ORIGINAL ARTICLE

Treatment and posttreatment effects of mandibular cervical headgear followed by fixed appliances in Class III malocclusion

Diego Rey,[a] David Angel,[b] Giovanni Oberti,[c] and Tiziano Baccetti[d]
Medellin, Colombia, and Florence, Italy

Introduction: In this cephalometric investigation, we compared the treatment and posttreatment effects on patients undergoing an initial phase of mandibular cervical headgear (MCH) therapy followed later by comprehensive edgewise therapy with untreated Class III controls. **Methods:** 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 3 months), all patients were in decelerative growth phases as determined by the cervical vertebral maturation method. 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. **Results and Conclusions:** 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°). (Am J Orthod Dentofacial Orthop 2008;133:371-8)

Orthopedic treatment of Class III malocclusion has generated controversy and become a challenge for the clinician because stability of the final results, after the active treatment period, can be problematic.[1-3] Several techniques and orthopedic appliances have been described to treat Class III malocclusion—Fränkel-3,[4,5] chincup,[6-8] facemask,[9-14] and mandibular cervical headgear (MCH).[15-18] Although there is much literature about the dentofacial changes of the first 3 treatment protocols, only a few authors have studied the effects of MCH as an alternate treatment for Class III malocclusion.

[a]Assistant professor and head, Department of Orthodontics, Institute of Health Sciences, CES University, Medellin, Colombia.
[b]Orthodontist, Institute of Health Sciences, CES University, Medellin, Colombia.
[c]Assistant professor, Department of Orthodontics, Institute of Health Sciences, CES University, Medellin, Colombia.
[d]Assistant professor, Department of Orthodontics, University of Florence, Florence, Italy; Thomas M. Graber Visiting Scholar, Department of Orthodontics and Pediatric Dentistry, School of Dentistry, University of Michigan, Ann Arbor, Mich.
Reprint requests to: Tiziano Baccetti, Universitá degli Studi di Firenze, Via del Ponte di Mezzo, 46-48, 50127, Firenze, Italy; e-mail, t.baccetti@odonto.unifi.it.
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Janzen and Bluher[19] reported that, after using mandibular retraction forces in monkeys, the sagittal position of the mandible remained relatively stable in relation to the cranial base; there were decreases in the mandibular plane and gonial angles, and the labial inclination of mandibular incisors; the lengthening of the mandibular ramus was less than expected. Histologically, those authors reported bone resorption in the posterior surface of the condyle and the posterior wall of the glenoid cavity, apposition in the anterior surface of the condyle, and absence of degenerative inflammatory changes. Joho[20] was the first to report the use of MCH, with forces directly applied on the mandibular molars in monkeys, and he proved its effectiveness for the treatment of Class III malocclusion. He described distalization of the mandibular molars and displacement of the mandible in a more posterior direction. In the temporomandibular joint, a wide area of bone remodeling was seen. The gonial angle was reduced during active treatment, and there were no significant changes during the retention period.

The use of the MCH in human subjects was investigated by Orton et al[15] and Battagel and Orton,[16,17] who contrasted also the dentofacial changes of the MCH with those of the facemask. The treatment protocol used by those authors consisted of a combina-

tion of a maxillary plate for incisor inclination and headgear to an intact mandibular dentition. The therapeutic effects reported for the MCH were similar to those indicated classically for the facemask in the early treatment of skeletal Class III malocclusions: correction of anterior crossbite without significant alterations in overbite, downward and backward rotation of the mandible, advancement of the maxillary complex, improvement in the inclination of the maxillary and mandibular incisors, and improvement in facial esthetics from more harmonious lip relationships. When reexamined at postretention, the subjects treated with the MCH protocol had a corrected incisor relationship. More recently, Arun and Erverdi[18] showed that treatment of Class III patients with MCH for 1 year produced significant inhibition of mandibular growth, increased lower face height, and distalization of the mandibular molars.

