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Improvement of Chin Profile after Mandibular Setback and Reduction Genioplasty for Correction of Prognathism and Long Chin

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Abstract
Background This study evaluated the changes in the chin profile after using mandibular setback and vertical chin reduction genioplasty to correct mandibular prognathism associated with a long and flat chin.
Methods Sixteen consecutive patients (6 male and 10 female) underwent surgery at a mean age of 22.6 years (range = 18.2–27.8 years). The evaluation consisted of hard and soft tissue analysis before and after treatment.
Results The results showed that improvement in facial profile, chin contour, and dental occlusion was achieved. After an average of 9.4-mm mandibular setback and 5.1-mm vertical osseous chin reduction, the thickness of soft tissue pogonion was increased by 4.0 mm, the supramentale thickness was increased by 1.8 mm, and lower-lip thickness was increased by 1.6 mm. Thus, the mentolabial fold increased from 3.4 to 4.7 mm and the mentolabial angle decreased from 153.4 to 136.9°. The vertical lip:chin ratio became normal.
Conclusion The results of this study demonstrated that mandibular setback combined with vertical chin reduction genioplasty offers an alternative for the treatment of patients suffering from mandibular prognathism with a long, nonprojecting chin.
Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Prognathism · Long chin · Bilateral sagittal split osteotomy · Genioplasty

Mandibular prognathism with a long face is one phenotype of Class III malocclusion. The lower face of those with mandibular prognathism often has a flat appearance with little or no prominence at the chin bottom and a reduced labiomental fold. As a consequence, prominent functional and aesthetic defects are present. General solutions to correct class III malocclusion are a combination of mandibular ramus osteotomy to setback the protruding mandible, LeFort I osteotomy to advance a deficient maxilla, and genioplasty. In selected patients with isolated mandibular prognathism with a long face and without a dental open bite, mandibular setback surgery combined with genioplasty to elevate and advance the chin could be considered, as the chin contour is important in facial aesthetics and should be harmonious with the mandible as well as other facial structures [1].

Chin projection, thickness of the chin pad, depth of the labiomental fold, and lower-lip position are considered important variables in the preoperative analysis for an ideal chin profile. The shape, position, and thickness of the soft tissue in the chin area can be changed by surgical osseous movement. Different chin profile changes after mandibular

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setback have been reported. Most studies reported a 1:1 ratio between soft and hard tissue changes at the mentolabial fold and chin following the mandibular setback, and the changes of the lower lip were less predictable [2–7]. However, some cephalometric studies have shown that the mentolabial fold became more concave after the mandibular setback [6, 8–10]. It was suggested that the increase in mentolabial fold depth was due to a decrease in soft tissue thickness in that area and normalization of perioral muscle function. Another study reported that the effects of mandibular setback on the chin area were a deepening of the mentolabial fold and an increase in lower-lip thickness [10].

The chin profile changes after vertical shortening and genial sagittal movement were relatively consistent in the literature. The depth of the labiomental fold increased after advancement genioplasty [11]. In patients who underwent both vertical reduction and anterior repositioning of the chin, the soft tissue advancement was greater leading to a much deeper labiomental fold than in patients who had only anterior repositioning [12]. Changing the vertical height of the chin appeared to have considerable influence on the labiomental fold [13, 14]. Patients with a small lower facial height tend to have a deepened fold, while patients with a large lower facial height often have a shallow fold. Isolated vertical reduction genioplasty for patients with vertical divergence of the lower face has rarely been reported. One study showed the vertical change of the pogonion following its superior repositioning, but it did not evaluate the changes in the labiomental fold; soft tissue thickness of the pogonion, menton, supramentale; and chin inclination [15].

Data on soft tissue changes following mandibular setback and chin reduction are lacking. Patients with mandibular prognathism and a long nonprojecting chin are not rare in plastic, cosmetic, and dental clinics. This article presents the results from such selected patients who underwent mandibular setback and vertical reduction genioplasty for correction of the deformity. An understanding of the changes in this region is essential in planning the surgical procedures.

Materials and Methods

Subjects from this retrospective study were chosen from the Department of Orthodontics, the Craniofacial Center, and the Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital. They were patients treated by one orthodontist (CTH) and one surgeon (LJL) using the surgical method. Sixteen patients (6 male and 10 female) with mandibular prognathism associated with a long chin and flattened labiomental sulcus underwent the surgical method that included bilateral sagittal split osteotomy (BSSO) of the ramus for mandibular setback and vertical chin reduction without genial advancement. During the operation, an upper osteotomy line is marked 3 cm below the incisor edge and at least 6 mm below the mental foramen lower edge. The lower osteotomy line is marked parallel to the upper osteotomy line and the distance is the amount of resection as planned. After resection, the lower segment is fixed to the superior edge at the same anterior surface. There was no genial advancement.

