Original Article

Camouflage treatment of skeletal Class III malocclusion with multiloop edgewise arch wire and modified Class III elastics by maxillary mini-implant anchorage

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ABSTRACT

Objective: To evaluate the effect of the multiloop edgewise arch wire (MEAW) technique with maxillary mini-implants in the camouflage treatment of skeletal Class III malocclusion.

Materials and Methods: Twenty patients were treated with the MEAW technique and modified Class III elastics from the maxillary mini-implants. Twenty-four patients were treated with MEAW and long Class III elastics from the upper second molars as control. Lateral cephalometric radiographs were obtained and analyzed before and after treatment, and 1 year after retention.

Results: Satisfactory occlusion was established in both groups. Through principal component analysis, it could be concluded the anterior-posterior dental position, skeletal sagittal and vertical position, and upper molar vertical position changed within groups and between groups; vertical lower teeth position and Wits distance changed in the experimental group and between groups. In the experimental group, the lower incisors tipped lingually 2.7 mm and extruded 2.4 mm. The lingual inclination of the lower incisors increased 3.5°. The mandibular first molars tipped distally 9.1° and intruded 0.4 mm. Their cusps moved 3.4 mm distally. In the control group, the upper incisors proclined 3°, and the upper first molar extruded 2 mm. SN-MP increased 1.6° and S-Go/N-ME decreased 1.

Conclusions: The MEAW technique combined with modified Class III elastics by maxillary mini-implants can effectively tip the mandibular molars distally without any extrusion and tip the lower incisors lingually with extrusion to camouflage skeletal Class III malocclusions. Clockwise rotation of the mandible and further proclination of upper incisors can be avoided. The MEAW technique and modified Class III elastics provided an appropriate treatment strategy especially for patients with high angle and open bite tendency. (*Angle Orthod.* 2013;83:630–640.)

KEY WORDS: Camouflage; Skeletal Class III; MEAW; Maxillary mini-implants

INTRODUCTION

The prevalence of skeletal Class III malocclusion varies among races. In the white population the incidence has been reported to be 1% to 5%, and in the Asian populations it is up to 14%.[1–5] This malocclusion is considered one of the most difficult to treat.[5,6] Nongrowing patients with skeletal Class III malocclusion could be treated by orthognathic surgery or orthodontic camouflage treatment. In severe cases, surgical procedures should be performed to correct the skeletal and dental discrepancies, as well as to improve facial esthetics and harmonize the profile.[7] In borderline cases where camouflage is possible and

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is a valid option, the treatment should camouflage the dental and skeletal discrepancies to an extent that could satisfy facial esthetic and functional concerns of the patient as much as possible.[8] This is sometimes difficult to achieve due to lack of adequate anchorage since adequate and proper anchorage control is fundamental to the success of orthodontic treatment.[9]

A common form of camouflage treatment strategy for skeletal Class III malocclusion is the use of multiloop edgewise arch wire (MEAW) technique and Class III elastics, which could upright the inclination of the lower teeth, reconstruct the occlusal plane, coordinate the width of both arches and torque of posterior teeth,[10] and decrease the Class III discrepancy.[11,12] Long Class III elastics have been reported, however, to extrude the upper molars and proclined the upper incisors when upper dentition is used as the anchor unit to move the lower dentition distally.[8,12,13] The resultant extrusion of the upper molars can lead to a clockwise rotation of the mandible, which increases the lower anterior facial height and decreases the overbite.[14] This effect would be beneficial in treatment of patients with low mandibular plane angle and deep bite because it helps correct the malocclusion and also reduces the chin prominence. Unfortunately, a high mandibular plane angle and an increased lower anterior face height are often two classic anatomic features of skeletal Class III malocclusion.[15] Extrusion of upper molars with the resultant clockwise mandibular rotation and increase in lower anterior face height would be, therefore, an undesirable outcome. Long Class III elastics may also further procline the upper anterior teeth which are already proclined as part of the dentoalveolar compensations in most skeletal Class III patients, compromising the profile esthetic outcome and stability of the treatment.[15]

To provide more appropriate anchorage and eliminate intermaxillary Class III elastics, extraoral appliances such as mandibular cervical headgear, high-pull headgear, and headgear with J-hook have been traditionally employed for distal movement of the lower arch in the treatment of skeletal Class III malocclusion.[11,12] Major disadvantages of extraoral anchorage are its general inconvenience, limited wearing time, and high dependence on patient cooperation. The aim of this study was to evaluate the effects of the MEAW technique with maxillary mini-implant anchorage for modified Class III elastics in the treatment of patients with skeletal Class III malocclusion.

MATERIALS AND METHODS

The study was approved by the ethical board of Sichuan University. Participation was voluntary, and informed consent documents were signed by all participants before they entered this retrospective study.

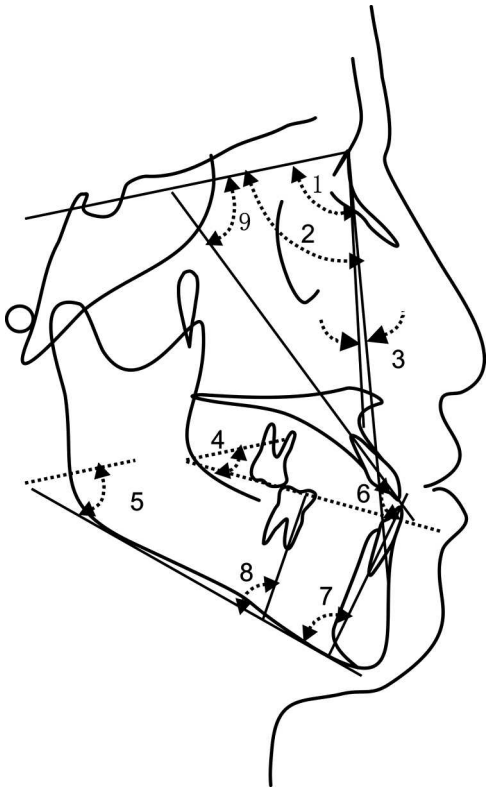

Figure 1. Cephalometric angular measurements. (1) SNA. (2) SNB. (3) ANB. (4) SN-OP. (5) SN-MP. (6) U1-L1. (7) L1-MP. (8) L6-MP. (9) U1-SN.

