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Progressive changes in patients with skeletal Class III malocclusion treated by 2-jaw surgery with minimal and conventional presurgical orthodontics: A comparative study

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Introduction: In this study, we aimed to compare treatment efficacy and postsurgical stability between minimal presurgical orthodontics and conventional presurgical orthodontics for patients with skeletal Class III malocclusion. **Methods:** Forty patients received minimal presurgical orthodontics (n = 20) or conventional presurgical orthodontics (n = 20). Lateral cephalograms were obtained before treatment, before orthognathic surgery, and at 1 week, 3 months, 6 months, and 12 months after surgery. **Results:** Changes of overjet and mandibular incisal angle before surgery were greater in the conventional presurgical orthodontics group than in the minimal presurgical orthodontics group. Postsurgical horizontal changes in Points A and B, overjet, and mandibular incisal angle showed significant differences among the time points. Most of the horizontal and vertical relapses in the maxilla and the mandible occurred within the first 6 months in both groups. **Conclusions:** Minimal presurgical orthodontics and conventional presurgical orthodontics showed similar extents and directions of skeletal changes in patients with Class III malocclusion. However, orthodontists and surgeons should preoperatively consider the postsurgical counterclockwise rotation of the mandible when using minimal presurgical orthodontics. Close and frequent observations are recommended in the early postsurgical stages. (Am J Orthod Dentofacial Orthop 2016;149:244-52)

Severe skeletal Class III malocclusions are commonly corrected by combined orthognathic surgery and orthodontic treatment. To show the true severity of the skeletal discrepancies and maximize the stability of the postsurgical occlusion, conventional presurgical orthodontic treatment (CPO), which involves aligning, leveling, decompensating, and coordinating the 2 arches, is performed. However, this is a time-consuming process. Luther et al[1] reported that the average presurgical treatment duration was 17 months (range, 7-47 months). It is characterized by progressive deterioration of facial esthetics and dental function because of decompensation of the anterior teeth. Although patients are motivated by the thought of eventual improvement in their facial appearance,[2] presurgical treatment can result in poor compliance[3] and negative effects on patients' self-confidence and social interactions.[4,5]

Recently, the surgery-first approach was introduced to correct skeletal problems without presurgical orthodontic treatment. The surgery-first approach clearly has the advantages of an initial improvement in facial esthetics,[6] patient satisfaction, and a positive influence on psychosocial aspects.[5] However, it can increase the risk of relapse with a relatively unstable postsurgical occlusion.[7] Facial esthetics and surgical stability should carry the same weight as the fundamental prerequisites for orthodontic-orthognathic treatment. Therefore, a new method of minimal presurgical orthodontics (MPO) not longer than 6 months has been proposed for patients who received orthognathic surgery.[8,9] MPO focuses on eliminating or minimizing surgical occlusal interferences by intruding the overerupted teeth and coordinating the maxillary and mandibular arches.[8,9]

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In addition to the advantage of initially improved facial esthetics, the postsurgical phenomenon of rapid regional movement[10-12] results in a significantly shorter time for patients treated with MPO.[13,14] Moreover, the modified position of soft tissues can provide a better environment and less resistance for tooth movement.

Although the popularity of the surgery-first approach and MPO has recently increased, relatively few reports based on homogeneous samples are available. Some reports have involved multisegmental LeFort I osteotomies[15-17] or buccal interdental corticotomies.[18] Those procdures may complicate the surgery, prolong the surgical duration, raise the risk of blood transfusion, and increase the surgical failure rate. Moreover, they can even create complications such as a palatal fistula during osteogenesis.[19] Some studies evaluating the surgery-first approach and MPO did not include controls or patients who underwent CPO for comparison.[20-22] In addition, serial lateral cephalograms traced in most of the published studies were completed at the debonding stage and showed large interindividual variations.[7,15,17,20] Moreover, most studies[7,15,17,20] on postsurgical stability of surgery-first approach and MPO did not include close and strict postsurgical monitoring at specific time points, except for 1 study that evaluated the postsurgical stability of surgery-first approach with intraoral vertical ramus osteotomy for 12 months.[23]

In this study, we aimed to compare the treatment efficacy, and postsurgical dental and skeletal stability between MPO and CPO for patients with skeletal Class III malocclusion who had orthognathic surgery. The null hyotheses were that MPO and CPO have similar efficacy, and that dental and skeletal stabilities in the MPO group are not worse compared with the CPO group.