The purpose of this study was to evaluate the therapeutic effects of a treatment protocol for Class III malocclusion consisting of MCH followed by fixed appliances. We analyzed both active treatment and posttreatment effects in consecutively treated patients and compared these effects with the growth changes in a control group of untreated Class III subjects.

MATERIAL AND METHODS

The treated group comprised 21 patients with dentoskeletal Class III malocclusion treated with MCH followed by fixed appliances. Success of the therapy was not a determinant for selection of patients, who were consecutively treated with this protocol by 1 operator (D.R.). At the initial observation (T1), all patients had Class III malocclusion characterized by anterior crossbite and Wits appraisal[21] of −1.5 mm or less. All patients were white. No permanent teeth were congenitally missing or extracted before or during treatment. Lateral cephalograms were taken at T1, at the end of 2-phase treatment (T2), and one and a half years after the end of treatment (T3).

A control group of 20 untreated subjects with dentoskeletal Class III malocclusion was obtained from the Department of Orthodontics at the University of Florence and the University of Michigan Elementary and Secondary School Growth Study.[22] Lateral cephalograms were available at 2 time periods that matched T1 and T3. Magnification was corrected to 8% enlargement for all radiographs of both the treated and the control samples. The mean ages at the various time periods in both groups and the length of treatment or observation are given in Table I.

Table I. Ages of the Class III study groups and length of treatment or observation

	MCH group (n = 21; 6 boys, 15 girls)		*Control group (n = 20; 8 boys, 12 girls)*	
	Mean	*SD*	*Mean*	*SD*
T1	10 y 2 m	1 y 3 m	9 y 9 m	1 y 7 m
T2	13 y 8 m	1 y 5 m	-	-
T3	15 y 3 m	1 y 9 m	15 y 1 m	1 y 10 m
T3-T1	5 y 1 m	1 y 6 m	5 y 4 m	1 y 3 m

As the first phase of the treatment protocol, bands were adapted on the mandibular first permanent molars with soldered double buccal tubes. The inner arch of the headgear was adapted with a bayonet stop, leaving the anterior part of the arch in front of the lips without interfering with lip seal. The external arch was adapted to the contour of each patient's face for better comfort, and the length was determined so that the line of action of the force passed through the center of resistance of the mandibular first permanent molar. At the first appointment, 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 a day. Cooperation was good for all of them.

About a year and a half later, all patients continued to use the MCH, and orthodontic correction was started in the maxillary arch with fixed appliances for aligning and leveling. One year later, fixed appliances were used in the mandibular arch to finish improving the occlusion until T2 (in some patients, Class III and vertical elastics were used during the last stages of treatment to eliminate minor occlusal discrepancies). Posttreatment registrations were taken at T3. During the posttreatment interval, the patients used only passive Hawley retainers.

The cervical stage (CS) of vertebrae development[23] was used to indicate the skeletal maturity of the subjects in both groups, independently of chronologic age. All patients with the MCH and fixed appliances had a prepubertal stage (CS 1-CS 3) of skeletal maturity at T1. At T3, all patients had a postpubertal stage of skeletal maturity (2 patients had reached CS 4; 19 of 21 patients had reached either CS 5 or CS 6). The stages were classified by an operator trained in this method (T.B.).

A customized digitization regimen and analysis were used for all cephalograms examined in this study. The regimen contained measurements from the analyses of Jacobson,[21] McNamara,[24] Ricketts,[25] and Steiner.[26]

Before the cephalometric analysis, the intraobserver variation was evaluated. Seven lateral cephalograms,

selected from various subjects in the study, were traced and measured at 2 times within a week. The measurements at both times for each patient were analyzed with the intraclass coefficient correlation, which varied between 0.966° for the SNB angle and 0.995° for the inclination of the maxillary incisor to the Frankfort horizontal line. These values indicated a high level of intraobserver agreement.

