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Chin Profile Changes in Skeletal Class III Following Bimaxillary Surgery with or without Advancement Genioplasty

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Purpose: This study sought to identify differences in hard and soft tissue chin profile changes in skeletal Class III patients after bimaxillary surgery, with or without advancement genioplasty.
Materials and Methods: The retrospective study was conducted based on cephalometric analysis of skeletal and soft tissue variables. Lateral cephalograms taken at 3 different time points were utilized: pre-operation (T0), immediately post-operation (T1), and at least 6 months (11.0±2.6 months) post-operation (T2). The 2 groups were matched for sample size (n=20 each). Data were analyzed using independent t-tests with Bonferroni correction.
Result: Group N (bimaxillary surgery alone) and Group G (bimaxillary surgery with an advancement genioplasty by horizontal sliding osteotomy) did not differ significantly in terms of demographic characteristics. The soft tissue chin thickness of Group G increased more after surgery, followed by a greater decrease during the postoperative period, and was eventually not significantly different from Group N at T2. On the other hand, the mentolabial sulcus depth of Group G (5.5±1.3 mm) was significantly greater than that of Group N (4.4±0.9 mm) (P=0.006) at T2.
Conclusion: Although Group G showed a statistically significantly greater decrease in soft tissue chin thickness during the postoperative period, there were no significant intergroup differences in the chin profile for at least 6 months after the surgery, except for the mentolabial sulcus depth, which was greater in Group G than in Group N.

Key Words: Chin; Genioplasty; Orthognathic surgery; Prognathism; Skeletal Class III

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Introduction

The chin contributes to facial harmony and perception of the face, and thus affects social interaction by representing communication and human character[1,2]. Individuals commonly view a facial profile with a deep or flat mentolabial angle as unattractive, and individuals with such features often express a desire for surgical correction[3]. Moreover, a prominent chin is associated with masculinity, whereas a less-projected chin suggests femininity[2].

In order to enhance the esthetics of the lower face by improving the profile of the soft tissue of the chin, advancement genioplasty, by horizontal sliding osteotomy, has proven to be a reliable technique[2,4]. For surgical treatment of skeletal Class III patients who present with mandibular prognathism, advancement genioplasty has frequently been performed in addition to bimaxillary surgery with mandibular setback to obtain optimal esthetic results[2].

Several studies have dealt with the esthetic outcome of advancement genioplasty. Most of these previous studies analyzed changes following genioplasty exclusively, or genioplasty in concert with mandibular advancement osteotomy in skeletal Class II patients[5-9]. Advancement genioplasty, which alters chin morphology, may result in a different lower facial profile as well as varied patients' satisfaction. However, to date, few studies have investigated the changes that occur after concomitant advancement genioplasty and bimaxillary surgery for mandibular setback in skeletal Class III cases[10,11].

The aim of this study was to identify differences in hard and soft tissue chin profile changes in skeletal Class III patients after bimaxillary surgery with or without advancement genioplasty by horizontal sliding osteotomy. The null hypothesis was that there would be no difference in the hard and soft tissue chin profile changes between the 2 groups of skeletal Class III patients during the postoperative period.

Materials and Methods

1. Study Design and Subjects

This retrospective study was based on the data of patients who underwent bimaxillary surgery from December 2015 to December 2017 in the Department of Oral and Maxillofacial Surgery, Yonsei University Dental Hospital, Seoul, Republic of Korea. This study followed the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of Yonsei University Dental Hospital (IRB No. 2-2019-0058). Written informed consent was obtained from all patients before the initiation of treatment.

The following patients were included: (1) Patients who had undergone presurgical orthodontic treatment with conventional bimaxillary surgery (1-piece Le Fort I osteotomy and bilateral intraoral vertical ramus osteotomy [IVRO]) and advancement genioplasty by horizontal sliding osteotomy, if necessary; (2) Patients older than 17 years, with minimal growth potential; (3) Patients with the presence of skeletal Class III malocclusion before surgery, with the angle formed by point A, the nasion, and point B (ANB) smaller than 0°; and (4) Patients with a complete series of identifiable lateral cephalometric radiographs.

