Journal of Dental Sciences 20 (2025) 1068–1077

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.e-jds.com

Original Article

Stability and outcome of surgical-orthodontic treatment in patients of Class III deformity with and without a history of orthodontic treatment

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Received 5 October 2024; Final revision received 5 December 2024
Available online 17 December 2024

KEYWORDS
Class III;
Orthognathic surgery;
Retreatment;
Stability;
Outcome

Abstract *Background/Purpose:* Many adult patients seeking surgical-orthodontic treatment have previously undergone orthodontic treatment during their youth. This study aimed to compare the stability and outcome of surgical-orthodontic treatment between Class III patients who had undergone previous orthodontic treatment and those who had not.
Materials and methods: 82 adult Class III patients who consecutively received surgery-first bimaxillary surgery were included, 30 who had not undergone orthodontic treatment (NFO group), 25 who had undergone orthodontic treatment with premolar extraction (FO-E group), and 27 who had undergone orthodontic treatment without premolar extraction (FO-NE group). Cone-beam computed tomography were obtained pre-surgery (T0), 1 week after surgery (T1) and after debonding (T2) to determine skeletal stability and treatment outcome of skeletal, dental and soft tissue structures. Self-report questionnaires including satisfaction with facial appearance and quality of life were also evaluated.
Results: Treatment outcome, satisfaction and quality of life did not differ significantly among the three groups except the mandibular alveolar thickness (6.3 ± 1.9 mm vs 5.3 ± 1.3 mm vs

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https://doi.org/10.1016/j.jds.2024.12.006

5.4 ± 1.5 mm, respectively for the NFO, FO-E and FO-NE groups). Neither group exhibited a significant difference in skeletal stability except in the anterior maxilla (ANS, 1.0 ± 1.2 mm vs 0.3 ± 0.7 mm vs 0.5 ± 0.8 mm, respectively for the NFO, FO-E and FO-NE groups). Mean relapse was ≤1 mm at the maxilla and <2 mm at the mandible within each group.
Conclusion: A history of orthodontic treatment in patients of Class III deformity with mandibular prognathism has limited effects on the final surgical-orthodontic correction outcome.

Introduction

Many adult patients seeking surgical-orthodontic treatment have previously received orthodontic treatment at their youth. Compared to the untreated patients, a greater proportion of those who had received orthodontic treatment reported a subjective need for treatment.[1] Orthodontists who perform retreatment may face challenges in managing these patients' high expectations.[2]

Skeletal Class III deformity of mild discrepancy could achieve good treatment effect through orthodontic camouflage, while surgical-orthodontic intervention is a necessity of satisfying outcome for severe discrepancy. Treatment of Class III deformity is known to be challenging,[3] especially for growing or borderline patients. Orthodontists should not only manage patient expectations but also the complexities of such cases. The key to ensuring the success of orthodontic treatment and preventing the need for future interventions is to carefully consider the patient's need and determine the optimal timing of treatment.[4]

There is a growing trend of patients seeking surgical-orthodontic treatment for Class III deformities who had undergone orthodontic camouflage at younger age. The reasons for seeking retreatment are varied and can involve desire to enhance both appearance and oral function, inadequacies in previous diagnosis and treatment planning, maturational changes or unfavourable skeletal growth.[5,6] Among these, aesthetic concerns are the primary reason.[6] According to Martino et al., the retreatment achieved successful skeletal correction through a combination of orthodontic and orthognathic treatment of a severe skeletal Class III deformity following previous orthodontic camouflage.[7] The result of combined treatment was a harmonious and pleasing appearance while respecting the unique characteristics of each patient.

A treatment combining orthodontics and orthognathic surgery is more invasive and generally more expensive compared to orthodontic camouflage, leading to the development and practice of the latter treatment modality. The burden of labor, economic and time aspects are even higher for retreatment because of the two times of treatment. The aim of this study was to compare the treatment duration, stability and outcome of surgical-orthodontic treatment between Class Ill patients with and without a history of orthodontic treatment. Based on the results of the current study, the authors hope to provide more information to clinicians when they are weighing the benefits and drawbacks between orthodontic camouflage and orthodontic-orthognathic treatment for Class III deformity.

Materials and methods

Patients

This retrospective study evaluated the craniofacial cone-beam computed tomography (CBCT) records of 82 consecutive non-growing skeletal Class III patients (ANB angle <0°) who received surgical-orthodontic treatment. They were divided into three groups according to whether they had undergone previous orthodontic treatment: 30 who had no previous orthodontic treatment (NFO group), 25 who had undergone previous orthodontic treatment with premolar extraction (FO-E group), and 27 who had undergone previous orthodontic treatment without premolar extraction (FO-NE group).