Forty-four nongrowing patients with skeletal Class III malocclusions at the Department of Orthodontics, West China Hospital of Stomatology, Chengdu, China, were included in this study. Inclusion criteria were: (1) mild to moderate skeletal Class III relationship ($-4^\circ \leq ANB^\circ \leq 0^\circ$); (2) Angle Class III molar relationship bilaterally; (3) no or mild crowding (<4 mm); (4) lack of a functional mandibular shift and inability of the mandible to move back spontaneously; and (5) lack of temporomandibular disorder symptoms. The experimental group consisted of 20 patients (10 male and 10 female) who were treated with MEAW and modified Class III elastics from the maxillary mini-implants. The control group consisted of 24 patients (10 male and 14 female) who were treated with MEAW and long Class III elastics from the upper second molars.

All of the patients were treated with 0.022 $\times$ 0.028-inch preadjusted edgewise appliances. Mandibular third molars were extracted before treatment, if presented. All of the teeth were banded or bonded, including the second molars in both arches. After initial alignment and leveling had been achieved by sequential use of round to rectangular Ni-Ti wires, a MEAW 0.018 $\times$ 0.025-inch stainless steel wire was placed on

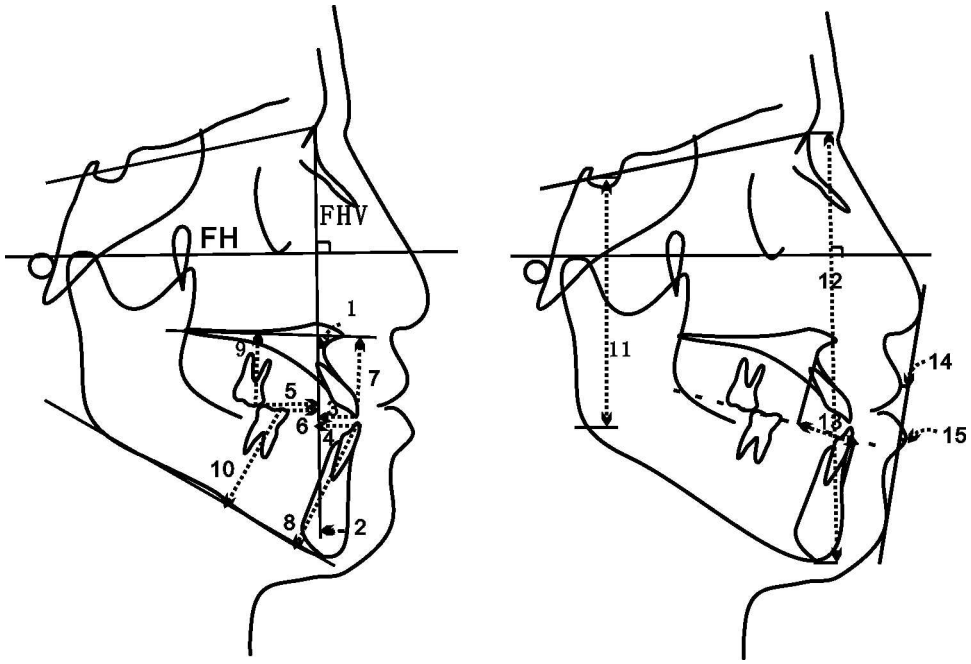

Figure 2. Cephalometric liner measurements: FHV (McNamara line) was drawn perpendicular to FH plane from the nasion. a: (1) A-McNamara line. (2) Pog-McNamara line. (3) U1-FHV, perpendicular distance from the edge of upper incisors to FHV. (4) L1-FHV, perpendicular distance from the edge of lower incisors to FHV. (5) U6-FHV, perpendicular distance from the mesial cusp of upper first molar to FHV. (6) L6-FHV, perpendicular distance from the mesial cusp of lower first molar to FHV. (7) U1-PP, perpendicular distance from the edge of upper incisors to palatal plane. (8) L1-MP, perpendicular distance from the edge of lower incisors to mandibular plane. (9) U6-PP, perpendicular distance from the mesial cusp of upper first molar to palatal plane. (10) L6-MP, perpendicular distance from the mesial cusp of lower first molar to mandibular plane. b: (11) S-Go. (12) N-Me. (13) Wits appraisal. (14) E line to upper lip. (15) E line to lower lip.

the lower arch and a straight stainless steel wire, size 0.019×0.025-inch, was placed on the upper. The multiloop edgewise arch wire (MEAW) had a reverse curve of Spee incorporated into it through a series of 3° to 5° tip-back bends on each tooth beginning with the first premolar and progressing posteriorly to the second molar. Mini-implants 1.6 mm in diameter and 9 mm in length were placed in the buccal interradicular spaces between the upper second premolars and the first molars in the experimental group. Symmetric or asymmetric light Class III elastics, size 5/16 inch and weight 3.5 ounces, were used from the implants in the experimental group and from the upper second molars in the control group to the first loops on the MEAW (mesial to the canines) to resolve the Class III malocclusion and/or to correct any lower midline shift. The Class III elastics were used until a Class I molar and canine relationship was achieved and for 2 more months after this to improve the stability of the result. Detailing and setting of the occlusion were done on the same arch wires with adjustments in the MEAW arch wires as necessary. Hawley retainers were placed on both arches immediately after the removal of the fixed appliances.

Digital lateral cephalometric radiographs and panoramic radiographs were taken by the same X-ray machine before treatment (T1, T1′), immediately after the active treatment (T2, T2′), and 1 year after retention (T3, T3′). T1, T2, and T3 represent the experimental group, and T1′, T2′, and T3′ the control group. All of the lateral cephalometric radiographs were randomly numbered and patients' identities were concealed during cephalometric analysis. The radiographs were digitally analyzed using WinCeph software version 7.0 for Windows (Rise Corporation, Sendai, Japan). The landmarks identified, the cephalometric planes, and the parameters used in the cephalometric analysis are shown in Figures 1 and 2. Each radiograph was analyzed three times by one experienced investigator, and the mean value of each parameter was used for further analysis.