The exclusion criteria were as follows: (1) Serious medical conditions for which hospitalization had been required prior to surgery; (2) A history of congenital defects or syndromes; (3) A history of prior orthognathic surgery; (4) Indication for single-jaw surgery or preorthodontic orthognathic surgery; (5) Facial asymmetry presented by menton deviation from the facial midline of more than 4 mm.

Patients were divided into 2 groups according to the type of surgery undertaken: bimaxillary surgery only: Group N, or simultaneous bimaxillary surgery and advancement genioplasty: Group G.

2. Surgical and Orthodontic Treatment

All patients underwent conventional bimaxillary surgery, including maxillary Le Fort I osteotomy with posterior impaction and bilateral IVRO for mandibular setback. For some patients, advancement genioplasty was performed simultaneously. All surgeries were performed by one surgeon (H.D.J.) using the same protocol.

For advancement genioplasty in patients in Group G, a labial mucosal vestibular incision was made and the mucoperiosteal flap was raised to expose the mental foramina, bilaterally. The mental nerves were preserved. With the inferior and posterior aspects of the bony segment attached to the periosteum, a horizontal sliding osteotomy was performed at the inferior border of the mandible using a reciprocating saw. When completely mobilized, the inferior segment was advanced horizontally[4,10] and fixed with biodegradable fixation screws (OSTEOTRANS-MX®, Takrion, Osaka, Japan)[12].

All patients underwent orthodontic treatment before and after the surgery at private clinics or at the Department of Orthodontics, Yonsei University Dental Hospital, Seoul, Republic of Korea.

3. Lateral Cephalometric Analysis

The material included lateral cephalograms taken at 3 different time points: pre-operatively (T0), immediately post-operatively (T1), and at least 6 months (11.0±2.6 months) post-operatively (T2). The surgical change was calculated by subtracting the values at T0 from those at T1, and the postoperative relapse was calculated by subtracting the values at T1 from those at T2. The lateral cephalograms were traced using V-ceph 5.5 (Osstem, Seoul, Korea) by an observer who was blinded to the clinical status of the patients. All reference planes were transferred from the T0

