INTRODUCTION

The excessively gingival display during smiling is an esthetic problem for some patients and has been treated by orthodontics alone or combined orthodontic-orthognathic surgical treatment, based on its etiology and clinical expression. In the patient with a gummy smile due to excessive vertical growth of maxilla, it would be esthetically inappropriate to simply intrude the maxillary anterior teeth because this procedure deteriorates the smile arc. The desirable and effective treatment would be to depress the whole maxillary arch through orthognathic surgery approach. Furthermore, when the gummy smile and obvious facial asymmetry are the chief complaints of an adult patient, the orthodontic treatment combined with surgery may be the favorable treatment option due to the significant skeletal improvement and more aesthetically pleasing results.

However, orthognathic surgery for Class III malocclusion presents some limitations due to the possibility of incomplete surgical correction or, more significantly, of postsurgical relapse. Proffit suggested that Class III surgical correction with maxillary advancement and mandibular setback would have better postsurgical

Case Report

COMBINED MULTI-SEGMENTAL SURGICAL-ORTHODONTIC TREATMENT IN SKELETAL CLASS III WITH FACIAL ASYMMETRY AND GUMMY SMILE: TWO-YEAR STABILITY

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This is a case of skeletal class III malocclusion with facial asymmetry, gummy smile, and maxillary canting, treated with bimaxillary surgery and orthodontic treatment. The two-jaw surgery was performed including a 3-pieces LeFort I segmental osteotomy, anterior segment impaction with clockwise rotation, and bilateral sagittal split osteotomies with genioplasty. Through the 2-year-4-month treatment procedure, the skeletal and occlusal relationship turned to be normal with esthetically pleasing smile and profile. Furthermore, in the two-year follow-up, we found the treatment results were quite stable no matter in skeletal or dental aspects.

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Keywords: skeletal class III malocclusion, facial asymmetry, gummy smile, maxillary canting, multi-segmental bimaxillary surgery.
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stability than single mandibular setback alone. Mucedero et al. also reviewed the stability factors for Class III malocclusion and concluded that a larger amount of relapse has to be expected in patients presented with great presurgical sagittal intermaxillary discrepancies, thus requiring a large amount of mandibular setback. In order to achieve stable treatment results, postsurgical predictability and stability are critical considerations of treatment planning.

Here we present a case of skeletal class III malocclusion with facial asymmetry, gummy smile, and maxillary canting, treated with bimaxillary surgery. The two-jaw surgery was performed including a 3-piece LeFort I segmental osteotomy for asymmetrical posterior impaction, anterior segment impaction with clockwise rotation, and a bilateral sagittal split osteotomy with genioplasty for mandible setback and chin deviation correction.

CASE REPORT

A 23-year-old female with chief complaints of gummy smile and facial asymmetry visited our OPD for orthodontic treatment evaluation. She denied any contributory systemic disease, with no known drug or food allergy. In the functional examination, she denied any TMJ symptoms and signs or other para-function.

Figure 1. Initial photographs and X-rays of the patients.
Pre-treatment data

Extraoral examination
The Frontal view revealed obvious facial asymmetry with chin deviation to right, mild lip canting with right side upward and mild mentalis muscle strain when closing her mouth (Figure 1). From smiling view, regional anterior cross-bite, about 4 mm gingival exposure from anterior to posterior, and upper gingival marginal discrepancy were found on her full smile. Relatively to facial midline, upper dental midline shift to her right side for 1 mm, while the lower dental midline shifted to her right for 4 mm. From lateral view, she had a convex profile, more protrusive lower lip, and shallow labial mental fold with inadequate chin projection.

Intraoral examination
The overbite was 1 mm; meanwhile, her bilateral upper lateral incisors were block-in and lower left central incisor had cross-bite with upper central incisors. The lower dental midline to upper dental midline was shifted to her right by 3 mm. The upper arch form was asymmetrical ovoid with moderate crowding, while the lower arch form was tapered with minimal crowding and 2 mm depth of curve of Spee bilaterally. The buccal segment revealed upper and lower right second premolar had lingual cross-bite, Class I canine and molar relationship at the right side, and Class III canine and molar relationship at left side.