Twenty randomly selected radiographs were measured 1 month apart to test the reliability of the measurements. A paired sample *t*-test showed high intraobserver reliability of the measurements ($P > .05$). Principal component analysis was employed to group-correlated variables into sets of uncorrelated variables called principal components. Comparison of the extracted principal components and original measurements within group was done by paired-sample *t*-test or by Wilcoxon signed rank test. Comparison of changes between groups was done by independent-samples

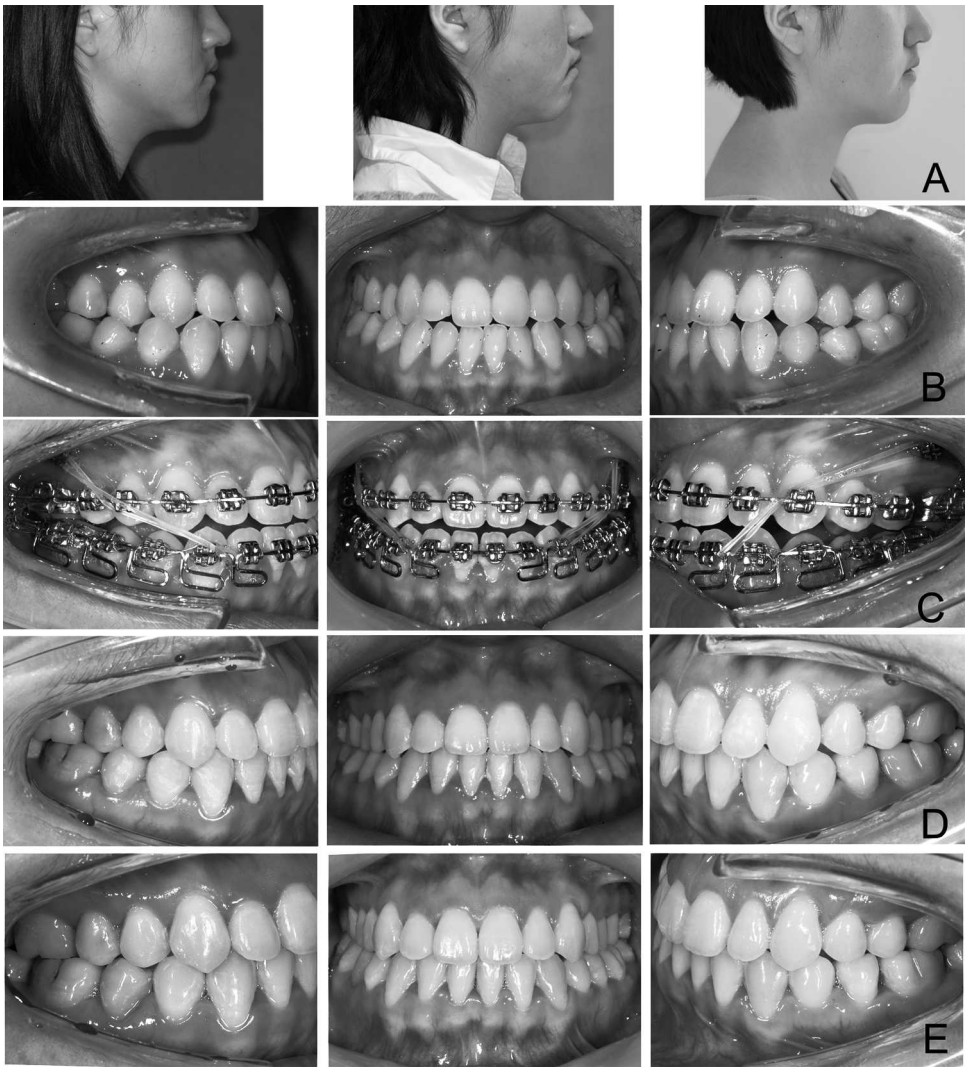

Figure 3. Photographs of one patient in the experimental group. (A) Profiles pretreatment and posttreatment, and 1 year after retention. (B) Intraoral photographs pretreatment. (C) Intraoral photographs during treatment. (D) Intraoral photographs posttreatment. (E) Intraoral photographs 1 year after retention.

t-test or by Mann-Whitney *U*-test. All statistical analysis was done using SPSS software for Windows (release 16.0, standard version, SPSS, Chicago, Ill). The level of statistically significant differences was $P < .05$.

RESULTS

Satisfactory occlusion was established for all patients. No one exhibited any temporomandibular problems. One mini-implant loosened and was replaced

Table 1. Summary of Principal Component Analysis

Principal Component	Variance Explained, %	Cumulative Variance, %	Variables	Representation
1	27.085	27.085	U1-FHV (mm), U1-SN (°), L1-FHV (mm), L1-MP (°), U1-LI (°), L6-FHV (mm)	Anterior-posterior dental position
			A-Mac line (mm), Pog-McNa line (mm), SNA (°), SNB (°), S-Go/N-ME, SN-MP (°), ODI	Skeletal sagittal and vertical position
			U6-PP (mm)	Upper molar vertical position
2	16.801	43.886	ANB (°), APDI, Wits distance (mm), overjet (mm)	Sagittal skeletal and dental discrepancy
3	11.735	55.620	SN-MP (°), S-Go/N-ME, SNA (°), SNB (°)	Sagittal and vertical skeletal position
4	8.220	63.841	Overbite (mm), U6-PP (mm), U1-PP (mm)	Overbite, vertical upper teeth position
5	7.773	71.614	L6-MP (mm), L1-MP (mm)	Vertical lower teeth position
6	5.034	76.648	Wits distance	Wits discrepancy

Table 2. Comparison of Six Principal Components Within Groups and Between Groups During Observation[a]