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

Statistical analysis

Descriptive statistics were calculated for all cephalometric measures at T1, T2, and T3 for the treated group, and at T1 and T3 for the control group. Additionally, mean differences and standard deviations were calculated for the T3-T1 changes in both 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 was performed on all variables to test the sample's normality. The test was significant for several variables and indicated lack of normality of the distribution of the examined parameters and recommended nonparametric statistics. Therefore, the Wilcoxon test and the Mann-Whitney U test were used for paired and unpaired comparisons, respectively.

The cephalometric measurements between T1 and T2, and between T2 and T3, in the treated group were compared with the Wilcoxon test to determine active treatment and posttreatment changes, respectively.

Before making the comparisons of the longitudinal changes, significant differences between the craniofacial starting forms at T1 were assessed with the Mann-Whitney U test between the treated and the control groups.

To assess the overall treatment and posttreatment effects of Class III correction, the craniofacial changes from T1 to T3 in the treated group were compared with those in the control group with the Mann-Whitney U test. The homogeneity between the 2 groups (type of malocclusion, mean ages at each observation time, sex distribution, and mean duration of observation intervals) allowed for comparisons without annualizing the data.

RESULTS

The statistical analysis showed several significant changes from T1 to T2 in the treated group (Table II). Midfacial length (Co-PtA), mandibular length (Co-Gn), and the maxillomandibular differential were significantly larger at T2 than at T1. The value for the Wits appraisal showed a significant difference (from −4.9 to −2.4 mm). Both upper and lower anterior facial heights had significantly larger values at T2; the same occurred for overbite and overjet, along with the inclination of the maxillary incisors to the Frankfort horizontal. Molar relationship showed a significant difference at T2 with respect to T1 (1.8 vs 3.3 mm). Several of these changes reflected both treatment and growth effects.

Only a few cephalometric variables showed significant changes from T2 to T3 in the treated group (Table II). Midfacial length (Co-PtA), mandibular length (Co-Gn), and lower anterior facial height were significantly larger at T3 than at T2. There was a significant difference in the molar relationship; it increased from 1.8 mm at T2 to 2.2 mm at T3. These changes reflected both treatment and growth effects.

No statistically significant differences were found between the groups at T1 (Table III). The only exceptions were a smaller value for the interincisal angle and a larger value for inclination of the maxillary incisors to the Frankfort horizontal line in the treated group.

The statistical comparison of the overall changes from T3 to T1 changes between the 2 groups showed several significant effects of 1-phase therapy followed by a posttreatment period (Table IV). Significantly smaller increases were found for Co-Gn, SNB angle, pogonion to nasion perpendicular, maxillomandibular differential, and ANB angle. Wits appraisal, MPA, and overjet showed significantly larger increases in the treated group compared with the controls. A significantly greater decrease was found for molar relationship in the treated group than in the untreated subjects.

DISCUSSION

We evaluated the treatment and posttreatment effects of MCH in young white subjects with Class III malocclusion. Specific features of the research included the following.

1. Treated subjects received an initial phase of MCH followed by a second phase of comprehensive fixed appliance therapy.
2. The overall treatment and posttreatment changes in the treated group were compared with growth chages in the untreated controls with Class III malocclusions.
3. Each subject had prepubertal skeletal maturity at T1 and was evaluated at T3 after the pubertal peak of mandibular growth, as assessed with the cervical vertebral method.[23]
4. The treated and control groups had no statistically significant differences as to race, sex distribution,

