Diego Rey, DDS, Cert Ortho[1]

Juan Fernando Aristizabal, DDS, Cert Ortho[2]

Giovanni Oberti, DDS, Cert Ortho[3]

David Angel, DDS, Cert Ortho[4]

MANDIBULAR CERVICAL HEADGEAR IN ORTHOPEDIC AND ORTHODONTIC TREATMENT OF CLASS III CASES

Aim: *To show craniofacial and dental changes to the mandibular dentition with the use of cervical headgear as well as the mechanics used in the early management of Class III malocclusions.* ***Methods:*** *Clinical photos and cephalometric radiographs of 5 patients with different types of Class III malocclusion treated with mandibular cervical headgear are shown in this article.* ***Results:*** *The use of the mandibular cervical headgear showed to be clinically effective in the treatment of different types of Class III malocclusions. The main effects of the appliance were posterior and anterior rotation of the mandible and distalization of the mandibular molars.* ***Conclusion:*** *The mandibular cervical headgear is a good alternative for the treatment of these cases and is well-accepted and tolerated by the patients.* World J Orthod 2006;7:165–176.

[1]Chairman, Department of Orthodontics, CES University, Medellín, Colombia.
[2]Chairman, Department of Orthodontics, Universidad del Valle, Cali, Colombia.
[3]Assistant Professor, Universidad CES, Medellín, Colombia.
[4]Orthodontist, Universidad CES and private practice of Orthodontics, Medellín, Colombia.

CORRESPONDENCE
Dr Diego Rey
Department of Orthodontics
Institute of Health Sciences
CES University
Medellín, Colombia
E-mail: rey@epm.net.co

Class III malocclusions are complex to diagnose and treat, and have been described, according to Angle's classification, as the mesial position of the mandibular arch with an anomalous anterior crossbite or edge-to-edge relationship.

A variety of orthodontic and orthopedic appliances for the management of skeletal Class III malocclusion have been described in the literature.[1–19] One of these appliances is the mandibular cervical headgear (MCH).[20–28] Canut[20] recommended the use of cervical headgear on the mandibular molars, with the objective of retracting the mandibular arch to reach solid intercuspation of the permanent teeth. Tenti[21] suggested the use of this mechanism for the orthopedic treatment of Class III malocclusion, through restriction of mandibular sagittal growth, with an effect similar to that obtained with the chin cup. However, he suggests that cervical headgear is a better option in cases where distal movement of the mandibular molars is not contraindicated. Some of the advantages of cervical headgear include its smaller size, better patient comfort, and support of other treatment elements. Marcotte[22] has written that because of the positive moment generated by cervi-

cal headgear, the posterior segments spread to move posteriorly and also help to flatten the occlusal plane. Orton et al[23] found distal drift of the mandibular molars (−1.1 mm) and retroclination of the mandibular incisors (−3.5 mm) when using the mandibular cervical headgear. Joho[24] evaluated the effect of the appliance in *Macaca mulatta*, and corroborated its effectiveness for treatment of Class III malocclusion, with mandibular arch length deficiency. His cephalometric evaluation indicated that there was distal movement of the molars (between 1 and 2 mm). He concluded that dental and skeletal changes could occur, causing a change from a normal Class I to a Class II relationship, with the use of extraoral forces applied directly to the mandibular first molars in *Macaca mulatta*. The molars moved distally, while the mandible moved posteriorly. The gonial angle became smaller in all the animals during the active treatment period and had no significant changes during relapse; articular remodeling took place, and the joints were relocated in an anterior direction during relapse after having been displaced posteriorly during active treatment. Khun[25] has suggested the use of cervical headgear on mandibular molars in maximum anchorage cases. Other authors, such as Gianelly,[26] have used this appliance on the mandibular dentition as a mechanical system for the correction of Class I malocclusions, using it as an anchorage system. Battagel and Orton,[27] in a retrospective cephalometric study of a group of Class III children who were candidates for orthodontic treatment alone, found that a nonextraction approach with the use of mandibular headgear resulted in better facial esthetics and they favored early treatment, which was shorter in comparison with the group treated via extraction and fixed appliances.

In a later study, Battagel and Orton[28] compared 44 children treated with mandibular headgear, 39 treated with facemask, and 30 Class III patients as controls. The 2 treatment groups showed similar therapeutic effects. Inverted overjet was corrected, maxillary incisors were labialized, and mandibular incisors retroclined. The mandible had a backward and downward rotation, and the soft tissue profile improved. Results indicated that both treatment approaches had the same treatment effect, although treatment with facemask could be initiated earlier, with slightly enhanced skeletal and profile changes.

The use of an extraoral force applied directly to the mandibular teeth has not been broadly described. This article seeks to show craniofacial and dental changes in 5 cases treated with MCH, as well as the mechanics used in the early management of Class III malocclusions.

CASE 1

Class III malocclusion in a nongrowing patient

A postpubertal female, 13 years of age, had a Class III occlusion on the left side and a Class I occlusion on the right, the mandibular anterior dentition was crowded, and the midline deviated to the right. There was a posterior crossbite in the premolar region. Overbite was 5% and overjet was in an edge-to-edge relationship. The patient had inherited her mother's prognathism (Figs 1a to 1e).