Principal Component	T2-T1		T3-T2		T2′-T1′		T3′-T2′		TC vs TC′		RC vs RC′	
	P	Sig	*P*	Sig	*P*	Sig	*P*	Sig	*P*	Sig	*P*	Sig
1	.000	***	.012	*	.001	***	.000	***	.000	***	.000	***
2	.370	NS	.218	NS	.290	NS	.440	NS	.109	NS	.125	NS
3	.351	NS	.709	NS	.689	NS	.162	NS	.509	NS	.229	NS
4	.279	NS	.737	NS	.346	NS	.424	NS	.229	NS	.423	NS
5	.004	***	.455	NS	.130	NS	.775	NS	.005	***	.465	NS
6	.003	***	.911	NS	.037	*	.841	NS	.003	***	.888	NS

[a] T1 indicates experimental group before treatment; T2, experimental group post treatment; T3, experimental group 1 year after retention; TC, treatment changes of experimental group; RC, retention changes of experimental group; T1′, control group before treatment; T2′, control group post treatment; T3′, control group 1 year after retention; TC′: treatment changes of control group; and RC′, retention changes of control group.
* $P < .05$; ** $P < .01$; *** $P < .001$. NS indicates not significant.

in the experimental group. The total treatment times of the experiment group and the control group were 14 months and 18.5 months, respectively. Figure 3 shows one patient in the experimental group.

Principal Component Analysis

Six principal components were extracted and compared in Tables 1 and 2. Further statistics were done to get more detailed information.

Table 3. Comparison of Patients in Experimental Group and Control Group at T1[a]

	T1		T1′		T1 vs T1′	
	Mean	SD	Mean	SD	*P*	Significance
Age, y	20.6	4.0	21.3	1.9	.143	NS
SNA, degrees	80.9	3.4	79.5	3.2	.158	NS
SNB, degrees	82.8	2.7	81.5	3.0	.161	NS
ANB, degrees	−1.9	1.3	−2.1	1.5	.647	NS
OP-SN, degrees	21.1	3.0	20.1	2.4	.196	NS
SN-MP, degrees	39.6	4.3	39.0	3.7	.599	NS
S-Go/N-ME	61.2	2.8	62.1	3.0	.321	NS
A-McNa line, mm	1.2	2.1	−1.1	2.7	.004	***
Pog-McNa line, mm	4.5	1.4	1.5	3.7	.004	***
APDI	95.7	3.3	95.4	3.9	.773	NS
ODI	58.8	5.4	59.8	6.3	.587	NS
U1-L1, degrees	127.0	6.0	131.6	6.1	.016	*
U1-SN, degrees	66.9	3.3	70.5	4.0	.002	**
L1-MP, degrees	81.4	4.3	81.4	5.0	.964	NS
L6-MP, degrees	83.1	4.2	82.5	4.3	.643	NS
U1-PP, mm	28.8	2.1	26.7	2.9	.009	**
U6-PP, mm	22.7	1.4	21.2	2.3	.009	**
L1-MP, mm	40.0	2.0	39.9	2.8	.936	NS
L6-MP, mm	31.1	1.0	30.1	2.4	.119	NS
U1-FHV, mm	7.7	4.1	4.2	4.2	.009	**
U6-FHV, mm	−25.2	4.2	−24.3	4.6	.518	NS
L1-FHV, mm	8.1	4.0	4.3	4.6	.007	**
L6-FHV, mm	−18.8	3.8	−19.6	5.2	.572	NS
Wits appraisal	−9.8	1.9	−8.8	2.1	.112	NS
Overjet, mm	−0.9	1.3	−1.3	2.3	.509	NS
Overbite, mm	−1.0	1.6	−0.1	1.4	.055	NS
UL-EP, mm	−1.1	1.7	−2.1	2.0	.083	NS
LL-EP, mm	0.9	1.0	0.7	2.1	.546	NS

[a] T1 indicates experimental group before treatment; T1′, control group before treatment. McNa line indicates McNamara line, line perpendicular to FH plane from the nasion; PTV, line perpendicular to FH plane from the nasion; U1-FHV, perpendicular distance from the edge of upper incisors to FHV; L1-FHV, perpendicular distance from the edge of lower incisors to FHV; U6-FHV, perpendicular distance from the mesial cusp of upper first molar to FHV; L6-FHV, perpendicular distance from the mesial cusp of lower first molar to FHV; the value was defined as "negative (−)" when the point was behind the line. L1-MP, the posterior angle between the axis of lower incisors and mandibular plane; L6-MP, the posterior angle between the axis of lower first molar and mandibular plane.
* $P < .05$; ** $P < .01$; *** $P < .001$. NS indicates not significant.

Table 4. Cephalometric Analysis of Patients in Experimental Group After Treatment and Retention[a]

