtained during treatment in the experimental group and those in control group I during a compatible time period.

Table 5 shows the *t*-test results between the posttreatment changes in the experimental group and those in control group II, during a compatible time period. Table 6 shows the correlation between the changes that occurred during treatment and during the posttreatment period in the experimental group.

Only the initial overjet presented a significant correlation with molar relationship relapse and overjet relapse ($r = .52$; $P = .010$ and $r = .43$; $P = .038$, respectively).

## DISCUSSION

### Experimental group

One of the criteria for selection of the experimental group was based on good results obtained at the end of treatment. Consequently, patient compliance in nonextraction Class II treatment was a crucial factor for the case to

**TABLE 2.** Means, Standard Deviations, and Results of the Independent *t*-test to Evaluate the Compatibility Between Experimental Group and Control group I at the Pretreatment Stage

| | Experimental (n = 23) | | Control I (n = 15) | | | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | *t* | *P* |
| Maxillary component | | | | | | |
| SNA | 81.89 | 2.96 | 80.82 | 3.10 | 1.06 | .29 |
| A-Nperp | 0.21 | 3.25 | −1.80 | 2.21 | 2.10 | .04 |
| Co-A | 84.30 | 4.55 | 83.31 | 4.38 | 0.66 | .50 |
| Mandibular component | | | | | | |
| SNB | 75.35 | 2.67 | 76.16 | 2.81 | −0.89 | .37 |
| P-Nperp | −8.66 | 6.18 | −9.12 | 3.21 | 0.26 | .79 |
| Co-Gn | 103.24 | 5.78 | 102.62 | 4.59 | 0.34 | .73 |
| Go-Gn | 67.46 | 4.51 | 67.74 | 3.83 | −0.19 | .84 |
| Co-Go | 49.76 | 3.75 | 48.18 | 2.74 | 1.39 | .17 |
| Maxillomandibular relationship | | | | | | |
| ANB | 6.53 | 1.29 | 4.67 | 1.37 | 4.22 | .00 |
| Wits | 2.41 | 2.60 | 0.06 | 2.31 | 2.83 | .00 |
| NAP | 11.44 | 3.95 | 7.72 | 3.98 | 2.82 | .00 |
| Co-A/CoGn | 81.68 | 2.00 | 81.18 | 2.79 | 0.64 | .52 |
| Vertical and horizontal components | | | | | | |
| SN.GoGn | 33.05 | 4.09 | 32.30 | 3.62 | 0.57 | .56 |
| FMA | 26.56 | 5.26 | 27.12 | 2.58 | −0.37 | .70 |
| SN.PP | 8.99 | 3.59 | 9.48 | 2.88 | −0.43 | .66 |
| SN.FOP | 20.35 | 4.40 | 21.47 | 4.54 | −0.75 | .45 |
| LAFH | 60.12 | 4.08 | 58.94 | 4.17 | 0.86 | .39 |
| S-Go | 66.36 | 5.06 | 66.04 | 4.26 | 0.20 | .84 |
| Maxillary dentoalveolar component | | | | | | |
| U1.PP | 121.48 | 5.61 | 113.48 | 7.58 | 3.73 | .00 |
| U1-ANSperp | 1.30 | 3.09 | −1.64 | 2.59 | −3.04 | .00 |
| U1-PP | 25.69 | 2.54 | 25.76 | 2.54 | −0.09 | .92 |
| U6-PP | 20.16 | 1.77 | 19.76 | 2.30 | 0.61 | .54 |
| U6-ANSperp | −30.04 | 2.37 | −31.12 | 2.32 | −1.36 | .17 |
| U1.NA (°) | 30.61 | 5.85 | 23.18 | 7.84 | 3.34 | .00 |
| U1-NA (mm) | 5.96 | 2.08 | 3.53 | 2.52 | 3.22 | .00 |
| Mandibular dentoalveolar component | | | | | | |
| IMPA | 96.58 | 4.78 | 94.48 | 5.26 | 1.26 | .21 |
| L1-Pgnperp | −7.80 | 2.11 | −8.09 | 2.94 | 0.35 | .72 |
| L1-MP | 37.07 | 2.78 | 35.63 | 1.80 | 1.77 | .08 |
| L1.NB (°) | 26.88 | 5.06 | 25.05 | 5.48 | 1.05 | .29 |
| L1-NB (mm) | 4.67 | 1.70 | 4.09 | 1.49 | 1.07 | .28 |
| L6-Pgnperp | −29.18 | 2.14 | −30.70 | 2.49 | 2.00 | .05 |
| L6-MP | 26.65 | 2.22 | 26.06 | 2.02 | 0.82 | .41 |
| Dentoalveolar relationships | | | | | | |
| Overjet | 9.15 | 2.42 | 4.97 | 1.79 | 5.72 | .00 |
| Overbite | 4.65 | 2.02 | 4.26 | 1.67 | 0.61 | .54 |
| Molar relationship | −1.60 | 1.45 | −0.10 | 1.10 | −3.40 | .00 |

be included in the sample, and this definitely reduced its size. Therefore, 23 patients were selected for this investigation. This number can be considered sufficient to produce reliable results because similar studies also used samples of similar sizes.[1,5,8,9]