Table II. Treatment and posttreatment changes in the treated group

	T1		*T2*		*T3*		*T1-T2*	*T2-T3*
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Significance (Wilcoxon test)*	*Significance (Wilcoxon test)*
Cranial base								
Cranial flexure (°)	126.8	4.3	128.1	4.9	128.4	5.0	*	NS
Maxillary skeletal								
Co-Pt A (mm)	81.0	4.8	84.2	4.8	85.2	4.5	†	*
SNA angle (°)	80.4	3.9	80.5	4.0	80.5	3.8	NS	NS
Pt A to nasion perp (mm)	−2.2	2.9	−1.4	2.8	−1.4	3.2	NS	NS
Mandibular skeletal								
Co-Gn (mm)	110.7	6.2	117.4	7.7	119.6	7.3	†	†
SNB angle (°)	79.9	3.1	79.4	3.6	79.6	3.7	NS	NS
Pg to nasion perp (mm)	−3.3	4.0	−2.3	4.5	−2.3	6.1	NS	NS
Gonial angle (°)	133.5	4.5	133.2	4.9	133.1	4.5	NS	NS
Maxillomandibular								
Wits (mm)	−4.9	2.3	−2.4	1.9	−2.7	2.0	†	NS
Max/mand diff (mm)	26.5	2.0	29.7	3.2	30.2	3.9	†	NS
ANB angle (°)	0.5	2.4	1.0	1.7	1.0	2.0	NS	NS
Vertical skeletal								
FH to palatal plane (°)	−0.4	2.4	−0.3	2.8	−0.4	2.9	NS	NS
MPA (°)	28.8	4.6	29.4	4.1	29.4	4.4	NS	NS
Nasion to ANS (mm)	49.8	3.5	53.2	3.5	53.6	3.8	†	NS
ANS to Me (mm)	63.6	4.0	68.8	4.6	70.0	4.3	†	*
Interdental								
Overbite (mm)	0.6	1.5	1.6	0.6	1.6	0.6	†	NS
Overjet (mm)	0.2	1.3	1.6	0.7	1.4	0.4	†	*
Interincisal angle (°)	132.2	9.9	129.0	5.5	128.0	6.5	NS	NS
Molar relationship (mm)	3.3	0.9	1.8	0.6	2.2	0.4	†	†
Maxillary dentoalveolar								
U1 to FH (°)	113.1	5.9	115.8	5.6	115.3	4.8	*	NS
Mandibular dentoalveolar								
L1 to Pt A Pg (mm)	2.4	2.1	2.1	1.8	2.4	1.9	NS	NS
L1 to MPA (°)	85.3	6.4	85.5	5.6	86.7	6.4	NS	NS
Soft tissue								
Nasolabial angle (°)	101.3	8.7	100.8	9.5	100.4	9.3	NS	NS

NS, not significant; *Max/mand diff,* Maxillomandibular differential; *FH,* Frankfort horizontal plane; *perp,* perpendicular.
*$P < .05$; †$P < .01$.

mean ages at T1 and T3, mean observation intervals, or craniofacial characteristics at T1. This similarity between groups allowed for direct comparison of treatment effects on the differences between the values at the 2 time intervals without annualization.

Active treatment changes

The response of the craniofacial complex to active orthopedic treatment of Class III malocclusion with MCH and fixed appliances was analyzed statistically with a paired test. This analysis provided information about combined treatment and growth changes. The role of treatment can be seen in the evaluation of the differences between T1 and T2 in the Wits appraisal. The Wits appraisal showed improvement of 2.5 mm, a statistically and clinically relevant result. Similarly, overjet improved by a net average of 1.4 mm, and molar relationship improved by an average of 1.5 mm at T2. Significant changes in midfacial length, mandibular length, maxillomandibular differential, and vertical facial measures were found.