	T2		T3		TC (T2-T1)				RC (T3-T2)			
	Mean	SD	Mean	SD	Mean	SD	*P*	Sig	Mean	SD	*P*	Sig
SNA, degrees	81.1	3.6	81.2	3.4	0.2	0.7	.208	NS	0.1	0.5	.626	NS
SNB, degrees	82.8	2.8	83.0	2.8	0.0	0.7	.878	NS	0.1	0.7	.466	NS
ANB, degrees	−1.7	1.4	−1.7	1.2	0.2	0.5	.114	NS	−0.1	0.5	.628	NS
OP-SN, degrees	18.6	2.1	19.0	2.0	−2.5	1.3	.000	***	0.1	0.2	.013	*
SN-MP, degrees	40.1	4.3	40.1	4.3	0.5	1.2	.093	NS	0.0	0.8	.978	NS
S-Go/N-ME	61.3	2.9	61.3	2.9	0.1	0.4	.337	NS	0.0	0.1	.704	NS
A-McNa line, mm	1.1	2.2	1.1	2.2	−0.1	0.4	.461	NS	−0.1	0.2	.285	NS
Pog-McNa line, mm	3.1	1.3	3.3	1.2	−1.4	1.5	.001	**	0.1	0.3	.132	NS
APDI	92.2	3.4	92.6	3.2	−3.6	2.4	.000	***	0.4	0.7	.028	*
ODI	61.0	6.1	60.4	5.9	2.3	3.0	.003	**	−0.7	0.7	.000	***
U1-L1, degrees	128.9	5.3	128.6	5.2	1.9	1.6	.000	***	−0.3	0.8	.079	NS
U1-SN, degrees	68.1	3.0	67.8	3.2	1.2	1.3	.001	**	−0.3	0.8	.102	NS
L1-MP, degrees	77.9	3.4	78.0	3.3	−3.5	2.5	.000	***	0.1	0.3	.076	NS
L6-MP, degrees	74.1	4.3	74.6	4.6	−9.1	3.4	.000	***	0.3	0.3	.001	**
U1-PP, mm	29.2	1.9	29.2	1.9	0.4	1.1	.124	NS	0.0	0.2	.691	NS
U6-PP, mm	22.9	1.4	22.9	1.4	0.1	0.3	.081	NS	0.0	0.2	.707	NS
L1-MP, mm	42.4	2.0	42.3	2.2	2.4	1.1	.000	***	−0.2	0.4	.090	NS
L6-MP, mm	30.7	1.1	30.9	1.0	−0.4	0.7	.027	**	0.1	0.3	.262	NS
U1-FHV, mm	7.6	4.0	7.5	4.0	−0.1	0.4	.374	NS	−0.1	0.1	.119	NS
U6-FHV, mm	−25.5	4.1	−25.4	4.1	−0.4	0.4	.000	***	0.1	0.1	.007	**
L1-FHV, mm	5.3	4.3	5.5	4.3	−2.7	1.2	.000	***	0.1	0.2	.018	*
L6-FHV, mm	−22.2	3.8	−22.0	3.8	−3.4	1.3	.000	***	0.2	0.2	.000	***
Wits appraisal	−4.9	3.4	−4.9	3.4	4.9	2.2	.000	***	0.1	0.8	.912	NS
Overjet, mm	2.3	0.6	2.3	0.6	3.2	1.1	.000	***	0.0	0.1	.058	NS
Overbite, mm	2.1	1.1	2.0	1.1	3.1	1.6	.000	***	−0.1	0.1	.005	**
UL-EP, mm	−1.2	1.7	−1.2	1.5	−0.1	0.3	.308	NS	0.0	0.3	.673	NS
LL-EP, mm	0.1	0.6	0.3	0.6	−0.8	1.1	.007	**	0.1	0.4	.121	NS

[a] T1 indicates experimental group before treatment; T2, experimental group post treatment; T3, experimental group 1 year after retention; TC, treatment changes of experimental group; and RC, retention changes of experimental group. McNa line indicates McNamara line, line perpendicular to FH plane from the nasion; PTV, line perpendicular to FH plane from the nasion; U1-FHV, perpendicular distance from the edge of upper incisors to FHV; L1-FHV, perpendicular distance from the edge of lower incisors to FHV; U6-FHV, perpendicular distance from the mesial cusp of upper first molar to FHV; L6-FHV, perpendicular distance from the mesial cusp of lower first molar to FHV; the value was defined as "negative (−)" when the point was behind the line. L1-MP, the posterior angle between the axis of lower incisors and mandibular plane; L6-MP, the posterior angle between the axis of lower first molar and mandibular plane.

* $P < .05$; ** $P < .01$; *** $P < .001$. NS indicates not significant.

Within-group Comparisons After Active Treatment

Table 3 shows ages and cephalometric analysis of the two groups before treatment. Descriptive statistics and comparisons after treatment are shown in Tables 4 and 5. Posttreatment measurements show OP-SN, Pog-McNa, APDI, L1-MP (°), L6-MP (°), L1-FHV, and L6-FHV decreased significantly, and L1-MP (mm), Wits distance, overjet, overbite, and ODI increased significantly in both groups. For the experimental group, U1-SN and U1-L1 increased significantly, and U6-FHV, L6-MP (mm), and LL-EP decreased significantly. The lower incisors tipped lingually 2.7 mm and extruded 2.4 mm. The lingual inclination of the lower incisors increased 3.5°. The mandibular first molars tipped distally 9.1° and intruded 0.4 mm. Their cusps moved 3.4 mm distally. The occlusal plane showed a counterclockwise rotation of 2.5°. The distance of lower lip to E line decreased 0.8 mm. In the control group, U1-SN and S-Go/N-Me decreased significantly and SN-MP, U6-PP, U1-PP, U1-FHV, UL-EP, L6-MP, and LL-EP increased significantly. The upper incisors proclined 3° and the upper first molar extruded 2 mm. SN-MP increased 1.6° and S-Go/N-ME decreased 1°. Superimpositions of cephalometric tracings of samples in two groups at pretreatment and posttreatment are presented in Figure 4.

Within-group Comparisons During Retention

During the retention time, several measurements changed significantly in the experimental group and even more changed in the control group, but the changes were very small. From clinical observation, the occlusion was well maintained.

Between-group Comparisons of Changes During Treatment and Retention

During treatment, the changes of several measurements such as S-Go/N-ME, U1-SN, and U6-PP were

Table 5. Cephalometric Analysis of Patients in Control Group After Treatment and Retention[a]