The mean age at surgery was 22.6 years (range = 18.2–27.8 years). All patients were nonsyndromic and noncleft Taiwanese patients. None of the patients' facial deformities were caused by trauma. Selection criteria for the patients were class III malocclusion with mandibular prognathism, concave profile, negative ANB angle, and pretreatment overjet of 0 mm or less without an open bite. The vertical lip:chin ratio (Sn-Stms/Stmi-Me′) was less than 1/2, the lower anterior facial height to total anterior facial height ratio (ANS-Me/N-Me) was more than 57 %, S-Go/N-Me was <63 %, and the distance of the lower incisor to the menton was more than 45 mm [16–18]. The depth of the labiomental fold was less than 4 mm, chin inclination (FH to Pog-B) was less than 90° [19], the Pog to NB line was less than 4 mm, and the (L1-NB)-(Pog-NB) length difference (Holdaway ratio difference) was more than 0 [20]. The average amount of mandibular setback was 9.4 mm and the average vertical osseous chin reduction was 5.1 mm. In addition to dental malocclusion, these patients suffered from psychosocial embarrassment because of their facial appearance. The treatment plan was discussed with the patients. It included an orthodontic phase (dental decompensation and finishing) and a surgical phase (BSSO setback and vertical chin shortening). Definition of the cephalometric landmarks, reference planes, and measurements are given in Table 1 and shown in Fig. 1. Pog position is defined as the most anterior point on the contour of the chin. It is to be noted that the pogonion point in the preoperative cephalogram could be included in the resection of segment. The position of the pogonion may also be changed at the postoperative cephalogram as the mandible is set back.

Data Recording and Analysis

Standard profile pictures and cephalometric films were obtained before treatment (T1, before the orthodontic treatment) and after treatment (T2, after the braces are detached). All cephalograms (Gx-Ceph, Gendex Corporation, Des Plaines, IL, USA) were taken under the same standardized setting, with patients asked to have lips in a relaxed position. The cephalograms were hand-traced on acetate paper by the same examiner (CTH). Hard tissue and

Table 1 Definition of cephalometric landmarks, reference planes, and measurements

Landmark	Definition
N	Nasion: the most anterior point of the frontonasal suture
Or	Orbitale: the lowermost point on the inferior margin of the orbit
L1	Crown edge of lower incisor
L6	Mesial buccal cusp tip of lower first permanent molar
B	Supramentale: the most posterior point on the outer counter of the mandibular alveolar process
Pog	Pogonion: most anterior point of the bony chin
Me	Menton: the most inferior point on the outline of the symphysis
Stmi	Stomion inferius: the highest point of lower lip
Stms	Stomion superius: the lowest point of upper lip
Li	Labrale inferius: a point indicating the mucocutaneous border of the lower lip
Si	Mentolabial sulcus: the point of greatest concavity in the midline between the lower lip and chin
Pog′	Soft tissue pogonion: the most anterior point on soft tissue chin
Me′	Soft tissue menton: the lowest point on the soft tissue chin
FH	Frankfort horizontal: constructed by drawing a line through Po and Or
Lower OP	Lower occlusal plane: A line drawn from the L1 to the L6
Chin inclination to FH	Inferior inside angle formed by the intersection of FH to Pog′-Si
Labiomental fold	Depth from Si perpendicular to the lower lip chin line
Lower-lip thickness	Linear distance from Li to the lower incisor
Sulcus thickness	Linear distance from Si to the hard tissue
Pog′ thickness	Linear distance from Pog′ to the hard tissue
Me′ thickness	Linear distance from Me′ to Me
LOP to Stmi	Linear distance from Stmi to occlusal plane
LOP to Li	Linear distance from Li to occlusal plane
LOP to Pog′	Linear distance from Pog′ to occlusal plane
LOP to Me	Linear distance from Me to occlusal plane
LOP to Me′	Linear distance from Me′ to occlusal plane
Sn-Stms/Stmi-me	Vertical lip:chin ratio
ANS-Me/N-Me	Lower anterior facial height proportion
S-Go/N-Me	Posterior to anterior facial height proportion
L1-Me	Chin height from the lower incisor to Me
Holdaway ratio difference	Linear difference between the measurement Pog-NB and lower incisor to NB
Pog-NB	Linear distance from Pog to NB line

soft tissue landmarks were identified on each cephalometric film to measure the angular, linear, and ratio changes. All the measurements were corrected for magnification by the scale on every cephalometric film. Pretreatment and post-treatment cephalograms were superimposed on the cranial base and the best fit of anterior mandibular border to show the mandibular movement and the genial movement. The mandibular occlusal plane from the lower first molar to the central incisor was registered as a reference line [21] to show the vertical changes of some hard and soft tissue.