### Control group I

The occlusal and cephalometric Class II characteristics of control group I were milder than those of the experimental group for the variables A-Nperp, ANB, Wits, U1.PP, U1-ANSperp, U1-NA, overjet, and molar relationship (Table 2). However, despite these limitations, a less than ideal control group is better than none, and in addition, other studies[10,11] have also used control groups with milder Class II characteristics than the experimental group. Others did not even use a control group to evaluate the effects of treatment.[12–14]

### Control group II

Table 3 demonstrates that the experimental group at the end of treatment and control group II presented several dif-

**TABLE 3.** Means, Standard Deviations, and Results of the Independent *t*-test to Evaluate the Compatibility Between Experimental Group and Control group II at the End of Treatment

| | Experimental (n = 23) | | Control II (n = 24) | | | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | *t* | *P* |
| Maxillary component | | | | | | |
| SNA | 80.53 | 2.49 | 81.00 | 3.03 | −0.58 | .56 |
| A-Nperp | −1.42 | 3.82 | −1.58 | 2.59 | 0.17 | .86 |
| Co-A | 86.11 | 4.35 | 86.39 | 5.09 | −0.20 | .84 |
| Mandibular component | | | | | | |
| SNB | 76.56 | 2.17 | 79.27 | 2.98 | −3.55 | .00 |
| P-Nperp | −7.28 | 7.20 | −3.82 | 5.69 | −1.83 | .07 |
| Co-Gn | 110.78 | 5.88 | 114.48 | 7.17 | −1.92 | .06 |
| Go-Gn | 71.55 | 5.42 | 74.99 | 5.89 | −2.07 | .04 |
| Co-Go | 54.65 | 4.31 | 54.48 | 4.66 | 0.12 | .89 |
| Maxillomandibular relationship | | | | | | |
| ANB | 3.95 | 1.71 | 1.72 | 1.83 | 4.29 | .00 |
| Wits | 1.99 | 2.41 | −1.91 | 2.53 | 5.40 | .00 |
| NAP | 5.41 | 4.61 | 0.87 | 4.93 | 3.25 | .00 |
| Co-A/CoGn | 77.75 | 2.05 | 75.51 | 2.25 | 3.55 | .00 |
| Vertical and horizontal components | | | | | | |
| SN.GoGn | 32.67 | 3.88 | 32.04 | 4.43 | 0.51 | .60 |
| FMA | 26.40 | 5.31 | 26.47 | 4.85 | −0.04 | .96 |
| SN.PP | 9.19 | 2.89 | 8.89 | 3.05 | 0.34 | .72 |
| SN.FOP | 16.43 | 4.69 | 16.90 | 4.96 | −0.33 | .73 |
| LAFH | 64.50 | 4.81 | 64.19 | 3.70 | 0.24 | .80 |
| S-Go | 72.45 | 5.74 | 72.93 | 5.30 | −0.29 | .76 |
| Maxillary dentoalveolar component | | | | | | |
| U1.PP | 111.93 | 6.70 | 113.16 | 4.55 | −0.73 | .46 |
| U1-ANSperp | −2.48 | 3.56 | −0.70 | 2.27 | 2.04 | .04 |
| U1-PP | 27.31 | 2.67 | 27.37 | 2.49 | −0.07 | .93 |
| U6-PP | 22.69 | 1.92 | 23.05 | 1.72 | −0.67 | .50 |
| U6-ANSperp | −30.81 | 2.89 | −27.48 | 2.31 | 4.36 | .00 |
| U1.NA (°) | 22.21 | 6.63 | 23.26 | 5.17 | −0.60 | .54 |
| U1-NA (mm) | 3.40 | 2.56 | 4.34 | 2.00 | −1.40 | .16 |
| Mandibular dentoalveolar component | | | | | | |
| IMPA | 99.36 | 7.16 | 90.36 | 4.49 | 5.18 | .00 |
| L1-Pgnperp | −7.85 | 2.56 | −10.92 | 2.50 | 4.15 | .00 |
| L1-MP | 38.01 | 2.56 | 38.11 | 2.02 | −0.15 | .87 |
| L1.NB (°) | 30.42 | 5.76 | 23.46 | 3.83 | 4.89 | .00 |
| L1-NB (mm) | 5.83 | 1.39 | 3.78 | 1.60 | 4.68 | .00 |
| L6-Pgnperp | −29.29 | 2.48 | −30.98 | 2.71 | 2.22 | .03 |
| L6-MP | 29.31 | 2.77 | 28.89 | 1.82 | 0.62 | .53 |
| Dentoalveolar relationships | | | | | | |
| Overjet | 2.72 | 0.73 | 2.77 | 0.61 | −0.26 | .79 |
| Overbite | 2.04 | 1.22 | 2.84 | 1.27 | −2.18 | .03 |
| Molar relationship | 2.31 | 0.70 | 1.70 | 0.75 | 2.89 | .00 |