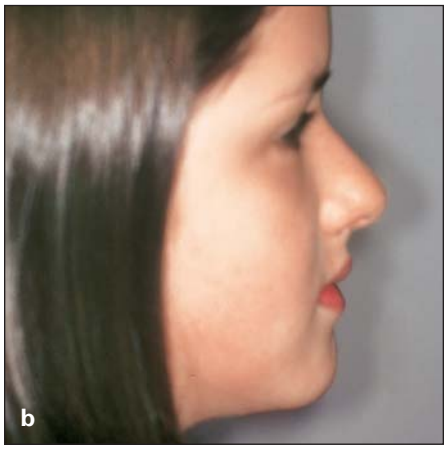
A Hyrax appliance was prescribed for the first 3 months; this was then combined with MCH for another 3 months. The MCH was worn 12 hours a day for another 18 months, combined with fixed orthodontic treatment used for alignment and finishing (Figs 1f to 1j). Cephalometrically, the patient was Class I and did not show any skeletal change during treatment (Fig 1k). The cephalometric analysis is shown in Table 1, which can be found in the WJO Web edition at www.quintpub.com.

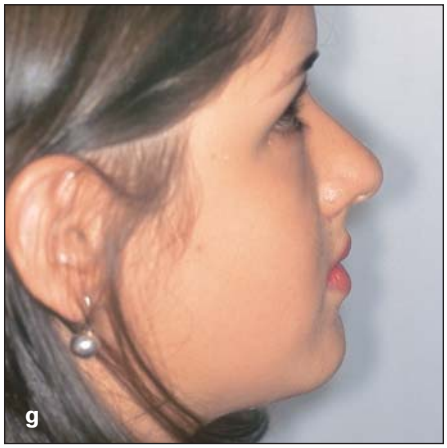
The treatment time was 2 years, and a Helkimo index test showed neither signs nor symptoms of temporomandibular joint (TMJ) dysfunction.

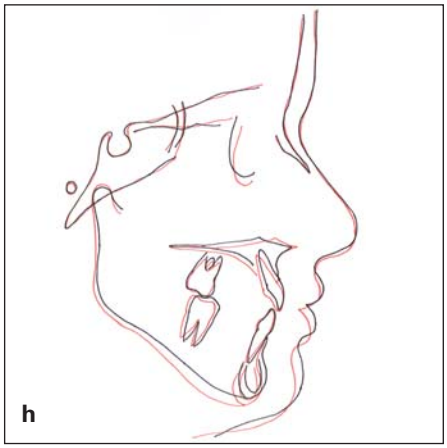
CASE 1

Figs 1a to 1e Pretreatment extraoral and intraoral views.

Figs 1f to 1k Posttreatment extraoral and intraoral views, and superimposition of cephalometric tracings (pretreatment, black; posttreatment, red).







CASE 2

Skeletal Class III malocclusion and mandibular prognathism in a growing patient

A prepubertal female, 9 years of age, had a Class III occlusion in the mixed dentition, with an impacted maxillary left canine and anterior crowding of both arches. The overbite was 10% and overjet was 1 mm; she had flared maxillary incisors and vertical mandibular incisors. The patient had inherited the prognathism (Figs 2a to 2e).

The initial treatment was with fixed appliances placed in the maxillary arch, to create space for the impacted canine. When the canine was in place, MCH was worn 12 hours a day. Following overcorrection of the Class III molar occlusion, alignment and leveling of the dentition were done (Figs 2f to 2j).

The MCH was removed after 1 year of treatment; orthodontic treatment was used for alignment and finishing. The total treatment time was 3 years. Cephalometrically, there was anterior growth of the maxilla and vertical growth of the mandible (Fig 2k). The cephalometric analysis is shown in Table 2 (see WJO Web edition).

CASE 3

Skeletal Class III malocclusion and maxillary deficiency

A male, 10 years of age, had a severe Class III molar occlusion in the mixed dentition, bilateral impacted maxillary canines, and a severe anterior crossbite. The overbite was 0% and overjet was −2 mm (Figs 3a to 3e). The patient's father also had a Class III malocclusion, with mandibular prognathism.

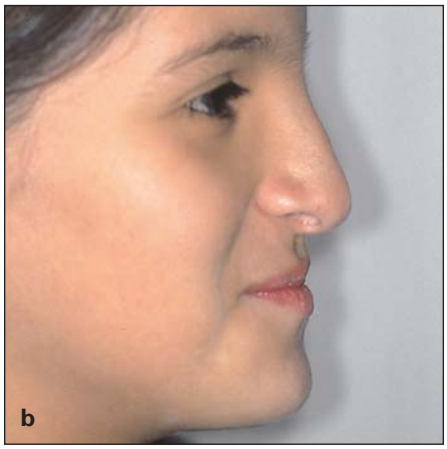
The initial treatment started with MCH, used as a facemask attached to the maxilla with elastics (5/16 inch, 6 oz) from the outer bow to an acrylic bite plane with hooks (Figs 3f and 3g). The maxillary canines were erupted ectopically. Following overcorrection and retention of the Class III molar occlusion, alignment and leveling of the dentition were carried out (Figs 3h and 3i). The MCH was removed after 2 years of treatment. The case was finished with conventional heavy archwires (Figs 3j to 3n).

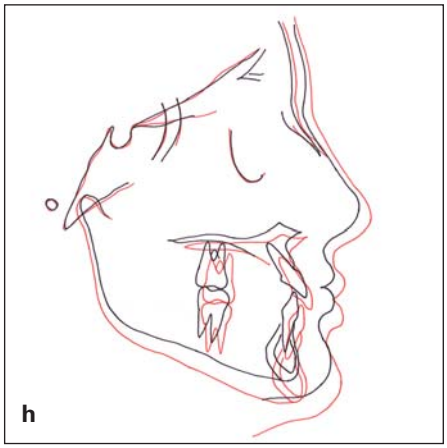
The Helkimo index test did not show signs or symptoms of TMJ dysfunction. Cephalometric tracings are shown in Fig 3o, and the cephalometric analysis is shown in Table 3 (see WJO Web edition).