Radiographic examination
In the panoramic X-ray, the morphology of bilateral condyles and ramus were asymmetrical with right side larger than the left side in width, and the four wisdom teeth were noted. From PA cephalometric analysis, the left mandibular body was longer than the right, and the chin and lower dental midline deviated to the right side for 4 mm. The occlusal plane was canting with right side upward 1.5 mm. From the lateral cephalometric analysis, the patient exhibited a skeletal class III facial pattern with mandibular prognathism, normal mandibular plane angle, and proclined upper incisors with retroclined lower incisors.

Diagnosis
Skeletally, the patient had a Class III jaw relationship with mandibular prognathism and normal mandibular plane angle; facial asymmetry with occlusal canting and chin deviation to the right side. Dentally, she had Angle Class III malocclusion with regional anterior cross-bite. The upper and lower dentition were crowding and midline shifting. Upper and lower right second premolars had lingual cross-bite. In soft tissue aspect, she had a convex profile and gummy smile; the soft tissue chin deviated and the lips were mild canting.

Treatment goal and treatment plan
The treatment goals for this patient were as the followings:

Sagittal: correct the mandibular prognathism and chin retrusion
Transverse: correct the mandibular asymmetry and maxillary yawing
Vertical: correct the gummy smile and maxillary canting
Dental: achieve canine Class I and molar Class II relationship; upper and lower midline coincidence; and establish proper overbite and overjet.

According to the diagnosis and chief complaints of this patient, we proposed her the treatment plan of orthodontic treatment combined with 2-jaw surgery.

The pre-surgical orthodontic treatment plan:
The upper and lower dentition need leveling, alignment, decompensation, and occlusal plane flattening. Four wisdom teeth were planned to be extracted before orthognathic surgery.

The orthognathic surgical plan:
The maxilla needs asymmetrical impaction at the anterior and posterior part to correct the gummy smile and occlusal plane canting; therefore, LeFort I with multi-pieces osteotomy and 14, 24 extractions during the surgery was planned. The mandible needs bilateral sagittal
split osteotomy and an asymmetrical setback to correct the mandibular prognathism and asymmetry. The chin may need genioplasty to correct the menton deviation and control the lower anterior facial height.

The post-surgical orthodontic treatment plan:
The finishing stage needs detailing the dental arch and settling the occlusion.

Treatment Progress

Pre-surgical orthodontic treatment

After consultation with this patient, fixed 0.022x0.028-in preadjusted appliances were placed. The upper and lower dentition were through leveling and alignment from round NiTi wire to rectangle stainless steel wire. Four wisdom teeth were all extracted by oral surgeon. Before the surgery, segmented archwires were inserted from canine to canine and from the second premolar to each second molar in the maxillary arch for the anterior segmental osteotomy and bilateral first premolar extractions.

Pre-surgical clinical examination

The presurgical phase took 17 months. The pre-op clinical examination showed the occlusal plane was canting with right side upward 1.5mm; the incisor show at rest was 6 mm, and the gummy smile was about 4 mm. The upper dental midline relative to facial midline shifted to the right for 1mm and lower shifted to the right for 3.5mm. The overbite was 2 mm and the overjet was 2.5 mm (Figure 2).

The cephalometric analysis and superimposition tracing of initial to pre-op showed the upper incisors were flared with control tipping and upper molars became tip-back due to the leveling and alignment; the inclination of lower incisors and the position of lower molars were maintained.

Figure 2. Preoperative extraoral and X-ray examination.
Orthognathic surgery

Following the surgical plan made by the orthodontist, in the maxilla, LeFort I with 3-piece osteotomy and 14, 24 extractions during the surgery were performed; the anterior segment was advanced 2.5 mm, impacted 3 mm with clockwise rotation, and the dental midline was coincident with the facial midline; the posterior 2-piece segments were both advanced to close the extraction space and asymmetrical impaction (R: 1 mm; L: 2.5 mm).