ferences, especially those related to the maxillomandibular relationship and to the mandibular dentoalveolar component. However, in spite of these characteristic differences between the two groups, it was considered that the normal occlusion group could be used as a reliable control to evaluate the changes because these changes are shown to be similar in Class II malocclusion and normal occlusion groups during this period.[15–18]

## Treatment changes

Although the main focus of this investigation is the posttreatment changes of the experimental group, knowledge of the treatment changes may help in the understanding of the stability or relapse of the investigated variables during the posttreatment period. The results from this work are in agreement with those of most studies (Table 4). There was

**TABLE 4.** Means, Standard Deviations, and Results of the *t*-test Between Treatment Changes That Occurred in the Experimental Group and in the Control group I, During a Compatible Time Period

| | Experimental (n = 23) | | Control I (n = 15) | | | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | *t* | *P* |
| Maxillary component | | | | | | |
| SNA | −1.36 | 1.67 | 1.14 | 1.36 | −4.82 | .00 |
| A-Nperp | −1.63 | 1.79 | 1.86 | 2.07 | −5.52 | .00 |
| Co-A | 1.80 | 2.10 | 4.68 | 3.18 | −3.35 | .00 |
| Mandibular component | | | | | | |
| SNB | 1.21 | 1.71 | 1.12 | 1.74 | 0.16 | .87 |
| P-Nperp | 1.37 | 3.26 | 3.34 | 4.63 | −1.54 | .13 |
| Co-Gn | 7.54 | 3.43 | 7.08 | 3.71 | 0.39 | .69 |
| Go-Gn | 4.08 | 2.47 | 4.14 | 2.28 | −0.06 | .94 |
| Co-Go | 4.89 | 2.65 | 4.74 | 2.64 | 0.16 | .87 |
| Maxillomandibular relationship | | | | | | |
| ANB | −2.57 | 1.21 | 0 | 1.03 | −6.46 | .00 |
| Wits | −0.42 | 2.06 | 1.90 | 2.36 | −3.20 | .00 |
| NAP | −6.02 | 2.84 | −0.44 | 2.81 | −5.94 | .00 |
| Co-A/CoGn | −3.93 | 1.48 | −0.90 | 1.74 | −5.72 | .00 |
| Vertical and horizontal components | | | | | | |
| SN.GoGn | −0.37 | 2.02 | −1.41 | 2.16 | 1.49 | .14 |
| FMA | −0.16 | 2.06 | −2.26 | 2.00 | 3.10 | .00 |
| SN.PP | 0.20 | 1.42 | −0.41 | 2.14 | 1.06 | .29 |
| SN.FOP | −3.92 | 4.44 | −4.56 | 2.68 | 0.49 | .62 |
| LAFH | 4.37 | 2.60 | 3.55 | 2.76 | 0.93 | .35 |
| S-Go | 6.09 | 2.64 | 6.18 | 3.46 | −0.08 | .92 |
| Maxillary dentoalveolar component | | | | | | |
| U1.PP | −9.54 | 8.05 | 0.70 | 3.59 | −4.61 | .00 |
| U1-ANSperp | −3.78 | 3.23 | 0.55 | 1.51 | 4.84 | .00 |
| U1-PP | 1.62 | 1.38 | 1.04 | 1.22 | 1.30 | .19 |
| U6-PP | 2.52 | 1.60 | 2.71 | 1.18 | −0.38 | .70 |
| U6-ANSperp | −0.76 | 2.15 | 0.24 | 1.45 | −1.59 | .11 |
| U1.NA (°) | −8.40 | 8.10 | −0.03 | 2.92 | −3.82 | .00 |
| U1-NA (mm) | −2.56 | 2.67 | 0.26 | 0.79 | −3.96 | .00 |
| Mandibular dentoalveolar component | | | | | | |
| IMPA | 2.78 | 6.96 | 0.70 | 3.72 | 1.06 | .29 |
| L1-Pgnperp | −0.05 | 2.36 | −0.61 | 1.38 | 0.82 | .41 |
| L1-MP | 0.93 | 2.09 | 2.28 | 1.42 | −2.17 | .03 |
| L1.NB (°) | 3.53 | 6.84 | 0.36 | 3.46 | 1.65 | .10 |
| L1-NB (mm) | 1.16 | 1.86 | 0.30 | 0.95 | 1.65 | .10 |
| L6-Pgnperp | −0.10 | 1.51 | 0.12 | 1.61 | 0.45 | .65 |
| L6-MP | 2.66 | 1.46 | 1.92 | 1.65 | 1.44 | .15 |
| Dentoalveolar relationships | | | | | | |
| Overjet | −6.42 | 2.18 | 0.47 | 1.15 | −11.21 | .00 |
| Overbite | −2.60 | 1.79 | −0.38 | 1.61 | −3.86 | .00 |
| Molar relationship | 3.92 | 1.56 | 0.21 | 1.04 | 8.08 | .00 |