The treatment effects of the MCH and fixed appliance protocol should be compared with those of Battagel and Orton.[17] However, their treated sample comprised subjects who underwent a single phase of orthopedic treatment with mandibular headgear combined with a removable plate in the maxillary arch. No fixed appliance therapy to refine the occlusion was used in that study. The outcomes indicated slightly greater improvements in SNB and ANB angles when compared with our investigation, along with a significant increase in mandibular inclination to occlusal and craniofacial structures that was not found in our study.[17] The amount of dental compensation through proclination of the maxillary incisors was much greater in the study by

Table III. Statistical comparison of cephalometric measurements between groups at T1

	MCH group (n = 21)		*Control group (n = 20)*		*Mann-Whitney U test*
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	*Significance*
Cranial base					
Cranial flexure (°)	126.8	4.3	128.9	5.0	NS
Maxillary skeletal					
Co-Pt A (mm)	81.0	4.8	79.7	4.6	NS
SNA angle (°)	80.4	3.9	79.3	4.4	NS
Pt A to nasion perp (mm)	−2.2	2.9	−1.8	2.7	NS
Mandibular skeletal					
Co-Gn (mm)	110.7	6.2	109.3	7.0	NS
SNB angle (°)	79.9	3.1	79.8	4.4	NS
Pg to nasion perp (mm)	−3.3	4.0	−2.1	6.6	NS
Gonial angle (°)	133.5	4.5	132.2	5.2	NS
Maxillomandibular					
Wits (mm)	−4.9	2.1	−5.6	3.2	NS
Max/mand diff (mm)	26.5	2.0	27.6	4.2	NS
ANB angle (°)	0.5	2.4	−0.2	2.5	NS
Vertical skeletal					
FH to palatal plane (°)	−0.4	2.4	0.0	2.1	NS
MPA (°)	28.8	4.6	29.3	4.9	NS
Nasion to ANS (mm)	49.8	3.5	48.5	4.6	NS
ANS to Me (mm)	63.6	4.0	61.8	5.2	NS
Interdental					
Overbite (mm)	0.6	1.5	1.0	1.6	NS
Overjet (mm)	0.2	1.3	−0.3	2.3	NS
Interincisal angle (°)	132.2	9.9	137.4	9.8	*
Molar relationship (mm)	3.3	0.9	4.1	1.8	NS
Maxillary dentoalveolar					
U1 to FH (°)	113.1	5.9	109.4	5.3	*
Mandibular dentoalveolar					
L1 to Pt A Pg (mm)	2.4	2.1	3.1	2.4	NS
L1 to MPA (°)	85.3	6.4	83.4	7.1	NS
Soft tissue					
Nasolabial angle (°)	101.3	8.7	103.0	9.2	NS

NS, not significant; *Max/mand diff,* Maxillomandibular differential; *FH,* Frankfort horizontal plane; *perp,* perpendicular.
*$P < .05$.

Battagel and Orton[17] (about 5°) than in ours (about 2.5°). Positive overjet correction was similar in both studies.

Posttreatment changes

The positive effects of the active treatment period did not relapse significantly during the posttreatment period. All subjects were reevaluated 1.5 years after fixed appliance therapy, when they had reached postpubertal skeletal maturity. Only passive Hawley retainers had been worn during the posttreatment period. Whereas the maxilla, the mandible, and the lower anterior facial height continued to grow significantly, Wits appraisal (−0.3 mm), ANB angle (0°), and overjet (−0.2 mm) remained substantially stable. Molar relationship, on the other hand, had a significant rebound, but it was not clinically relevant (0.4 mm).

When our data are compared with those of Battagel and Orton,[16] they found greater amounts of rebound for overjet (−0.9 mm) and ANB angle (−1.4°). However, their posttreatment observation period was longer (about 5.5 years), and the average age of their patients at the beginning of treatment (12.5 years) was significantly greater than in our study.

Overall treatment and posttreatment effects

To evaluate overall treatment and posttreatment effects of the treatment protocol of MCH and fixed appliances, we used a control group of untreated white subjects with Class III malocclusion.