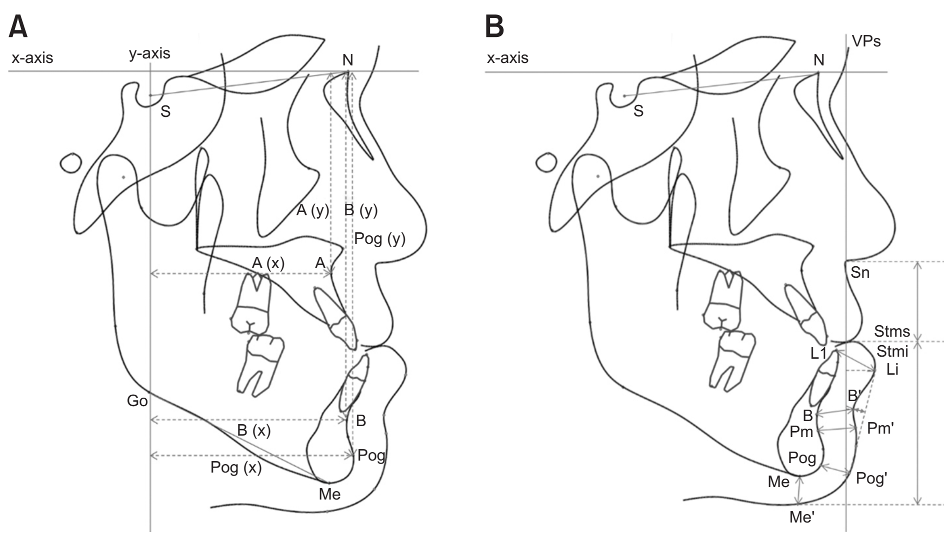

Fig. 1. Landmarks and reference planes. (A) Definitions of measurement for the cephalometric analysis of the hard tissue. S: sella, N: nasion, A: point A, B: point B, Pog: pogonion, Me: menton, Go: gonion, x-axis: a line through N 7° up from SN plane, y-axis: a line perpendicular to x-axis and passing through S, A(x): horizontal position of point A, A(y): vertical position of point A, B(x): horizontal position of point B, B(y): vertical position of point B, Pog(x): horizontal position of pogonion, Pog(y): vertical position of pogonion. (B) Definitions of measurement for the cephalometric analysis of the soft tissue. L1: tip of the mandibular central incisor, Pm: protuberance menti, Sn: subnasale, Stms: stomion superius, Stmi: stomion inferius, Li: labrale inferius, B′: soft tissue point B, Pm′: soft tissue protuberance menti, Pog′: soft tissue pogonion, Me′: soft tissue menton, VPs: a line perpendicular to x-axis and passing through Sn, Li-VPs: distance to Li from VPs, B′-VPs: distance to B′ from VPs, Pog′-VPs: distance to Pog′ from VPs (measurements to the right side of VPs are notated with a positive (+) value and measurements to the left of VPs are notated with a negative (–) value), Pog′-B′: the difference between Pog′-VPs and B′-VPs (a positive (+) value when Pog′ is positioned anterior to B′), LLt: distance between L1 and Li, Bt: distance between B and B′, Pmt: distance between Pm and Pm′, Pogt: distance between Pog and Pog′, Met: distance between Me and Me′, Sn-Stms: distance between Sn and Stms measured parallel to VPs, Stmi-Me: distance between Stmi and Me measured parallel to VPs, Sulcus depth: distance from B′ perpendicular to the Li-Pog′ line, Mentolabial angle: angle formed by Li, B′, Pog′.

through T2 cephalograms by superimposition of the sella (S)–nasion (N) plane.

The horizontal reference plane (x-axis) was constructed by drawing a line through the N, 7° up from the SN plane[13] (Fig. 1). The vertical reference plane for the hard tissue (y-axis) was drawn as the line perpendicular to the x-axis and passing through the S[14]. The vertical reference plane for the soft tissue (VPs) was also perpendicular to the x-axis, but passed through the subnasale (Sn). The positions of the landmarks in relation to the x- and y-axes and VPs were recorded for linear measurements. The cephalometric variables assessed for the present study are illustrated in Fig. 1.

4. Study Variables

1) Primary predictor

The type of surgery conducted was the primary predictor variable in this study. Group N included patients who underwent bimaxillary surgery only, and Group G included patients who underwent bimaxillary surgery with advancement genioplasty.

2) Primary outcomes

Four angular and 6 linear cephalometric measurements were used to describe skeletal changes. The 4 angular measurements included the SNA, SNB, ANB, and SN-GoMe, while the 6 linear measurements included A(x), A(y), B(x), B(y), Pog(x), and Pog(y).

Moreover, 12 linear and 1 angular cephalometric measurement were used to determine soft tissue changes. The 12 linear measurements were Li-VPs, B′-VPs, Pog′-VPs, Pog′-B′, LLt, Bt, Pmt, Pogt, Met, Sn-Stms, Stmi-Me, and sulcus depth, while the angular measurement was the mentolabial angle.

5. Reliability

To assess the reliability of measurements, 10% of the lateral cephalograms were randomly selected for retracing. All measurements were repeated by the same investigator, 4 weeks after the initial examination. The method error was calculated by Dahlberg formula ranged from 0.20 to 0.30 and from 0.15 to 0.30 degrees for linear and angular measurements, respectively.

6. Statistical Analysis

All statistical analyses were carried out using IBM SPSS software ver. 21.0 (IBM Corp., Armonk, NY, USA) for Windows. Based on a preliminary study, a minimum sample size of 18 was required (G*Power 3; Dusseldorf, Germany), with a P-value of less than 0.05 indicating statistical significance, power of 95%, and an effect size of 0.25 for detecting differences in skeletal and soft tissue chin profile changes over time (T0, T1, and T2) between the 2 groups.

To verify the normality of the data distribution, the Shapiro–Wilk test was applied. Descriptive statistics, such as the mean and the standard deviation (SD), were used to describe each variable in the study. In order to find any significant differences between the groups, an independent t-test with Bonferroni correction (α=0.05/3) was performed.

