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Soft tissue thickness changes in the lower face following bimaxillary surgery with advancement genioplasty in skeletal Class III malocclusion

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Abstract

Background In patients with skeletal Class III malocclusion, additional genioplasty is frequently required to enhance lower facial esthetics after orthognathic surgery. This study aimed to evaluate soft tissue thickness changes in the lower face before and after bimaxillary surgery with advancement genioplasty in patients with skeletal Class III malocclusion.

Methods Ninety-four patients were included: 57 patients underwent bimaxillary surgery alone (Group N), and 37 patients underwent bimaxillary surgery with advancement genioplasty (Group G). Changes in hard tissue landmarks and soft tissue thickness before and after surgery were analyzed from reconstructed three-dimensional cone-beam computed tomography (CBCT) images. CBCT images were taken pre-surgery (T0) and at least 6 months post-surgery (T1). Within- and between-group changes were tested with paired and independent *t*-tests; Pearson correlations assessed associations between skeletal advancement (Pogonion and Menton) and soft tissue thickness.

Results After surgery, soft tissue thickness at Pogonion (Pog–Pog') increased in Group N but decreased significantly in Group G (−1.90 ± 3.93 mm; $p = 0.006$), with a significant intergroup difference ($p = 0.014$). In contrast, soft tissue thickness at Menton (Me–Me') did not change significantly in Group N but increased significantly in Group G (3.14 ± 8.87 mm; $p = 0.038$), with a significant intergroup difference ($p = 0.034$). Pearson correlation analysis indicated that skeletal advancement was negatively associated with Pog–Pog' ($p < 0.05$) and total chin soft tissue thickness ($p < 0.01$), whereas B–B' and Me–Me' showed no significant correlations.

Conclusions In skeletal Class III patients undergoing bimaxillary surgery with advancement genioplasty, soft tissue thickness decreased at Pogonion and increased at Menton; Pogonion thinning scaled with skeletal advancement.

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While genioplasty can counteract mandibular setback-related thickening, excessive advancement risks over-thinning. Clinicians should anticipate these responses, calibrate advancement magnitude, and consider selective adjunctive soft tissue procedures.

Keywords Advancement genioplasty, Soft tissue thickness changes, Class III malocclusion, Three-dimensional analysis

Background

The chin is a critical factor for facial esthetics, perception, and lower face harmony [1–3]. In skeletal Class III deformities, where both horizontal and vertical chin disharmony are common, osseous advancement genioplasty is often considered after mandibular setback because it is a safe and effective method for reshaping the chin [4]. When combined with bimaxillary surgery, advancement genioplasty refines mandibular soft tissue contours by increasing the thickness of the inferior labial sulcus and deepening the labiomental fold, thereby improving overall esthetic outcomes [1].

Despite overall effectiveness, some patients experience complications or suboptimal esthetic results after advancement genioplasty, underscoring the need for accurate preoperative prediction and a clear recognition of its limits [4, 5]. However, reported soft tissue to hard tissue movement ratios after genioplasty vary widely (≈ 0.6:1 to 1.1:1), and lower face soft tissue responses that are relatively predictable after mandibular setback alone become less predictable when genioplasty is added [6–9]. Moreover, studies specifically evaluating soft tissue changes after bimaxillary surgery with concomitant advancement genioplasty are limited, and much of the existing work relies on two-dimensional lateral cephalometry, highlighting the need for quantitative data to refine prediction and surgical planning in this setting [1, 4].

Recently, cone-beam computed tomography (CBCT) has been widely used not only to image soft and hard tissues but also to evaluate three-dimensional (3D) facial changes relative to underlying skeletal movements [10, 11]. This technology enables quantitative assessment of changes in soft tissue thickness from preoperative to postoperative, and in the lower face, the magnitude of thickness change directly explains how skeletal repositioning is reflected in external appearance [11, 12]. Moreover, given quantitative evidence that lower face soft tissue volume distribution influences postoperative esthetic appraisal, evaluating thickness change is clinically relevant [13].

Therefore, this study aimed to evaluate changes in lower facial soft tissue thickness in patients with skeletal Class III malocclusion who underwent bimaxillary surgery with advancement genioplasty. The null hypothesis was that soft tissue thickness would not differ significantly between patients who underwent genioplasty and those who did not.

Methods

Study design and subjects

The study adhered strictly to the Declaration of Helsinki (2013). The Institutional Review Board of Yonsei University Dental Hospital (IRB No. 2–2024-0031) granted a waiver for ethics approval and informed consent for the use of anonymized and retrospectively analyzed data.

This retrospective study included Asian patients who sought treatment at the Department of Orthodontics and the Department of Oral and Maxillofacial Surgery at Yonsei University Dental Hospital, Seoul, Republic of Korea, between January 2018 and December 2022.

Inclusion criteria

- Age ≥ 18 years.
- Skeletal Class III malocclusion, defined as an ANB angle (point A–nasion–point B) < 0.
- Requirement for conventional orthognathic bimaxillary surgery (1-piece Le Fort I osteotomy and bilateral intraoral vertical ramus osteotomy) with presurgical orthodontics, with advancement genioplasty performed if deemed necessary.
- No severe dentofacial anomalies, such as cleft lip or palate.