MATERIAL AND METHODS

This retrospective cohort study included consecutive patients who underwent orthognathic and orthodontic treatment at Peking University School and Hospital of Stomatology in Beijing, China, from 2010 to 2014. The inclusion criteria were as follows: skeletal Class III malocclusion (ANB, $\leq 0°$, with or without facial asymmetry); no extractions, except for the third molars; history of bimaxillary surgery (1-piece LeFort I osteotomy, bilateral sagittal split ramus osteotomy, and genioplasty, if required) with rigid fixation; and a complete series of identifiable lateral cephalograms. Patients with cleft lip or palate, syndromic craniofacial deformities, or a history of correction of Class III deformities by other techniques or genioplasty only were excluded. This study was approved by the institutional review board of Peking University School and Hospital of Stomatology (RB00001052-11039). Orthodontic treatment and orthognathic surgery were performed by 2 orthodontists (Y.Z., Y.Z.) and 2 surgeons (Z.L., X.W.). The orthodontists used the same archwire procedures (0.014-in, 0.016-in, 0.016 $\times$ 0.022-in, and 0.019 $\times$ 0.025-in nickel-titanium; and 0.019 $\times$ 0.025-in stainless steel). Two surgeons with more than 20 years of orthognathic surgical experience (150-200 patients per year) performed the surgeries. Every surgical plan was determined in team discussions.

A total of 40 patients received MPO ($n = 20$) or CPO ($n = 20$). All patients were assessed to be suitable for MPO, but those in the MPO group were more eager for better and faster esthetic improvement without progressive deterioration. The MPO group included 14 female and 6 male patients aged 15 to 25 years (mean, 20.9 $\pm$ 2.1 years); the CPO group included 8 female and 12 male patients aged 16 to 34 years (mean, 22.5 $\pm$ 4.9 years). In the MPO group, the average presurgical treatment duration was 3.3 months (range, 0.5-6 months). Active orthodontic treatment was performed to eliminate surgical interferences. In the CPO group, the presurgical phase, including leveling and alignment, space consolidation, and general coordination of both arches, spanned an average of 18.1 months (range, 16-34 months). No expansion protocol except orthodontic wires (associated with miniscrews when necessary) was performed in either group. Face-bow transfer, dental cast mounting, and paper surgery were performed for all patients. In addition to the LeFort I osteotomy and the bilateral sagittal split ramus osteotomy, 19 patients in the MPO group and 16 in the CPO group had undergone genioplasty. Rigid internal fixation with 4 microplates at the bilateral pyriform aperture and zygomaticomaxillary crest and 2 miniplates at the mandibular osteotomy site, together with monocortical screws, were inserted during the LeFort I osteotomy and the bilateral sagittal split ramus osteotomy. Another 2 miniplates were added to patients having genioplasty. All patients had braces during the whole treatment. Patients in the MPO group had surgery with nickel-titanium wires, which allowed postsurgical orthodontic treatment to start as soon as possible. Because the stiffness of nickel-titanium archwires is relatively too low to bear the intermaxillary fixation force, intermaxillary fixation with miniscrews was routinely used to maintain the maxillary and mandibular positions before and after wafer removal, whereas elastics between the stainless steel wires were used in the CPO group.

Lateral cephalography (OP100; Instrumentarium Tuusula, Finland) was performed before treatment