Table 1. Demographic and clinical characteristics (N=40)

Variable	Group N (n=20)	Group G (n=20)	P-value
Gender			0.751[a]
Men	10 (50.0)	12 (60.0)	
Women	10 (50.0)	8 (40.0)	
Age (yr)	23.4±5.9	22.4±3.2	0.968[b]
BMI (kg/m^2)	22.2±3.6	22.1±4.6	0.938[c]
Menton deviation (mm)	1.0±2.4	0.7±2.1	0.749[c]
Chin advancement (mm)	0.0±0.0	5.0±1.0	<0.001[c]

Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty, BMI: body mass index.
Values are presented as number (%) or mean±standard deviation.
[a]P-value calculated with chi-squared test. [b]P-value calculated with Mann–Whitney U-test. [c]P-value calculated with the independent t-test.

Result

1. Preoperative Characteristics of the 2 Groups

Of the 86 cases in the database, 40 patients (20 men and 20 women) were suitable for the present study after applying inclusion and exclusion criteria (Table 1). Group N included 20 patients (10 men and 10 women) with a mean age of 23.4 years (SD, 5.9 years), and Group G included 20 patients (12 men and 8 women) with a mean age of 22.4 years (SD, 3.2 years). There were no significant differences between the 2 groups in terms of demographic characteristics. Body mass index (BMI) and the amount of menton deviation did not show significant differences between the 2 groups. The mean amount of chin advancement by genioplasty was 0 mm (SD, 0 mm) in Group N and 5 mm (SD, 1 mm) in Group G, which were statistically significantly different (P<0.001).

Table 2. Mean and standard deviation of the preoperative cephalometric variables (T0)

Outcome variable	Group N	Group G	Between groups P-value
SNA (°)	81.3±3.6	82.5±3.6	0.296
SNB (°)	86.1±2.8	84.8±3.3	0.184
ANB (°)	–4.8±3.1	–2.2±2.0	0.004*
SN-GoMe (°)	32.6±4.4	37.5±5.6	0.005*
A(x) (mm)	62.0±5.2	65.3±5.5	0.063
A(y) (mm)	66.2±4.7	70.3±3.3	0.003*
B(x) (mm)	67.0±5.5	66.2±6.9	0.714
B(y) (mm)	111.2±7.1	119.3±4.4	<0.001*
Pog(x) (mm)	64.9±7.2	60.6±8.5	0.095
Pog(y) (mm)	131.8±6.8	138.7±7.6	0.004*
Li-VPs (mm)	11.5±3.4	11.6±3.5	0.881
B'-VPs (mm)	5.2±4.2	3.8±4.2	0.317
Pog'-VPs (mm)	2.8±5.6	–4.2±4.3	<0.001*
Pog'-B' (mm)	–2.3±2.6	–8.1±3.1	<0.001*
LLt (mm)	16.1±2.6	16.1±3.4	0.994
Bt (mm)	14.7±2.2	16.6±3.4	0.038
Pmt (mm)	15.5±2.4	17.0±3.6	0.155
Pogt (mm)	11.7±2.5	10.4±2.5	0.121
Met (mm)	8.9±2.5	8.3±2.3	0.412
Sn-Stms (mm)	23.6±2.5	25.5±2.5	0.021
Stmi-Me (mm)	57.2±5.3	59.0±4.2	0.250
Mentolabial sulcus depth (mm)	3.5±1.2	3.7±3.7	0.795
Mentolabial angle (°)	156.6±9.1	160.5±12.7	0.267

Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty.
Refer to Fig. 1 for the definition of landmarks.
P-value calculated with the independent t-test with Bonferroni correction.
*P<0.05/3.