The inclusion criteria were (1) adult patient with no significant facial asymmetry (menton deviation ≤ 4 mm, nose deviation ≤ 3°, lip cant ≤ 4°),[8–10] (2) surgery-first bimaxillary surgery involving Le Fort I osteotomy and bilateral sagittal split osteotomy (BSSO) by attending surgeons at Chang Gung Craniofacial Center, (3) virtual surgical planning and post-surgical orthodontic treatment by one experienced orthodontist who had been an attending of orthodontic specialist at the craniofacial center for more than 25 years, and (4) complete CBCT records at three time points (before treatment, one week after surgery and after orthodontic debonding). Patients with major systemic diseases, congenital facial anomalies or a history of craniofacial trauma or orthognathic surgery were excluded. This study was approved by the hospital's Institutional Review Board.

Cone-beam computed tomography analysis

CBCT was acquired before treatment (T0), one week after surgery (T1), and after orthodontic debonding (T2) using an i-CAT 3D Dental Imaging System (Imaging Sciences International, Hatfield, PA, USA) with the following parameters: 120 kVp, 0.4 mm × 0.4 mm × 0.4 mm voxel size, 40 s scan time, and 20 cm × 20 cm field of view. The patient's head was aligned with Frankfort horizontal (FH) plane, parallel to the ground. Patients were instructed to keep their mouths gently closed in centric occlusion during the scan.

Images were stored in the Digital Imaging and Communications in Medicine (DICOM) format and then transferred to a workstation (Avizo v7.1 software, VSG, Bordeaux, France) for rendering into volumetric images, which were analyzed by a single investigator (AC). Before analysis, the 3D images were reoriented as follows: (1) the axial plane

was aligned parallel to the FH plane and passed through the nasion (N); (2) the midsagittal plane was set perpendicular to the axial plane and passed through both N and basion (Ba); and (3) the coronal plane passed through N, perpendicular to the axial and midsagittal planes. Cranial structures unaffected by surgery were used to superimpose the CBCT images at T0, T1, and T2, aligning them within the same 3D coordinates with N as the reference point.

Surgical movement and post-surgical stability

Five skeletal midline landmarks—anterior nasal spine (ANS), posterior nasal spine (PNS), point A, point B, and pogonion (Pog)—were used to assess surgical and post-surgical changes of the maxilla and mandible (see Fig. 1). Changes were measured from T0 to T1 (surgical movement) and from T1 to T2 (post-surgical stability). Jaw movements in the sagittal and vertical direction were assessed. The outcomes were assigned a positive value for posterior or superior movement and a negative value for anterior or inferior movement.

Treatment change and outcome at follow-up

Treatment change and outcome for the facial skeleton, teeth, and soft tissues were evaluated using CBCT images taken at T0 and T2. Skeletal and dental measurements included jaw protrusion and sagittal relationship, incisor angle, and occlusion. Soft tissue measurements involved linear distances and angles of the nose, mouth, cheek, lips, chin, and jaw angle (Table 1) (see Fig. 1). In addition, the patients were inquired about their level of satisfaction at T2 regarding specific aspects of facial appearance, including the overall face, face shape, nose, cheek, lips, teeth, upper gum and chin. The Body Image Quality of Life Inventory (BIQLI)[11] was also used to assess an individual's perception of body image and how their functions have affected their overall quality of life which consists of chewing, speech, smile, confidence and social life. Scales range from 0 to 10: 0 represents very unsatisfied, 5 is acceptable, and 10 is very satisfied. The higher scores indicate a greater level of patient satisfaction.

Reliability

Nine patients, three from each group, were randomly selected. The CBCT assessments were repeated by the same researcher twice with an interval of two weeks. Intra-inter reliability, as indicated by interclass correlation coefficient (ICC), was excellent (Mean ICC, 0.990; 95 % confidence interval, 0.989 to 0.992).

Statistical analysis

The statistical software package SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA) was used. All descriptive statistic were presented by mean and standard deviation. Shapiro—Wilk test was used to testify the normal distribution of data. Paired t-test was performed to determine surgical movement (T1-T0), post-surgical stability (T2-T1), and treatment change (T2-T0). One-way ANOVA followed by a post-hoc LSD and chi-square test were used to compare difference among three groups for continuous and categorical variables, respectively. The results were considered significant if $P < 0.05$.

Results

The mean age of the study population was 23.2 $\pm$ 4.5 years; 52 were females. All FO patients had undergone previous full-mouth orthodontic treatment during their junior high school without the use of chin cap or maxillary protraction for the correction of anterior cross bite or dental crowding at other hospitals or dental clinics. Higher percentage of the patients underwent genioplasty and extraction of upper premolars during surgical-orthodontic treatment in the NFO group compared with both FO groups. The overall duration of post-surgical follow-up was 21.5 $\pm$ 8.6 months, with no significant differences among the three groups (Table 2).