CASE 2

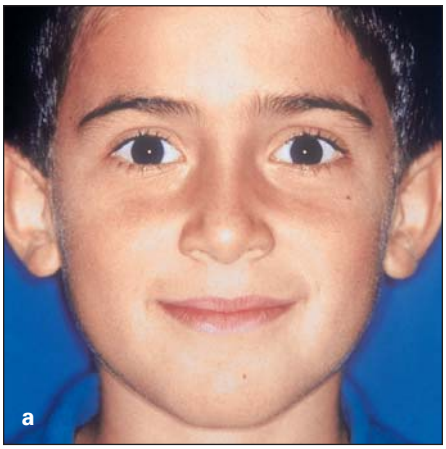
Figs 2a to 2e Pretreatment extraoral and intraoral views.

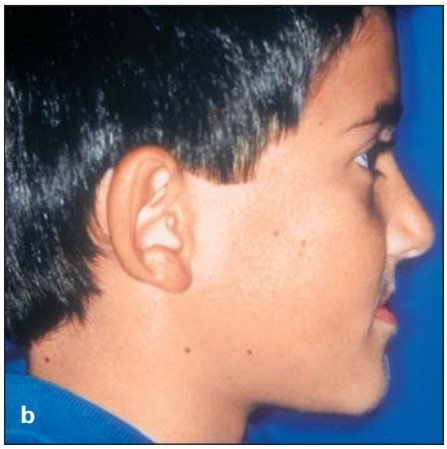
Figs 2f to 2k Posttreatment extraoral and intraoral views, and superimposition of cephalometric tracings (pretreatment, black; posttreatment, red).





CASE 3



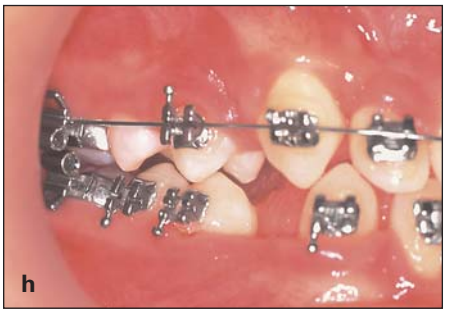


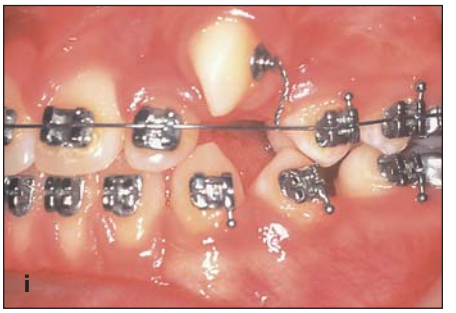
Figs 3a to 3e Pretreatment extraoral and intraoral views.

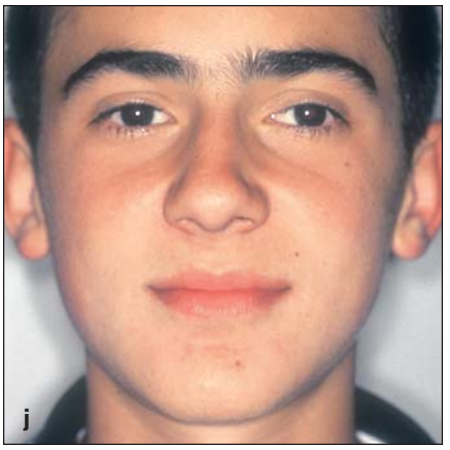
Figs 3f and 3g MCH with an occlusal plate for maxillary protraction.

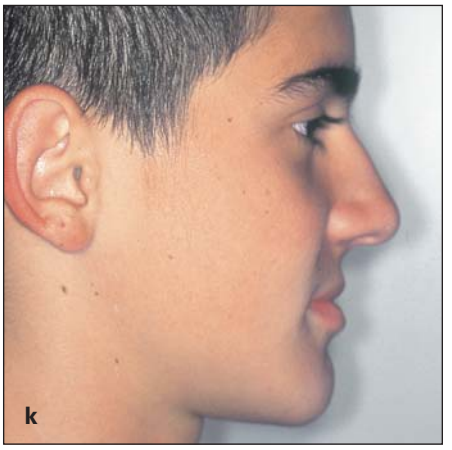
Figs 3h and 3i Treatment.

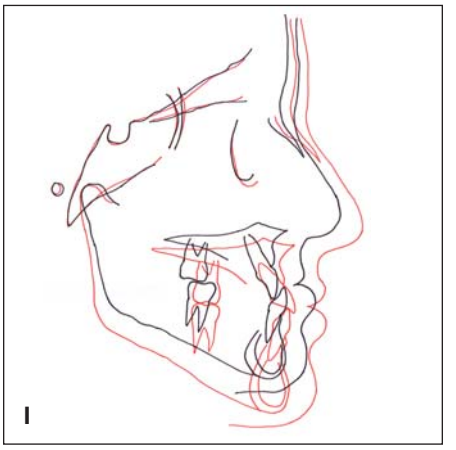
Figs 3j to 3o Posttreatment extraoral and intraoral views, and superimposition of cephalometric tracings (pretreatment, black; posttreatment, red).