Over 5 years 4 months (T1-T3), including both active treatment and posttreatment observations, mandibular headgear therapy appears to induce significant favorable changes compared with growth in untreated

Table IV. Statistical comparison of the T3-T1 changes between the groups

	MCH group (n = 21)		*Control group (n = 20)*		*Mann-Whitney U test*	
Cephalometric measurement	*Mean*	*SD*	*Mean*	*SD*	*Difference*	*Significance*
Cranial base						
Cranial flexure (°)	1.7	2.3	0.8	3.0	1+0.9	NS
Maxillary skeletal						
Co-Pt A (mm)	4.3	4.6	4.2	2.9	+0.1	NS
SNA angle (°)	0.1	2.9	0.2	2.7	−0.1	NS
Pt A to nasion perp (mm)	0.8	2.4	0.5	2.1	+0.3	NS
Mandibular skeletal						
Co-Gn (mm)	8.9	5.3	13.4	5.8	−4.5†	
SNB angle (°)	−0.3	2.1	3.3	2.9	+3.6†	
Pg to nasion perp (mm)	0.9	4.1	4.8	4.5	+3.9†	
Gonial angle (°)	−0.4	1.8	−1.4	3.3	−1.0	NS
Maxillomandibular						
Wits (mm)	2.0	1.9	−2.0	3.1	+4.0†	
Max/mand diff (mm)	3.8	3.1	9.6	4.6	−4.8†	
ANB angle (°)	0.5	1.9	−1.9	1.9	+2.4†	
Vertical skeletal						
FH to palatal plane (°)	0.0	2.1	−0.6	2.3	+0.6	NS
MPA (°)	0.7	2.9	−2.1	3.2	+2.8*	
Nasion to ANS (mm)	3.9	3.3	4.7	4.0	−0.8	NS
ANS to Me (mm)	6.5	2.9	6.4	4.3	+0.1	NS
Interdental						
Overbite (mm)	1.0	1.4	0.7	2.0	+0.3	NS
Overjet (mm)	1.3	1.2	−1.4	2.7	+2.7†	
Interincisal angle (°)	−4.2	7.1	−2.8	11.9	−1.4	NS
Molar relationship (mm)	−1.1	0.8	3.3	2.9	−4.4†	
Maxillary dentoalveolar						
U1 to FH (°)	2.3	4.4	3.4	6.2	−1.1	NS
Mandibular dentoalveolar						
L1 to Pt A Pg (mm)	0.0	1.4	1.3	2.2	−1.3	NS
L1 to MPA (°)	1.4	4.9	−1.5	7.0	+2.9	NS
Soft tissue						
Nasolabial angle (°)	−0.8	7.0	−2.3	9.9	+1.5	NS

NS, not significant; *Max/mand diff,* Maxillomandibular differential; *FH,* Frankfort horizontal plane; *perp,* perpendicular.
*$P < .05$; †$P < .01$.

Class III subjects. The most prominent skeletal components of long-term treatment outcome are related to significant modifications in the position of the mandible, as measured by the SNB angle and the distance from pogonion to nasion perpendicular. These changes accounted almost completely for the improvements in the Wits appraisal and the maxillomandibular differential (4 and 4.8 mm, respectively). The net improvement in the long-term skeletal relationship also was indicated by an increase in the ANB angle of about 2.5° when compared with the controls. Significant backward rotation of the mandibular plane in relation to the Frankfort horizontal line was also recorded (2.8°), a skeletal change assisting in the improvement of the sagittal maxillomandibular relationship.

The residual sagittal occlusal correction consisted of 2.7 and 4.4 mm improvements for overjet and molar relationships, respectively, in the treated group when compared with the controls. The inclination of the mandibular incisors at T3 (and at T2, Table II) was maintained at values that were similar to the T1 measurements. The MCH with its favorable effects on the position of the teeth (shown by the significant improvement in molar relationship) enabled the clinician to prevent buccal tipping of the mandibular incisors to compensate for the Class III dentoskeletal pattern.