Exclusion criteria

- History of serious medical conditions requiring hospitalization within the past three months.
- History of orthodontic treatment or orthognathic surgery.
- History of trauma or cosmetic surgical procedures (e.g., zygomatic enhancements).
- Indication for single-jaw surgery or a surgery-first approach.
- Absence of a complete identifiable series of CBCT records.

Patients who underwent only bimaxillary surgery were assigned to Group N, and patients who received bimaxillary surgery with advancement genioplasty were assigned to Group G. All patients underwent conventional bimaxillary surgery, which included a maxillary Le Fort I osteotomy with posterior impaction and bilateral intraoral vertical ramus osteotomy for mandibular setback. In Group G, advancement genioplasty involved making a labial mucosal vestibular incision and raising the mucoperiosteal flap to expose the mental foramina bilaterally. Once completely mobilized, the inferior segment was advanced horizontally and secured with biodegradable fixation screws (OSTEOTRANS-MX®, Takrion, Osaka, Japan) [14, 15]. All patients received pre- and postoperative orthodontic treatment at the Department of Orthodontics, Yonsei University Dental Hospital.

Outcome assessment

CBCT images obtained pre-surgery (T0) and a minimum of 6 months post-surgery (T1) were analyzed by the same individual using the Invivo dental software program (version 6.0; Anatomage, San Jose, CA, USA). The horizontal reference plane was established as the Frankfort horizontal (FH) plane, defined by the left and right porions and the left orbitale, while the plane perpendicular to the FH plane, passing through the nasion and basion, was designated as the midsagittal plane. The coronal plane was created perpendicular to the FH and midsagittal planes, intersecting at the nasion (Fig. 1, A). The nasion was set as the origin point (0,0,0), and coordinates for other landmarks were determined based on these settings. All records were deidentified and traced by the same observer. A total of 14 landmarks, hard tissue, and their corresponding soft tissues (ANS-Pr', A-Sn', Uli-Ls', Lli-Li', B-B', Pog-Pog', and Me-Me', Table 1), were traced, and the soft tissue thickness was measured (Fig. 1, B). 3D coordinates were recorded for each landmark at T0 (x_0, y_0, z_0) and T1 (x_1, y_1, z_1). The displacement of each landmark was defined as the Euclidean distance between the positions at the two time points: $\sqrt{((x_1 - x_0)^2+(y_1 - y_0)^2+(z_1 - z_0)^2)}$.

A regional superimposition on the mandibular segment was conducted to assess chin movement following advancement genioplasty, independent of orthognathic surgery. This technique was used as a voxel-based 3D method for segments without volume changes for bilateral intraoral vertical ramus osteotomy and genioplasty. The mandibular superimposition excluded the ramus and symphysis and involved the inferior border of the mandible from the front of the ramus to the posterior of the symphysis (Fig. 2A). The 3D distance between hard tissue Pogpnion (Pog) and Menton (Me) was calculated using the landmark coordinate system before surgery and the coordinate system that appeared after superimposition.

In the CBCT image, a region of interest (ROI) box was selected at the front of the mental foramen on both sides, and the B point of the chin area and the hard and soft tissues of the chin were extracted as a stereolithography file (Fig. 2B). Total chin soft tissue thickness was measured quantitatively using the program Geomagic Control X (3D Systems, Rock Hill, SC). The root mean square value of the shortest distance between the hard and soft tissue surfaces before and after surgery was calculated. The distances between those surfaces were displayed as a color map with color-coded distances.