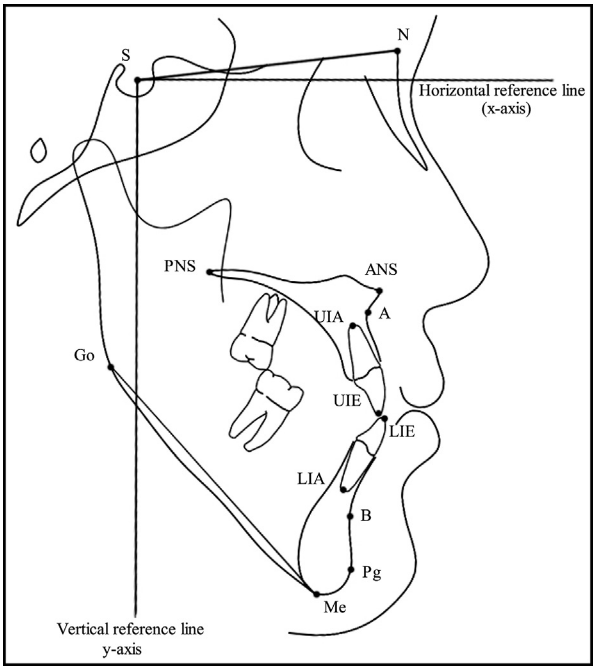

Fig 1. Landmarks and reference lines. The *horizontal reference line* (HRL, x-axis) passes through sella turcica (S) and 7° below the S-N (nasion) plane, and the *vertical reference line* (VRL, y-axis) is perpendicular to the HRL at sella. *ANS*, Anterior nasal spine; *PNS*, posterior nasal spine; *A*, innermost point of the contour from ANS to the crest of the maxillary alveolar process; *B*, innermost point of the contour from the bony chin to the alveolar bone junction; *UIE*, upper incisor edge; *UIA*, upper incisor apical; *LIE*, lower incisor edge; *LIA*, lower incisor apical; *Pg*, pogonion; *Me*, menton; *Go*, gonion.

(T0), before surgery (T1), and 1 week (T2), 3 months (T3), 6 months (T4), and 12 months (T5) after surgery. All cephalograms were digitized for cephalometric analysis with Ceph_analysis software (developed by Peking University) by the same observer blinded to the clinical progress of patients. The horizontal reference line passed through sella turcica and 7° below the sella-nasion plane, and the vertical reference line was perpendicular to horizontal reference line at sella (Fig 1). The definitions of the measured variables are summarized in Table I.

Statistical analysis

Statistical analyses were performed using SPSS software (version 16.0; SPSS, Chicago, Ill). To evaluate intraexaminer reliability, 10 randomly selected films from the 40 patients were retraced and digitized at 4-week intervals. Intraclass correlation coefficients were calculated and showed intraexaminer reliability of more than 0.997. The independent-sample *t* test was used to compare the initial measurements, presurgical treatment durations, and progressive changes between the MPO and CPO groups at the serial time points (significant at $P < 0.05$).

Table I. Definitions of reference lines and measurements

Measurement	*Definition*
HRL	Line through sella and 7° below the SN plane
VRL	Line through sella and perpendicular to HRL
A-x (mm)	Perpendicular distance from A-point to VRL
B-x (mm)	Perpendicular distance from B-point to VRL
ANS-y (mm)	Perpendicular distance from ANS to HRL
PNS-y (mm)	Perpendicular distance from PNS to HRL
Me-y (mm)	Perpendicular distance from Me to HRL
ANS-Me (mm)	Distance between ANS and Me parallel to VRL
Overjet (mm)	Distance between UIE and LIE parallel to VRL
Overbite (mm)	Distance between upper UIE and LIE parallel to HRL
MP/HRL (°)	Angle between the mandibular plane (Go-Me line) and HRL
UI/PP (°)	Angle between the UI axis (UIA-UIE line) and palatal plane (PNS-ANS line)
IMPA (°)	Angle between the mandibular incisor axis (LIA-LIE line) and the mandibular plane

RESULTS

There were no significant differences in the initial skeletal and dental measurements between the MPO and CPO groups (Table II).

As shown in Table III, the presurgical and total durations in the MPO group were significantly shorter than those in the CPO group ($P < 0.001$). A comparison of the mean changes in the cephalometric parameters from initial treatment to orthognathic surgery (T0-T1) between the MPO and CPO groups is given in Table IV. The changes in IMPA (MPO, 0.41°; CPO, 7.72°; $P < 0.01$) and overjet (MPO, −0.08 mm; CPO, −3.14 mm; $P < 0.001$) were significantly different between the groups. However, there was no statistically significant difference in the skeletal and dental changes from T1 to T2 between the MPO and CPO groups (Table IV). The maxilla in the MPO group showed an average forward movement of A-point by 3.05 mm. Meanwhile, the anterior nasal spine in the maxilla moved slightly downward by 0.25 mm, whereas the posterior nasal spine in the maxilla moved upward by 1.18 mm. The CPO group achieved surgical correction of the maxilla by a 3.24-mm forward movement of A-point, a 0.56-mm downward movement of anterior nasal spine, and a 0.29-mm upward movement (slight) of posterior nasal spine. The mandible was set back by movements in B-point of 5.25 mm in the MPO group and

Table II. Initial (T0) craniofacial and dental baseline values for 40 patients treated with MPO or CPO