The measurements, including the vertical distance from Stm, Li, Si, Pog′, and Me′ to occlusal plane; the sagittal distance (soft tissue thickness) from incisor to Li, point B to Si, and Pog to Pog′; the angulation of the mentolabial angle, chin inclination, and facial convexity; the changes in the ratios of vertical lip:chin, PFH/ATFH, LFH/ATFH, and Holdaway ratio difference, were used to analyze the changes from T1 to T2.

To estimate the error from localizing the reference points and the manual procedures, 16 selected radiographs were repeated for tracing and measurement at a particular interval by the same examiner (CTH). The causal error was calculated according to Dahlberg's formula [22]. The systematic errors were ascertained by using paired *t*-tests. The paired *t*-test for differences between the replications showed no statistically significant difference. These results indicated high reliability of the measurements.

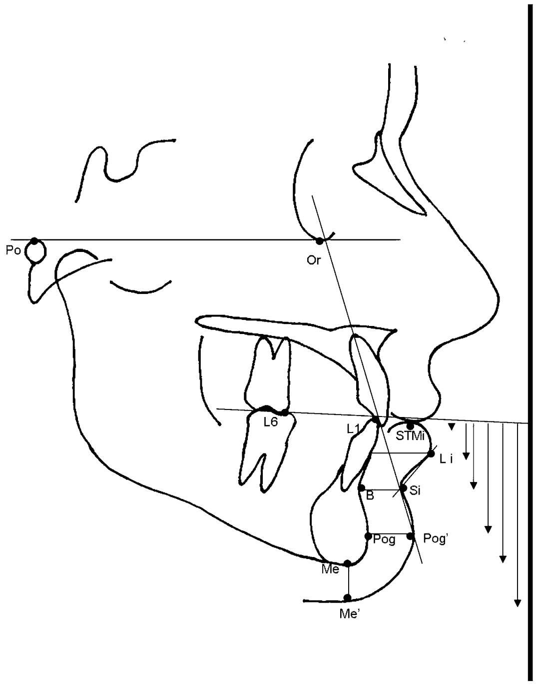

Fig. 1 Cephalometric landmarks and the angular and linear measurement

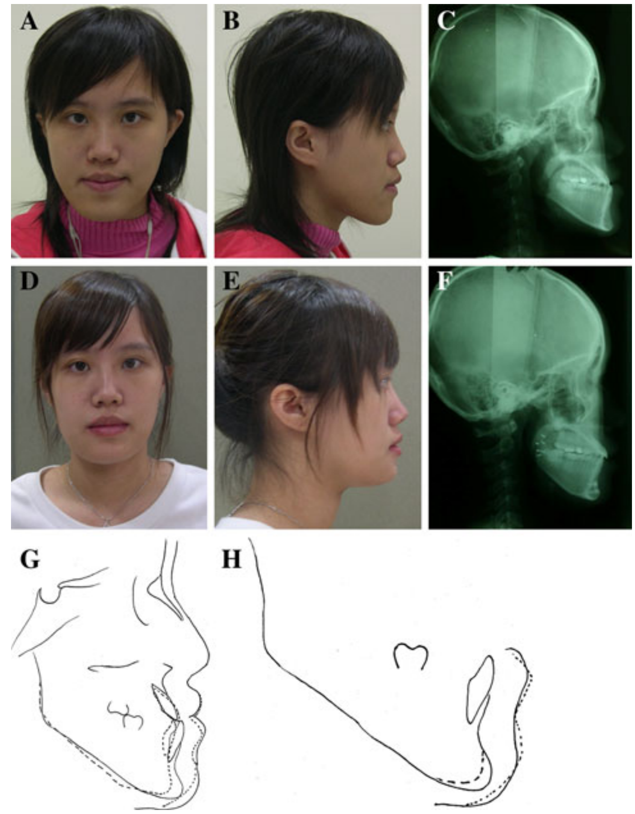

Fig. 2 **a–c** Pretreatment view of a 22-year-old woman who underwent a mandibular setback and vertical chin reduction. **d–f** Post-treatment view when braces were detached. **g–h** Superimposition of cephalometric radiograph, registered on cranial base and best fit of mandibular anterior border, to show mandibular movement and genial movement

Means and standard deviations were calculated for all variables. To test for the statistical significance of the changes in the cephalometric variables between T1 and T2, the paired t test was used to determine the mean treatment changes. A value of $p < 0.05$ was considered significant.

To calculate the relationship between hard tissue and soft tissue changes, the increase in the soft tissue thickness of Pog was compared with the amount of vertical reduction of the chin, and the superior movement of soft tissue Me was compared with the superior movement of the hard tissue Me. A Pearson correlation analysis was performed to determine the relationship between the amount of hard tissue movement and the change in thickness of soft tissue. A $p < 0.05$ was considered significant.

Results

The mean total treatment time was 18 months (range = 12–30 months). The mean presurgical orthodontic treatment was 5 months (range = 3–10 months) for dental decompensation. The postsurgical orthodontic treatment was 11 months (range = 6–12 months for maximum interdigitation). The mandibular prognathism and long chin height was corrected and general aesthetic improvement of class III deformity was obtained in all cases (Figs. 2, 3, 4).