significant forward growth restriction in the maxillary complex[13,14,19–21] (Figure 2) with no significant changes in the mandibular component,[13] improvement in the basal bone relationship,[14,20,21] and favorable changes in the vertical components. The maxillary incisors were uprighted and retracted in their basal bones[13,14,19,20,22] (Figure 3), and the mandibular incisors had a statistically significant smaller vertical development than control group I. Because of dentoalveolar and skeletal changes, the overbite and the overjet were significantly reduced during treatment, as compared with control group I.[13]

## Posttreatment changes

In the posttreatment period, most of the maxillary complex changes were consequent to normal growth and development (Table 5). The maxilla resumed its natural growth pattern[12,23] without showing a meaningful contribution to the relapse of the anteroposterior relationship dis-

**TABLE 5.** Means, Standard Deviations, and Results of the *t*-test Between Posttreatment Changes in the Experimental Group and in the Control group II During a Compatible Time Period

| | Experimental (n = 23) | | Control II (n = 24) | | | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | *t* | *P* |
| Maxillary component | | | | | | |
| SNA | 0.56 | 2.03 | 0.21 | 1.28 | 0.71 | .47 |
| A-Nperp | 0.55 | 1.92 | −0.58 | 1.37 | 2.34 | .02 |
| Co-A | 1 | 2.06 | 1.69 | 2.08 | −1.13 | .26 |
| Mandibular component | | | | | | |
| SNB | 0.35 | 1.77 | 0.87 | 1.30 | −1.15 | .25 |
| P-Nperp | 0.86 | 3.33 | 0.39 | 2.65 | 0.54 | .58 |
| Co-Gn | 1.42 | 3.20 | 4.20 | 2.97 | −3.08 | .00 |
| Go-Gn | 1.30 | 2.30 | 1.65 | 1.88 | −0.55 | .58 |
| Co-Go | 1.24 | 2.67 | 3.79 | 2.50 | −3.36 | .00 |
| Maxillomandibular relationship | | | | | | |
| ANB | 0.22 | 1.28 | −0.67 | 0.92 | 2.75 | .00 |
| Wits | 0.23 | 1.93 | 0.67 | 2.07 | −0.75 | .45 |
| NAP | 0.35 | 3.06 | −1.75 | 1.96 | 2.81 | .00 |
| Co-A/CoGn | −0.03 | 1.76 | −1.25 | 0.97 | 2.97 | .00 |
| Vertical and horizontal components | | | | | | |
| SN.GoGn | −0.92 | 2.09 | −1.67 | 1.92 | 1.27 | .20 |
| FMA | −0.95 | 1.93 | −0.94 | 1.57 | −0.02 | .98 |
| SN.PP | −0.36 | 1.61 | −0.66 | 1.51 | 0.64 | .51 |
| SN.FOP | −0.49 | 3.22 | −3.53 | 3.85 | 2.92 | .00 |
| LAFH | 0.80 | 2.23 | 2.18 | 2.26 | −2.11 | .04 |
| S-Go | 1.58 | 2.83 | 4.07 | 3.25 | −2.79 | .00 |
| Maxillary dentoalveolar component | | | | | | |
| U1.PP | 0.53 | 4.31 | −0.07 | 2.14 | 0.61 | .54 |
| U1-ANSperp | 0.11 | 1.74 | 0.08 | 1.20 | −0.07 | .93 |
| U1-PP | 0.6 | 0.98 | 0.76 | 0.80 | −0.62 | .53 |
| U6-PP | 0.31 | 1.27 | 1.75 | 1.29 | −3.85 | .00 |
| U6-ANSperp | 0.99 | 1.69 | 0.87 | 1.68 | −0.23 | .81 |
| U1.NA (°) | 0.33 | 4.76 | 0.37 | 2.25 | −0.04 | .96 |
| U1-NA (mm) | 0.26 | 1.90 | 0.75 | 0.95 | −1.11 | .27 |
| Mandibular dentoalveolar component | | | | | | |
| IMPA | −0.19 | 4.87 | 0.57 | 2.30 | −0.69 | .48 |
| L1-Pgnperp | −0.12 | 1.34 | −0.32 | 1.51 | 0.47 | .63 |
| L1-MP | 1.22 | 1.80 | 1.21 | 1.06 | 0.03 | .97 |
| L1.NB (°) | −0.71 | 4.97 | −0.23 | 2.56 | −0.41 | .68 |
| L1-NB (mm) | 0.11 | 1.22 | 0 | 0.64 | 0.41 | .68 |
| L6-Pgnperp | 0.90 | 1.06 | 0.30 | 1.75 | 1.40 | .16 |
| L6-MP | 1.11 | 1.57 | 1.26 | 1.53 | −0.32 | .75 |
| Dentoalveolar relationships | | | | | | |
| Overjet | 0.40 | 1.31 | −0.15 | 0.53 | 1.93 | .05 |
| Overbite | 1.05 | 1.11 | −0.20 | 0.85 | 4.38 | .00 |
| Molar relationship | −0.41 | 0.94 | −0.24 | 1 | −0.60 | .55 |

