Original Article

Long-Term Outcomes of Class III Treatment with Mandibular Cervical Headgear Followed by Fixed Appliances

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ABSTRACT

Objective: To evaluate the stability of the outcomes of mandibular cervical headgear (MCH) and fixed appliance–treated Class III patients at a long-term posttreatment (5 years) observation, compared with well-matched untreated Class III controls, following a previous report on the short-term outcomes of this protocol.

Materials and Methods: The treated group consisted of 20 patients with dentoskeletal Class III malocclusions treated with a two-phase protocol consisting of MCH and fixed appliances, while the control group comprised 18 untreated subjects with similar dentoskeletal Class III malocclusion. Lateral cephalograms of both patients and controls were analyzed at two time points: posttreatment (PT), after two-phase treatment; and long term (LT). All patients were at a postpubertal stage of skeletal maturity at PT, and they showed CS6 at LT, thus revealing completion of pubertal craniofacial growth.

Results: In the long term, the treatment group showed significantly smaller values for mandibular length (Co-Gn), SNB angle, maxillomandibular differential, and molar relation. When compared with the controls, the treated patients exhibited also greater values for ANB angle, Wits appraisal, and overjet at LT. No significant difference between the two groups was found for the changes occurring from PT to LT.

Conclusions: Favorable dentoskeletal outcomes induced by MCH and fixed appliances remained stable in the long term; untreated Class III malocclusion did not show any tendency toward self-improvement during the postpubertal interval. (*Angle Orthod.* 2009;79:828–834.)

KEY WORDS: Class III malocclusion; Mandibular headgear; Long-term assessment; Cephalometrics

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INTRODUCTION

One of the most problematic clinical aspects of dentofacial orthopedics in Class III malocclusions is the possibility of relapse after the active treatment period.[1–3] Although there is much literature about the dentofacial changes induced by different treatment protocols in the short term,[4–13] only a few authors have studied the posttreatment changes in Class III patients.[14] Even fewer are those studies that have analyzed the stability of treatment results at a postpubertal stage of development.[15–17] The most recent of these investigations[17] evaluated the therapeutic effects of a treatment protocol for Class III malocclusion consisting of mandibular cervical headgear (MCH) followed by fixed appliances. The favorable skeletal effects of the treatment protocol consisted mainly of smaller increases in mandibular length and advancement, with the final outcome of significant improvement in sagittal skeletal and dental relationships. A concurrent study[18] dem-

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onstrated that the prevalence of TMJ problems in subjects treated with MCH and fixed appliances was not greater than in untreated subjects or subjects with Class I malocclusions treated with standard fixed appliances.

Previously Reported Data: Treatment and Short-term Posttreatment Outcomes of MCH and Fixed Appliance Therapy

In a previous cephalometric investigation,[17] we compared the treatment and posttreatment effects on patients undergoing an initial phase of MCH therapy followed by comprehensive edgewise therapy with untreated Class III controls. At the initial observation (T1), all patients had Class III malocclusion characterized by anterior crossbite or edge-to-edge incisors and a Wits appraisal of −1.5 mm or less. All patients were of white ancestry. No permanent teeth were congenitally missing or extracted before or during treatment. The treated sample consisted of 21 patients treated consecutively with MCH before the pubertal growth spurt (average age, 10 years 2 months at the beginning of treatment). At the final observation period (average age, 15 years 7 months), all patients were in decelerating growth phases as determined by the cervical vertebral maturation method (CS 4 to CS 6).[19] Active treatment and posttreatment effects were evaluated in the treated group with nonparametric statistical analysis for paired samples. The treated sample was compared with a nonparametric statistical test for independent samples with 20 untreated Class III subjects who were matched for malocclusion, sex, and stage of cervical vertebral maturation to the treatment group.

No significant differences in the craniofacial forms of treated and untreated subjects were present at T1. MCH therapy followed by fixed appliances was shown to be an effective treatment for the correction of skeletal Class III malocclusion at postpubertal observation. The favorable skeletal effects consisted mainly of smaller increases in mandibular length and advancement with respect to the controls, with the final outcome of significant improvements in the sagittal skeletal (+4 mm for the Wits appraisal) and dental (+2.7 mm for overjet, −4.4 mm for molar relationship) parameters. This treatment protocol also induced significant downward rotation of the mandible (2.8°).