Table 2 gives the patients' characteristics and surgical movement. Table 3 gives the pretreatment and post-treatment cephalometric measurements of all patients. Vertical changes in the positions of Me, Me′, Pog′, and the lower lip were all significant except the supramentale. The average superior movement of point Me after surgery was 5.2 mm, followed by point Me′ with a 1.8-mm change. The Pog′ moved upward by 3 mm and the lower lip moved downward by 3.9 mm, which resulted in improvement in the vertical lip:chin ratio of 0.40–0.48. The distance between Me and Me′ increased by 3.4 mm and became thickened. The changes in soft tissue thickness were statistically significant. The thickness of soft tissue Pog′ increased by 4 mm, the supramentale thickness increased by 1.8 mm, and lower-lip thickness increased by 1.6 mm. The mentolabial fold deepened and increased from 3.4 to 4.7 mm and the mentolabial angle decreased by 16.9° (from 153.4 to 136.9°). The chin inclination (FH to Pog-B) increased by 10.3° (from 82.7 to 93°). The proportion of anterior lower facial height to total facial height and posterior facial height to anterior facial height did not change significantly.

The ratio between the upward movement of the soft tissue Me′ point and the corresponding hard tissue Me point was 0.36 to 1. The correlation coefficient was 0.11 and not significant ($p = 0.70$). There was no further

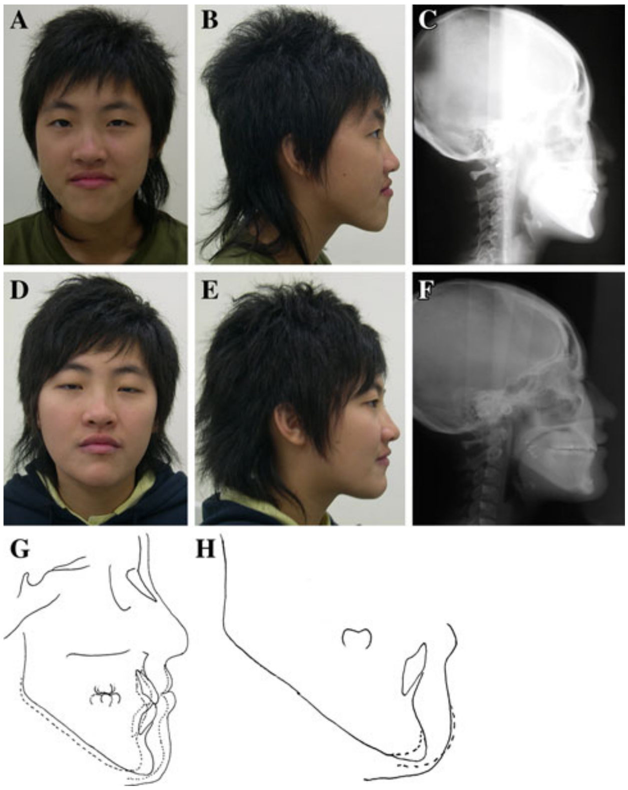

Fig. 3 **a–c** Pretreatment view of a 20-year-old woman who underwent a mandibular setback and vertical chin reduction. **d–f** Post-treatment view when braces were detached. **g–h** Superimposition of cephalometric radiograph, registered on cranial base and best fit of mandibular anterior border, to show mandibular movement and genial movement

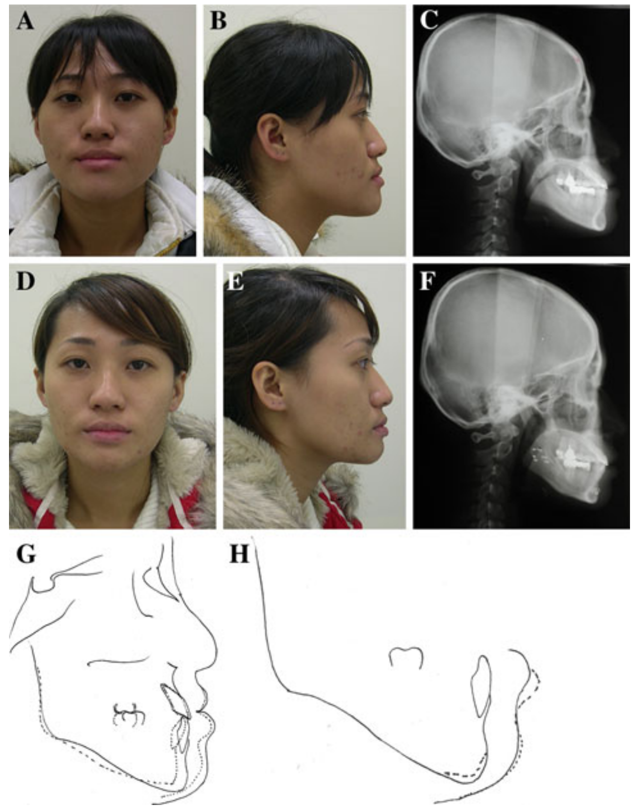

Fig. 4 **a–c** Pretreatment view of a 25-year-old woman who underwent a mandibular setback and vertical chin reduction. **d–f** Post-treatment view when braces were detached. **g–h** Superimposition of cephalometric radiograph, registered on cranial base and best fit of mandibular anterior border, to show mandibular movement and genial movement