Baseline characteristics

Before surgery, the baseline clinical characteristics of the patients did not differ significantly among the three groups (Table 3). In all groups, all patients exhibited mandibular

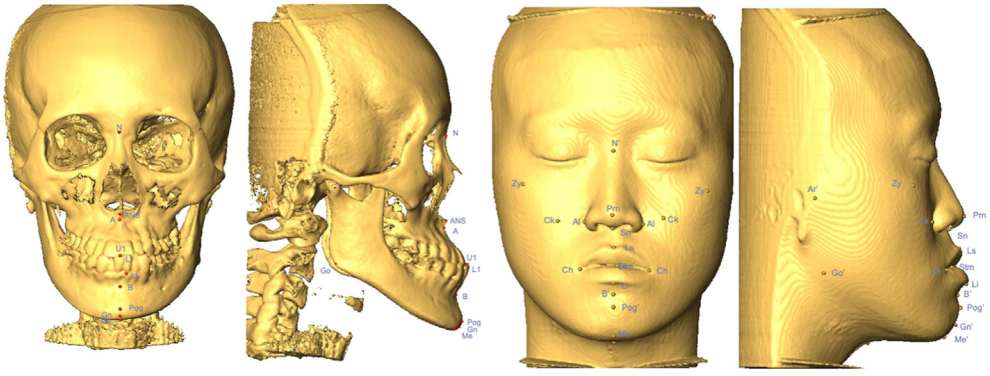

Figure 1 Skeletal, dental and soft tissue landmarks used in this study. Please refer to Table 1 for further information about these landmarks.

Table 1 Skeletal, dental, and soft tissue variables.

Skeletal and dental variables	Definition
SNA (°)	Angle formed by the intersection of sella-nasion and nasion-A lines
SNB (°)	Angle formed by the intersection of sella-nasion and nasion-B lines
ANB (°)	Angle formed by the intersection of nasion- A and nasion-B lines
SN-PP (°)	Angle formed by the intersection of sella-nasion and ANS-PNS lines
SN-MP (°)	Angle formed by the intersection of sella-nasion and gonion-menton lines
SN-U1 (°)	Angle formed by the long axis of upper central incisor and the sella-nasion line
L1-MP (°)	Angle formed by the long axis of lower central incisor and the gonion-menton line
Overjet (mm)	The horizontal distance from labial surface of the lower incisor to the labial surface of upper incisor
Overbite (mm)	The vertical distance from the lower incisal edge to the upper incisal edge
Symphysis width at Pog (mm)	The distance from pogonion to the furthest point on the lingual contour of the symphysis
Symphysis width at B (mm)	The distance from point B to point B1 (the outermost point of the lingual cortex)
Symphysis width at Id (mm)	The distance from labial to lingual side of point Id (infradentale, the most anterior superior point of the labial mandibular alveolar crest, situated between the lower central incisors)
Soft tissue variables	Definition
Nasal width (mm)	The distance between right and left alar points (Al—Al)
Mouth width (mm)	The distance between right and left cheilions (Ch—Ch)
Facial width (mm)	The distance between right and left soft tissue zygions (Zy'-Zy')
Upper lip height (mm)	The distance from subnasale to stomion (Sn-Sto)
Chin height (mm)	The distance from stomion to soft tissue menton (Sto-Me')
Cheek prominence (mm)	The distance from the most anterior coronal plane of pupil to the most prominence of cheek (left and right sides)
Chin protrusion (mm)	The distance from the line of soft tissue nasion-subnasale to soft tissue pogonion (N'Sn-Pog')
Nasal tip angle (°)	Angle between soft tissue nasion, pronasale and subnasale (N'-Prn-Sn)
Nasolabial angle (°)	Angle between pronasale, subnasale and labial superius (Prn-Sn-Ls)
Labiomental angle (°)	Angle between labiale inferius, soft tissue point B and soft tissue pogonion (Li—B'-Pog')
Cheek angle (°)	Angle between soft tissue zygion, cheek and chelion (Zy'-Ck-Ch) (left and right sides)
Jaw angle (°)	Angle between soft tissue articulare, soft tissue gonion and soft tissue menton (Ar'-Go'-Me') (left and right sides)

Abbreviations. ANS: Anterior nasal spine; PNS: posterior nasal spine.

prognathism, retroclination of lower incisors, and a negative overjet.

Surgical movement

Table 4 displays the surgical movement of the maxilla and mandible among the three groups. The overall surgical movement can be summarized as follows: a posterior maxillary impaction combined with a setback and clockwise pitch of the maxillomandibular complex. Pogonion was setback by a mean of 5.0—7.7 mm. Most of the surgical movement was within a similar range in the three groups. The advancement of the ANS was significant in the NFO group with a mean of 3.2 ± 1.5 mm ($P < 0.05$), while the extrusion of the ANS was significant in the FO-E and FO-NE groups with means of −1.3 ± 2.0 mm and −1.4 ± 1.7 mm, respectively ($P < 0.05$). The setback of the point B was less in the FO-E group than in the NFO and FO-NE groups ($P < 0.01$) (Table 4).