Table 3. Comparison of surgical changes (T1-T0) between the 2 groups

Outcome variable	Group N	Group G	Between groups P-value
SNA (°)	0.7±1.8	0.9±1.6	0.748
SNB (°)	–6.5±2.0	–6.2±1.5	0.586
ANB (°)	7.3±2.6	7.2±1.9	0.852
SN-GoMe (°)	7.3±2.6	3.3±2.2	<0.001*
A(x) (mm)	1.0±1.5	1.0±1.8	0.951
A(y) (mm)	–0.0±2.1	–0.8±1.8	0.203
B(x) (mm)	–12.5±3.9	–12.9±3.2	0.742
B(y) (mm)	–0.1±2.2	–2.0±2.9	0.025
Pog(x) (mm)	–15.7±5.3	–9.5±4.5	<0.001*
Pog(y) (mm)	–2.0±5.7	–4.8±4.6	0.096
Li-VPs (mm)	–9.1±3.8	–10.5±3.5	0.223
B'-VPs (mm)	–14.2±3.8	–14.4±2.6	0.876
Pog'-VPs (mm)	–16.5±5.4	–9.8±3.4	<0.001*
Pog'-B' (mm)	–2.2±2.3	4.5±3.1	<0.001*
LLt (mm)	4.2±2.4	5.2±2.7	0.190
Bt (mm)	0.4±1.5	1.2±2.4	0.206
Pmt (mm)	0.8±2.1	3.2±3.1	0.010*
Pogt (mm)	1.3±1.3	2.8±1.6	0.003*
Met (mm)	0.6±1.2	1.8±1.5	0.009*
Sn-Stms (mm)	2.6±1.4	2.9±1.2	0.531
Stmi-Me (mm)	–2.5±1.4	–4.0±2.2	0.018
Mentolabial sulcus depth (mm)	2.6±1.4	3.1±3.8	0.621
Mentolabial angle (°)	–15.3±8.1	–23.5±11.2	0.012*

T0: pre-operation, T1: immediately post-operation, Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty.
Values are presented as mean±standard deviation.
Refer to Fig. 1 for the definition of landmarks.
P-value calculated with the independent t-test with Bonferroni correction.
*P<0.05/3.

The preoperative properties of the 2 studied groups are presented in Table 2. There were statistically significant differences between the 2 groups in terms of several variables. The mean ANB was a smaller negative value in Group G than in Group N (P=0.004). The mean SN-GoMe was smaller in Group N than in Group G (P=0.005). Group G demonstrated greater values than Group N for A(y) (P=0.003), B(y) (P<0.001), and Pog(y) (P=0.004), indicating that Group G had a relatively vertical facial pattern with a higher mandibular plane angle than that of Group N. In addition, Group G showed lower values for Pog′-VPs (P<0.001) and Pog′-B′ (P<0.001) relative to Group N.

2. Comparison of Surgical Changes

There were statistically significant differences between the 2 groups terms of surgical changes (Table 3). The mean increase of SN-GoMe was 7.3° (SD, 2.6°) in Group N and 3.3° (SD, 2.2°) in Group G (P<0.001).

Despite the comparable amount of mandibular setback, as disclosed by B(x) changes (–12.5 mm [SD, 3.9 mm] in Group N and –12.9 mm [SD, 3.2 mm] in Group G), genioplasty moved the Pog forward resulting in a significant difference in the Pog(x) change: –15.7 mm (SD, 5.3 mm) in Group N and –9.5 mm (SD, 4.5 mm) in Group G (P<0.001). Pog′-VPs displayed a significant difference for the same reason: –16.5 mm (SD, 5.4 mm) in Group N and –9.8 mm (SD, 3.4 mm) in Group G (P<0.001). Pog′-B′ decreased 2.2 mm (SD, 2.3 mm) in Group N, while it increased 4.5 mm (SD, 3.1 mm) in Group G (P<0.001). The amount of soft tissue thickness increase was greater in Group G than in Group N, with significant differences for Pmt (P=0.010), Pogt (P=0.003), and Met (P=0.009). The mentolabial angle was reduced more in Group G (–23.5 ± 11.2°) than in Group N (–15.3 ± 8.1°) (P=0.012) during the surgery.

3. Comparison of Postoperative Relapse

During the postoperative period, the soft tissue thickness showed a greater amount of decrease in Group G than in Group N, with significant differences for Bt (P=0.004), Pmt (P=0.003), Pogt (P<0.001) and Met (P=0.004) (Fig. 2 and Table 4).

At least 6 months after the surgery, there were 3 variables with significant differences between the 2 groups (Table 5). The mean ANB was 2.7° (SD, 1.9°) in Group N and 4.4° (SD, 2.0°) in Group G (P=0.011). In addition, the mean B(y) was 109.5 mm (SD, 7.0 mm) in Group N and 115.7 mm (SD, 5.0 mm) in Group G (P=0.003). Finally, the mentolabial sulcus depth was greater in Group G (5.5 mm [SD, 1.3 mm]), than in Group N (4.4 mm [SD, 0.9 mm]) (P=0.006; Fig. 2).