correlation between the changes of upward movement of hard tissue Me and the forward movement of soft tissue Pog′ (ratio = 0.79:1; $r = 0.24$, $p = 0.37$) as shown in Table 4.

Discussion

The chin is a key aesthetic unit that contributes to the balance and harmony of the lower third of the face. The position of the deep point of the labiomental fold has an important effect on the appearance of the chin. Factors that could influence the shape of the labiomental fold include lower-lip position, vertical chin height, chin prominence, and soft tissue thickness. Generally, the lower third of the face is divided by the stomion on contact of both lips, and the length of the stomion to menton should be twice the length of the stomion to the subnasale. The nose–lip–chin relationship is decided by a vertical line drawn through the midpoint of the nasal length and touching the upper lip. The pogonion is on the line or slightly behind it. There are several ways to assess chin position, chin height, position of the lips, and labiomental sulcus and nasal relationship, including the zero meridian or profile line by Gonzalez-Ulloa, Rickett's E-line, or the Holdaway angle [19, 23, 24]. However, the ideal position or proportion may differ among races and cultures. For Asian people, the lower lip should be in contact with the E line for an ideal facial profile. The variation in soft tissue thickness on the chin will influence the soft tissue response to skeletal alteration. Therefore, the movement of the bony chin and the change in the corresponding soft tissue should be carefully planned before surgery.

It should be noted that there are several treatment choices for patients with prognathism, and two-jaw surgery is more commonly applied in our institution. This article presents the outcome of 16 selected patients who underwent mandibular setback and vertical reduction genioplasty for the treatment of mandibular prognathism with a long and nonprojecting chin. The results showed that the method was able to correct the protruding mandible and long flat chin in these patients and improve the facial profile as well as the chin contour. In all patients, a preoperative concave soft tissue profile was corrected, demonstrated by the increased facial convexity angle, decreased SNB, and

Table 2 Patient characteristics and surgical skeletal movement

Variables	Patients ($n = 16$)				
	Mean	SD	Min	Max	Norms[b]
Age at surgery (years)	22.6	3.4	18.2	27.8	
SNA (degree)	80.3	2.2	78.0	83.4	83 ± 4
SNB (degree)	83.4	3.1	79.8	88.5	81 ± 4
A to Nasion perpendicular (mm)	0.5	2.5	−5	4	
Pog to Nasion perpendicular (mm)	8.8	8.1	−10	22	
ML/NSL (degree)	39.4	6.7	30	50	31 ± 4
Overjet (mm)	−4.6	2.8	−1	−9	
Nasolabial angle (degree)	82.8	12.1	57	98	95
G-Sn-Pog′ (degree)	-0.86	6.5	7	−12	14 ± 0.6
Lip length ratio, Sn-Stms/Stmi- Me′	0.40	0.05	0.32	0.44	
Mentolabial fold depth (mm)	3.37	1.1	1.0	4	4 ± 1.5
Chin inclination to FH (degree)[a]	82.7	12.0	58	96	90 ± 7
ANB (degree)	−3.6	2.1	− 1.2	− 6.5	
Amount of mandibular setback (mm)	9.4	2.2	6	14	
Amount of vertical chin reduction (mm)	5.1	1.1	4	7	
Pog to NB line	1.4	1.2	0	2	
Lower incisor to Me	50.1	2.9	47	55	
ANS-Me/N-Me	0.58	0.02	0.53	0.61	
S-Go/N-Me	0.61	0.05	0.56	0.67	

[a] From [19]

[b] From [28]

increased ANB (Table 3). These changes were statistically significant. The anterior and lower facial height was decreased by moving the mandible posteriorly and superiorly. Vertical osseous chin reduction further shortened the lower anterior facial height. The 3.9-mm downward movement of the lower lip and 1.8-mm upward movement of Me′ contributed to the change in the vertical lip:chin ratio (Sn-Stms/Stmi-Me′), which increased from 40 to 48 %, and therefore the long chin was corrected. From our results we found that the Me′ did not follow the Me in a 1:1 ratio after 5.1-mm osseous chin reduction. The point Me′ moved up only 1.8 mm, which corresponded to hard tissue movement with a ratio of 0.35:1. This ratio is greater than the ratio of 0.25:1 as reported by others [25]. Moreover, the distance between Me and Me′ increased from 6.2 to 9.6 mm. It is apparent that there is a soft tissue accumulation effect with increased fullness when the underlying bone is reduced. As the correlation coefficient was 0.11 and did not reach statistical significance ($p = 0.70$), we did not see any correlation between the changes in Me′ and the superior movement of Me.