Treatment and Retention Protocols

As the first phase of the treatment protocol, an MCH was adapted on bands on the first lower molars. The length of the extraoral arch was determined so that the line of action of the force passed through the center of resistance of the mandibular first permanent molar. The force delivered was 300 g per side, and it was checked at monthly appointments. All patients received instructions to use the appliance for 14 hours per day. Cooperation was good for all of them. About 1.5 years later, all patients continued to use the MCH, and orthodontic correction was started in the maxillary arch with fixed appliances. One year later, fixed appliances were used in the mandibular arch to finish improving the occlusion. After fixed appliances were removed, the patients used passive Hawley retainers.

Objective of the Present Study: Long-term Evaluation of Posttreatment Outcomes

The purpose of the present study was to evaluate the stability of the outcomes of the MCH and fixed appliance protocol in Class III patients at the completion of active craniofacial growth, at an average time interval of 5 years following therapy. Treatment and long-term posttreatment outcomes will be compared with a longitudinal control group of untreated subjects with Class III malocclusions.

MATERIALS AND METHODS

In the current follow-up study, the treated group consisted of 20 patients with dentoskeletal Class III malocclusion treated consecutively with MCH followed by fixed appliances by one operator. Success of the therapy was not a determinant for selection of patients. One patient dropped out from the original treatment sample during the follow-up interval because he could not be located at recall. Lateral cephalograms were taken 2 years after the end of two-phase treatment (PT) and about 5 years after the end of treatment as a long-term observation (LT).

A control group of 18 untreated subjects with dentoskeletal Class III malocclusion was obtained from the Department of Orthodontics at the University of Florence, Italy, and the University of Michigan. Long-term observations could not be obtained for two subjects of the original control sample used in our previous study.[17] All subjects in the treatment group were of white ancestry. Lateral cephalograms were available at two time periods that matched PT and LT. Magnification was corrected to 8% enlargement for all radiographs of both the treated and the control samples. Demographics for the two examined groups are shown in Table 1. No forward functional displacement of the mandible was present in any of the subjects in either group.

Skeletal Maturity

The cervical stage (CS) of vertebrae development[19] was used to indicate the skeletal maturity of the sub-

Table 1. Ages of the Class III Study Groups and Duration of Treatment or Observation

	MCH Group (n = 20): 5 Boys, 15 Girls		Control Group (n = 18): 6 Boys, 12 Girls	
	Mean	SD	Mean	SD
Before treatment[a]	10 y 5 mo	1 y 3 mo	10 y 1 mo	1 y 7 mo
Posttreatment (2 y after end of treatment) (PT)[b]	15 y 7 mo	1 y 5 mo	15 y 3 mo	1 y 8 mo
Long term (5 y after the end of treatment) (LT)[b]	18 y 5 mo	1 y 4 mo	17 y 10 mo	1 y 6 mo
Before treatment to PT interval[a]	5 y 1 mo	1 y 6 mo	5 y 3 mo	1 y 3 mo
PT to LT interval[b]	3 y 1 mo	1 y 2 mo	2 y 10 mo	1 y 2 mo

[a] As reported in a previous short-term study.[17]
[b] Current study.

jects in both groups, independently of chronologic age. All patients with the MCH and fixed appliances were at a postpubertal stage (CS4-CS6) at PT, and they all presented with CS6 at LT, thus indicating completion of pubertal craniofacial growth. The stages were classified by an operator trained in this method.

Cephalometric Analysis

A customized digitization regimen and analysis were used for all cephalograms examined in this study. The regimen contained measurements from the analyses of Jacobson,[20] McNamara,[21] Ricketts,[22] and Steiner.[23]

Before the cephalometric analysis, the intraobserver variation was evaluated. Fourteen lateral cephalograms, selected from various subjects in the study, were traced and measured two times within a week. The measurements at both times for each patient were analyzed with the intraclass coefficient correlation, which varied between 0.96° for the SNB angle and 0.99° for the inclination of the maxillary incisor to the Frankfort horizontal line. These values indicated a high level of intraobserver agreement.

Linear measurement errors ranged from 0.1 to 0.3 mm (SD, 0.8 mm), and angular measurements varied by 0.2° (SD, 0.4°–0.6°).

Statistical Analysis

Descriptive statistics were calculated for all cephalometric measures at PT and LT in the treated and control groups. The data were analyzed with SPSS software (version 12.0; SPSS, Chicago, Ill). Statistical significance was tested at $P < .05$ and $P < .01$.