Post-surgical stability

There was no significant difference in post-surgical stability among the three groups except for the anterior maxilla (ANS). Regarding the maxilla, the ANS in the NFO group showed a mean relapse of 1.0 ± 1.2 mm ($P < 0.001$), which was significantly larger than the relapse in both FO groups ($P < 0.05$). Regarding the mandible, the point B and Pog exhibited relapse in an upward and forward direction, with no significant difference among the three groups. A mean relapse of 1.4—1.8 mm was present at Pog (Table 5).

Treatment change and outcome

The treatment change (T2-T0) and outcome (T2) were within a similar range among the three groups, except for the upper symphyseal thickness (at point B and Id levels, mandibular alveolar thickness) (Table 3). The decrease in the upper symphyseal thickness was significant in the FO groups. The overall mean treatment change among all patients can be summarized as follows (Table 3): increase in maxillary protrusion (1.4°), decrease in mandibular protrusion (3.6°), clockwise pitch of palatal plane (5.3°), proclination of lower incisors (7.0°), increase in overjet (6.3 mm), increase in nasal width (1.1 mm), upper lip height (1.6 mm), cheek protrusion (1.4 mm), nasolabial angle (6.9°), and cheek angle (9.6°), and decrease in chin height (3.7 mm), chin protrusion (6.6 mm), and labiomental angle (16.3°) (see Fig. 2).

Table 2 Patient demographics and clinical characteristics among three groups.

Parameter	Total (n = 82)	NFO Group (n = 30)	FO-E Group (n = 25[a])	FO-NE Group (n = 27)	*P*
Age at surgery, years; mean ± SD	23.2 ± 4.5	23.4 ± 4.2	23.6 ± 5.5	22.7 ± 3.8	0.777[b]
Gender (male), *n* (%)	30 (37 %)	16 (53 %)	7 (28 %)	7 (26 %)	0.057[c]
With maxillary segmentation, *n* (%)	7 (9 %)	4 (13 %)	1 (4 %)	2 (7 %)	0.452[c]
With genioplasty, *n* (%)	53 (65 %)	25 (83 %)	12 (48 %)	16 (59 %)	0.019[c,d]
Extraction of upper premolars at or after surgery, *n* (%)	14 (17 %)	12 (40 %)	0 (0 %)	2 (7 %)	0.000[c,d]
Extraction of lower premolars at or after surgery, *n* (%)	2 (2 %)	0 (0 %)	0 (0 %)	2 (7 %)	0.124[c]
Duration of post-surgical follow-up, months; mean ± SD	21.5 ± 8.6	21.5 ± 8.5	21.6 ± 7.4	21.5 ± 9.9	1.000[b]

Abbreviation. NFO: No previous orthodontic treatment; FO-E: Previous orthodontic treatment with premolar extraction; FO-NE: Previous orthodontic treatment without premolar extraction.

[a] 9 patients with a history of upper premolar extraction, 8 patients with a history of lower premolar extraction, and 8 patients with a history of both upper and lower premolars extraction.

[b] One-Way ANOVA.

[c] Chi-square test.

[d] NFO > FO-E, FO-NE.

Satisfaction with the final outcome

All three groups showed a high satisfaction with facial appearance and a high BIQLI at T2, with no statistically intergroup differences (Table 6). Patients gave the highest satisfaction score regarding the teeth (8.5 ± 1.3), followed by chin (8.4 ± 1.4) and overall facial shape (8.3 ± 1.1). The lowest satisfaction score was reported for the nose (6.6 ± 1.8). The mean score for BIQLI was highest for the smile (8.5 ± 1.2) and lowest for speech (7.6 ± 1.8).

Discussion

Several studies have investigated the stability or outcomes of surgical-orthodontic treatment for Class III deformities,[12–19] but so far no studies comparing these outcomes among Class III adult patients with and without a history of orthodontic treatment during adolescence have been published. This retrospective study aimed to investigate whether a previous orthodontic camouflage has effects on Class III patients undergoing surgical-orthodontic treatment.

Prior to the initiation of surgical-orthodontic treatment, the maxillofacial and dental variables exhibited similarity among the three groups despite of a history of comprehensive camouflage orthodontic treatment in the FO groups, all of which demonstrated Class III deformity with mandibular prognathism. In comparison to the Taiwanese normative data of 3D cephalometric measurements,[20] the mandibular plane and the maxillary position were within normal ranges. The upper incisors were within the normal range of inclination, whereas the lower incisors exhibited more retroclination. Also, all patients had a negative overjet and a vertically prolongated chin.