A significant increase in the thickness of the soft tissue Pog′ (3.96 mm) and lower lip (1.59 mm) was obtained after chin shortening and contributed to the increase in the depth of the mentolabial fold by 1.28 mm and an average decrease in the mentolabial angle of 16.9°. These differential increases in thickness result in an increase in chin prominence, chin inclination, and depth of the mentolabial fold. The ratio between the forward movement of Pog′ and the amount of vertical chin reduction was 0.79:1, but there was an insignificant correlation between both factors ($r = -0.24, p > 0.05$). Nevertheless, vertical chin reduction surgery can have some effect on increasing chin projection and thus improving chin contour clinically. The reason for the increase in the thickness of soft tissue could be the increase in the volume of the soft tissue of the chin associated with the vertical movement of bony tissue and relaxation of the strained mentalis muscle and orbicularis oris muscle after bony shortening surgery. It was reported that Pog′ movement in the superior direction was paralleled by the bony segment after vertical chin reduction and, therefore, the horizontal relationship between Pog′ and Pog did not change after the operation [15]. In our study, the Pog′ did not follow the Pog in parallel. The Pog′ moved up 3.0 mm while there was a 5.1-mm vertical reduction. The exact positions of Pog and Pog′ are sometimes not easy to find, especially in patients with a flat chin or ill-defined chin

Table 3 Cephalometric measurements before surgery (T1) and after surgery (T2)

Variables	T1		T2		T2–T1		
	Mean	SD	Mean	SD	Mean	95 % CI	p*
Vertical change (mm)							
OP-Me	50.09	1.63	44.90	2.91	−5.18	−4.62 to −5.75	0.000
OP-Me′	56.37	2.62	54.56	2.27	−1.81	−1.25 to −2.37	0.006
Me-Me′	6.18	1.56	9.62	1.45	3.43	4.27 to 2.60	0.000
OP-Pog′	38.43	3.74	35.33	3.06	−3.03	−3.77 to −2.29	0.000
OP-supramentale	13.56	12.01	14.62	12.56	1.06	0.52 to −2.65	0.201
OP-vermillion border	3.40	4.04	7.28	3.16	3.87	5.23 to 2.51	0.000
OP-stomion	4.96	3.11	1.03	2.39	−3.87	−5.26 to −2.48	0.000
L1-Me	50.09	1.63	44.90	2.91	−5.18	−4.62 to −5.75	0.000
Sagittal changes (mm)							
Pog′ thickness	10.56	1.36	14.53	2.28	3.96	4.71 to 3.21	0.000
Supramentale thickness	12.06	1.81	13.84	2.24	1.78	2.52 to 1.04	0.000
Lower-lip thickness	12.81	2.94	14.34	2.68	1.59	2.33 to 0.72	0.000
Labiomental sulcus	3.37	1.14	4.65	0.76	1.28	1.78 to 0.77	0.000
Overjet	-3.06	2.48	1.93	0.92	5.00	−6.29 to −3.70	0.000
Pog-NB	1.40	1.22	1.71	1.25	0.25	0.86 to 0.23	0.024
L1-NB	6.12	1.25	6.8	1.47	0.68	1.26 to 0.11	0.020
(L1-NB)-(Pog-NB) length difference	4.75	2.35	5.06	2.26	0.31	−0.91 to −0.28	0.275
Angular changes							
Facial convexity angle	−0.86	6.51	8.65	3.62	9.47	5.51 to 13.46	0.000
SNB	83.93	3.06	79.06	2.40	−4.87	−3.75 to −5.90	0.000
ANB	-3.62	2.06	1.25	1.12	4.87	3.75 to 5.99	0.000
Chin inclination	82.71	12.06	93.00	9.30	10.28	12.77 to 7.78	0.000
Mentolabial angle	153.37	9.44	136.9	7.94	−16.91	−12.42 to −21.61	0.000
Ratio changes							
Sn-Stms/Stmi-Me	0.40	0.05	0.48	0.05	0.08	0.06 to 0.11	0.000
ANS-Me/N-Me	0.57	0.02	0.56	0.02	−0.01	−0.02 to 0.08	0.154
S-Go/N-Me	0.61	0.05	0.63	0.05	0.02	0.00 to 0.04	0.072

* $p < 0.05$ indicates significant difference

contour. It is accepted that correction of the long, nonprojecting chin requires both vertical reduction and sagittal augmentation; however, from our study, vertical chin reduction without advancement seems to have an effect on increasing the labiomental fold and chin prominence. These changes can be applied when planning the surgical procedure, during intraoperative assessment, and adjustment of osseous movement [26].