An exploratory Shapiro-Wilks test indicated lack of normality of the distribution of the examined parameters. Therefore, the nonparametric Mann-Whitney *U*-test was used for comparisons. Significant differences between the craniofacial forms at both PT and LT time points were assessed between the treated and the control groups. Because of the homogeneity of the two groups as to type of malocclusion, gender distribution, cephalometric magnification, skeletal maturation at the three time points, and duration of observation intervals, between-group comparisons were performed also on the changes in the craniofacial variables between PT and LT at T2 and T3 to test for treatment stability.

RESULTS

The statistical comparison of the craniofacial forms at PT between the two groups showed several significant effects of two-phase therapy of Class III malocclusion followed by retention (Table 2). These results were already described by the previous report,[17] which also showed the absence of significant pretreatment differences between the two groups, with the exception of more proclined upper incisors in the starting form of the treatment group.[17] At PT, the treatment group showed significantly smaller values for Co-Gn, SNB angle, maxillomandibular differential, and molar relation. When compared with the controls, at PT the treated patients exhibited also greater values for ANB angle, Wits appraisal, and overjet.

All of these differences remained statistically significant at LT (Table 3), with the addition of significantly smaller values for the distance from pogonion to the nasion perpendicular and of significantly greater values for the MPA in the treated group in the LT.

No significant differences between the two groups were assessed for the changes in the dentofacial variables from PT to LT time points (Table 4). This outcome revealed absence of a relapse tendency in the transition from the posttreatment to the long-term observations.

DISCUSSION

In the present controlled clinical trial on consecutively treated patients, we evaluated the long-term posttreatment effects of MCH and fixed appliances in growing subjects with Class III malocclusions following a preliminary report that described the treatment and short-term posttreatment outcomes for this protocol.[17] Several methodological and clinical features of the research need to be clarified:

- The long-term follow-up observation was recorded

Table 2. Statistical Comparison of the Treated and Control Class III Groups at the Short-term Posttreatment Observation (PT)[a]

	PT Treated Group (n = 20) 15 y 7 mo 5 Male; 15 Female CS 4 or 5 or 6		PT Control Group (n = 18) 15 y 3 mo 6 Male; 12 Female CS 4 or 5 or 6		Statistical Comparison (Mann-Whitney *U*-Test)
	Mean	SD	Mean	SD	Difference
CranFlex, °	128.1	5.2	128.3	5.0	−0.2, ns
CO-A, mm	85.5	4.3	83.2	4.6	+2.3, ns
SNA, °	81.1	4.0	79.8	4.1	+1.4, ns
Pt A to N, mm	−1.1	3.3	−1.8	3.4	−0.7, ns
CoGn, mm	118.9	6.5	123.2	6.6	−4.3*
SNB, °	79.9	3.8	82.5	3.2	−2.6*
Pog to N, mm	−2.0	4.1	−3.7	4.0	−1.7, ns
ArGoMe, °	132.9	4.4	131.1	4.5	+1.8, ns
WITS, mm	−2.4	2.3	−7.4	2.2	+5.0**
MaxMandDiff, mm	33.4	4.7	39.8	4.7	−6.4**
ANB, °	1.2	2.0	−2.4	2.1	+3.6**
FH-PP, °	−1.1	2.2	−0.1	2.1	−1.0, ns
MPA, °	29.1	4.1	27.0	4.0	+2.1, ns
N-ANS, mm	52.2	3.0	51.8	3.6	+0.4, ns
ANS-Me, mm	69.5	4.4	66.8	4.7	+2.7, ns
Overbite, mm	1.6	0.7	0.9	0.9	+0.8, ns
Overjet, mm	1.7	0.6	−1.3	0.7	+3.0**
MolRel, mm	2.2	0.5	5.7	0.7	−3.5**
U1-FH, °	116.4	4.9	116.2	4.8	+0.2, ns
L1 A-Pog, mm	2.5	2.1	2.2	2.2	+0.3, ns
L1 MPA, °	87.1	6.3	86.7	6.0	+0.4, ns
Nasolabial angle,°	101.8	10.3	103.8	9.8	−2.0, ns

[a] This observation represents the starting form for the current study on long-term posttreatment changes following mandibular cervical headgear and fixed appliance therapy. ns indicates not significant.

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

approximately 5 years after the end of treatment, when all subjects had reached CS6 in skeletal maturity.

- The posttreatment changes in the treated group were compared with the growth changes in the untreated controls with Class III malocclusions.
- The treated and control groups had no statistically significant differences as to race, gender distribution, mean age, mean observation intervals, or craniofacial characteristics at initial observation (as assessed in the preliminary report[17]).