He et al.[21] examined the camouflage treatment of skeletal Class III malocclusion in non-growing patients using a combination of multiloop edgewise arch wire and modified (from the maxillary mini-implants) or conventional Class III elastics. The results indicated insignificant improvement of the ANB angle (0.2 ± 0.5° and 0.1 ± 0.4°, respectively) but significant retroclination of the lower incisors (L1-MP, −3.5 ± 2.5° and −2.3 ± 3.2°, respectively). Both orthodontic treatments in their study achieved a positive overjet and a stable occlusion, which remained stable one year after treatment. These reported outcomes of orthodontic camouflage therapy differ from the initial values observed in the patients who had a history of orthodontic treatment (FO-E and FO-NE groups) in this study. Since the patients in the current study had their previous orthodontic treatment during their junior high school, it is likely that relapse and/or subsequent growth effects have contributed to the differences in the dental and maxillofacial morphology.

At follow-up (T2), all patients had a more favourable maxillofacial and dental morphology. However, the symphysis was thinner at the levels of point B and Id in the patients who had undergone previous orthodontic treatment (FO-E and FO-NE groups), suggesting repeated or longer orthodontic treatment was associated with decrease in the mandibular alveolar thickness. Thinner alveolar thickness implied higher possibility of the presence of bony dehiscence or fenestration which has long been suspected as predisposing factors for gingival recession.[22–24]

At surgery, all patients underwent maxillary posterior impaction with maxillomandibular rotational setback with a clockwise pitch. The amount of mandibular setback varied for each group based on the vertical facial pattern and sagittal maxillomandibular relationship. At follow-up, the maxilla showed good stability in the vertical direction, but significant relapse was observed in the sagittal direction at ANS and point A, ranging from 0.3 to 1.0 mm. Though statistically significant, this amount of relapse is too small to be clinically meaningful. These post-surgical changes are also likely due to bony remodeling of the anterior maxilla, a possible consequence of the maxillary advancement.[18] The significantly larger backward movement of 1.0 mm at ANS in the NFO group than that (0.3 mm and 0.5 mm) in both FO groups could be the results of larger remodeling or relapse after the larger forward movements during surgery. While

Table 3 Comparison of treatment change (T2-T0) and outcome (T2) of maxillofacial and dental structures within a group and among three groups[a].