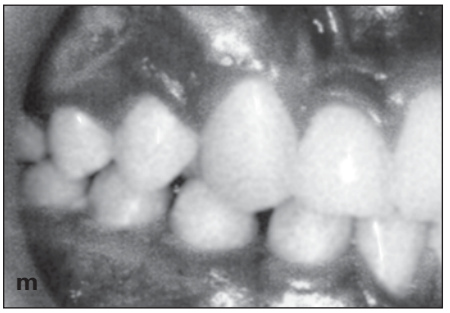


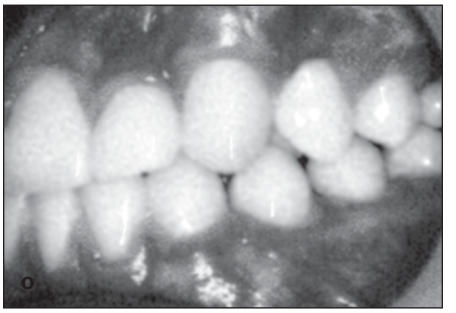












CASE 4

Class III malocclusion and mandibular asymmetry

A female patient, 12 years of age, with laterognathism on the left side, had a permanent Class III occlusion, with a functional posterior crossbite on the left, including the mandibular lateral incisor and canine, and midline deviation to the left. The anterior dentition was crowded in both arches. The overbite and overjet were edge to edge (Figs 4a to 4e). The patient had inherited her mother's prognathism.

A quad helix was prescribed for 6 months and was then combined with MCH for another 6 months. The fixed appliances were then placed. Six months later, the quad helix was removed. The MCH was worn 12 hours a day for 18 months, combined with fixed orthodontic treatment used for alignment and finishing (Figs 4f to 4j).

Treatment time was 30 months. Following treatment, a genioplasty was done to counteract the mandibular deviation. The Helkimo index test showed minimum TMJ dysfunction, with clicking on the right side. The pre- and posttreatment cephalometric superimposition is shown in Fig 4k, and the cephalometric analysis is presented in Table 4 (see WJO Web edition).

CASE 5

Class III malocclusion with maxillary deficiency and mandibular anterior crowding

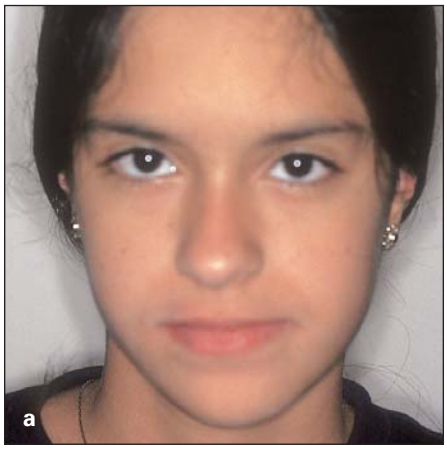
A postpubertal female, 13 years of age, had a permanent Class III occlusion at the end of mixed dentition; the midline deviated 1 mm to the left side. There was anterior crowding of the mandibular arch. The overbite and overjet were edge to edge, and the mandibular incisors were retroclined. The patient had inherited the prognathism, as well as a low midfacial hypoplasia, from her father (Figs 5a to 5e).

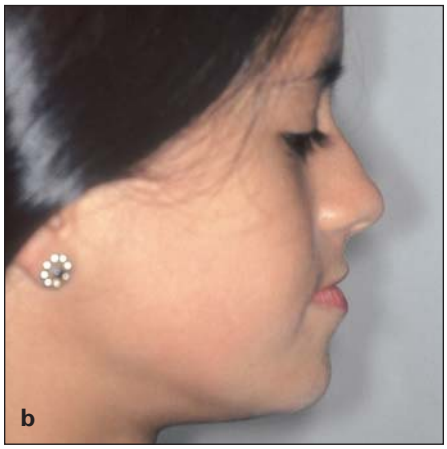
MCH was prescribed, and was worn 14 hours a day. Fixed appliances were then placed on the maxillary arch, with advanced arches. The MCH was worn with intermaxillary elastics (5/16 inch, 6 ounces) (Figs 5f and 5g). The mandibular second molars were extracted, and fixed appliances were placed for retraction of the mandibular arch; rectangular wires were used to finish the case (Figs 5h to 5l). The pre- and posttreatment cephalometric superimposition is shown in Fig 5m, and the cephalometric analysis is shown in Table 5 (see WJO Web edition).

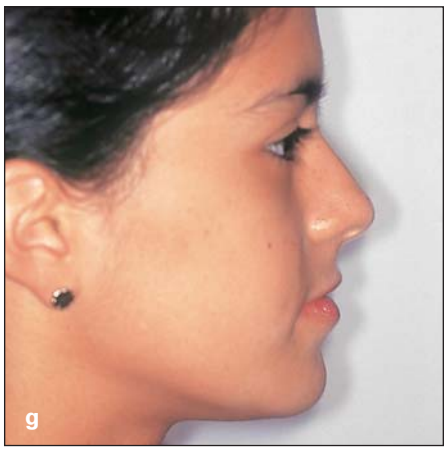
CASE 4

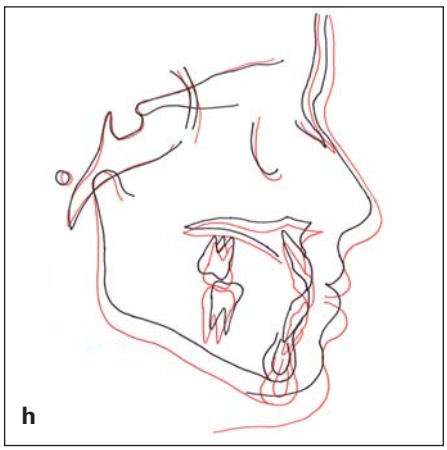
Figs 4a to 4e Pretreatment extraoral and intraoral views.

Figs 4f to 4k Posttreatment extraoral and intraoral views, and superimposition of cephalometric tracings (pretreatment, black; posttreatment, red).