	T2′		T3′		TC′ (T2′-T1′)				RC′ (T3′-T2′)			
	Mean	SD	Mean	SD	Mean	SD	*P*	Sig	Mean	SD	*P*	Sig
SNA, degrees	79.5	3.2	79.5	3.3	0.1	0.5	.534	NS	0.0	0.3	.701	NS
SNB, degrees	81.5	3.0	81.5	3.1	−0.1	0.3	.191	NS	0.1	0.3	.306	NS
ANB, degrees	−1.9	1.6	−2.0	1.8	0.1	0.4	.113	NS	−0.1	0.4	.309	NS
OP-SN, degrees	18.2	2.7	18.4	2.6	−1.8	0.8	.000	***	0.2	0.2	.000	***
SN-MP, degrees	40.6	3.7	40.4	3.8	1.6	1.0	.000	***	−0.1	0.2	.005	**
S-Go/N-ME	61.1	3.1	61.1	3.1	−1.0	1.1	.000	***	0.1	0.1	.004	**
A-McNa line, mm	−1.1	2.9	−1.0	2.9	0.0	0.7	.903	NS	0.0	0.1	.103	NS
Pog-McNa line, mm	0.2	3.4	−0.4	4.3	−1.3	2.4	.011	*	0.1	0.1	.001	**
APDI	93.7	4.0	94.0	3.9	−1.7	2.2	.001	**	0.2	0.2	.000	***
ODI	61.2	6.2	61.0	6.3	1.4	2.4	.008	**	−0.2	0.2	.000	***
U1-L1, degrees	130.7	7.1	130.7	6.9	−1.0	4.7	.356	NS	0.0	0.5	.756	NS
U1-SN, degrees	67.6	3.6	67.8	3.6	−3.0	1.5	.000	***	0.2	0.3	.001	**
L1-MP, degrees	79.1	5.0	79.3	4.9	−2.3	3.2	.002	**	0.2	0.4	.044	*
L6-MP, degrees	75.7	4.2	75.7	4.1	−6.8	3.5	.000	***	−0.1	0.4	.393	NS
U1-PP, mm	28.0	3.1	27.8	3.1	1.3	1.4	.000	***	−0.1	0.2	.001	**
U6-PP, mm	23.2	2.4	23.1	2.4	2.0	1.6	.000	***	−0.1	0.2	.012	*
L1-MP, mm	41.6	3.4	41.4	3.3	1.6	1.7	.000	***	−0.2	0.2	.000	***
L6-MP, mm	30.1	2.4	30.2	2.4	0.2	0.8	.242	**	−0.1	0.1	.053	NS
U1-FHV, mm	5.3	3.9	5.2	3.9	1.1	1.2	.000	***	−0.1	0.1	.003	**
U6-FHV, mm	−23.7	4.1	−23.8	4.2	0.6	2.0	.164	NS	−0.1	0.2	.143	NS
L1-FHV, mm	2.9	3.7	2.9	3.7	−1.5	1.8	.001	**	0.1	0.2	.211	NS
L6-FHV, mm	−21.7	4.3	−21.6	4.4	−2.1	2.0	.000	***	0.1	0.2	.029	*
Wits appraisal	−6.0	3.2	−6.2	3.2	2.8	2.5	.000	***	−0.2	0.1	.000	***
Overjet, mm	2.0	0.5	1.9	0.6	3.3	2.2	.000	***	−0.1	0.2	.001	**
Overbite, mm	2.2	0.4	2.1	0.4	2.3	1.4	.000	***	−0.1	0.2	.002	**
UL-EP, mm	−0.5	2.1	−0.6	2.1	1.7	1.0	.000	***	−0.1	0.2	.016	*
LL-EP, mm	1.7	2.0	1.7	2.0	1.1	1.7	.006	**	−0.1	0.2	.079	NS

[a] T1′ indicates control group before treatment; T2′, control group post treatment; T3′, control group 1 year after retention; TC′: treatment changes of control group; and RC′, retention changes of control group. McNa indicates McNamara line, line perpendicular to FH plane from the nasion; PTV, line perpendicular to FH plane from the nasion; U1-FHV, perpendicular distance from the edge of upper incisors to FHV; L1-FHV, perpendicular distance from the edge of lower incisors to FHV; U6-FHV, perpendicular distance from the mesial cusp of upper first molar to FHV; L6-FHV, perpendicular distance from the mesial cusp of lower first molar to FHV; the value was defined as "negative (−)" when the point was behind the line. L1-MP, the posterior angle between the axis of lower incisors and mandibular plane; L6-MP, the posterior angle between the axis of lower first molar and mandibular plane.

* $P < .05$; ** $P < .01$; *** $P < .001$. NS indicates not significant.

significantly different (Figure 5; Table 6). During retention, the changes of ODI, U1-SN, for example, were significantly different.

DISCUSSION

Orthodontists are still striving to develop biomechanical systems that can overcome the undesired side effects of extrusion of anchorage teeth, mandibular rotation, and increase in lower anterior face height when treating skeletal Class III malocclusions.[11,12,16,17] In the treatment of Class III patients using protraction headgear or during maxillary expansion, for instance, prevention of adverse vertical tooth movements and mandibular counterclockwise rotation are desirable, particularly in patients with an open bite tendency.[16,17] Camouflage treatment does not exclude orthodontists from better controlling tooth movements. On the contrary, treatment with more rational mechanical systems should be developed to improve treatment results. Successful camouflage treatment should camouflage both the skeletal and soft tissue discrepancies, achieve a good and acceptable facial esthetic result, and establish a stable occlusion.

Both kinds of orthodontic treatments to camouflage the skeletal Class III malocclusion in this study achieved good occlusion and were stable after 1 year, though observation in the long term is still needed. Changes of principal component 1 indicated that the anterior-posterior dental position, skeletal sagittal and vertical position, and upper molar vertical position changed during treatment within groups and between groups; changes of components 5 and 6 in the experimental group and between-group comparisons demonstrated that vertical lower teeth position and Wits values changed in experimental group, and the amount of changes varied between the two groups. More specifically, both groups exhibited a decrease of pogonion to McNamara line (Pog-McNa line), APDI, L1-MP (°), L6-MP (°), L1-FHV, L6-FHV, OP-SN, and