Parameters	Total (n =82)			NFO Group (n = 30)			FO-E Group (n = 25)			FO-NE Group (n = 27)			ANOVA *P*-value	
	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	*P* T0	*P* T2
Skeletal and dental variables														
SNA (°)	81.2±3.7	82.6±3.5	<0.001	81.4±3.5	83.0±3.3	<0.001	81.8±4.2	83.2±3.6	0.002	80.3±3.3	81.5±3.5	0.002	0.312	0.159
SNB (°)	83.3±4.6	81.7±3.7	<0.001	85.9±5.4	81.7±4.0	<0.001	84.9±4.4	82.3±3.7	<0.001	85.0±3.7	81.0±3.2	<0.001	0.652	0.428
ANB (°)	-4.2±2.8	0.9±1.7	<0.001	-4.5±3.2	1.3±2.0	<0.001	-3.2±1.8	0.8±1.4	<0.001	-4.7±2.9	0.6±1.7	<0.001	0.112	0.354
SN-PP (°)	10.7±3.8	16.0±4.1	<0.001	11.7±4.4	15.6±4.6	<0.001	9.8±3.8	15.4±4.0	<0.001	10.5±3.2	16.9±3.5	<0.001	0.196	0.346
SN-MP (°)	32.9±6.9	33.6±5.9	0.206	32.0±7.7	33.6±5.8	0.139	33.5±5.5	33.4±5.5	0.874	33.5±7.3	34.0±6.6	0.568	0.651	0.936
SN-U1 (°)	111.0±8.2	110.4±8.4	0.496	110.5±9.8	110.1±10.1	0.801	110.5±7.3	109.6±8.1	0.563	112.0±7.3	111.5±6.7	0.723	0.766	0.697
L1-MP (°)	85.4±9.0	92.4±7.3	<0.001	83.6±8.5	92.0±7.1	<0.001	86.7±9.0	90.6±7.2	0.009	86.3±9.5	94.6±7.2	<0.001	0.374	0.121
Overjet (mm)	-3.4±3.6	2.9±0.8	<0.001	-4.2±3.0	2.8±0.8	<0.001	-2.8±4.2	2.6±1.0	<0.001	-3.2±3.7	3.1±0.6	<0.001	0.351	0.160
Overbite (mm)	0.6±2.8	1.8±0.7	<0.001	1.2±3.7	1.9±0.8	0.362	0.3±2.1	1.7±0.7	0.002	0.0±2.1	1.9±0.6	<0.001	0.277	0.727
Symphysis thickness at Pog (mm)	13.4±2.0	14.0±2.7	0.005	13.6±2.2	14.6±3.1	0.009	13.4±1.9	13.6±1.9	0.273	13.3±1.8	13.6±2.7	0.340	0.842	0.268
Symphysis thickness at B (mm)	6.0±1.5	5.7±1.7	0.008	6.2±1.6	6.3±1.9	0.767	5.8±1.4	5.3±1.3	0.023	6.0±1.6	5.4±1.5	0.005	0.648	0.047[b]
Symphysis thickness at Id (mm)	5.8±0.7	5.4±0.7	<0.001	6.0±0.7	5.7±0.6	0.016	5.6±0.6	5.2±0.8	0.018	5.7±0.8	5.3±0.7	0.004	0.056	0.019[b]
Soft tissue variables														
Nasal width (mm)	38.9±3.0	40.0±2.8	<0.001	39.7±2.8	40.7±2.6	0.007	38.8±2.8	39.9±3.0	<0.001	38.1±3.2	39.4±2.7	<0.001	0.129	0.218
Mouth width (mm)	48.8±4.4	49.5±4.0	0.104	48.7±4.1	50.2±4.0	0.003	48.9±5.1	49.3±4.6	0.738	48.8±4.1	49.1±3.4	0.745	0.984	0.544
Face width (mm)	110.6±7.1	109.5±7.2	0.010	112.2±7.0	111.6±6.7	0.440	109.4±6.0	107.6±6.6	0.009	110.0±8.0	108.9±7.9	0.134	0.285	0.118
Upper lip height (mm)	22.3±3.2	23.9±2.9	<0.001	22.4±3.5	24.2±2.8	<0.001	22.5±2.9	23.8±2.8	0.003	22.0±3.3	23.6±3.0	0.001	0.826	0.689
Chin height (mm)	49.7±4.7	46.0±3.6	<0.001	49.8±5.2	45.8±3.4	<0.001	49.8±4.2	47.0±3.6	<0.001	49.5±4.6	45.5±3.7	<0.001	0.967	0.28
Cheek protrusion (mm)	6.6±2.5	8.1±2.7	<0.001	6.4±2.6	7.9±2.7	<0.001	6.4±2.8	7.8±2.5	<0.001	7.1±2.2	8.4±2.7	<0.001	0.517	0.669
Chin protrusion (mm)	-2.8±5.6	-9.4±3.7	<0.001	-2.1±5.1	-9.8±3.5	<0.001	-3.8±5.4	-8.7±3.6	<0.001	-2.6±6.4	-9.6±4.1	<0.001	0.551	0.551
Nasal tip angle (°)	97.4±9.6	97.9±9.8	0.402	100.5±8.7	100.6±10.0	0.941	96.7±8.8	96.7±8.6	0.997	94.5±10.4	96.0±10.4	0.116	0.052	0.168
Nasolabial angle (°)	102.9±11.8	109.8±11.2	<0.001	103.4±13.2	112.3±11.0	0.001	103.6±12.2	107.0±12.5	0.012	101.6±9.8	109.5±9.6	<0.001	0.788	0.221

(*continued on next page*)

Table 3 *(continued)*

Parameters	Total (n = 82)			NFO Group (n = 30)			FO-E Group (n = 25)			FO-NE Group (n = 27)			ANOVA *P*-value	
	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	T0	T2	*P* (T2-T0)	*P* T0	*P* T2
Labiomental angle (°)	147.6±20.8	131.3±16.2	<0.001	145.8±25.9	128.6±20.5	0.005	147.4±18.3	134.0±15.3	<0.001	149.9±16.6	131.8±11.0	<0.001	0.765	0.474
Cheek angle (°)	159.0±11.8	149.4±9.2	<0.001	159.1±11.1	146.7±8.4	<0.001	159.3±10.0	152.3±7.6	<0.001	158.6±14.2	149.7±10.7	<0.001	0.977	0.077
Jaw angle (°)	133.2±6.8	135.3±6.8	0.007	133.2±6.8	135.3±5.8	0.005	134.1±4.9	134.5±7.1	0.737	134.2±6.9	136.2±7.6	0.191	0.236	0.686

Abbreviation. NFO: No previous orthodontic treatment; FO-E: Previous orthodontic treatment with premolar extraction; FO-NE: Previous orthodontic treatment without premolar extraction.

[a] data are mean ± SD.

[b] NFO > FO-E, FO-NE.

there was no significant difference in the mandibular relapse among the three groups, there was a mild mandibular vertical and sagittal movement at follow-up. The mandible underwent an upward and forward movement, ranging from a mean of 0.6–1.6 mm and 1.2–1.8 mm, respectively, after surgery. To sum up, neither group exhibited a significant difference in stability, with mean maxillary relapse being ≤1 mm and mandibular relapse being <2 mm (Table 5). These extents of relapse had been reported in the literature of surgery-first approach and should be addressed in the stage of treatment planning.[12–18]