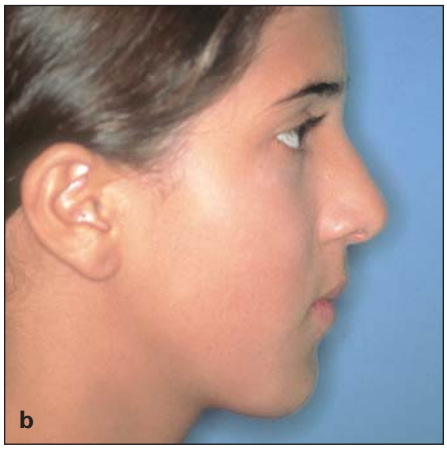








CASE 5

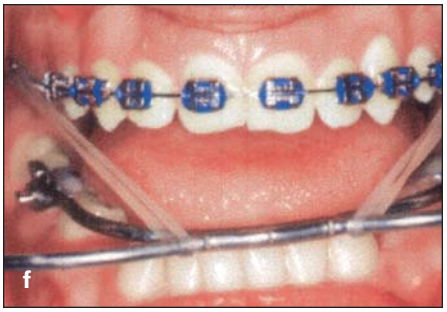


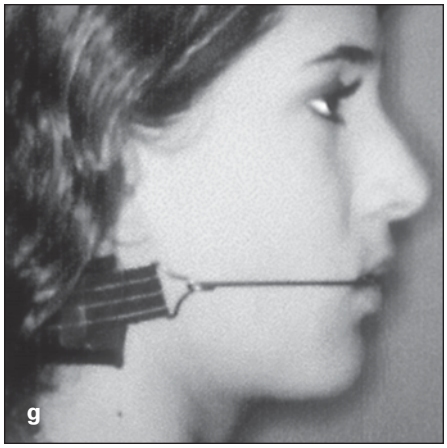
Figs 5a to 5e Pretreatment extraoral and intraoral views.

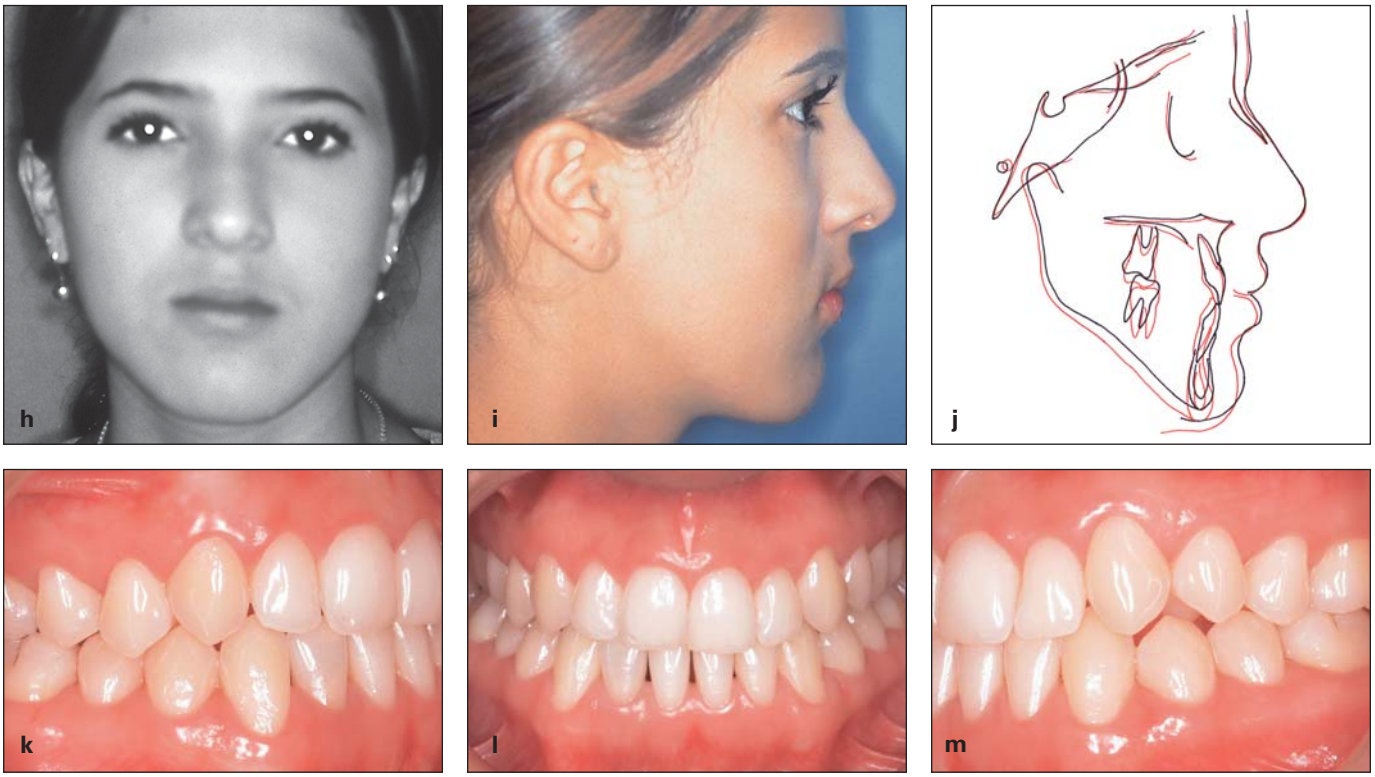
Fig 5f MCH with intermaxillary elastics for maxillary protraction.

Fig 5g MCH in position.