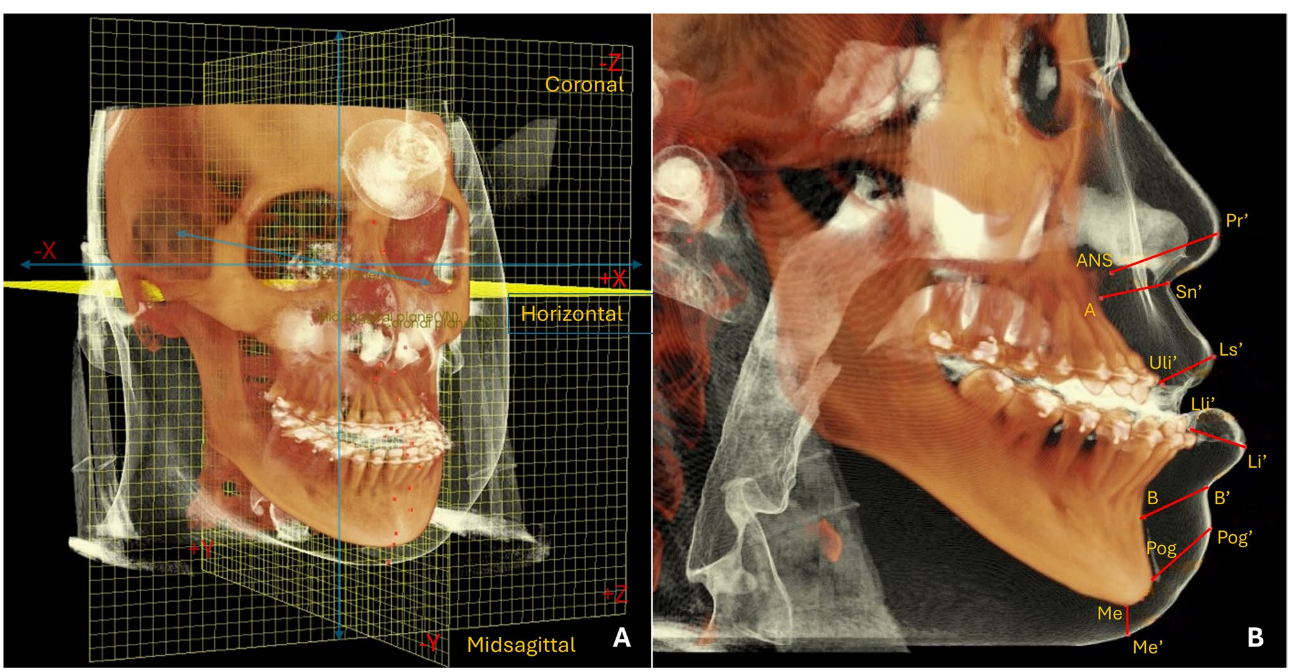

Fig. 1 **A**: Reference plane and coordinate system. The nasion was set as the zero point. X-axis: (+) left, (-) right; y-axis: (+) posterior, (-) anterior; and z-axis: (+) inferior, (-) superior; **B**: Landmarks and measurements (ANS-Pr', A-Sn', Uli-Ls', Lli'-Li', B-B', Pog-Pog', and Me-Me')

Table 1 Landmark and soft tissue measurement definitions

	Direction	Soft tissue measurement	Definition
Maxilla	Antero-posterior (y-axis)	ANS-Pr′	The most anterior mid-point of the anterior nasal spine of the maxilla (ANS) to the most anterior midpoint of the nasal tip (Pr′).
		A-Sn′	The point of maximum concavity in the mid-line of the alveolar process of the maxilla (A) to the midpoint on the nasolabial soft tissue contour between the columella crest and the upper lip (Sn′).
		Uli′-Ls′	Upper lip interior (Uli′) to the midpoint of the vermillion line of the upper lip (Ls′).
Mandible	Antero-posterior (y-axis)	Lli′-Li′	Lower lip interior (Lli′) to the midpoint of the vermillion line of the lower lip (Li′).
		B-B′	The point of maximum concavity in the midline of the alveolar process of the mandible (B) to the most posterior midpoint on the labiomental soft tissue contour that defines the border between the lower lip and the chin (B′).
		Pog-Pog′	The most anterior midpoint of the chin on the outline of the mandibular symphysis (Pog) to the most anterior midpoint of the chin (Pog′).
	Vertical (z-axis)	Me-Me′	The most inferior midpoint of the chin on the outline of the mandibular symphysis (Me) to the most inferior midpoint on the soft tissue contour of the chin located at the level of the three-dimensional cephalometric hard tissue menton (Me′).

Sample size calculation

On the basis of a preliminary study [11], a minimum sample size of 21 was required within each group, with a *p* value < 0.05 indicating statistical significance, a power of 80%, and an effect size of 0.8 for detecting differences in soft-tissue changes between T0 and T1 (G*Power, version 3.1; Heinrich Heine University Dusseldorf, Dusseldorf, Germany).

Statistical analysis

All statistical analyses were conducted using SPSS (version 26.0; IBM, Seoul, Korea). The Shapiro-Wilk test was employed to assess the normality of the data distribution. Descriptive statistics, such as the mean and standard deviation, were used to describe the distribution of the study variables. Differences in demographic characteristics, including gender and age, between the two groups were analyzed using the chi-square test and the Mann-Whitney U test. A paired *t*-test was utilized to compare conditions before and after surgery within each group, while an independent *t*-test was used to compare changes between the groups. The Pearson correlation analysis was used to ascertain the relationship between hard tissue movement and soft tissue changes. Intra-observer reliability was ascertained by comparing measurements from original examinations with those from repeat examinations conducted 2 weeks later. The method error was evaluated using the intraclass correlation coefficient, which registered at 0.827 for all measurements.

Results

Baseline characteristics of the groups

This study included a total of 94 patients. Among these, Group N included 57 patients (29 males, 28 females) with a mean age of 24.44 years; Group G comprised 37 patients (22 males, 15 females) with a mean age of 23.95 years. There were no significant differences in the demographic characteristics between the two groups (Table 2). Although not statistically significant, the higher proportion of patients in Group G with SN-MP values greater than 37 ° suggests that this group includes relatively more hyperdivergent patients compared to Group N.

Soft tissue thickness at pre-surgery (T0)

Group G exhibited significantly greater B–B’ ($p < 0.001$) and Pog–Pog’ ($p = 0.022$) before surgery. All other preoperative soft tissue thicknesses did not differ between groups (Table 3).

Soft tissue thickness at post-surgery (T1)

Postoperatively, Group G exhibited significantly greater soft tissue thickness at ANS–Pr’, B–B’, and Me–Me’ (p= 0.021, p= 0.004, and p= 0.010, respectively; Table 4). No other sites differed between groups; notably, although Pog–Pog’ was significantly greater in Group G at T0, this difference was no longer present postoperatively (Tables 3–4).