crepancy. Only changes in the variable A-Nperp showed a statistically significant increase and therefore a trend toward relapse. However, a change of 0.5 mm in a mean period of five years should not be considered as clinically significant.[24]

On the other hand, changes in Co-Gn and Co-Go clearly show a reduction in the mandibular growth rate in the posttreatment period (Figure 4; Table 5), which is in accordance with other studies.[1,12] The presence of a statistically significant inverse correlation between the changes in Go-Gn during and after treatment shows that the greater the mandibular growth during treatment, the smaller it will be in the posttreatment period (Table 6). Works published by De Vincenzo[4] and Pancherz and Hansen[12] also demonstrated similar correlations with regard to mandibular growth.

Therefore, because the mandible showed a reduced growth rate and the maxilla resumed its normal development, a slight increase in the ANB and NAP angles were expected to occur as reported by others.[12,25] The same was true for the Co-A/Co-Gn ratio where a more reduced

**TABLE 6.** Means, Standard Deviations, and Results of Pearson's Correlation Test Between Changes That Occurred During and After Treatment in the Experimental Group (n = 23)

| | Treatment changes | | Posttreatment changes | | | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | *r* | *P* |
| Maxillary component | | | | | | |
| SNA | −1.36 | 1.67 | 0.56 | 2.03 | 0.00 | .97 |
| A-Nperp | −1.63 | 1.79 | 0.55 | 1.92 | −0.35 | .09 |
| Co-A | 1.80 | 2.10 | 1 | 2.06 | −0.40 | .05 |
| Mandibular component | | | | | | |
| SNB | 1.21 | 1.71 | 0.35 | 1.77 | −0.15 | .48 |
| P-Nperp | 1.37 | 3.26 | 0.86 | 3.33 | −0.31 | .14 |
| Co-Gn | 7.54 | 3.43 | 1.42 | 3.20 | −0.26 | .22 |
| Go-Gn | 4.08 | 2.47 | 1.30 | 2.30 | −0.44 | .03 |
| Co-Go | 4.89 | 2.65 | 1.24 | 2.67 | −0.34 | .10 |
| Maxillomandibular relationship | | | | | | |
| ANB | −2.57 | 1.21 | 0.22 | 1.28 | −0.25 | .24 |
| Wits | −0.42 | 2.06 | 0.23 | 1.93 | −0.40 | .05 |
| NAP | −6.02 | 2.84 | 0.35 | 3.06 | −0.13 | .54 |
| Co-A/CoGn | −3.93 | 1.48 | −0.03 | 1.76 | −0.39 | .05 |
| Vertical and horizontal component | | | | | | |
| SN.GoGn | −0.37 | 2.02 | −0.92 | 2.09 | −0.12 | .56 |
| FMA | −0.16 | 2.06 | −0.95 | 1.93 | −0.14 | .50 |
| SN.PP | 0.20 | 1.42 | −0.36 | 1.61 | −0.24 | .26 |
| SN.FOP | −3.92 | 4.44 | −0.49 | 3.22 | −0.44 | .03 |
| LAFH | 4.37 | 2.60 | 0.8 | 2.23 | −0.24 | .27 |
| S-Go | 6.09 | 2.64 | 1.58 | 2.83 | −0.10 | .64 |
| Maxillary dentoalveolar component | | | | | | |
| U1.PP | −9.54 | 8.05 | 0.53 | 4.31 | −0.46 | .02 |
| U1-ANSperp | −3.78 | 3.23 | 0.11 | 1.74 | −0.43 | .04 |
| U1-PP | 1.62 | 1.38 | 0.60 | 0.98 | −0.20 | .35 |
| U6-PP | 2.52 | 1.60 | 0.31 | 1.27 | −0.08 | .71 |
| U6-ANSperp | −0.76 | 2.15 | 0.99 | 1.69 | −0.36 | .08 |
| U1.NA (°) | −8.4 | 8.10 | 0.33 | 4.76 | −0.43 | .03 |
| U1-NA (mm) | −2.56 | 2.67 | 0.26 | 1.90 | −0.46 | .02 |
| Mandibular dentoalveolar component | | | | | | |
| IMPA | 2.78 | 6.96 | −0.19 | 4.87 | −0.65 | .00 |
| L1-Pgnperp | −0.05 | 2.36 | −0.12 | 1.34 | −0.30 | .15 |
| L1-MP | 0.93 | 2.09 | 1.22 | 1.80 | −0.47 | .02 |
| L1.NB (°) | 3.53 | 6.84 | −0.71 | 4.97 | −0.63 | .00 |
| L1-NB (mm) | 1.16 | 1.86 | 0.11 | 1.22 | −0.47 | .02 |
| L6-Pgnperp | −0.10 | 1.51 | 0.9 | 1.06 | −0.12 | .57 |
| L6-MP | 2.66 | 1.46 | 1.11 | 1.57 | −0.32 | .12 |
| Dentoalveolar relationships | | | | | | |
| Overjet | −6.42 | 2.18 | 0.40 | 1.31 | −0.38 | .06 |
| Overbite | −2.60 | 1.79 | 1.05 | 1.11 | −0.51 | .01 |
| Molar relationship | 3.92 | 1.56 | −0.41 | 0.94 | −0.45 | .02 |