Figs 5h to 5m Posttreatment extraoral and intraoral views, and superimposition of cephalometric tracings (pretreatment, black; posttreatment, red).







DISCUSSION

The MCH is a good alternative for the treatment of these patients, who were part of a study that sought to evaluate the craniofacial changes achieved with the appliance in the orthopedic and orthodontic treatment of Class III malocclusion.

The MCH is not bulky and is well tolerated by patients. Its use improves the condition of Class III malocclusions, particularly in cases of light to moderate severity. The MCH allows a backward and downward rotation of the mandible, which improves Class III dysplasia, as seen in the cephalometric records of these cases (see Tables 1 to 5, in the WJO Web edition at www.quintpub.com). Indeed, the distalizing force of MCH corrects inferior arch crowding. In this study, there were no patients with moderate or severe TMJ dysfunction. However, it is important not to exceed 8 oz of force per side with the MCH.

The MCH can help with maxillary protraction, using elastics to the maxilla (5/16 inch, 6 oz) anchored from the external arch of the MCH to an acrylic arch, in early treatment cases; or to hooks of banded maxillary first molars, when the maxillary arch is properly supported with a heavy arch, in nongrowing patients. In either method, the maximum force of the elastic should be 6 oz per side and the springs of the extraoral appliance should be passively adjusted, thus avoiding TMJ overload.

It is also useful to prepare the bands on the mandibular first molars by cementing with reinforced light-cured ionomer-type cement. The inferior bands should have a double tube, rectangular for the fixed appliance and round 0.045 inch for the headgear. Round tube placement should be occlusal or gingival, depending on the condition of the patient's hygiene and occlusal interference. Then, placement of the inner arch is determined, as is the location of the springs (force, 6 to 8 oz per side), preferably with a secure system.

The appliance should be used an average of 12 hours a day. It should be checked every 2 weeks during the first month, and then at least once a month. Although it is certain that the MCH is a valuable tool in the therapeutic management of this type of malocclusion, appropriate diagnosis is the fundamental tool in determining which patients should receive this therapy.

CONCLUSION

The use of the MCH was shown to be clinically effective in the mechanotherapy of these 5 cases.

ACKNOWLEDGMENT

We give our thanks to Dr Juan Manuel Cardenas and Dr Adolfo Contreras for their comments and help with this report.

REFERENCES

1. McNamara JA, Huge SA. The functional regulator (FR-3) of Fränkel. Am J Orthod 1985;88: 409–424.
2. Fränkel R. Maxillary retrusion in Class III and treatment with the function corrector III. Trans Eur Orthod Soc 1970:249–259.
3. Kerr WJS, TenHave TR. A comparison of three appliance systems in the treatment of Class III malocclusion. Eur J Orthod 1988;10:203–214.
4. Kerr WJS, TenHave TR, McNamara JA Jr. A comparison of skeletal and dental changes produced by function regulators (FR-2 and FR-3). Eur J Orthod 1989;11:235–242.
5. Loh MK, Kerr WJS. The function regulator III: Effects and indications for use. Br J Orthod 1985;12:153–157.
6. Ulgen M, Firatli S. The effects of the Fränkel function regulator on the Class III malocclusion. Am J Orthod Dentofacial Orthop 1994; 105:561–567.
7. Robertson NRE. An examination of treatment changes in children treated with the functional regulator of Fränkel. Am J Orthod 1983;83: 299–310.
8. Suzuki N. A cephalometric observation on the effect of the chin cap. J Jpn Orthod Soc 1972; 31:64–74.
9. Thilander B. Treatment of Angle Class III malocclusion with chin cup. Trans Eur Orthod Soc 1963;39:384–398.
10. Mitani H, Fukazawa H. Effects of chin cap force on the timing and amount of mandibular growth associated with anterior reversed occlusion (Class III malocclusion) during puberty. Am J Orthod 1986;90:454–463.
11. Matsui Y. Effect of chin cap on the growing mandible. J Jpn Orthod Soc 1965;24:165–181.
12. Graber LW. Chin cup therapy for mandibular prognathism. Am J Orthod 1977;72:23–41.
13. Chong YH, Ive JC, Årtun J. Changes following the use of protraction headgear for early correction of Class III malocclusion. Angle Orthod 1996;66:351–362.
14. Ellis E III, McNamara JA Jr. Components of adult Class III malocclusion. J Oral Maxillofac Surg 194;42:295–305.
15. Mermigos J, Full CA, Andreasen G. Protraction of the maxillofacial complex. Am J Orthod Dentofacial Orthop 1990;98:47–55.
16. Dellinger EL. A preliminary study of anterior maxillary displacement. Am J Orthod 1973;63: 509–516.
17. Irie M, Nakamura S. Orthopedic approach to severe skeletal Class III malocclusion. Am J Orthod 1975;67:377–392.
18. Cozzani G. Extraoral traction and Class III treatment. Am J Orthod 1981;80:638–650.
19. Jackson GW, Kokich VG, Shapiro PA. Experimental and postexperimental response to anteriorly directed extraoral force in young macaca nemestrina. Am J Orthod 1979;75:318–333.
20. Canut JA. Clase III. In: Ortodoncia Clínica, ed 1a. Barcelona: Editorial Salvat, 1988:443–479.
21. Tenti FV. Class III Orthopedic treatment. In: Atlas of Orthodontic Appliances. Tenti FV (ed). Barcelona: Caravel, 1986:259–264.
22. Marcotte MR. Headgear. In: Biomechanics in Orthodontics. Marcotte MR (ed). Toronto: BC Decker, 1990:83–99.
23. Orton HS, Sullivan PG, Battagel JM. The management of Class III and Class III tendency occlusions using headgear to the mandibular dentition. Br J Orthod 1983;10:2–12.
24. Joho JP. The effects of extraoral low-pull traction to the mandibular dentition of macaca mulatto. Am J Orthod 1973;64:555–577.
25. Kuhn RJ. Control of anterior vertical dimension and proper selection of extraoral anchorage. Angle Orthod 1969;38:340–349.
26. Gianelly A. Mandibular cervical traction in the treatment of Class I malocclusions. Am J Orthod 1971;60:257–263.
27. Battagel JM, Orton HS. Class III malocclusion: A comparison of extraction and nonextraction techniques. Eur J Orthod 1991;13:212–222.
28. Battagel JM, Orton HS. A comparative study of the effects of customized facemask therapy or headgear to the lower arch on the developing Class III face. Eur J Orthod 1995;17:467–482.