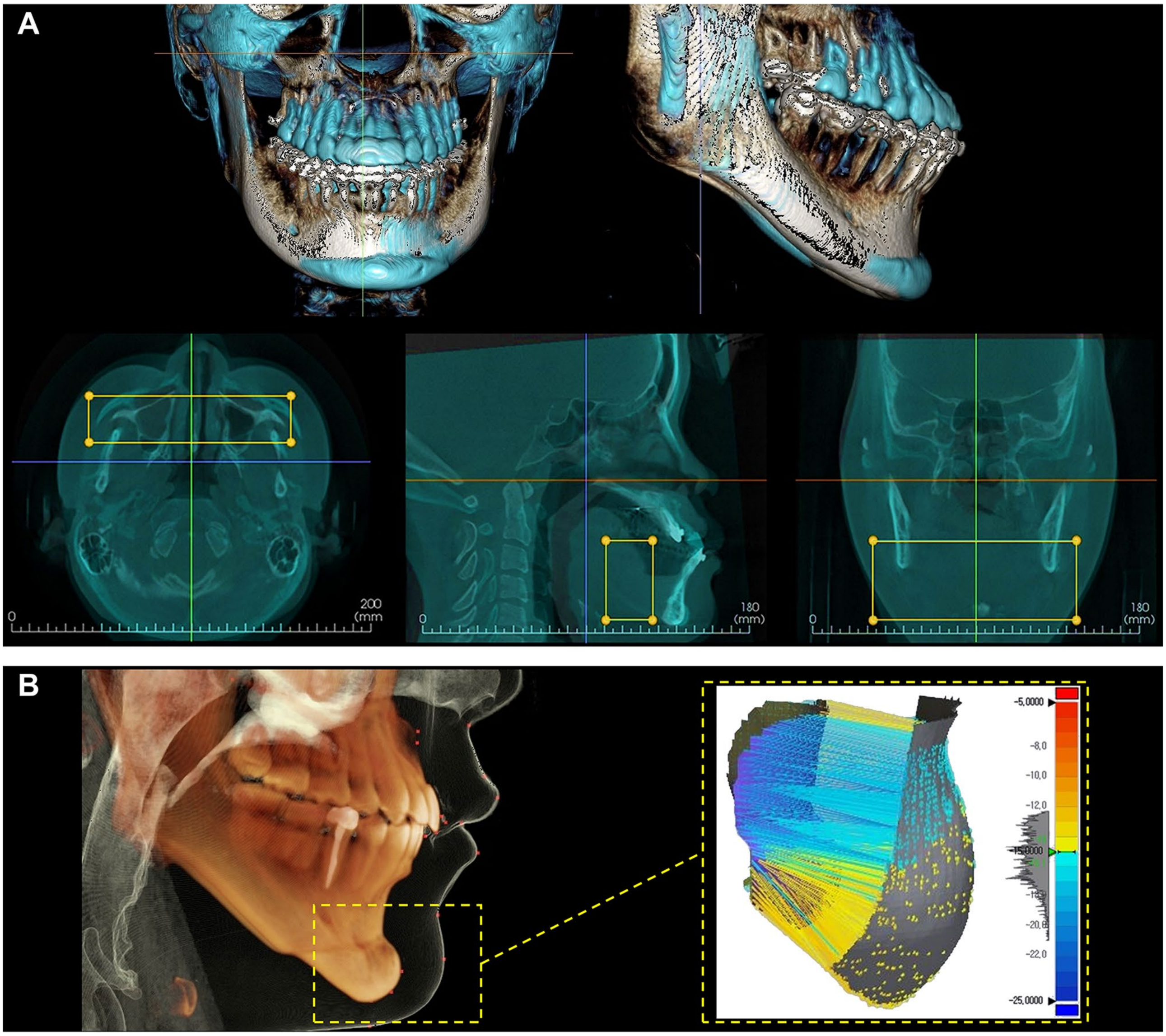

Fig. 2 Three-dimensional comparison of change in soft tissue morphology. **A**: Regional mandibular superimposition. This technique excluded the ramus and symphysis and involved superimposing the inferior border of the mandible from the front of the ramus to the posterior of the symphysis. **B**: Total chin soft tissue thickness measurement. A region of interest box was selected at the front of the mental foramen on both sides and the B point of the chin area, and the hard and soft tissues of the chin were extracted as a stereolithography file. The Geomagic Control X (3D Systems, Rock Hill, SC, USA) program was used to measure total chin soft tissue thickness

Soft tissue thickness changes after surgery (T1-T0)

In Group N, soft tissue thickness increased significantly at all sites except Me–Me', which showed no significant change. In Group G, most sites also increased; however, Pog–Pog′ showed a significant reduction (−1.90 ± 3.93 mm, p= 0.006), whereas Me–Me′ increased (+3.14 ± 8.87 mm, p= 0.038). Between-group differences in change were significant at B-B', Pog-Pog', and Me-Me' (all $p<$ 0.05, Table 5).