change was expected, thus suggesting a slight trend toward relapse of the Class II anteroposterior maxillomandibular relationship (Table 5).

Growth that usually takes place in the posttreatment period is characterized by a mandibular counterclockwise rotation in response to the vertical redirection of condylar growth,[26] as also observed by a decrease in angles SN.GoGn, FMA, and SN.PP (Table 5). The occlusal plane also exhibited a counterclockwise rotation but rather smaller than in the normal occlusion subjects. A statistically significant inverse correlation was detected for the occlusal plane rotation during and after treatment, ie, the greater its counterclockwise rotation during treatment, the more it reduced in the posttreatment period (Table 6). The significantly smaller changes for LAFH and S-Go related to total mandibular growth and to mandibular ramus growth in height, respectively, which again reflect the more reduced mandibular growth in the experimental group than in control group II, in the posttreatment period (Table 5).

A statistically significant inverse correlation was ob-

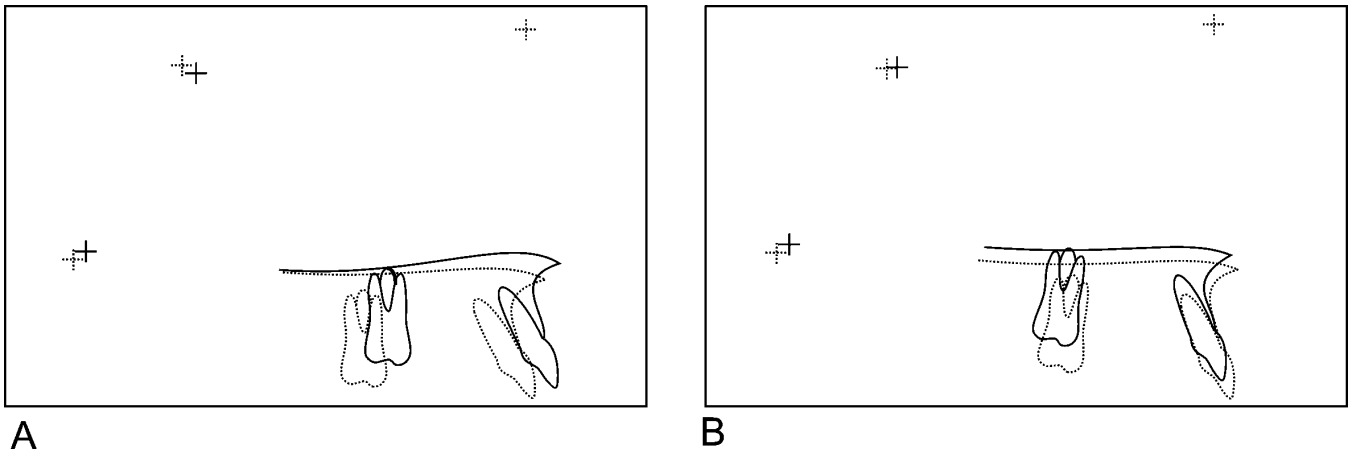


**FIGURE 2.** The software Dentofacial Planner 7.2, used to measure the variables, is capable of creating a mean tracing for each group, at each stage. Therefore, Figures 2 through 4 are based on superimposition of these mean tracings to illustrate the differences of the changes between the experimental and control groups. (A) Superimposition on BaN, registered on N, of the initial (continuous) and final (dotted) mean tracings of the experimental group (n = 23). (B) Same superimposition of the initial (continuous) and final (dotted) mean tracings of control group I (n = 15).

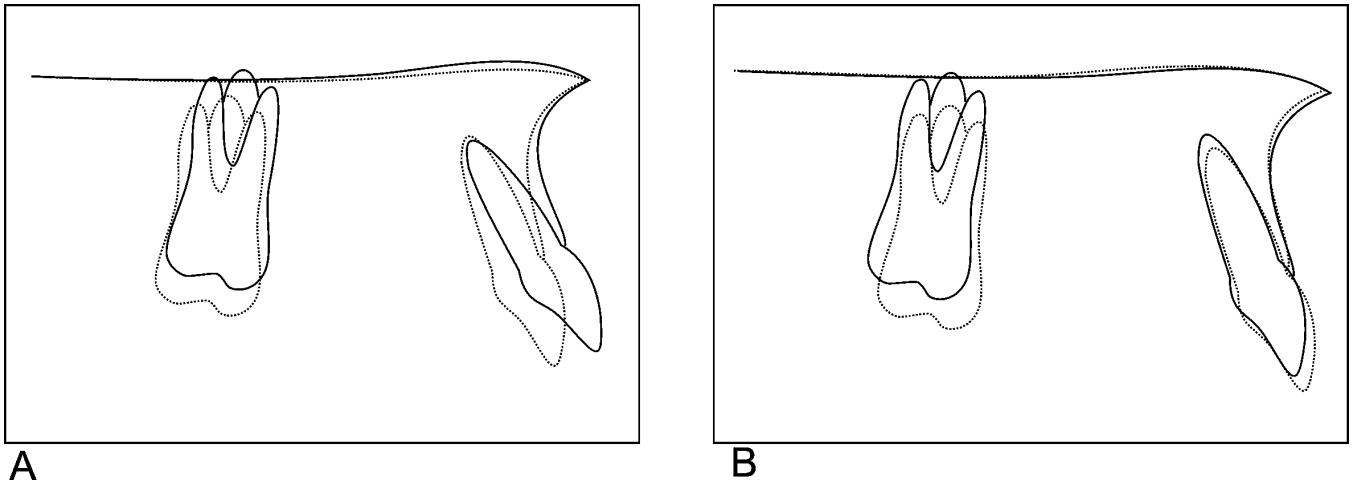