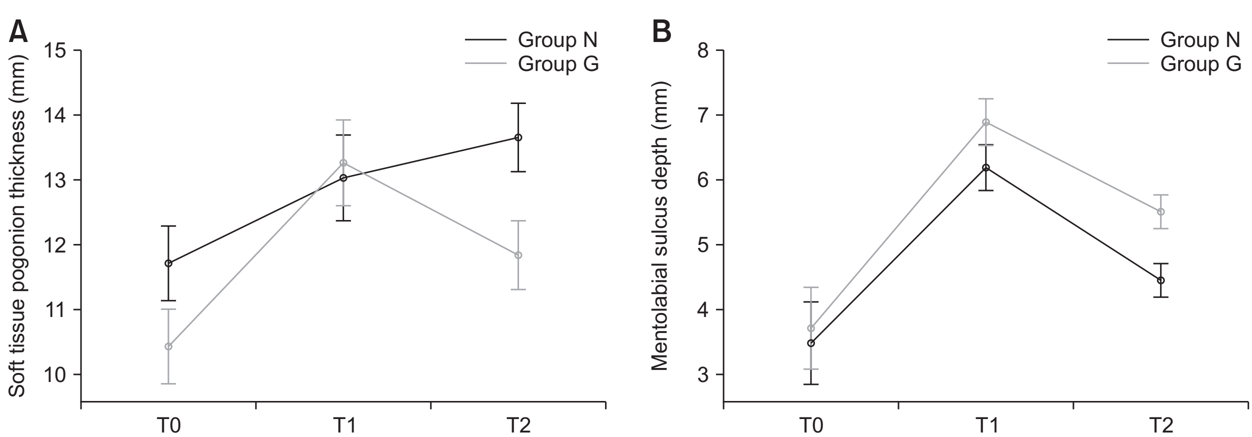

Fig. 2. Differences in the chin profile changes between the 2 groups. (A) Change in the soft tissue thickness at the pogonion. (B) Change in the mentolabial sulcus depth.

T0: pre-operation, T1: immediately post-operation, T2: at least 6 months (11.0±2.6 months) post-operation, Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty.

Table 4. Comparison of postoperative relapse (T2-T1) between the 2 groups

Outcome variable	Group N	Group G	Between groups P-value
SNA (°)	–0.0±1.4	–0.6±2.1	0.300
SNB (°)	–0.2±1.4	–0.1±1.3	0.771
ANB (°)	0.2±1.3	–0.5±1.9	0.177
SN-GoMe (°)	2.3±2.2	2.2±2.0	0.906
A(x) (mm)	–0.2±1.5	–0.9±2.3	0.265
A(y) (mm)	–0.4±1.8	–1.4±2.6	0.160
B(x) (mm)	–0.6±2.6	–0.2±2.4	0.690
B(y) (mm)	–1.5±1.3	–1.5±1.7	0.976
Pog(x) (mm)	–0.7±3.6	–0.4±3.5	0.814
Pog(y) (mm)	–1.5±6.0	0.7±5.8	0.230
Li-VPs (mm)	–1.3±2.9	–1.4±2.6	0.945
B′-VPs (mm)	0.9±2.8	–0.7±2.1	0.033
Pog′-VPs (mm)	1.4±3.4	–0.7±2.4	0.028
Pog′-B′ (mm)	0.4±2.2	0.0±2.2	0.557
LLt (mm)	–2.4±2.4	–3.1±1.8	0.343
Bt (mm)	–0.6±1.4	–2.5±2.3	0.004*
Pmt (mm)	–0.9±1.7	–3.3±2.7	0.003*
Pogt (mm)	0.6±1.7	–1.4±1.3	<0.001*
Met (mm)	–0.0±1.5	–1.3±1.1	0.004*
Sn-Stms (mm)	–1.0±1.2	–1.1±1.6	0.825
Stmi-Me (mm)	–1.5±1.8	–1.3±2.0	0.742
Mentolabial sulcus depth (mm)	–1.7±1.5	–1.3±1.5	0.465
Mentolabial angle (°)	9.1±9.2	10.6±10.6	0.630

T1: immediately post-operation, T2: at least 6 months (11.0±2.6 months) post-operation, Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty.
Values are presented as mean±standard deviation.
Refer to Fig. 1 for the definition of landmarks.
P-value calculated with the independent t-test with Bonferroni correction.
*P<0.05/3.