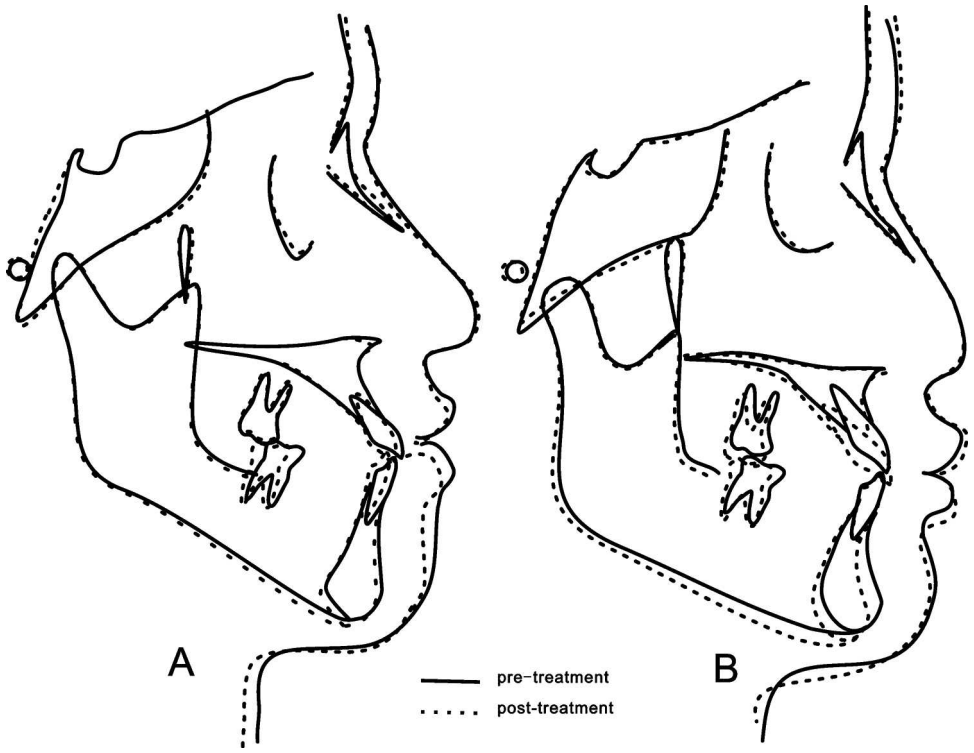

Figure 4. Superimpositions of cephalometric tracings on sella-nasion plane at sella at pretreatment (black line) and posttreatment (dotted line). (A) One sample in the experimental group. (B) One sample in the control group.

an increase regarding L1-MP (mm), Wits appraisal, overjet, overbite, and ODI, which contribute to the correction of occlusal relationship. The Pog to McNamara line linear distance decreased, indicating a reduction in the chin prominence. The significant decrease in the APDI and Wits distance indicated a reduction in the anterior-posterior discrepancy. The reduction in ODI demonstrated a decrease in the tendency to have an open bite.

Some treatment effects, however, were quite different between the two groups. In the experimental group, there was no extrusion of upper molars or any clockwise rotation of the mandible. Normal overjet and overbite were achieved mainly through distal movement of lower dentition and extrusion of the lower incisors. The upper incisors were not further proclined, and were, in fact, retracted a little because of broadening of the upper arch. The upper incisors were just a little extruded and this helped establish an adequate overbite with the lower incisors, while the patients had no gummy smile after the treatment. The mandibular first molars were tipped distally, effectively without any extrusion. In the control group, however, the upper incisors were proclined, the upper molars were extruded, and the anterior face height and the mandibular angle were increased. These changes resulting from intermaxillary Class III elastics would be an undesirable outcome in patients with open bite, long face, or high mandibular plane angle and should be avoided for facial balance and esthetics.[16,18,19] The lower lip is often protruded in relation to the upper in skeletal Class III patients.[20] The reduction of lower lip protrusion in the experimental group improved facial esthetics, while the upper and lower lips became more protrusive in the control group.

The successful camouflage treatment of patients in the experimental group depended on the proper selection of patients, effective and efficient mechanics of the system, and satisfactory anchorage control. All patients in this study had mild to moderate skeletal Class III relationship, acceptable profiles, and slight crowding on both dentitions, and this made nonsurgical treatment possible. Vertical discrepancies such as a high mandibular plane angle and horizontal discrepancies such as crossbite and mandibular deviation in some patients, however, may complicate the camouflage treatment. All pretreatment panoramic radiographs showed lower posterior teeth to be mesially tipped, making the MEAW technique suitable for camouflage treatment of these patients.

Mini-implants in the upper alveolar bone were used to provide anchorage needed to correct the Class III malocclusion. Patients have been reportedly treated by mini-implants in the mandible to move lower molars distally without the MEAW technique with good results.[21,22] In order to distally upright the lower teeth