	MPO		*CPO*		
	Mean	*SD*	*Mean*	*SD*	P
SNA (°)	81.11	3.99	80.15	2.79	0.38
SNB (°)	85.02	4.19	85.44	4.01	0.75
ANB (°)	−3.90	2.83	−5.30	2.86	0.13
SNPg (°)	85.34	4.71	86.11	4.27	0.59
ANS-Me (mm)	69.65	4.66	70.44	6.74	0.67
MP/HRL (°)	29.10	7.66	28.23	4.69	0.67
Overjet (mm)	−2.17	2.75	−1.58	2.56	0.49
Overbite (mm)	−0.20	1.99	−0.07	3.28	0.88
Maxillary crowding (mm)	1.63	1.44	1.30	1.30	0.46
Mandibular crowding (mm)	1.85	2.03	2.25	1.45	0.48
UI/PP (°)	59.99	6.33	63.02	4.77	0.10
IMPA (°)	77.55	8.00	75.08	7.26	0.31

Table III. Presurgical and total treatment duration (months) in the MPO and CPO groups

	MPO		*CPO*		
	Mean	*SD*	*Mean*	*SD*	P
Presurgical duration	3.30	1.98	18.10	5.61	<0.001*
Total duration	20.40	6.37	27.50	4.51	<0.001*

Independent t test: $^*P$ <0.01.

6.57 mm in the CPO group. In addition, menton in the mandible tended to move 0.38 mm upward in the MPO group and 0.57 mm downward in the CPO group, with no significant differences between the groups. With regard to changes from T0 to T2 (Table IV), there were no significant differences in any parameter except IMPA (MPO, 0.20°; CPO, 8.80°; P <0.001) between the groups. At T5, there were 14 patients in the MPO group and 9 in the CPO group with Class I molar relationships, closed bites anteriorly, and coincident midlines at 1 year.

The postsurgical stability of the different dentoskeletal characteristics in the MPO and CPO groups were closely observed and measured at the consecutive time points up to 12 months (Table V). Horizontal changes in A-point were significantly different between the 2 groups at 3 months after surgery (T2-T3; MPO, 0.47 mm; CPO, −1.00 mm; P <0.05) and were maintained until the sixth month (T3-T4; MPO, −1.12 mm; CPO, 0.63 mm; P <0.05). Significant differences in SNA (MPO, −0.91°; CPO, 0.85°; P <0.01) and ANB (MPO, −0.93°; CPO, −0.05°; P <0.01) were also observed between the 2 groups from T3 to T4. On the other hand, there were no significant differences in the horizontal movement of B-point and pogonion in the mandible and the vertical relapse of anterior nasal spine and posterior nasal spine in the maxilla and menton in the mandible. All parameters were stable from T4 to T5 in both groups, with no significant differences.

During the 12-month observation period (T2-T5) after surgery, overjet in the MPO group decreased by a greater extent than that in the CPO group (MPO, −1.23 mm; CPO, −0.09 mm; P <0.05) because of a greater increase in IMPA in the MPO group (MPO, 4.04°; CPO, 0.05°; P <0.05), indicating a small presurgical decompensation in the retroclined mandibular incisors in the MPO group. The angle between the maxillary central incisor and the palatal plane showed no significant difference because no extractions were performed. There was no significant difference between the 2 groups in the horizontal relapse of A-point in the maxilla and B-point and pogonion in the mandible. Vertical changes in B-point in the mandible were significantly different between the groups (P <0.01). Changes in SNA and ANB were also significantly different between the groups (P <0.05). Vertical changes in the anterior nasal spine and posterior nasal spine in the maxilla and menton in the mandible showed no significant differences between groups, as did the angle between the mandibular plane and the horizontal reference line.

Horizontal changes in A-point in the maxilla and B-point in the mandible and vertical changes in menton in the maxillomandibular complex at different times are shown in Figures 2-4. Most of the horizontal relapse in the maxilla and the mandible occurred during the first 6 months after surgery in both groups, whereas most of the vertical relapse occurred during the first 3 months.

DISCUSSION

In this study, we evaluated progressive skeletal and dental changes and postsurgical stability based on cephalometric investigations at various intervals in patients with skeletal Class III malocclusion treated with different presurgical treatment protocols (MPO or CPO). The comparisons included serial skeletal and dental changes and postsurgical stability between the groups. We also assessed the progressive tendency of changes in the horizontal and vertical dimensions.