The results of patients' reported treatment outcomes based on questionnaires provided information on satisfaction regarding facial appearance and the BIQLI among the three groups after debonding. All groups showed a high level of satisfaction and quality of life. The positive impact of orthognathic surgery on facial esthetics, oral function and social aspects was in line with the results of literature.[24–28] No significant differences were found in the mean score among the groups. This result implies that the previous orthodontic treatment neither enhanced nor diminished the patients' satisfaction of orthodontic-orthognathic treatment. Nevertheless, the burden on patients is undoubtedly increased with the first- and second-time treatments. Thus, for borderline cases, orthodontic camouflage should be performed with caution. The authors suggest delaying orthodontic camouflage after growth completeness not only for stable results but also for confirming the expectation of patients. The decisive factor for choosing orthodontic camouflage or orthodontic-orthognathic treatment in modern society might be which treatment modality can meet the expectation of the patients as aesthetic concerns are often the primary reason for seeking orthodontic retreatment.[6] On the other hand, when satisfaction with specific facial area was assessed, the lowest satisfaction was observed with the nose, while the highest satisfaction was reported with the teeth. Widening of the alar base and superior repositioning of the nasal tip were common findings after correcting skeletal Class III deformity involving maxillary advancement.[19,29–32] These changes particularly bother the Asian population because the Asian population has an intrinsic unfavorable nasal form. Asada et al. reported significantly higher satisfaction in the appearance of the mouth, smile and treatment outcome for patients in the 2-jaw surgery group compared to those undergoing only mandibular setback.[33] Similarly, in this study, all the patients were managed with 2-jaw surgery, and the mean score of the BIQLI was highest for the smile.

In conclusion, early camouflage orthodontic treatment had limited effects on the treatment duration, stability and outcome of definitive surgical-orthodontic treatment in Class III patients with mandibular prognathism. All three groups of Class III patients achieved a favorable profile and stable skeletal outcome, as well as a high level of satisfaction and quality of life, regardless of a history of previous orthodontic treatment, following surgical-orthodontic treatment at skeletal maturity. These findings provide clinicians with better understanding of treatment timing for patients with mandibular prognathism. Also, early orthodontic camouflage should be performed on carefully selected patients such as those of mild skeletal discrepancy

Table 4 Comparison of surgical change (T1-T0) of facial skeleton within a group and among three groups.

Position (mm)	NFO Group (n = 30)			FO-E Group (n = 25)			FO-NE Group (n = 27)			ANOVA
	Mean	SD	*P* (T1-T0)	Mean	SD	*P* (T1-T0)	Mean	SD	*P* (T1-T0)	*P*
Sagittal direction (-anterior, + posterior)										
ANS	−2.0	2.5	<0.001	−0.5	2.0	0.210	−0.3	2.7	0.588	0.016[a]
PNS	−3.2	1.5	<0.001	−2.3	2.2	<0.001	−2.5	1.6	<0.001	0.103
Point A	−1.7	1.6	<0.001	−1.7	1.4	<0.001	−1.2	1.4	<0.001	0.362
Point B	9.0	4.4	<0.001	5.9	2.8	<0.001	8.5	3.1	<0.001	0.006[b]
Pog	7.7	6.0	<0.001	5.0	4.4	<0.001	7.2	4.3	<0.001	0.122
Vertical direction (-inferior, + superior)										
ANS	−0.1	2.1	0.728	−1.3	2.0	0.005	−1.4	1.7	<0.001	0.033[a]
PNS	3.4	2.6	<0.001	3.3	2.5	<0.001	4.3	2.2	<0.001	0.241
Point A	0.0	2.0	0.934	−1.5	1.9	0.001	−1.3	2.1	0.004	0.014[c]
Point B	0.8	4.1	0.266	2.1	4.0	0.013	2.2	3.6	0.003	0.322
Pog	0.3	3.5	0.650	1.3	2.8	0.310	1.8	3.6	0.016	0.245

Abbreviations. ANS: Anterior nasal spine; PNS: posterior nasal spine; Pog: pogonion; NFO: No previous orthodontic treatment; FO-E: Previous orthodontic treatment with premolar extraction; FO-NE: Previous orthodontic treatment without premolar extraction.
[a] NFO < FO-E, FO-NE.
[b] NFO, FO-NE > FO-E.
[c] NFO > FO-E, FO-NE.

Table 5 Comparison of post-surgical change (T2-T1) of facial skeleton with a group and among three groups.