Skeletal changes after surgery (T1-T0)

At A point, both groups showed significant superior movement; Group G exhibited greater superior displacement (−5.41± 0.97 mm) than Group N (−2.47± 7.54 mm; p= 0.047). Although both groups exhibited a comparable amount of mandibular setback at point B (9.07 ± 10.84 mm in Group N and 7.15 ± 7.92 mm in Group G), the Pog and Me movement changes in Group G were less than those in Group N ($p<$ 0.05), owing to advancement genioplasty. In the vertical changes, Group G exhibited a 2.35± 5.33 mm upward movement at Pog, which was

Table 2 Sample characteristics (N=94)

Variables	Group N (n=57)	Group G (n=37)	Between-group comparison
Gender, n (%)			
Male	29 (50.9)	22 (59.5)	0.415[a]
Female	28 (49.1)	15 (40.5)	
Age, y (mean ± SD)	24.44 ± 2.84	23.95 ± 2.35	0.485[b]
ANB, ° (mean ± SD)	−3.78 ± 2.29	−3.19 ± 2.40	0.240[c]
SN-MP, ° (mean ± SD)	34.96 ± 5.90	36.56 ± 5.18	0.182[c]
<27 (%)	4 (7.1)	0 (0)	0.243[a]
27–37 (%)	32 (56.1)	24 (51.1)	
>37(%)	21 (36.8)	23 (48.9)	
Menton deviation, mm (mean ± SD)	4.63 ± 3.57	5.44 ± 4.51	0.493[c]

Group N only orthognathic surgery group, *Group G* orthognathic surgery with advancement genioplasty group, *ANB* A point–nasion-B point, *SN-MP* sella-nasion to mandibular plane, *SD* standard deviation

[a] *p* value was calculated using the chi-square test

[b] *p* value was calculated using the Mann-Whitney U test

[c] *p* value was calculated using an independent *t*-test

Table 3 Comparison of soft tissue thickness between groups before surgery

Soft tissue thickness (mm)	Group N	Group G	Between-group comparison
ANS-Pr′	23.42 ± 2.38	24.49 ± 3.54	0.082
A-Sn′	13.67 ± 1.89	14.05 ± 1.96	0.354
Uli′-Ls′	10.74 ± 2.14	10.92 ± 2.30	0.706
Lli′-Li′	11.58 ± 1.90	11.73 ± 2.03	0.728
B-B′	**11.73 ± 2.13**	**14.34 ± 3.64**	**0.000‡**
Pog-Pog′	**11.54 ± 2.31**	**13.37 ± 4.33**	**0.022†**
Me-Me′	6.83 ± 1.62	7.03 ± 2.13	0.616

Data are presented as mean ± standard deviation. Group comparisons were tested using the independent *t*-test

Group N only orthognathic surgery group, *Group G* orthognathic surgery with advancement genioplasty group, *ANS* Anterior nasal spine, *Pr′* Pronasale, *A* point A, *Sn′* Subnasale, *Uli′* Upper lip interior, *Ls′* Labrale superius, *Lli′* Lower lip interior, *Li′* Labrale inferius, *B* point B, *B′* soft tissue point B, *Pog* Pogonion, *Pog′* Soft tissue pogonion, *Me* Menton, *Me′* soft tissue menton

† p <0.05, ‡ p <0.001. Variables showing significant between-group differences are highlighted in bold

significantly greater than Group N ($p < 0.05$). No difference in horizontal movement was observed (Table 6).

Correlation between soft tissue changes and 3D surgical movements

The correlation between soft tissue changes and 3D surgical movements of advancement genioplasty was evaluated in Group G. In Group N, the color transition patterns between T0 and T1 were similar in the area below the lower lip, suggesting little change in soft tissue thickness. In contrast, Group G demonstrated a marked shift from blue at T0 to yellow at T1 in the pogonion region, indicating a significant reduction in chin soft tissue thickness after surgery. These findings highlight different postoperative response patterns between the two groups (Fig. 3). The change in Pog-Pog' was negatively correlated with the movement of hard tissue Pog ($p< 0.05$) and Me ($p< 0.01$). Additionally, a negative correlation was found with total chin area soft tissue thickness and movement of hard tissue Pog ($p< 0.05$) and Me ($p< 0.01$) (Table 7).

Table 4 Comparison of soft tissue thickness between groups after surgery

Soft tissue thickness(mm)	Group N	Group G	Between-group comparison
ANS-Pr′	**26.75 ± 2.55**	**28.09 ± 2.90**	**0.021†**
A-Sn′	15.26 ± 1.99	15.36 ± 1.97	0.819
Uli′-Ls′	12.67 ± 2.63	13.17 ± 2.17	0.341
Lli′-Li′	12.84 ± 1.91	12.97 ± 1.90	0.755
B-B′	**12.42 ± 1.75**	**13.57 ± 2.04**	**0.004†**
Pog-Pog′	12.34 ± 2.13	11.48 ± 2.20	0.060
Me-Me′	**7.01 ± 1.80**	**10.17 ± 8.84**	**0.010†**

Data are presented as mean ± standard deviation. Group comparisons were tested with an independent *t*-test

Group N only orthognathic surgery group, *Group G* orthognathic surgery with advancement genioplasty group, *ANS* Anterior nasal spine, *Pr′* Pronasale, *A* point A, *Sn′* Subnasale, *Uli′* Upper lip interior, *Ls′* Labrale superius, *Lli′* Lower lip interior, *Li′* Labrale inferius, *B* point B, *B′* soft tissue point B, *Pog* Pogonion, *Pog′* soft tissue pogonion, *Me* Menton, *Me′* soft tissue menton