Recently, Lee et al[22] evaluated the postsurgical relapse after mandibular setback surgery with MPO and found a significant decrease in the vertical dimensions and a significant increase in the horizontal dimensions. However, the study lacked a control group that underwent conventional surgical-orthodontic treatment. Moreover, Joh et al[8] compared the hard and soft tissue changes between patients who had MPO and CPO. Their study was conducted with homogeneous samples and included no extractions with bimaxillary surgery. However, their postsurgical observation

Table IV. Treatment changes with presurgical orthodontics (T0-T1), surgical movement (T1-T2), and treatment efficacy (T0-T2) in the MPO and CPO groups

	T0-T1					*T1-T2*					*T0-T2*				
	MPO		*CPO*			*MPO*		*CPO*			*MPO*		*CPO*		
	Mean	*SD*	*Mean*	*SD*	P	*Mean*	*SD*	*Mean*	*SD*	P	*Mean*	*SD*	*Mean*	*SD*	P
Horizontal changes (mm)															
A-x	0.60	−1.18	0.11	1.95	0.34	3.05	2.22	3.24	1.98	0.78	3.65	2.15	3.35	2.43	0.68
B-x	0.22	2.40	0.06	2.13	0.83	−5.25	3.21	−6.57	3.02	0.19	−5.03	3.50	−6.51	3.99	0.22
Pg-x	0.17	2.37	−0.04	2.36	0.77	−2.87	4.38	−4.73	4.00	0.17	−2.69	4.66	−4.77	5.15	0.19
Overjet	−0.08	1.14	−3.14	1.84	<0.001*	6.73	3.72	8.61	2.78	0.08	6.66	3.04	5.47	3.10	0.23
Vertical changes (mm)															
ANS-y	−0.13	1.02	0.07	1.20	0.58	0.25	2.13	0.56	2.12	0.64	0.12	2.34	0.63	2.31	0.49
PNS-y	−0.02	0.73	−0.11	0.66	0.69	−1.18	1.25	−0.29	1.67	0.06	−1.20	1.47	−0.39	1.55	0.10
B-y	1.12	2.54	1.25	2.39	0.87	−0.20	3.80	0.05	3.82	0.84	0.92	3.98	1.30	3.70	0.76
Me-y	1.03	2.68	0.61	1.68	0.55	−0.38	2.51	0.57	3.31	0.31	0.65	3.27	1.18	3.22	0.61
Overbite	−0.21	0.84	−0.50	2.13	0.57	1.32	1.91	1.41	2.29	0.89	1.11	2.29	0.91	3.23	0.82
Angular changes (°)															
SNA	−1.58	1.31	0.18	1.59	0.28	2.44	2.38	2.95	2.33	0.56	4.02	2.09	3.13	2.04	0.18
SNB	−0.01	0.85	0.03	1.28	0.90	−2.62	1.85	−3.61	1.72	0.09	−2.63	1.89	−3.58	2.10	0.14
ANB	0.66	0.84	0.15	1.20	0.13	6.00	2.62	6.56	2.75	0.51	6.65	2.52	6.71	2.59	0.95
MP/HRL	0.37	1.79	0.05	1.47	0.54	−1.38	4.02	−0.84	2.26	0.60	−1.01	3.68	−0.78	2.53	0.82
UI/PP	1.93	3.74	1.02	7.71	0.64	0.57	4.19	2.08	3.29	0.21	2.51	5.59	3.11	6.86	0.76
IMPA	0.41	3.08	7.72	7.02	<0.001*	−0.21	6.23	1.08	3.16	0.42	0.20	5.04	8.80	7.38	<0.001*

Independent *t* test: $^{*}P < 0.01$.
Horizontal and vertical changes: positive values indicate forward and downward movement.
Angular changes: positive values indicate increase.
Overbite and overbite: positive values indicate increase.

intervals were inadequate and ended with debonding, which varied among the subjects.

In our study, the MPO and CPO groups showed similar severities in sagittal and vertical skeletal discrepancies before treatment. During the presurgical phase, CPO involved alignment, leveling, and dental decompensation in both arches, whereas MPO focused mainly on the elimination of surgical interferences without progressive deterioration of facial esthetics. Therefore, decompensation of the retroclined mandibular incisors was apparent in the CPO group from T0 to T1, resulting in a significantly greater overjet correction and a significantly longer presurgical phase in this group from T0 to T1. This finding was consistent with the study of Joh et al,[8] where overjet correction in the CPO group was greater, although it was not significantly different from that in the MPO group.