Table 4 Soft-tissue/hard-tissue ratio in vertical movement, sagittal movement (T2–T1), and its correlation coefficient

Variables	Soft tissue/hard tissue	Correlation coefficient	p*
Pog-Pog′ (sagittal):L1-Me (vertical)	0.79:1	−0.24	0.37
Li-Me′ (vertical):L1-Me (vertical)	0.36:1	0.11	0.70

* $p < 0.05$ indicates significant difference

Isolated anterior movement of the chin increases the labiomental fold depth, whereas inferior chin movement, i.e., increasing vertical dimension of the chin, has the visual effect of decreasing fold depth and vice versa [14]. In other words, visual compensation for the disproportion in the anteroposterior plane can be achieved by changing its vertical dimension. It was reported that chin advancement would deepen the mentolabial fold and a vertical lengthening would soften the fold and decrease fold depth [11]. On the other hand, vertical shortening of the chin also can have the visual effect of increasing the fold depth and chin projection. Gallagher et al. [12] reported that in patients who had both vertical reduction of the chin and anterior repositioning augmentation, the soft tissue advancement was greater than that in patients who had only straight anterior repositioning of the segment. In our study, we have the similar finding that vertical reduction of the chin can have the effect of soft tissue advancement.

It was reported that mandibular setback surgery can also deepen the labiomental fold, increase the facial convexity, and induce thinning and lengthening of the upper lip with a concomitant increase in nasolabial angle [6, 27]. Naoumova et al. [10] stated that the after mandibular setback there was an increase of 2 mm in lower-lip thickness, a decrease of 1 mm in soft tissue thickness at the mentolabial fold region (B-Si), mostly no change in thickness at the chin (Pog-Pog′), and thus an increase in the labiomental fold depth of 1 mm. Mobarak [6] had similar long-term changes in the soft tissue profile following mandibular setback surgery: an increase of 0.4 mm in labiomental fold depth, a decrease of 0.28 mm in soft tissue thickness at the mentolabial fold region (B-Si), and no change in thickness at the chin (Pog-Pog′) at the end of follow-up period. He suspected that the deepening of the labiomental fold is most probably related to the decrease in soft tissue thickness in that area, not the increase of soft tissue thickness on Pog′. In our study, the thickness at the mentolabial fold region (B-Si, supramentale) was increased by 1 mm, not decreased as the above-mentioned reports. Apparently, the increase in thickness in that area was due to the vertical chin reduction and not to the mandibular setback. The differential increase in thickness in the lower lip, the mentolabial fold region, and the lower lip can change the concave shape in that area. The vertical chin reduction and mandibular setback together may have a double effect on deepening the labiomental fold. Therefore, care is needed when planning such an operation with BSSO setback alone or as an adjunct to superior–anterior repositioning of the chin, as the soft tissue advancement may exceed the amount of anterior repositioning of the segment resulting in overcorrection of chin prominence.

Mobarak [6] reported that an inferior movement of the lower lip and insignificant movement of Pog′, Si′, and Me′ were noted after mandibular setback. In our study, vertical chin reduction genioplasty was incorporated and the results show that the Pog′ and Me′ followed the hard tissue movement in a significant upward direction (though not in a ratio of 1:1), and the Si and lower lip went downward insignificantly. The downward movement of Si could be explained by the inferior movement of the lower lip and tension relief after mandibular setback. This superior movement of Pog′ contributes to the increase of mentolabial fold depth due to the shortening of the distance between Pog′ and lower lip.

The Holdaway ratio was used to evaluate the relationship between the distance from the lower incisor to the NB line and from the Pog to the NB line. Holdaway believes that ideally these two measurements should be equal. The ideal lengths of L1-NB and Pog-NB are approximately 4 mm and the ratio difference is zero. From our study, the pretreatment mean value of Pog-NB was 1.4 mm and L1-NB was 6.1 mm. It seems that the chin is deficient more than the forward position of L1. However, the variation in soft tissue thickness can sometimes cover the hard tissue discrepancy and one can still obtain a satisfactory result. In our study, the Holdaway ratio difference did not change much (from 4.75 to 5.06), but the soft tissue chin has been improved after treatment.

Two-jaw surgery is common in many Class III cases. A more convex profile can be obtained by the clockwise rotation of the maxilla-mandibular complex. However, lower-jaw surgery with genioplasty can also be an option in some selected cases. The soft tissue accumulation and thickening of Pog′ can be a concern after vertical reduction genioplasty, and as the amount reduced increases, soft tissue bunching becomes more prominent and may be problematic. In this regard, one should be careful about designing surgical methods. Data reported from this study can serve as a reference for surgical planning.

A weakness of this study is the relatively small sample size, which does not allow for general outcome predictions. So far, the results have been satisfactory, but the long-term results have to await the passage of time. This study did not intend to eliminate other established treatment procedures for patients with class III malocclusion. It showed that mandibular setback with vertical chin reduction is an alternative treatment for patients with mandibular prognathism in whom this chin is long and flat.