Table 1 Case 1 cephalometric analysis

	Pretreatment (13 years of age)	Treatment (14 years of age)	Final (15 years of age)	Retention (21 years of age)
Skeletal				
Facial angle (S-N-Pog) (degrees)	78	79	78	77
SNA (degrees)	79	80	79	77
SNB (degrees)	77	78	76.5	76
ANB (degrees)	2	1	2.5	1
N-A-Pog (degrees)	2	2	2.5	1
Wits (mm)	−1	−1	0	0.5
MP-FH (degrees)	35	35.5	32	32
Y axis of growth (degrees)	69	68	69	70
ANS-Me (mm)	65	67	68	68
Co-A (mm)	79	79	79	79
ANS-PNS (mm)	51	51	51	51
Co-Gn (mm)	107	109	109	109
N-A (mm)	−4	−4	−2	−2
N-Pog (mm)	−10	−11	−9	−8
Go-Me (mm)	71	72	71	74
N-ANS (mm)	51	50	51	53
IEE-PNS (mm)	47.5	48.5	48	47
Ar-Go (mm)	39	38	38	39
Ar-Go-Me (degrees)	131	130	128	128
Ar-Go-N (degrees)	52	51	49	49
N-Go-Me (degrees)	79	79	79	79
Dental				
Interincisal angle (degrees)	136	133	133	133
11-FH (degrees)	105	109	111	113
11-SN (degrees)	99	104	104	105
11-A-Pog (mm)	3	3.5	3	4
11-PP (mm)	25.5	27	27	27
16-PP (mm)	20	20	20	21
41-MP (degrees)	83	80	80	80
41-A-Pog (mm)	0	1	1	1
41-A-pog (degrees)	22	20	20	21
41-MP (mm)	36	38	39	40
46-MP (mm)	26	27	28	28
Facial				
S-N-Pog (degrees)	86	87	85	85
Lower lip–H line (mm)	0.5	0	0.5	0
Upper sulcus–H line (mm)	5	5	5	5
Nasolabial angle (degrees)	105	104	105	103

Table 2 Case 2 cephalometric analysis

	Pretreatment (9 years of age)	Treatment (11 years of age)	Final (12 years of age)	Retention (15 years of age)
Skeletal				
Facial angle (S-N-Pog) (degrees)	80.5	80.5	80	79
SNA (degrees)	76.5	76	76	76
SNB (degrees)	79	79	78	78.5
ANB (degrees)	−2.5	−3	−2	−2.5
N-A-Pog (degrees)	−4	−9	−8	−8
Wits (mm)	−5	−6	−4	−4
MP-FH (degrees)	24	28	27.5	25
Y axis of growth (degrees)	65	66	66.5	68
ANS-Me (mm)	62	67	68	69
Co-A (mm)	89	87	88	89
ANS-PNS (mm)	55	55	55	55
Co-Gn (mm)	114	120	122	123.5
N-A (mm)	−6	−9	−7	−5
N-Pog (mm)	−4.5	−7	−5	−1.5
Go-Me (mm)	70	76	78	78
N-ANS (mm)	53	55	56	57
IEE-PNS (mm)	47	48	50	51
Ar-Go (mm)	48	49	48	49
Ar-Go-Me (degrees)	130.5	130	131	131
Ar-Go-N (degrees)	58	56	56	56
N-Go-Me (degrees)	72.5	74	75	75
Dental				
Interincisal angle (degrees)	137	135	132.5	129
11-FH (degrees)	119	115	118	116
11-SN (degrees)	112	110	110	107
11-A-Pog (mm)	5	6	6	5.5
11-PP (mm)	23.5	29	29	30
16-PP (mm)	20.5	24	24	25
41-MP (degrees)	80	83	83	90
41-A-Pog (mm)	0	2	2	2
41-A-Pog (degrees)	15	22	21	29
41-MP (mm)	36	38	38	40
46-MP (mm)	26	28	28	29
Facial				
S-N-Pog (degrees)	89.5	89	89	87
Lower lip–H line (mm)	0	0	0	1
Upper sulcus–H line (mm)	6	6	7	6
Nasolabial angle (degrees)	105	107	105	106