Table 5. Comparison of the cephalometric variables between the 2 groups at least 6 months after the surgery (T2)

Outcome variable	Group N	Group G	Between groups P-value
SNA (°)	82.1±3.3	82.9±3.5	0.464
SNB (°)	79.3±3.3	78.4±3.3	0.402
ANB (°)	2.7±1.9	4.4±2.0	0.011*
SN-GoMe (°)	42.3±4.7	43.1±5.5	0.640
A(x) (mm)	62.8±4.7	65.3±4.9	0.099
A(y) (mm)	65.7±4.7	67.9±3.7	0.107
B(x) (mm)	53.8±6.8	53.0±6.7	0.715
B(y) (mm)	109.5±7.0	115.7±5.0	0.003*
Pog(x) (mm)	48.4±8.8	50.6±8.3	0.424
Pog(y) (mm)	128.2±10.3	134.6±8.0	0.035
Li-VPs (mm)	1.0±3.2	–0.3±3.1	0.189
B′-VPs (mm)	–8.0±4.4	–11.3±3.7	0.017
Pog′-VPs (mm)	–12.2±5.3	–14.9±4.2	0.087
Pog′-B′ (mm)	–4.2±2.3	–3.6±2.4	0.434
LLt (mm)	17.8±2.2	18.2±2.6	0.589
Bt (mm)	14.5±1.5	15.4±1.8	0.116
Pmt (mm)	15.5±1.8	16.8±2.0	0.033
Pogt (mm)	13.6±2.5	11.8±2.1	0.020
Met (mm)	9.6±2.7	8.8±2.4	0.368
Sn-Stms (mm)	25.1±2.7	27.3±2.8	0.022
Stmi-Me (mm)	53.0±5.0	53.5±3.5	0.727
Mentolabial sulcus depth (mm)	4.4±0.9	5.5±1.3	0.006*
Mentolabial angle (°)	150.4±7.2	147.7±9.5	0.313

Group N: bimaxillary surgery alone, Group G: bimaxillary surgery with an advancement genioplasty.
Values are presented as mean±standard deviation.
Refer to Fig. 1 for the definition of landmarks.
P-value calculated with the independent t-test with Bonferroni correction.
*P<0.05/3.

Discussion

For skeletal Class III patients with mandibular prognathism who manifest a contour-deficient chin and lack of a mentolabial fold, mandibular setback alone can yield a blunt chin resulting in poor esthetics of the lower face. By increasing the chin prominence relative to the mandible and lower lip, advancement genioplasty can improve facial aesthetics[15]. Nevertheless, even an experienced practitioner often feels apprehension at the appearance of an "awkwardly bulging" chin immediately after bimaxillary surgery associated with advancement genioplasty. Instead of conceiving a vague hope that the chin will transform "naturally" with the lapse of time, as a professional, an orthodontist should predict the results and reassure patients based on objective data. Unlike previous studies[5-9], which evaluated how much an advancement genioplasty improved the chin profile, this study sought to identify differences in the hard and soft tissue chin profile changes in skeletal Class III patients after bimaxillary surgery, with or without an advancement genioplasty. We found statistically meaningful intergroup differences in changes in the soft tissue chin thickness during the postoperative period and in the mentolabial sulcus depth at least 6 months after the surgery. However, the soft tissue chin thickness and the mentolabial angle did not differ significantly between the 2 groups.

Since their use was first introduced by Arnett and Bergmanm[16,17], the relative projections of the lower lip, soft tissue point B, and soft tissue Pog to a true vertical line (TVL) have been widely used. However, the natural head position was inconsistent when taking each cephalogram. Drawn perpendicular to the SN-7 plane, VPs was designed instead of the TVL to improve reproducibility and visibility, thus allowing an exact evaluation of the soft tissue chin profile changes throughout the observation period. We therefore used this approach in our study.

At T0, Group G manifested a significantly smaller negative value of ANB, higher mandibular plane angle, and greater values of A(y), B(y), and Pog(y) than Group N, implying a relatively vertical facial pattern in Group G. In addition, Group G presented lower values of Pog′-VPs and Pog′-B′ relative to Group N, meaning that the soft tissue Pog was more posteriorly positioned in Group G. These preoperative characteristics of Group G might have served as an indication for advancement genioplasty.