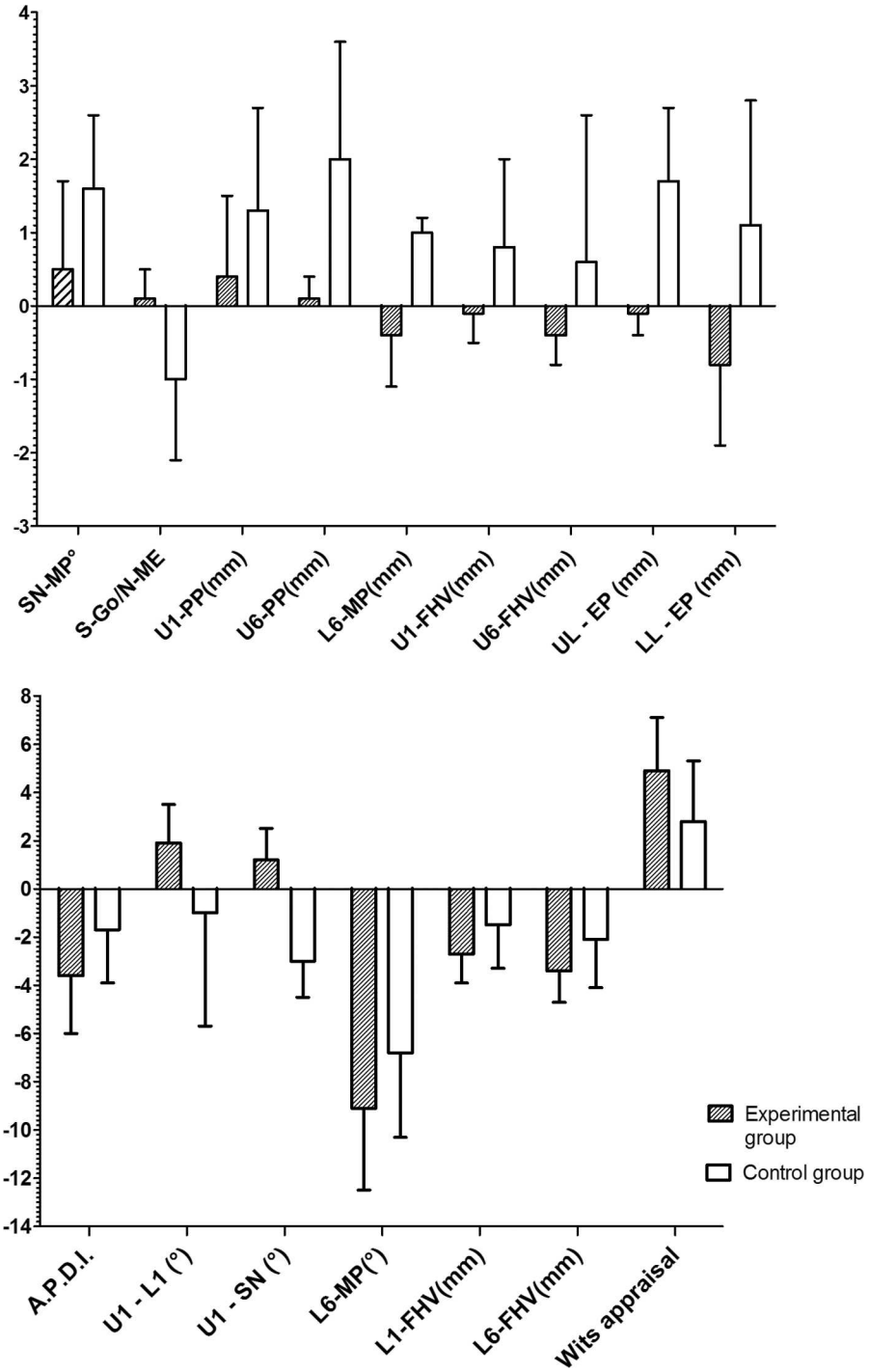

Figure 5. Significantly different treatment effects between groups.

without hindering tooth movement, the mini-implant in the mandible sometimes has to be placed in the retromolar region, the ramus, or the mandibular external oblique line. It is more difficult and flap surgery may be needed, sometimes causing greater tissue damage. Insertion of mini-implants in the upper jaw is easier in practice, is associated with less pain and discomfort, and shows a higher success rate. Several clinicians have observed that the cortical bone of the mandible is thick relative to the maxilla, which causes insertion torque to be higher, and so failure rate of insertion in the mandible is fairly high.[23,24] The buccal interradicular space between the upper second premolar and the first molar, the inserting position in this

Table 6. Comparison of Treatment and Retention Changes of Patients Between Experimental Group and Control Group[a]

	TC vs TC′		RC vs RC′	
	P	Significance	*P*	Significance
SNA, degrees	.425	NS	.362	NS
SNB, degrees	.131	NS	.800	NS
ANB, degrees	.859	NS	.795	NS
OP-SN, degrees	.114	NS	.329	NS
SN-MP, degrees	.002	**	.748	NS
S-Go/N-ME	.000	***	.106	NS
A-McNa line, mm	.615	NS	.145	NS
Pog-McNa line, mm	.903	NS	.640	NS
APDI	.009	**	.981	NS
ODI	.304	NS	.001	**
U1-L1, degrees	.003	**	.066	NS
U1-SN, degrees	.000	***	.001	**
L1-MP, degrees	.168	NS	.605	NS
L6-MP, degrees	.037	*	.133	NS
U1-PP, mm	.023	*	.031	*
U6-PP, mm	.000	***	.133	NS
L1-MP, mm	.085	NS	.908	NS
L6-MP, mm	.017	*	.028	*
U1-FHV, mm	.000	***	.207	NS
U6-FHV, mm	.001	**	.004	**
L1-FHV, mm	.013	*	.327	NS
L6-FHV, mm	.020	*	.387	NS
Wits appraisal	.005	**	.248	NS
Overjet, mm	.207	NS	.053	NS
Overbite, mm	.095	NS	.527	NS
UL-EP, mm	.000	***	.117	NS
LL-EP, mm	.000	***	.025	*

[a] TC indicates treatment changes of experimental group; RC, retention changes of experimental group; TC′, treatment changes of control group; and RC′, retention changes of control group. McNa indicates McNamara line, line perpendicular to FH plane from the nasion; PTV, line perpendicular to FH plane from the nasion; U1-FHV, perpendicular distance from the edge of upper incisors to FHV; L1-FHV, perpendicular distance from the edge of lower incisors to FHV; U6-FHV, perpendicular distance from the mesial cusp of upper first molar to FHV; L6-FHV, perpendicular distance from the mesial cusp of lower first molar to FHV; the value was defined as "negative (−)" when the point was behind the line. L1-MP, the posterior angle between the axis of lower incisors and mandibular plane; L6-MP, the posterior angle between the axis of lower first molar and mandibular plane.

* $P < .05$; ** $P < .01$; *** $P < .001$. NS indicates not significant.

study, is the most popular location for insertion of mini-implant for anatomic considerations since this area is usually fairly wide.[23] Also, the force direction of Class III elastics from the first lower loop to the maxillary mini-implant is suitable for the extrusion of lower anterior teeth and, therefore, can benefit the open bite and occlusal plane correction. Placing the mini-implant in the maxilla, therefore, is an alternative, especially when it is difficult to insert in the mandible for some patients. Patients easily wore and replaced the elastics with little discomfort, and compliance was high. The Class III elastics were used for less than 6 months in the experimental group.

CONCLUSIONS

- The MEAW technique with modified Class III elastics by maxillary mini-implants can effectively tip the mandibular molars distally without any extrusion and tip the lower incisors lingually with extrusion to camouflage skeletal Class III malocclusions.
- Clockwise rotation of the mandible and further proclination of upper incisors can be avoided. The MEAW technique and modified Class III elastics provides an appropriate treatment strategy especially for patients with high angle and open bite tendency.

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