† $p < 0.05$. Variables with significant between-group differences are highlighted in bold

Table 5 Comparison of soft tissue thickness changes between groups before and after surgery

	Group *N*		Group G		
Soft tissue thickness (mm)	Change (T1-T0)	*p*-value	Change (T1-T0)	*p*-value	Between-group comparison
ANS-Pr′	3.33 ± 2.19	0.000**	3.59 ± 2.65	0.000**	0.652
A-Sn′	1.59 ± 1.60	0.000**	1.31 ± 1.35	0.000**	0.157
Uli′-Ls′	1.93 ± 2.48	0.000**	2.25 ± 2.36	0.000**	0.787
Lli′-Li′	1.26 ± 1.90	0.000**	1.24 ± 1.99	0.001*	0.589
B-B′	**0.69 ± 1.91**	**0.008***	**−0.77 ± 3.69**	**0.211**	**0.011†**
Pog-Pog′	**0.80 ± 2.19**	**0.008***	**−1.90 ± 3.93**	**0.006***	**0.014†**
Me-Me′	**0.18 ± 1.76**	**0.445**	**3.14 ± 8.87**	**0.038***	**0.034†**

Data are presented as mean ± standard deviation. Positive and negative values indicate increases and decreases in soft tissue thickness. Within-group comparisons were performed using a paired *t*-test; between-group comparisons were performed using an independent *t*-test

Group N only orthognathic surgery group, *Group G* orthognathic surgery with advancement genioplasty group, *ANS* Anterior nasal spine, *Pr′* Pronasale, *A* point A, *Sn′* Subnasale, *Uli′* Upper lip interior, *Ls′* Labrale superius, *Lli′* Lower lip interior, *Li′* Labrale inferius, *B* point B, *B′* soft tissue point B, *Pog* Pogonion, *Pog′* soft tissue pogonion, *Me* Menton, *Me′* soft tissue menton

* $p < 0.05$, ** $p < 0.001$: within-group comparisons

† $p < 0.05$: between-group comparisons. Variables with significant between-group differences are highlighted in bold

Discussion

Although advancement genioplasty is frequently added to bimaxillary surgery with mandibular setback in mandibular prognathism because of its esthetic

Table 6 Comparison of skeletal changes between groups before and after surgery

		Group *N*		Group G		
Landmark	Direction	Change (T1-T0)	*p*-value	Change (T1-T0)	*p*-value	Between-group comparison
A	X	−0.16 ± 2.33	0.595	0.29 ± 1.97	0.371	0.781
	Y	−0.12 ± 9.94	0.928	−3.85 ± 1.54	0.017*	0.073
	Z	**−2.47 ± 7.54**	**0.017***	**−5.41 ± 0.97**	**0.000****	**0.047†**
B	X	−0.49 ± 3.44	0.289	−0.12 ± 3.56	0.836	0.621
	Y	9.07 ± 10.84	0.000**	7.15 ± 7.92	0.000**	0.356
	Z	0.28 ± 7.74	0.788	−0.08 ± 8.48	0.954	0.833
Pog	X	−0.49 ± 3.59	0.306	−0.44 ± 3.97	0.500	0.953
	Y	**10.33 ± 11.32**	**0.000****	**4.78 ± 10.23**	**0.007***	**0.018†**
	Z	**0.73 ± 7.05**	**0.436**	**−2.35 ± 5.33**	**0.011***	**0.018†**
Me	X	−0.53 ± 3.68	0.283	0.08 ± 4.23	0.913	0.465
	Y	**10.54 ± 11.44**	**0.000****	**5.15 ± 8.88**	**0.001***	**0.017†**
	Z	0.92 ± 7.06	0.330	−1.56 ± 6.29	0.141	0.087