**FIGURE 3.** (A) Superimposition on the palatal plane, registered on the anterior nasal spine, of the initial (continuous) and final (dotted) mean tracings of the experimental group (n = 23). (B) Same superimposition of the initial (continuous) and final (dotted) mean tracings of control group I (n = 15).

served to exist between the changes occurring during and after treatment in the variables U1.PP, U1-ANSperp, U1.NA, and U1-NA, ie, the more the maxillary incisors are uprighted or retracted, the less stable they are in the posttreatment period (Table 6) as reported by others.[12,27] Pearson's correlation coefficient also indicated that the more the mandibular incisors are labially tipped during treatment, the less their stability in the posttreatment period, as also reported by Elms et al.[28] However, despite this trend, there was stability of the sagittal position of the incisors (Figure 4; Table 5). Consequently, stability of the sagittal changes of the maxillary and mandibular incisors contributed to stability of the overjet correction (Table 5).

A statistically significant inverse correlation was observed between the overbite changes during and after treatment, ie, the greater its reduction during treatment, the less its stability in the posttreatment period (Table 6). This correlation was also found by Uhde et al.[29] This result indirectly confirms that the greater the pretreatment overbite, the greater is the relapse tendency, as reported by others.[30,31] There was a statistically significant relapse of the overbite, confirming this correlation (Table 5).

The experimental group developed much less vertical maxillary molar development than control group II (Table 5). Thus, this statistically significant difference between the groups suggests a certain relapse of maxillary molar extrusion that probably occurred during the fixed appliance treatment period.