Table 3 Case 3 cephalometric analysis

	Pretreatment (9 years of age)	Treatment (12 years of age)	Final (14 years of age)	Retention (16 years of age)
Skeletal				
Facial angle (S-N-Pog) (degrees)	82	81	82	86
SNA (degrees)	77	77	79	80
SNB (degrees)	80	79	80	83
ANB (degrees)	−3	−2	−1	−3
N-A-Pog (degrees)	−5	−4	−4	−6
Wits (mm)	−8	−5	−2.5	−6
MP-FH (degrees)	26	28	26.5	23.5
Y axis of growth (degrees)	67	68	67.5	65
ANS-Me (mm)	59.5	66	67.5	72
Co-A (mm)	78	82.5	84.5	86.5
ANS-PNS (mm)	50	54	57	58
Co-Gn (mm)	108	115.5	119.5	127.5
N-A (mm)	−3	−3	−2	−1
N-Pog (mm)	2.5	1	4	9
Go-Me (mm)	63.5	69	71.5	73
N-ANS (mm)	50	52.5	55	56
IEE-PNS (mm)	50	53	56	56
Ar-Go (mm)	41,.5	43	45	52.5
Ar-Go-Me (degrees)	134	132.5	130.5	132
Ar-Go-N (degrees)	46	54	52.5	53.5
N-Go-Me (degrees)	88	78.5	78	78.5
Dental				
Interincisal angle (degrees)	140	129	124	133
11-FH (degrees)	112	124	127	124
11-SN (degrees)	102	115	117	115
11-A-Pog (mm)	−2	2	4	2
11-PP (mm)	27	27	27	30
16-PP (mm)	18	21	22.5	25
41-MP (mm)	82.5	80	83	79
41-A-Pog (mm)	3	1	2	0
41-A-Pog (degrees)	25	21	25.5	24
41-MP (mm)	37	39	41	41
46-MP (mm)	25	27	28	32
Facial				
S-N-Pog (degrees)	88	86	87	89
Lower lip−H line (mm)	4	2	2	1
Upper sulcus−H line (mm)	2	3	4	4
Nasolabial angle (degrees)	107	104	106	107

Table 4 Case 4 cephalometric analysis

	Pretreatment (10 years of age)	Treatment (14 years of age)	Final (15 years of age)	Retention (16 years of age)
Skeletal				
Facial angle (S-N-Pog) (degrees)	81	80	80	80
SNA (degrees)	81	80.5	79.5	80.5
SNB (degrees)	80	78.5	78.5	78
ANB (degrees)	1	2	1	2.5
N-A-Pog (degrees)	0	1	0	1
Wits (mm)	−1.5	−2.5	−2	−2.5
MP-FH (degrees)	23	27	24	24
Y Axis of Growth (degrees)	66	68.5	68	68
ANS-Me (mm)	61	68	68	69
Co-A (mm)	79,5	84	84	84
ANS-PNS (mm)	48	50	53	54
Co-Gn (mm)	107	114	114	115
N-A (mm)	0	−2	0	−0.5
N-Pog (mm)	0	−5	0	−2
Go-Me (mm)	64.5	68	70	70
N-ANS (mm)	48.5	51.5	51	50
IEE-PNS (mm)	45.5	49	49	49
Ar-Go (mm)	46	49	49	49
Ar-Go-Me (degrees)	126	125	123	124
Ar-Go-N (degrees)	52.5	49.5	49	50.5
N-Go-Me (degrees)	73.5	75.5	74	73.5
Dental				
Interincisal angle (degrees)	130	139	133	133
11-FH (degrees)	117	111	116	114
11-SN (degrees)	107	102	105	106
11-A-Pog (mm)	4	3,5	4	4
11-PP (mm)	25	29	28	29
16-PP (mm)	20	20	21	21
41-MP (degrees)	90	82	88	89
41-A-Pog (mm)	3	1	2	2
41-A-pog (degrees)	22.5	16	22.5	22
41-MP (mm)	38	41	41	41
46-MP (mm)	28	33	32	32
Facial				
S-N-Pog (degrees)	86.5	89	88	89
Lower lip−H line (mm)	2	1	2	1
Upper sulcus−H line (mm)	2.5	5	5	4
Nasolabial angle (degrees)	114	113	111	108

Table 5 Case 5 cephalometric analysis

	Pretreatment (13 years of age)	Treatment (14 years of age)	Final (16 years of age)	Retention (17 years of age)
Skeletal				
Facial angle (S-N-Pog) (degrees)	87	87.5	87	87
SNA (degrees)	77	77	76	77
SNB (degrees)	78	76	76	76
ANB (degrees)	−1	1	0	1
N-A-Pog (degrees)	−5	−2	−2	−3
Wits (mm)	−10	−5	−3	−3
MP-FH (degrees)	35	36	40	40
Y axis of growth (degrees)	62	62	64	64.5
ANS-Me (mm)	72	75	77.5	77
Co-A (mm)	84	88.5	87	87
ANS-PNS (mm)	50	50	50	50
Co-Gn (mm)	121	127	130	129.5
N-A (mm)	−6.5	−4	−5	−5
N-Pog (mm)	−7	−8	−7	−7.5
Go-Me (mm)	67	68.5	69	70
N − ANS (mm)	52	54	55	53
IEE-PNS (mm)	49	50	49	50
Ar-Go (mm)	47	47	46	46
Ar-Go-Me (degrees)	142	142	143	143
Ar-Go-N (degrees)	55	54.5	55	55
N-Go-Me (degrees)	87	87.5	88	88
Dental				
Interincisal angle (degrees)	145	141	145	145
11-FH (degrees)	105	110	107	107
11-SN (degrees)	100	104	100	101
11-A-Pog (mm)	1.5	3	2	2
11-PP (mm)	30	29.5	30.5	30
16-PP (mm)	23	23	24	24
41-MP (degrees)	73	72	70	69
41-A-Pog (mm)	1	0	−1	−1
41-A-Pog (degrees)	17	16	16	16
41-MP (mm)	38	41	41	41
46-MP (mm)	30	28	30	30
Facial				
S-N-Pog (degrees)	80	80	80	80
Lower lip−H line (mm)	1	0	0.5	1
Upper sulcus−H line (mm)	4	5	6	6
Nasolabial angle (degrees)	95	95	96	96