In the mandible, BSSO to perform asymmetric setback (average 6 mm) and yaw rotation to center the lower dental midline to upper midline; the genioplasty was for centering the chin (4 mm shift to the left side) and chin augmentation, and maintaining the lower anterior facial height. A rigid fixation with miniplates and miniscrews fixed the maxillary segments in the final position. No interocclusal splint or postoperative maxillomandibular fixation was used.

Post-surgical orthodontic treatment

Through the postoperative orthodontic treatment, the occlusal steps between the anterior and posterior segments of the anterior segmental osteotomy were leveled and aligned through NiTi wire and 3/16-inch, 6 oz vertical intermaxillary elastics wearing the whole day except meals and tooth brushing. The root divergence between upper canines and 2nd premolars were corrected by bracket repositioning. After finishing and detailing at the post-op stage for 10 months, the full mouth fixed appliances were debonded with Hawley retainers delivery. The total treatment period was 28 months.

Treatment Results

Posttreatment records showed that all treatment objectives were achieved with good esthetic and occlusal results: the facial asymmetry had an obvious improvement, and the chin point was aligned with the facial midline (Figure 3). The patient was also satisfied with the excessively reduction of the gummy smile and the consonant smile arc. Dentally, proper overbite and overjet with canine class I and molar class II relationship were achieved. The occlusion had good interdigitation. The upper and lower dental midlines were coincident with the facial midline. No any dysfunction of TMJ or masticatory muscle appeared after treatment. The panoramic showed well bone healing and improved root parallelism, especially the upper canines and 2nd premolars, from post-op to debonding. The cephalometric analysis showed that successful dental decompensation and surgical correction of the skeletal Class III jaw discrepancy were achieved: the ANB angle and the Wits appraisal increased from -1° to 4.5° and from -8 to 0 mm, respectively; the mandibular incisors were proclined from 90° to 93° relative to the mandibular plane (IMPA); the maxillary incisors were uprighted from 120° to 98° with respect to SN (U1 to SN); and the mandibular plane angle (SN-MPA, FMA) was maintained (Table 1). The cephalometric superimpositions of pretreatment and posttreatment radiographs showed that the maxilla moved forward and upward both 2 mm, and the mandible moved back 6 mm (Figure 5). Dental movements included upper incisal uprighting, mesial movement of the maxillary molars, and proclination of the mandibular incisors. The facial profile was improved with upper and lower lips retraction, labiomental fold deepening, and final convexity increased.

DISCUSSION

This is a case of skeletal Class III with mandible prognathism, facial asymmetry, occlusal plane canting, and unpleasing gummy smile. The problems were corrected with orthodontic treatment combined with double-jaw orthognathic surgery. Through the 2-year-4-month treatment procedure, the skeletal and occlusal relationship turned to be normal with esthetically pleasing smile and balanced facial profile. Furthermore, in the two-year follow-up, we found the treatment results were quite stable no matter in skeletal or dental aspects.
Figure 3. Photographs and X-ray at completion of treatment.

Table 1. Summary of cephalometric analysis.