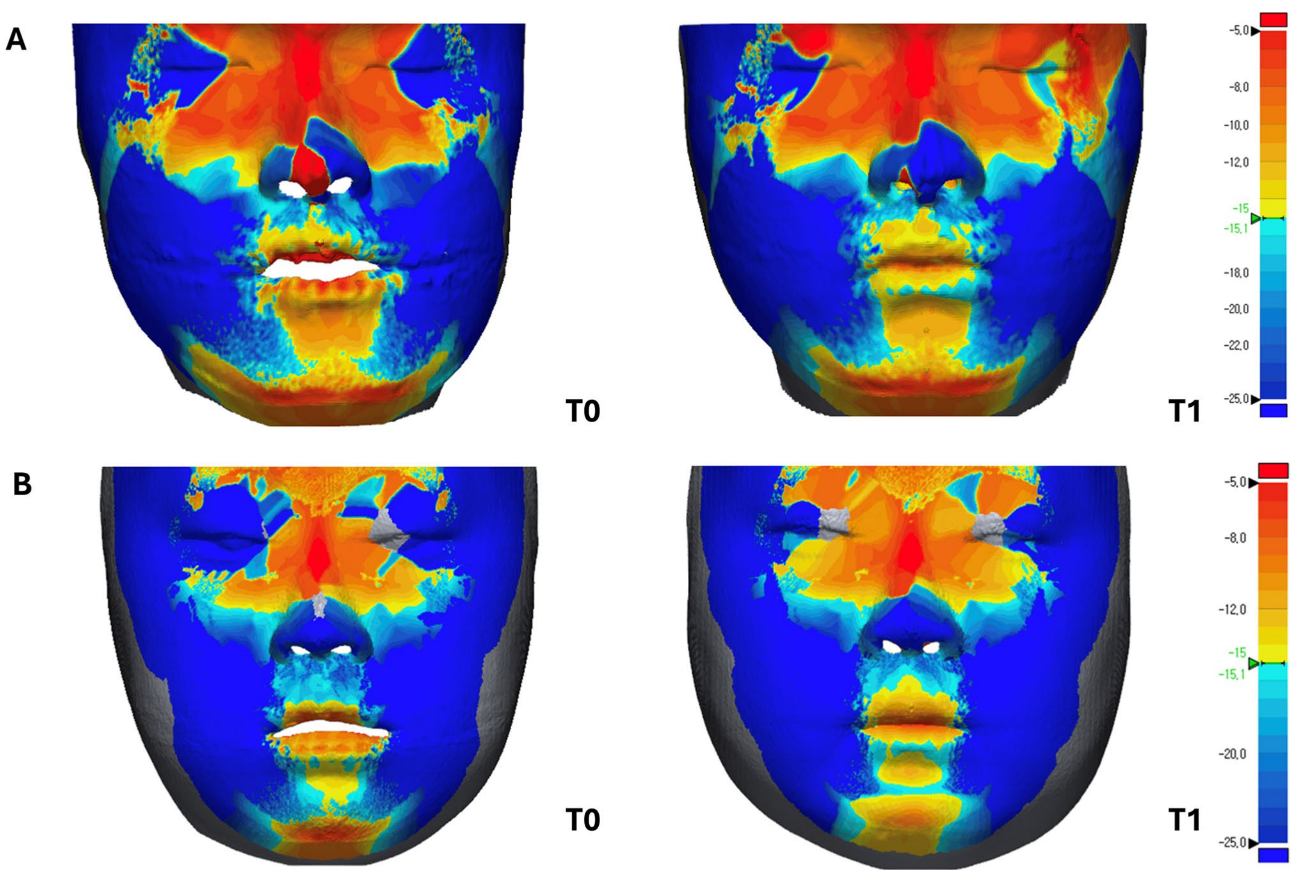

Fig. 3 Three-dimensional color maps showing changes in total chin soft tissue thickness between pre-surgery (T0) and post-surgery (T1). **A** Group N: In the area below the lower lip, the color distribution remained similar between T0 and T1, indicating minimal changes in soft tissue thickness. **B** Group G: In the Pogonion region, the color shifted from blue at T0 to yellow at T1, demonstrating a reduction in soft tissue thickness. The color scale on the right of each figure represents the distance from the soft tissue to the underlying bone; a shift toward blue indicates an increase in thickness, whereas a shift toward yellow/red indicates a decrease

benefits, systematic and quantitative evidence on soft-tissue behavior remains limited [16]. To our knowledge, this is the first CBCT-based evaluation of lower facial soft tissue after bimaxillary surgery with advancement genioplasty in skeletal Class III patients. These findings aim to enhance the predictability of soft tissue morphology during surgical planning and to provide additional, evidence-based considerations for clinical decision-making.

In Group N, mandibular setback shortened the mandible anteroposteriorly, compressing the soft tissues and

Table 7 Correlation of soft tissue changes with three-dimensional surgical movements in advancement genioplasty

Variables, mm	B-B'	Pog-Pog'	Me-Me'	Total chin soft tissue changes
Pog	0.214	**−0.415***	−0.008	**−0.414***
Me	−0.067	**−0.605****	0.041	**−0.463****

Pearson's correlation analysis was performed

Variables with significant correlations are highlighted in bold

B point B, *Pog* Pogonion, *Me* Menton

*$p < 0.05$; **$p < 0.01$

leading to overall thickening of the lower facial soft tissue, which underwent only bimaxillary surgery. Conversely, in Group G, where advancement genioplasty was performed, the B-B' thickness decreased by 0.77± 3.69 mm, and the Pog-Pog' thickness decreased by 1.90± 3.93 mm. These findings suggest that advancement genioplasty not only offsets the tissue thickening caused by mandibular setback but can also result in thinning of the chin soft tissue compared with the preoperative state. Clinically, soft tissue thickening after mandibular setback can be esthetically unfavorable; the observed attenuation with adjunctive advancement genioplasty therefore supports its use beyond the traditional rationale of deepening the mentolabial sulcus and improving the lower facial profile. Importantly, however, our data indicate that patients with already thin baseline chin soft tissue may experience an undesired loss of chin volume after advancement genioplasty. If advancement genioplasty is indicated in such cases, concomitant chin augmentation or contouring should be considered.