To our knowledge, this study represents the first attempt to evaluate the stability of Class III treatment results by taking into account records collected by the end of active craniofacial growth (CS6) and by including longitudinal long-term observations of untreated Class III controls. All treated subjects exhibited a stage CS6 at LT when they were recalled for the long-term reevaluation. Most of them (all the 16 females, and 1 male) had reached CS6 at least 2 years before the final recall (LT). The age of patients at LT ranged from 16 years 9 months (female patient) to 20 years 6 months (male patient). As indicated previously, the group of untreated Class III subjects who served as controls was followed longitudinally until young adulthood as well, similarly to the treated group. All Class III control subjects showed CS6 at LT: once again, this mature developmental stage had been attained at least 2 years before LT in the vast majority of control subjects (all 12 females and 2 males). The age of Class III controls at LT ranged from 16 years 3 months (female subject) to 20 years 4 months (male subject).

The short-term posttreatment effects recorded at PT remained substantially stable at LT. The differences between the two study groups at the long-term observation revealed significantly smaller values in the treatment group for mandibular length (Co-Gn, −5.7 mm) and protrusion (NPog, −1.9 mm: SNB, −2.2°), thus leading to significant improvements in the Wits (6.6 mm), maxillomandibular differential (−6.5 mm), ANB (3.8°), overjet (3.9 mm), and molar relation (−4.5 mm). In addition to these dentoskeletal effects, a greater value for the mandibular plane angle (2.5° difference) was recorded in the treated group versus the controls in the long term. The treated sample did not exhibit the tendency to a counterclockwise rotation of the mandibular plane to the cranial base that was apparent in the Class III controls. This finding confirms previous indications that recommended MCH and fixed appliance therapy in Class III patients with a low-angle ten-

Table 3. Statistical Comparison of the Treated and Control Class III Groups at the Long-term Posttreatment Observation (LT)

	LT Treated Group (n = 20) 18 y 6 mo 4 Males; 16 Females CS 6		LT Control Group (n = 18) 17 y 10 mo 6 Males; 12 Females CS 6		Statistical Comparison (Mann-Whitney *U*-Test)
	Mean	SD	Mean	SD	Difference
CranFlex, °	128.4	5.4	127.8	5.2	−0.2, ns
CO-A, mm	86.3	4.3	84.8	4.3	+1.5, ns
SNA, °	81.4	4.5	80.2	4.1	+1.2, ns
Pt A to N, mm	−0.8	3.1	−1.8	3.3	+1.0, ns
CoGn, mm	120.8	6.1	126.5	5.8	−5.7**
SNB, °	80.4	3.4	82.6	2.9	−2.2*
Pog to N, mm	−2.0	3.2	−3.9	2.1	+1.9*
ArGoMe, °	132.9	4.4	131.8	4.4	+1.1, ns
WITS, mm	−2.7	2.7	−9.1	2.3	+6.6**
MaxMandDiff, mm	34.6	4.7	41.1	4.4	−6.5**
ANB, °	1.0	2.3	−2.8	2.0	+3.8**
FH-PP, °	−1.3	2.3	−0.5	2.2	−0.8, ns
MPA, °	28.9	4.4	26.4	3.3	+2.5*
N-ANS, mm	52.9	2.8	53.7	3.0	−0.8, ns
ANS-Me, mm	70.3	4.5	69.2	4.4	+1.1, ns
Overbite, mm	1.4	0.8	0.6	0.7	+0.8, ns
Overjet, mm	1.7	0.7	−2.2	0.6	+3.9**
MolRel, mm	2.4	0.7	6.9	0.7	−4.5**
U1-FH, °	117.0	4.8	115.7	4.9	+1.3, ns
L1 A-Pog, mm	2.4	3.6	3.1	2.1	−0.7, ns
L1 MPA, °	86.5	5.7	85.5	6.2	+1.0, ns
Nasolabial angle, °	102.0	10.1	104.6	9.7	−2.6, ns

[a] ns indicates not significant.
* $P < .05$; ** $P < .01$.

dency.[17] The amount of dental compensation through proclination of upper incisors and lingual inclination of lower incisors was very limited in the current study, both after treatment and in the long term. This was probably due to a specific use of the fixed appliances, and it may explain differences in dental outcomes with regard to previous studies.[13]

When the changes between the short-term posttreatment observation and the long-term posttreatment observation were compared between the treated group and the controls, no significant differences were found. Generally, the differences between the two groups for the modifications in the dentofacial variables were modest, never exceeding 1.5 mm or 1.5°. It should be noted that sagittal and occlusal relationships did not show any tendency to relapse, with the exception of a smaller amount of sagittal growth of the maxilla (Co-A, −0.8 mm in the treatment group compared with controls, not statistically significant).