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References

1. Trauner R, Obwegeser H (1957) The surgical correction of mandibular prognathism and retrognathia with consideration of genioplasty. Oral Surg 10:677–689
2. Gjorup H, Athanasiou AE (1991) Soft-tissue and dentoskeletal profile changes associated with mandibular setback osteotomy. Am J Orthod Dentofac Orthop 100:312–323
3. Schatz JP, Tsimas P (1995) Cephalometric evaluation of surgical orthodontic treatment of skeletal Class III malocclusion. Int J Adult Orthodont Orthognath Surg 10:173–180
4. Lin SS, Kerr WJ (1998) Soft and hard tissue changes in Class III patients treated by maxillary surgery. Eur J Orthod 20:25–33
5. Enacar A, Taner T, Toroglu S (1999) Analysis of soft tissue profile changes associated with mandibular setback and double-jaw surgery. Int Adult Orthod Orthognath Surg 14:27–35
6. Mobarak KA, Krogstad O, Espeland L, Lyberg T (2001) Factors influencing the predictability of soft tissue profile changes following mandibular setback surgery. Angle Orthod 71:216–227
7. Eggensperger N, Lieger O, Thuer U, Iizuka T (2007) Soft tissue profile changes following mandibular advancement and setback surgery an average of 12 years postoperatively. J Oral Maxillofac Surg 65:2301–2310

8. Fanibunda KB (1989) Change in the facial profile following correction for mandibular prognathism. Br J Oral Maxillofac Surg 27:277–286
9. Hu J, Wang D, Luo S, Chen Y (1999) Differences in soft tissue profile changes following mandibular setback in Chinese men and women. J Oral Maxillofac Surg 57:1182–1186
10. Naoumova J, Soderfeldt B, Lindman R (2008) Soft tissue profile changes after vertical ramus osteotomy. Eur J Orthod 30:359–365
11. McBride KL, Bell WH (1980) Surgical correction of dentofacial deformities. Saunders, Philadelphia, p 1210
12. Gallagher DM, Bell WH, Storum KA (1984) Soft tissue changes associated with advancement genioplasty performed concomitantly with superior repositioning of the maxilla. J Oral Maxillofac Surg 42:238–242
13. Rosen HM (1991) Aesthetic refinements in genioplasty: the role of the labiomental fold. Plast Reconstr Surg 88:760–767
14. Rosen HM (1995) Aesthetic guidelines in genioplasty: the role of facial disproportion. Plast Reconstr Surg 95:463–469
15. Krekmanov L, Kahnberg K (1992) Soft tissue response to genioplasty procedures. Br J Oral Maxillofac Surg 30:87–91
16. Burstone CJ, James RB, Legan H, Murphy GA, Norton LA (1979) Cephalometrics for orthognathic surgery. J Oral Surg 36:269–277
17. Legan H, Burston CJ (1980) Soft tissue cephalometric analysis for orthognathic surgery. J Oral Surg 38:744–751
18. Bell WH, Proffit WR, White RP (1980) Surgical correction of dentaofacial deformities, volume I. Saunders, Philadelphia, pp 137–150
19. Xu TM, Liu Y, Yang MZ, Huang W (2006) Comparison of extraction versus nonextraction orthodontic treatment outcomes for borderline Chinese patients. Am J Orthod Dentofac Orthop 129:672–677
20. Holdaway RA (1983) A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Am J Orthod 84:1–28
21. Chaushu G, Blinder D, Taichber S, Chaushu S (2001) The effect of precise reattachment of the mentalis muscle on the soft tissue response to genioplasty. J Oral Maxillofac Surg 59:510–516
22. Dahlberg G (1940) Statistical methods for medical and biological students. Interscience Publications, New York
23. Gonzalez-Ulloa M (1962) Quantitative principles in cosmetic surgery of the face (profileplasty). Plast Reconstr Surg 29:186–198
24. Ricketts RM (1981) Perspectives in the clinical application of cephalometrics. The first five years. Angle Orthod 51:115–150
25. Roszkowski MJ (1995) Soft tissue changes associated with orthognathic surgery. Oral and maxillofacial surgery knowledge update, vol 1, part II. Rosemont, IL: AAOMS, pp 57–73
26. Yu CC, Bergeron L, Lin CH, Chu YM, Chen YR (2009) Single-splint technique in orthognathic surgery: intraoperative checkpoints to control facial symmetry. Plast Reconstr Surg 124:879–886
27. Wisth PJ (1975) Integumental profile changes caused by surgical treatment of mandibular protrusion. Int J Oral Surg 4:32–39
28. Moate SJ, Darendeliler MA (2002) Cephalometric norms for the Chinese: a compilation of existing data. Aust Orthod J 18:19–26