In Group G, contrary to the reduction in soft tissue thickness observed at the B-B' and Pog-Pog' during surgery, there was a significant increase in the soft tissue Me-Me'. This could be attributed to the upward movement of the bony segment during genioplasty, in addition to the upward movement of the B point in Group G. Furthermore, the A point in Group G also showed a significant upward movement, indicating that the surgery in this group was generally aimed at reducing anterior facial height. Clinically, although advanced genioplasty improves the anterior profile, inferior facial fullness at Me–Me' may be perceived as unaesthetic (e.g., heaviness or ptosis). We therefore recommend reassessment after postoperative stabilization (typically ≥6–12 months, after edema has resolved) and, in appropriately selected patients, consideration of adjunctive soft-tissue debulking or contouring (e.g., submental/chin liposuction) may be warranted.

Beyond analyzing the absolute change in thickness, we also examined the correlation between changes in soft tissue thickness and the magnitude of skeletal movement achieved by genioplasty. To quantify the amount of surgical movement, mandibular superimposition was performed. Because traditional stable landmarks for mandibular superimposition, such as the symphysis, mental foramen, and lingual foramen, are directly affected by genioplasty [17, 18], we adopted volume-based superimposition rather than landmark-based registration. Specifically, the remaining inferior border of the mandible was used as the reference while excluding the osteotomy regions (the ramus for orthognathic surgery and the symphysis for genioplasty). The analysis showed that hard tissue movements at Pog and Me were negatively correlated with changes in Pog-Pog' and with total chin soft tissue thickness after advancement genioplasty. In other words, greater anterior advancement was associated with a thinner soft tissue envelope at the chin, which may be esthetically undesirable in some patients. When substantial advancement is required, it may be prudent to reconsider the distribution of skeletal movements (e.g., maxillary anteroposterior positioning and the magnitude of mandibular setback) to avoid over-thinning of the chin soft tissue.

In our study, the proportion of high-angle patients was higher in Group G than in Group N, although this difference did not reach statistical significance. This aligns with previous reports indicating that patients with hyperdivergent Class III deformities are more likely to undergo genioplasty during orthognathic surgery than hypodivergent individuals [11]. Given that high-angle patients often present with thin baseline chin soft-tissue, surgeons should anticipate the possibility of further thinning induced by advancement genioplasty and incorporate this into preoperative planning [19]. Accordingly, a comprehensive assessment of the initial skeletal morphology of the chin, the position of Pog, and the overall facial pattern can guide decisions about whether adjunctive genioplasty should be included and, if so, determine the appropriate extent and vector of movement.

Postoperative stability is influenced by the suprahyoid musculature and perimandibular connective tissue attachments, bone remodeling, and resorption patterns [20]. Changes in soft tissue due to swelling following genioplasty were the most common during the first six months, with most studies showing minimal relapse at 1-year post-surgery [21].Therefore, this study assessed bone remodeling, soft tissue swelling, and functional adaptation a minimum of 6 months post-surgery. However, another study focusing on long-term stability reported an average relapse rate of 8% over three years following genioplasty [9], and most relapses occurred in the pogonion area, a vital factor to consider during genioplasty.

The limitation of this study is that the inclusion of patients undergoing bimaxillary surgery introduces a confounding factor related to the surgical alterations of the maxilla. To purely assess the effect of genioplasty on soft tissue thickness, it would have been preferable to study patients who underwent single-jaw surgery on the mandible alone. Additionally, this study had a limitation in that it did not explore other potential influences on soft tissue thickness, such as body weight, muscle, or soft tissue elasticity. Therefore, future research should consider other factors that might influence soft tissue thickness following genioplasty to provide a more comprehensive understanding.

Conclusion

A general increase in lower facial soft tissue thickness (except menton) was found in skeletal Class III patients undergoing bimaxillary surgery. However, when advancement genioplasty was performed, Pogonion thickness significantly decreased while Menton thickness increased. Moreover, Pogonion soft tissue thinning correlated with greater skeletal advancement. Therefore, while genioplasty can counteract setback-related thickening, excessive advancement risks over-thinning. Clinicians should be aware of these soft tissue thickness changes when planning advancement genioplasty, calibrate the advancement magnitude, and consider a selective adjunctive soft tissue procedure.

Abbreviations

Pog	Pogonion
Me	Menton
CBCT	Conebeam computed tomography
3D	Three-dimensional
ANS	Anterior nasal spine
Pr′	Pronasale
A	Point A
Uli′	Upper lip inside
Ls′	Labrale superius
Lli′	Lower lip inside
Li′	Labrale inferius
B	Point B
B′	Soft tissue point B
Pog′	Soft tissue pogonion
Me′	Soft tissue menton
T0	Pre-surgery
T1	Post-surgery

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Authors' contributions
Y-N.K: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. E-H.A.C: Investigation, Writing – review & editing. U.M: Conceptualization, Formal analysis, Methodology. J-H.Y: Methodology, Investigation, Formal analysis. J-Y.C: Resources, Supervision, Writing – review & editing. S-H.P: Supervision, Writing – review & editing. J-Y.K: Supervision, Writing – review & editing. S-H.C: Conceptualization, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing, Funding acquisition. H-S.Y: Conceptualization, Project administration, Supervision, Validation, Writing – review & editing.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
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. 2-2024-0031). A waiver for ethics approval and informed consent for the use of anonymized and retrospectively analyzed data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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