From the analysis of the results of the present long-term controlled clinical trial, it can be derived that, when left untreated, Class III malocclusion does not show any improvement during the postpubertal ages until the completion of active growth. These data are in agreement with previous observations from both large cross-sectional studies[24] and smaller longitudinal investigations of growth in untreated Class III malocclusion.[11]

In the long term, the effects of an orthopedic/orthodontic treatment protocol such as MCH and fixed appliances appear to be stable since the dentoskeletal improvements achieved during active treatment are successfully able to withstand unfavorable posttreatment growth trends in Class III patients. It should be emphasized that active treatment and retention were not discontinued in any of the treated patients until a postpubertal stage of skeletal development had been attained (CS4 to CS6). The persistence of therapy during the pubertal growth spurt was probably one of the factors accounting for the substantial stability of the outcomes in the postretention period. In fact, long-term observations on chin cup treatment[25] have shown that therapeutic effects achieved before puberty may be challenged significantly by the recurrence of the Class III growth pattern at puberty. Similar findings have been described for the RME and facial mask protocol in Class III malocclusion.[11]

The MCH and fixed appliances protocol did not produce any therapeutic effect in the maxilla either after active therapy or in the long term, in accordance with previously reported data.[17] Therefore, it appears that this treatment regimen can be particularly indicated for

Table 4. Statistical Comparison of the Changes in the Treated and Control Class III Groups During the Interval From Short-term to Long-term Posttreatment Observation (PT to LT)

	Treated Group (n = 20) PT-LT Changes		Control Group (n = 18) PT-LT Changes		Statistical Comparison (Mann-Whitney *U*-Test)
	Mean	SD	Mean	SD	Difference
CranFlex, °	+0.3	1.4	−0.5	1.2	+0.8, ns
CO-A, mm	+0.8	1.3	+1.6	1.4	−0.8, ns
SNA, °	+0.3	1.2	+0.3	1.4	0.0, ns
Pt A to N, mm	−0.3	0.9	0.0	1.1	−0.3, ns
CoGn, mm	+1.9	2.1	+3.2	2.3	−1.3, ns
SNB, °	+0.5	1.4	+0.1	1.4	+0.4, ns
Pog to N, mm	0.0	1.2	−0.2	1.3	−0.2, ns
ArGoMe, °	0.0	1.5	+0.7	1.7	−0.7, ns
WITS, mm	−0.3	1.6	−1.7	1.8	+1.4, ns
MaxMandDiff, mm	+1.1	2.1	+1.8	2.0	−0.7, ns
ANB, °	−0.2	1.3	−0.4	1.5	+0.2, ns
FH-PP, °	−0.2	1.3	−0.4	1.2	+0.2, ns
MPA, °	−0.2	1.4	−0.6	1.6	+0.4, ns
N-ANS, mm	+0.7	2.1	+1.8	2.2	−1.1, ns
ANS-Me, mm	+0.9	2.2	+2.4	2.5	−1.5, ns
Overbite, mm	−0.2	0.8	−0.3	0.9	+0.1, ns
Overjet, mm	0.0	1.2	−0.9	1.1	+0.9, ns
MolRel, mm	+0.2	1.1	+1.2	1.0	+1.0, ns
U1-FH, °	+0.6	1.8	−0.5	1.9	+1.1, ns
L1 A-Pog, mm	−0.1	2.6	+0.9	2.0	−1.0, ns
L1 MPA, °	+0.6	2.9	−1.2	2.6	+0.6, ns
Nasolabial angle, °	−0.2	3.2	+0.8	2.8	−1.0, ns

[a] ns indicates not significant.
* $P < .05$; ** $P < .01$.

the treatment of moderate Class III malocclusions associated with mandibular prognathism and normal- to low-angle vertical relationships. Finally, the cephalometric analysis used in the present study did not include any soft-tissue profile measurements for the facial profile (eg, soft-tissue pogonion) or facial proportions. These aspects deserve to be examined by further research.

CONCLUSIONS

- Significant dentoskeletal outcomes in terms of improvement of mandibular prognathism, Wits appraisal, overjet, and molar relationship induced by MCH and fixed appliances remained stable in the long term.
- In the long term, the treatment protocol produced less anterior rotation of the mandibular plane than untreated Class III controls.

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