Position (mm)	NFO Group (n = 30)			FO-E Group (n = 25)			FO-NE Group (n = 27)			ANOVA
	Mean	SD	*P* (T2-T1)	Mean	SD	*P* (T2-T1)	Mean	SD	*P* (T2-T1)	*P*
Sagittal direction (-anterior, + posterior)										
ANS	1.0	1.2	<0.001	0.3	0.7	0.017	0.5	0.8	0.004	0.014[a]
PNS	0.1	1.1	0.612	0.2	1.0	0.254	0.2	0.8	0.124	0.835
Point A	0.7	1.2	0.004	0.6	0.7	0.006	0.7	0.7	<0.001	0.864
Point B	−1.3	2.0	0.001	−1.3	1.3	<0.001	−1.2	1.6	<0.001	0.970
Pog	−1.4	2.2	0.001	−1.7	1.7	<0.001	−1.8	1.6	<0.001	0.736
Vertical direction (-inferior, + superior)										
ANS	0.2	1.4	0.480	−0.2	1.0	0.450	0.0	0.8	0.793	0.521
PNS	−0.2	1.1	0.243	−0.4	0.9	0.260	−0.3	0.7	0.048	0.747
Point A	0.1	1.3	0.779	0.2	1.0	0.419	0.3	0.6	0.017	0.688
Point B	1.6	2.3	0.001	0.6	1.3	0.005	0.8	1.7	0.015	0.130
Pog	1.5	2.4	0.002	0.9	1.2	<0.001	0.8	1.1	0.001	0.456

Abbreviations. ANS: Anterior nasal spine; PNS: posterior nasal spine; Pog: pogonion; NFO: No previous orthodontic treatment; FO-E: Previous orthodontic treatment with premolar extraction; FO-NE: Previous orthodontic treatment without premolar extraction.
[a] NFO > FO-E, FO-NE.

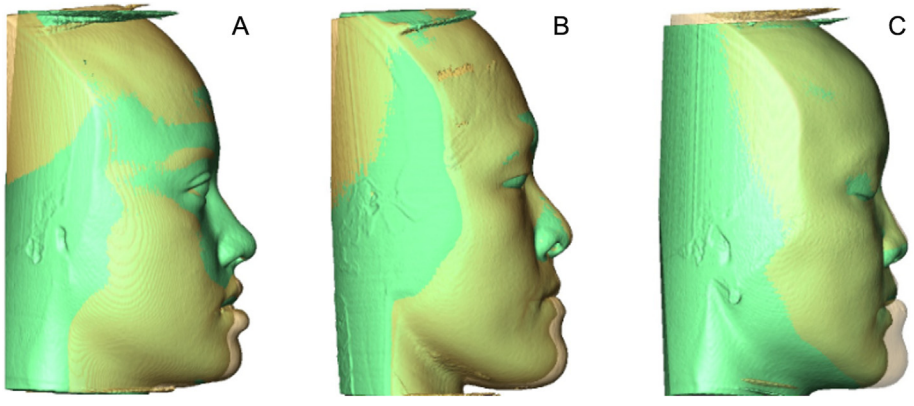

Figure 2 Comparison of soft tissue - before treatment (T0, yellow) and after debonding (T2, green). NFO group, no previous orthodontic treatment (A); FO-E, previous orthodontic treatment with premolar extraction (B); FO-NE group, previous orthodontic treatment without premolar extraction (C).

Table 6 Satisfaction rating scores after treatment: satisfaction with facial appearance and Body Image Quality of Life Inventory (BIQLI) among three groups.

Score	Total (n = 82)		NFO Group (n = 30)		FO-E Group (n = 25)		FO-NE Group (n = 27)		ANOVA
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*
Satisfaction (range = 0 to 10)									
Face	8.3	1.1	8.2	1.3	8.5	1.1	8.3	1.0	0.652
Face shape	8.3	1.1	8.2	1.3	8.4	1.1	8.3	0.8	0.721
Nose	6.6	1.8	6.0	1.7	6.9	2.0	7.2	1.7	0.058
Cheek	7.4	1.6	7.0	1.8	7.5	1.6	7.7	1.2	0.281
Lips	7.3	1.7	7.4	1.8	7.2	1.9	7.5	1.4	0.882
Teeth	8.5	1.3	8.4	1.4	8.8	1.1	8.3	1.5	0.447
Upper gum	8.0	1.7	8.0	1.9	7.8	1.8	8.1	1.4	0.822
Chin	8.4	1.4	8.4	1.8	8.3	1.1	8.4	1.2	0.946
BIQLI (range = 0 to 10)									
Chewing	8.4	1.5	8.5	1.4	8.4	1.8	8.3	1.3	0.912
Speech	7.6	1.8	7.3	1.9	7.5	2.0	8.0	1.4	0.297
Smile	8.5	1.2	8.5	1.3	8.4	1.3	8.5	1.0	0.884
Confidence	8.3	1.2	8.2	1.3	8.4	1.2	8.4	1.0	0.785
Social life	7.8	1.8	7.4	2.2	7.9	2.0	8.3	0.9	0.272

Abbreviations. NFO: No previous orthodontic treatment; FO-E: Previous orthodontic treatment with premolar extraction; FO-NE: Previous orthodontic treatment without premolar extraction.

with mandibular prognathism or less demanding on esthetics; otherwise, it would become an additional burden for patients who eventually seek orthodontic-orthognathic treatment to solve their skeletal and esthetic discrepancy.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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