<table>
<thead>
<tr>
<th>SKELETAL</th>
<th>INITIAL</th>
<th>PRE-OP</th>
<th>POST-TX</th>
<th>2Y FU</th>
<th>NORM</th>
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<tr>
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<td>84</td>
<td>87</td>
<td>86</td>
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<td>SNB (°)</td>
<td>85</td>
<td>85</td>
<td>82.5</td>
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<td>ANB (°)</td>
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<td>4.5</td>
<td>4</td>
<td>3.2-5.0</td>
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<tr>
<td>SN-MP (°)</td>
<td>32</td>
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<td>32</td>
<td>31</td>
<td>33.8-38.4</td>
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<tr>
<td>SN-FH (°)</td>
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<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>6.7</td>
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<tr>
<td>Wits Appraisal (mm)</td>
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<td>-8</td>
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<td>0</td>
<td>-1.0±1.0</td>
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<td>A-Nv (mm)</td>
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<td>2</td>
<td>4</td>
<td>3.5</td>
<td>0±2</td>
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<tr>
<td>Pog-Nv (mm)</td>
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<td>1.5</td>
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<td>UAFH/LAFH (%)</td>
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<tr>
<td>U1-SN (°)</td>
<td>115</td>
<td>120</td>
<td>98</td>
<td>98</td>
<td>103.9-108.8</td>
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<tr>
<td>U1-NA (°)</td>
<td>31</td>
<td>35</td>
<td>12</td>
<td>13</td>
<td>22.8±5.7</td>
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<td>U1-NA (mm)</td>
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<td>12</td>
<td>3</td>
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<td>L1-MP (°)</td>
<td>90</td>
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<td>93</td>
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<tr>
<td>L1-NB (°)</td>
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<td>L1-NB (mm)</td>
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<th>SOFT TISSUE</th>
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<td>0.7-3.1</td>
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<tr>
<td>E-line:Lower (mm)</td>
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<td>6</td>
<td>1</td>
<td>1.2</td>
<td>0.2-3.4</td>
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<tr>
<td>Facial convexity (°)</td>
<td>7</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>8-16</td>
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Surgical-orthodontics of Skeletal Class III Malocclusion

Figure 5. Overall superimposition of initial, pre-op and finish cephalometric tracings.

Figure 6. Overall superimposition of initial, finish, and 2yrs follow up cephalometric tracing.
The key elements for successful treatment and long-term stability might be the proper differential diagnosis, treatment planning for the chief complaint, and the skillful interdisciplinary treatment procedures.

The gummy smile phenotype may have a multifactorial etiology of excessive gingival margin-to-lip distance when the patient smiles, including the gingival overgrowth, anterior dentoalveolar extrusion, vertical maxillary excess, and hyperactivity of upper lip elevator muscle. The present patient had not only the increased maxillary incisors exposure (6 mm) at rest position but also excessive gingival display from anterior to posterior (4 mm on average) and more distance the upper lip moved upward (about 13 mm) when broad smile position. The overbite and incisal clinical crown length were within normal limit. Therefore, we supposed the etiology of gummy smile was the vertical maxillary excess pattern with the hyperactive upper lip. According to Garber and Salama, orthognathic surgery with LeFort I osteotomy and upward impaction was indicated. And an injection of botulinum toxin-A to the upper lip elevator muscles may be needed in the future. Our patient was satisfied with her improved gummy smile just after orthognathic-orthodontic combined treatment, so she didn't have any other minor cosmetic surgery.

In this case, to improve the facial asymmetry, maxillary vertical excess, and occlusal plane canting, a complex surgical procedure including Y-shaped 3-pieces LeFort I osteotomy of maxilla and BSSO with genioplasty of mandible was carried out. The anterior segment osteotomy and impaction with clockwise rotation decreased the gingival display, improved the incisor inclination and the smile arc, and led to the reduction in labial prominence and increase in nasolabial angle. The maxillary posterior asymmetrical impaction was for canting correction and maxilla-mandible complex (MMC) clockwise rotation. And the maxillary posterior midline split corrected the torque problem of posterior teeth and coordinated the posterior transverse dimension of maxilla and mandible. Furthermore, BSSO asymmetrical setback and genioplasty corrected the facial asymmetry due to the different mandibular body length and menton deviation. The chin augmentation also improved the chin projection and labial-mental sulcus, harmonized the profile.

About the long-term stability of surgical Class III treatment, Busby et al have reported 80% of the bimaxillary surgery group showed less than 4 mm of postsurgical change. The two-year posttreatment cephalometric tracing of this case showed that A-point moved backward 0.5 mm and the pogonion moved forward 0.5 mm relative to the N-perpendicular to FH line (Nv line). The ANB reduce 0.5 degrees, and the mandibular plane angle reduces 1 degree. These clinically non-relevant changes can be seen as adaptive bone remodeling at the gonial angles and chin portion of the mandible. The good long-term stability of this case, who presented 8mm sagittal jaws discrepancies before surgery, was contributed by proper surgical plan and skilled surgical technique.