A statistically significant inverse correlation was also found between changes in molar relationship during and

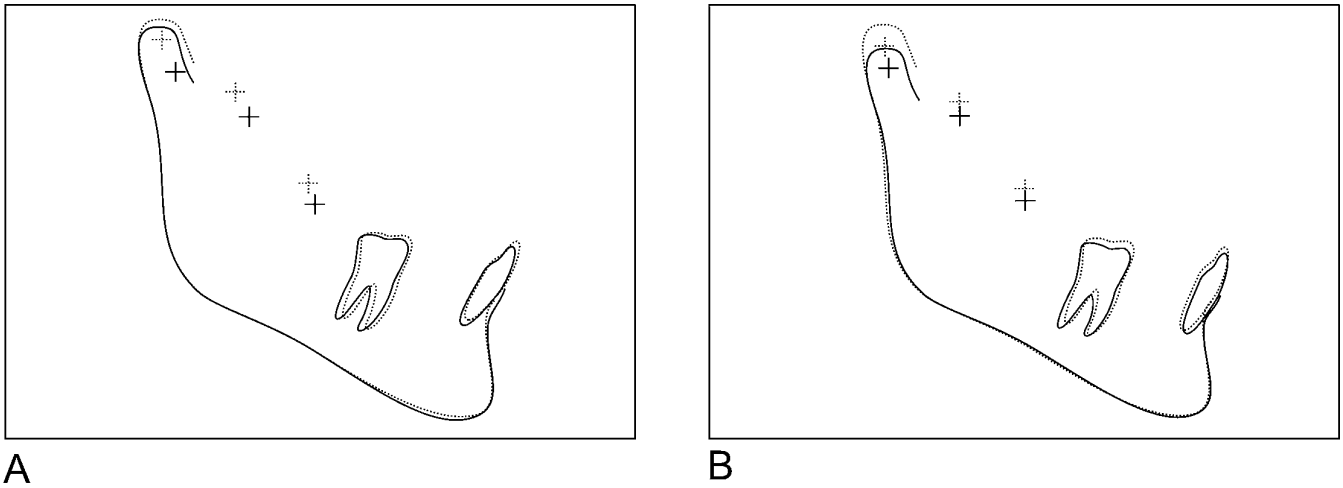


**FIGURE 4.** (A) Superimposition on the mandibular plane, registered on the symphysis, of the final (continuous) and posttreatment (dotted) mean tracings of the experimental group (n = 23). (B) Same superimposition of the initial (continuous) and final (dotted) mean tracings of control group II (n = 24).

after treatment, ie, the greater its change during treatment, the less its stability (Table 6). However, the correlation coefficient was low (−0.45). This was also reported by Pancherz and Hansen[12] after Herbst appliance treatment. Despite this tendency, the molar relationship was stable in the posttreatment period (Table 5).

Active retention time, length of posttreatment period, initial Class II malocclusion severity (ANB and Wits), and initial molar relationship did not present any correlation with molar relationship and overjet relapse. These results are similar to those of Fidler et al,[32] who found no association between overjet relapse and pretreatment cephalometric characteristics in Class II, division 1 cases. The only initial variable showing a significant correlation with molar relationship and overjet relapse was initial overjet, and the values for these correlations were low ($r$ = .52 and $r$ = .43), as reported previously.[27] Taking into account the dentoalveolar changes stability of the overjet and molar relationship, it can be inferred that the unfavorable posttreatment growth produced small negative effects on the occlusion, so that the occlusal relationship achieved was maintained. However, it has to be emphasized that the stability achieved was probably consequent to the amount of active retention used during the fixed appliance phase of treatment, although no correlation could be demonstrated.

## CONCLUSIONS

The anteroposterior dentoalveolar changes obtained with the headgear-activator combined appliance, followed by fixed edgewise appliances, were demonstrated to be stable on a long-term basis.

Sagittal position of both the maxilla and the mandible was stable in the long term. However, a slight relapse of the maxillomandibular relation correction occurred, probably because the maxilla resumed its normal development and the mandible showed a growth rate significantly smaller than the control group.

The overbite exhibited a statistically significant relapse, which was directly proportional to the amount of its correction.

There were low but significant inverse correlations between the changes in Go-Gn during and after treatment and between the uprighting of the maxillary incisors, labial tipping of the mandibular incisors, and the amount of molar relationship correction during treatment and their stability in the posttreatment period.

Active retention time, length of the posttreatment period, initial Class II malocclusion severity (ANB and Wits), and initial molar relationship did not present any correlation with molar relationship and overjet relapse. However, the initial overjet presented a low but statistically significant correlation with molar relationship relapse and overjet relapse.

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