During the surgery, despite a comparable amount of mandibular setback, as revealed by B(x) change, a simultaneous advancement genioplasty offset some of this amount in Group G, reducing the posterior movement of the hard and soft tissue Pog. Pog′-B′ decreased 2.2 mm in Group N, presumably by clockwise rotation of the mandible, whilst it increased 4.5 mm in Group G, by actual advancement of the bony Pog. Obviously, the amount of soft tissue thickness increase was greater at every point measured in Group G, yet significant differences were observed only for Pmt, Pogt, and Met. With the bony Pog sliding forward relative to point B, an 8.2° greater decrease in the mentolabial angle was seen in Group G. Elhaddaoui et al.[11] also reported statistically significantly more pronounced thickening of the soft tissue at point B and the Pog, as well as a greater decrease in the mentolabial angle in the group that underwent bimaxillary surgery with advancement genioplasty than in the group that underwent bimaxillary surgery alone. Our findings corroborated their results, although the soft tissue thickness increase at point B did not show a significant difference between the groups in our study.

In contrast, during the postoperative period, the soft tissue thickness exhibited a greater amount of decrease in Group G than in Group N, with significant differences for Bt and Pmt, Pogt and Met. Interestingly, the chin soft tissue thickness of Group G experienced a greater increase during surgery, followed by a greater decrease during the postoperative period, and was eventually not significantly different from Group N at T2. This may be attributable to the additional flap manipulation necessitated by the genioplasty, which might have caused further tissue swelling. During the postoperative period, tissue redistribution and decline of the swelling of the soft tissue in the chin area might have contributed to the greater decrease of its thickness in Group G[12].

On the other hand, there was a noticeable intergroup difference in the mentolabial sulcus depth at T2. Notwithstanding the common objective of the surgeries, *i.e.*, to place the mandible in the anteroposteriorly normal position, Group G consequently acquired a significantly deeper mentolabial sulcus. Whether a deeper mentolabial sulcus is esthetically advantageous remains disputable, as studies regarding the esthetic criteria for the mentolabial region are insufficient. Only a few studies were dedicated to investigation of the ideal mentolabial sulcus depth, either through the ethnicity-specific population averages or through a preference survey of laypersons and professionals. Legan and Burstone[18] suggested an ideal mentolabial sulcus depth of 4±2 mm, based on analysis of 40 Caucasian adults with Class I occlusion and normal facial proportions. Lew et al.[19] disclosed a mentolabial sulcus depth of 3.5±2 mm, based on data from 48 Chinese adults with harmonious facial profile, as selected by professionals and lay judges. Ghorbanyjavadpour and Rakhshan[20] revealed a mean value of mentolabial sulcus depth of 6.23 mm from 15 profiles that were highly rated by 10 Iranian laypersons. Moreover, the perception of attractiveness by the practitioner and the patient do not necessarily coincide[21,22]. This study could provide valuable information to facilitate communication about chin profile changes in skeletal Class III patients undergoing bimaxillary surgery with advancement genioplasty, which is indispensable for a patient-centered treatment.

This retrospective study contained inevitable limitations. First, the sample size was small and thus was not sufficient to allow generalization of the results. Even though BMI was taken into consideration, postoperative stability of the soft tissue can be influenced by numerous other factors, such as soft and hard tissue relapse, preoperative soft tissue thickness, gender, muscle strain, and the amount of surgical movement[23,24]. Furthermore, BMI itself may have changed during the postoperative period. Further investigation is needed to confirm the results of this study. An exhaustive controlled study with a larger sample size that also involves 3-dimensional aspects of facial esthetics should be designed to explore the effect of advancement genioplasty. The cultural and ethnic differences in perceived aesthetics of mentolabial region should be further explored, together with quantitative analysis of patients' satisfaction from an esthetic perspective.

Conclusion

Although Group G showed a statistically greater decrease in the soft tissue chin thickness during the postoperative period, there were no significant intergroup differences in the chin profile at least 6 months after the surgery, except for the mentolabial sulcus depth, which was greater in Group G than in Group N.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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