To avoid a large mandibular setback, which also was proved to be the critical risk factor for horizontal relapse of the mandible, we designed a moderate amount of mandibular setback (6 mm) and minimal maxillary advancement (2.5 mm) to correct the presurgical skeletal discrepancy. This two-jaw surgical approach can keep limited mandibular setback while had enough Class III surgical correction.

Considering correction of the occlusal plane canting, we chose to impact both left and right posterior segments of maxilla asymmetrically rather than moving one side up and the other side down. One of the reasons is the downward movement of the maxilla has quite problematic in stability, and it was one of the risk factors for the horizontal mandibular relapse. In the meanwhile, posterior impaction of maxilla will decrease the posterior gingival display and improve the posterior gummy smile. Furthermore, MMC clockwise pitch rotation results in the posterior rotation of menton and advancement of the gummy smile phenotype may have a multifactorial etiology of excessive gingival margin-to-lip distance when the patient smiles, including the gingival overgrowth, anterior dentoalveolar extrusion, vertical maxillary excess, and hyperactivity of upper lip elevator muscle. The present patient had not only the increased maxillary incisors exposure (6 mm) at rest position but also excessive gingival display from anterior to posterior (4 mm on average) and more distance the upper lip moved upward (about 13 mm) when broad smile position. The overbite and incisal clinical crown length were within normal limit. Therefore, we supposed the etiology of gummy smile was the vertical maxillary excess pattern with the hyperactive upper lip. According to Garber and Salama, orthognathic surgery with LeFort I osteotomy and upward impaction was indicated. And an injection of botulinum toxin-A to the upper lip elevator muscles may be needed in the future. Our patient was satisfied with her improved gummy smile just after orthognathic-orthodontic combined treatment, so she didn't have any other minor cosmetic surgery.

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paranasal structures, which is proved to have positive esthetic and stable outcomes for skeletal Class III deformities.

Proffit proposed the idea that better maintenance of the ramus inclination and better mandibular stability can be obtained with 2-jaw surgery than with isolated setback. Just as the superimposition of the cephalometric tracing in this case (Figure 6), though it would be more accurate to check in three-dimensional virtual model, our surgeons controlled the inclination of ramus at surgery from pre- to post-surgery. MMC clockwise pitch rotation technique also maintain or reduction of the length of masticatory muscle. This largely eliminated the possibility of mandibular relapse and TMJ postoperative symptomatology due to not altering the orientation and stretching of the pterygo-masseteric sling that exerted an upward and forward force at the gonial angle and then carried the chin forward.

Multi-segmental osteotomy may involve many risks, such as dental and periodontal injury in conjunction with the interdental osteotomy. To reduce these risks, we planned to extract the bilateral upper first premolars during the operation. This can preserve more interdental alveolar bone and reduce the injury of dental root when performing the interdental osteotomy. Although the postoperative stability of multi-segmental maxillary osteotomies is controversial, Kretschmer et al. reported that segmentation of the maxilla did not provoke major skeletal or dental instability and should be considered whenever indicated. Arpornmaeklong et al. reported that stable occlusal interdigitation is necessary for postoperative healing and stability, and the improved intercuspation was an important factor for the significant difference of stability between single-piece and multi-piece maxilla. After 2-year follow up of our patient, we found the relapse compared with debonding was minimal in dental, skeletal, and facial profile (Figure 4). The patient had good compliance with removable retainers,
and the occlusion improved to excellent intercuspation. The most comforting things were that she kept good oral health and a confident smile.

**CONCLUSION**

The patients have complicated craniofacial deformities demand various complex orthognathic surgeries combined with more meticulous treatment planning based on their etiology and excellent surgical skills. In this report, through multi-segmental osteotomy surgery and orthodontic treatment, a successful result and a 2-year post-treatment stability were both obtained.

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