The treatment results of Class III malocclusion with the MCH should be contrasted with the effects of the classic treatment modality directed to the mandible in Class III patients: chincup therapy. Arun and Erverdi[18] performed a cephalometric comparison of mandibular headgear and chincup appliances in the short term. Chincup therapy inhibited the development of the upper

face and effectively controlled the vertical dimension in addition to the posterior positioning of the mandible, whereas MCH therapy produced significant reduction in mandibular growth, along with increased lower face height and distal movement of the mandibular molars. As for long-term changes, previous studies on chincup therapy indicated either similar outcomes when compared with MCH therapy[27] or both inhibition of mandibular growth and improvement in the maxillary position in the posttreatment period[28] (a favorable change not seen with the MCH).

A controversial aspect connected with orthopedic upward/backward forces applied to the condyle is the possible development of temporomandibular dysfunction. This issue has been related mostly to chincups, although there are no data in the literature about mandibular headgear. However, a study by Dibbets and van der Weele[29] relieved the concerns of clinicians who use forces directed to the condyle to treat patients with skeletal Class III malocclusions. Gökalp et al[30] abd Arat et al[31] recently demonstrated that, when chincup-like appliances are used during developmental ages, there will be no adverse effect on the condyle-disc relationship. None of the treated subjects in our study reported signs or symptoms of temporomandibular disorders during or after therapy.

Although not a direct aim of this study, these outcomes on the postpubertal effectiveness of MCH therapy are comparable with the long-term results of 2-phase Class III treatment with maxillary expansion and protraction followed by fixed appliance of Westwood et al.[14] The similarities between the 2 studies, including 2-phase treatment protocol, use of untreated Class III controls, duration of the overall observation period, type of cephalometric analysis, evaluation of skeletal maturity, and posttreatment period, mean that the 2 treatment protocols for Class III malocclusion can be compared. However, radiologic examination at T2 with the MCH and before fixed appliances would have been helpful to elucidate differences or similarities between facemask and MCH treatments. At the postpubertal appraisal, the effects of MCH and fixed appliance therapy are analogous to those of rapid maxillary expansion (RME) and facemask therapy followed by fixed appliances, although the absolute amount of correction is greater for the maxillary expansion and protraction protocol. The overall improvement in the Wits appraisal was about 6 mm for RME therapy; it was 4 mm for the MCH protocol. Overjet correction was 4.5 mm for RME, whereas it was only 2.7 mm for the MCH protocol. The greater correction in the maxillomandibular relationships with RME and facemask therapy is due mainly to its long-term effect on the maxilla (+1.2 mm), whereas this effect is absent in the MCH protocol. On the other hand, MCH and fixed appliance can induce greater correction of the molar relationship (4.4 vs 3.9 mm after RME and facemask therapy), since the position of the mandibular molars is a direct target of MCH treatment. Finally, MCH and fixed appliance therapy produces significant downward rotation of the mandible that was not found by Westwood et al[14] amont the long-term effects of RME and facemask therapy. Therefore, it appears that, when contrasted with the facemask, MCH is indicated for more moderate forms of dentoskeletal Class III malocclusion, possibly with a distinctive pattern of horizontal mandibular growth. However, the downward mandibular rotation worsened overbite in the treated sample at T3 (+0.3 mm with respect to the controls).

CONCLUSIONS

We compared the treatment effects of an initial phase of MCH therapy followed by a second phase of comprehensive fixed appliance therapy with untreated Class III controls. Each subject was evaluated after the pubertal peak of mandibular growth with the cervical vertebral method.

The following treatment and posttreatment craniofacial modifications were seen during a 5-year-4-month observation period.

1. Treatment with the MCH followed by fixed appliances induced significant dentoskeletal responses in terms of improvement of Wits appraisal, overjet, and molar relationship; these changes remained stable during the posttreatment period.
2. Overall, MCH therapy is an effective treatment for the correction of skeletal Class III malocclusion in the long term. The favorable skeletal effects consisted mainly of smaller increases in mandibular length and advancement, with the final outcome of significant improvement in sagittal skeletal and dental relationships. A side effect of this treatment protocol was significant downward rotation of the mandible.

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