In our study, the sagittal and vertical movements in both jaws from T1 to T2 showed no significant differences between the 2 groups. From the sagittal view, all 40 patients in both groups were generally corrected with a greater amount of mandibular setback compared with maxillary advancement. From the vertical view, the MPO and CPO groups achieved surgical correction of the maxilla by posterior impaction and anterior downward rotation. There were no significant differences between the vertical changes in anterior nasal spine and posterior nasal spine in the 2 groups. However, the posterior segment of the maxilla was impacted more in the MPO group, and the anterior segment showed slightly more downward movement in the CPO group. The clockwise surgical rotation of the maxilla contributed to the resolution of the maxillary dental decompensation. With regard to the vertical mandibular measurement at B-point, there were few changes in the MPO and CPO groups. In our study, 87.5% of the patients (35 of 40 patients: 19 in the MPO group, and 16 in the CPO group) had undergone genioplasty to achieve harmonious facial esthetics. Menton moved upward by 0.38 mm in the MPO group and downward by 0.57 mm in the CPO group, without a significant difference between groups. In the traditional view, to increase the amount of surgical setback and achieve normal postsurgical overjet, presurgical orthodontic treatment was needed to arrange the maligned teeth in the best possible position in each jaw before surgery.[24] In our study, the sagittal and vertical changes from T0 to T2 showed no significant differences between the MPO and CPO groups, except for IMPA. Therefore, bimaxillary surgery combined with MPO or CPO had a similar treatment efficacy for patients with skeletal Class III malocclusion.

Table V. Postsurgical changes during various intervals in cephalometric variables in the MPO and CPO groups

	T2-T3					*T3-T4*					*T4-T5*					*T2-T5*				
	MPO		*CPO*			*MPO*		*CPO*			*MPO*		*CPO*			*MPO*		*CPO*		
	Mean	*SD*	*Mean*	*SD*	P	*Mean*	*SD*	*Mean*	*SD*	P	*Mean*	*SD*	*Mean*	*SD*	P	*Mean*	*SD*	*Mean*	*SD*	P
Horizontal changes (mm)																				
A-x	0.47	2.35	−1.00	1.95	0.04*	−1.12	2.41	0.63	0.64	0.01†	−0.27	1.37	0.05	1.87	0.55	−0.91	1.35	−0.32	2.06	0.29
B-x	0.80	3.30	−0.50	1.85	0.14	−0.07	3.73	1.20	1.40	0.17	0.55	2.15	0.03	1.03	0.35	1.28	2.44	0.73	2.25	0.47
Pg-x	0.69	3.69	−0.56	2.04	0.19	−0.05	4.24	1.40	1.53	0.16	0.77	2.08	0.00	1.07	0.15	1.42	2.63	0.84	2.36	0.47
Overjet	−0.97	1.73	0.19	0.79	0.01*	−0.27	0.82	−0.02	0.82	0.33	0.01	1.10	−0.26	0.79	0.37	−1.23	1.90	−0.09	1.19	0.03*
Vertical changes (mm)																				
ANS-y	0.26	2.43	0.30	1.38	0.95	−0.44	1.54	0.14	1.42	0.22	0.32	1.28	0.11	0.98	0.56	0.13	2.52	0.55	1.48	0.53
PNS-y	0.08	0.88	0.04	0.62	0.87	−0.08	1.14	−0.01	0.74	0.82	0.45	1.02	−0.04	0.77	0.09	0.46	0.86	−0.01	0.84	0.09
B-y	−2.33	2.19	−1.88	1.51	0.46	−1.32	2.85	0.58	1.50	0.01*	1.04	3.26	0.94	1.57	0.90	−2.60	2.17	−0.36	2.04	0.00†
Me-y	−2.05	2.51	−1.69	1.29	0.57	−0.42	2.33	−0.31	1.06	0.85	0.41	1.95	0.04	0.81	0.43	−2.06	1.63	−1.96	1.45	0.84
Overbite	1.12	0.94	1.08	0.55	0.85	0.04	0.77	0.16	0.55	0.57	−0.27	0.75	0.01	0.58	0.20	0.88	1.33	1.24	0.76	0.31
Angular changes (°)																				
SNA	−0.57	1.89	−1.21	1.93	0.06	−0.91	1.74	0.85	1.24	0.00†	−0.57	1.89	0.00	1.07	0.25	−1.58	1.31	−0.36	2.06	0.03*
SNB	0.16	1.41	−0.50	1.26	0.13	0.03	1.67	0.90	1.09	0.06	0.12	1.41	−0.10	0.77	0.56	0.30	1.45	0.31	1.38	0.99
ANB	−0.26	1.05	−0.71	1.37	0.25	−0.93	0.98	−0.05	0.94	0.01†	−0.69	1.24	0.10	1.17	0.05*	−1.88	0.78	−0.67	1.79	0.01†
MP/HRL	0.22	2.48	1.14	1.68	0.18	−0.16	2.27	−0.57	1.25	0.49	0.07	1.52	−0.10	0.89	0.67	0.13	2.04	0.47	1.66	0.56
U1/PP	−2.80	4.45	−2.82	2.75	0.99	0.73	3.33	−1.17	2.75	0.06	−0.39	4.15	0.00	2.29	0.72	−2.47	6.51	−3.98	3.50	0.37
IMPA	−0.21	6.23	−0.53	3.62	0.07	1.15	3.40	−0.55	3.40	0.12	0.40	2.80	1.13	2.30	0.38	4.04	5.19	0.05	4.43	0.01*

Independent *t* test: *$0.01 < P < 0.05$; †$P < 0.01$.

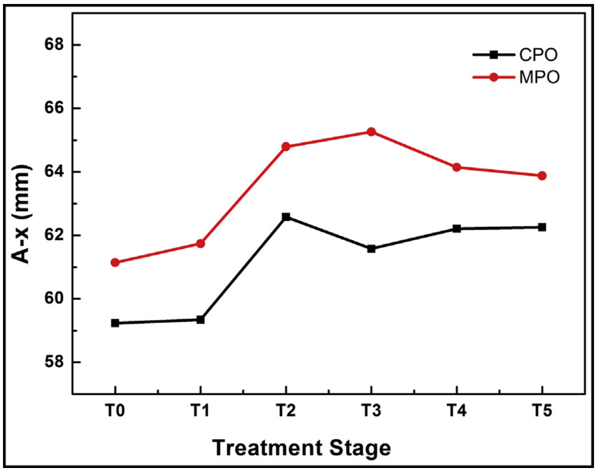

Fig 2. Horizontal changes in A-point during the study period (T0-T5) in the MPO and CPO groups. A-point, innermost point of the contour from the anterior nasal spine to the crest of the maxillary alveolar process.

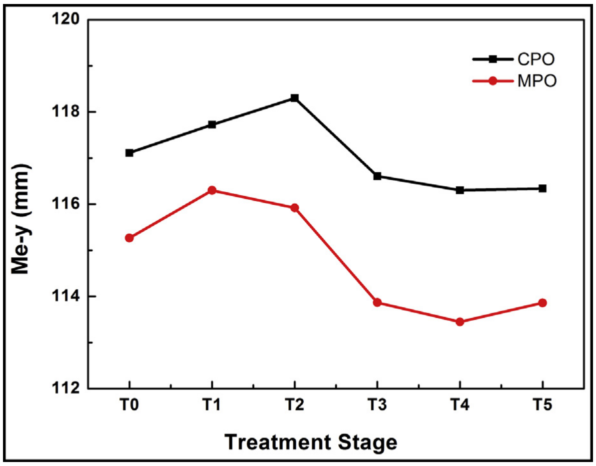

Fig 4. Vertical changes in menton during the study period (T0-T5) in the MPO and CPO groups.

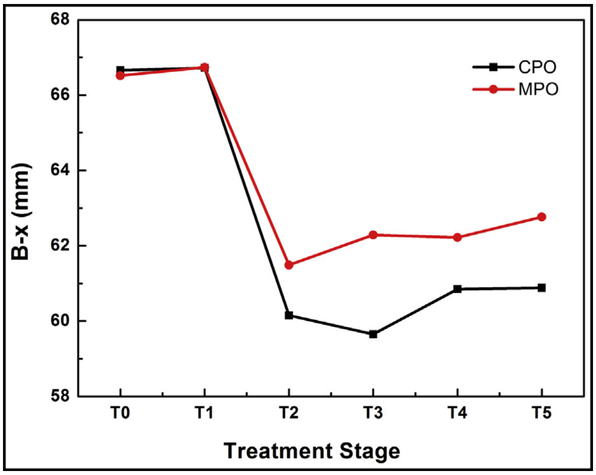

Fig 3. Horizontal changes in B-point during the study period (T0-T5) in the MPO and CPO groups. B-point, innermost point of the contour from the bony chin to the alveolar bone junction.

The maxilla in the CPO group showed more significant backward movement of A-point during the first 3 months (T2-T3) after surgery, with a slightly forward movement from T3 to T4. In contrast, the maxilla in the MPO group showed a slightly forward movement during the first 3 months. This may have been due to the use of short Class III elastics immediately after surgery in the MPO group. Elastics were regularly applied between opposing miniscrews placed interapically in the maxilla and the mandible in the MPO group, whereas intermaxillary elastics were used in the CPO group. Cephalometric analysis also demonstrated that elastics between miniscrews in the early postsurgical stage were effective in achieving more favorable horizontal stability in the maxilla in the MPO group. With regard to dental alignment, most miniscrews were removed 3 months after surgery in the MPO group. This may have caused an unfavorable and greater sagittal relapse in the MPO group than in the CPO group in the next 3 months (T3-T4). The horizontal changes at the different times (Figs 2-4) suggested that it would be advisable to delay the removal of skeletal anchorage within 6 months after surgery in the MPO group. In the vertical plane, the maxillary positions in both groups remained stable throughout the observation period, with similar downward movements in the anterior segment and unnoticeable changes in the posterior segment. These results showed that intermaxillary fixation between opposing miniscrews seemed to have effects on vertical control that were similar to those of elastics between the maxillary and mandibular teeth.

Similar to previous reports, our study verified more forward and upward movements of the mandible in the sagittal and vertical planes, respectively, in the MPO group than in the CPO group, without significant differences during the first 3 months after surgery.[8] The counterclockwise rotation of the mandible in the MPO group may have been caused by subsequent settling of the bite caused by rapid dental alignment. Moreover, the duration of the mandibular counterclockwise rotation after surgery was longer in the MPO group than in the CPO group because the MPO group did not undergo a complete alignment and leveling process before surgery. This continuous mandibular rotation in the MPO group may have caused the vertical plane to be reduced significantly from T3 to T4 compared with the CPO group. Therefore, it is better to eliminate the surgical interferences and obtain adequate alignment when MPO is used. The orthodontists and surgeons should reserve an exact vertical and sagittal space for mandibular rotation in the MPO group.

This study showed no significant skeletal changes between the MPO and CPO groups from T2 to T5, except for the SNA and ANB angles, and the vertical changes in B-point of the mandible. The counterclockwise rotation of the mandible during the first 6 months was considered to be the major cause of the significant difference at T5. The significant differences in SNA and ANB were consistent with the horizontal relapse of A-point. Overjet was reduced more in the MPO group than in the CPO group. The maxillary incisors were proclined less in the MPO group, although the difference was not significant. This was attributed to the intermaxillary Class III elastics between the miniscrews in the MPO group that minimized the incisal proclination during the first 3 months. IMPA in the MPO group increased significantly compared with the CPO group. As shown in Figures 2-4, most of the horizontal and vertical relapses in the MPO and CPO groups occurred during the first 6 months, although some relapse was also observed from T4 to T5. This was probably associated with the progressive reconstruction of the muscles and the clockwise rotation of the proximal segment during surgery.

There were more patients in the MPO group than in the CPO group with a Class I molar relationship, closed bites anteriorly, and coincident midlines at 1 year. These were attributed to earlier surgery and the regional accelerated phenomenon in the MPO group. Surgery and postsurgical orthodontics for at least 5 months were performed in all patients in the MPO group at 1 year, whereas presurgical orthodontics were not finished for some patients in the CPO group.

This study was limited to a 2-dimensional analysis. Further studies based on 3-dimensional measurements should be performed to improve the prediction of MPO.

CONCLUSIONS

In this study, patients with skeletal Class III malocclusions were treated with MPO or CPO followed by bimaxillary surgery and observed for 12 months. The following conclusions were drawn.

1. There were no significant differences in skeletal changes and treatment efficacy after surgery in the MPO and CPO groups, but the patients in the MPO group had much shorter presurgical durations and greater improvements of their facial esthetics at an early stage of treatment.
2. During the postsurgical phase, the mandible rotated counterclockwise more in the MPO group. Therefore, adequate presurgical alignment and leveling of both arches are necessary. Furthermore, close monitoring and maintenance of skeletal anchorage for 6 months after surgery are suggested when MPO is used.

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