Anterior Decompensation Using Segmental Osteotomy for Patients With Mandibular Asymmetry

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To obtain sufficient correction of facial asymmetry by orthognathic surgery, precise and sufficient dental decompensation during preoperative orthodontic treatment is needed. Facial asymmetry often includes complicated 3-dimensional dental compensation in the anterior alveolar region, which can limit the treatment options and lengthen the treatment time. As an alternative, anterior decompensation using segmental osteotomy (ADSO) with the patient under local anesthesia could be a reasonable approach, as it represents an effective, selective, and relatively safe method for correcting lower anterior disharmony during preoperative treatment. Furthermore, ADSO can quickly eliminate anterior compensation and move the teeth to their proper positions such that the basal bone supports them beyond the anatomic limits. Precise evaluation and diagnosis using data obtained from 3-dimensional computed tomography should be performed for accurate ADSO. The present report describes the versatile use of ADSO for 2 patients with different types of severe facial asymmetry. In the first case, ADSO was performed to correct the anterior dentoalveolar yaw and in the second, to change the vertical positioning and inclination of the anterior teeth. In both cases, sufficient elimination of anterior compensation using ADSO guaranteed successful improvement of the facial asymmetry and stabilization of occlusion after orthognathic surgery. The use of ADSO during preoperative treatment can quickly and effectively correct lower anterior disharmony and facilitate surgical correction of facial asymmetry.

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Patients with severe facial deformity are generally treated using a combination of orthodontic and orthognathic surgical therapies to improve both occlusion and facial esthetics.1 The general surgical orthodontic management includes preoperative orthodontic treatment to decompensate the malocclusion, surgical correction of the skeletal discrepancy, and postoperative detailing and finishing of the occlusion.2 However, the preoperative orthodontic treatment involves progressive deterioration of the facial esthetics and dental function for long periods.3 Therefore, a “surgery first” approach, which proceeds with orthognathic surgery after either minimum or no preoperative orthodontic preparation, has been widely preferred as an alternative treatment.4

Patients with severe facial asymmetry, however, often experience extreme dental compensation to maintain normal interarch positioning under abnormal jaw relationships. Complicated, 3-dimensional dental compensation is often present in the anterior alveolar region and includes abnormal inclination, discrepancy between the dental and skeletal midline, and anterior canting inconsistent with posterior canting. It is difficult to correct these problems because of the anatomic
limitations, such as the thickness of the alveolar bone or thin symphysis in the anterior dentoalveolar area.\textsuperscript{5,6}

If dental decompensation is inadequate, it will be impossible to achieve sufficient correction of the skeletal discrepancy and ideal occlusion.\textsuperscript{7} For better results, it is critical to adequately eliminate the dental compensation and move the teeth back to their proper positions for the basal bones to firmly support them.\textsuperscript{8,9} Thus, a 'surgery first' approach cannot adequately address improvement of facial esthetics in patients with severe facial asymmetry.

As an alternative, anterior decompensation using segmental osteotomy (ADSO) with the patient under local anesthesia offers an effective, selective, and relatively safe method for correcting lower anterior disharmony during preoperative treatment (Fig 1). It can reduce the preoperative orthodontic treatment time and overcome the anatomic limitations such as a thin symphysis or poor periodontal support. Furthermore, this approach can perform precise 3-dimensional dental decompensation undisturbed by interdigitation with other teeth, soft
tissue forces, and the limitations of orthodontic mechanics.

The present report describes the surgical and orthodontic treatment of 2 patients with different types of severe facial asymmetry and the use of ADSO during preoperative treatment to facilitate surgical correction of the facial asymmetry.

**ADSO Protocol**

The evaluation and diagnosis of mandibular asymmetry using data from 3-dimensional cone-beam computed tomography (CBCT) should be performed before ADSO. Mandibular asymmetry can be described 3-dimensionally by the translation, roll, and yaw. Translation refers to the bodily shift of the mandible to the deviated side, roll to the rotation of the mandible around the anteroposterior axis, and yaw to the rotation of the mandible around the vertical axis.

The 3-dimensional evaluation helps to determine which patients will be appropriate for ADSO treatment. The indications for using ADSO to correct disharmony between the dentoalveolus and basal bone include changing the 3-dimensional position and inclination of anterior teeth, correcting the midline discrepancy with the midline mandibular basal bone, and leveling the occlusal plane.

Orthodontic preparation is necessary before ADSO, at least for the vertical osteotomy lines during the surgical procedure. For patients with lower premolar extraction, the extraction space can be used for vertical osteotomy lines; however, in those without extraction, control of the angulation of the adjacent teeth is a prerequisite for using the vertical osteotomy lines. If the spaces for the vertical osteotomies are prepared, the full-size rectangular stainless steel arch wire will be engaged passively. Model surgery, using a 3-dimensional model analyzer on a dental cast, should be performed immediately before ADSO to analyze the 3-dimensional movement of the anterior segment and create a surgical splint.

Surgery can be performed in an outpatient clinic (Fig 1C,D). First, the labial and lingual vestibules and inferior alveolar, lingual, and mental nerves are infiltrated with a local anesthetic. Second, a vestibular incision for the mucoperiosteal flap is made. Third, a buccal mucoperiosteal flap is reflected, controlling the bleeding, to expose the anterior mandibular alveolar bone. Fourth, a horizontal osteotomy is performed, using a piezoelectric surgical device (Piezosurgery, Mectron, Italy), more than 5 mm below the root apex of the anterior teeth, which is determined from the preoperative CBCT scan. Finally, interdental vertical osteotomies are performed using a round bur bilaterally to connect the 2 ends of the horizontal osteotomy. In patients in whom the lower premolars are extracted, vertical osteotomies are conducted along with the extraction socket lines. In those without extraction, the root configuration of adjacent teeth is evaluated using both the preoperative CBCT scan and palpation during surgery. The vertical osteotomies, which start from the bottom where the horizontal cut ends, are made as deep as possible into the bone to form a trapezoidal bone segment. A spatula osteotome and mallet are used to deepen the osteotomies from the labial side until the lingual mucosa is detected.

The maximum mobilization of the dento-osseous segment is confirmed after completing the osteotomies. Preservation of the lingual mucosa and labial-attached gingival is important, both to maintain the blood supply to the dento-osseous segment and to prevent reduction of the gingival margin. After trimming the bones, fixation using a plate and screws (Osteomed LP, Osteomed Corp, Addison, TX) on the horizontal osteotomy line is performed, adjusted by
FIGURE 2. A to D, Pretreatment photographs and radiographs of patient 1. (Fig 2 continued on next page.)

FIGURE 3. A, Pretreatment panoramic radiograph. (Fig 3 continued on next page.)

the surgical splint made in advance. Finally, after insertion of a rubber drain, the wound is closed with surgical sutures. If the lower premolars have been extracted, tight ligatures are placed between adjacent teeth on both sides of the vertical osteotomies. Two weeks after ADSO, the orthodontic treatment can resume.

**Case Reports**

**CASE 1: YAW CORRECTION OF THE ANTERIOR SEGMENT WITH LOWER PREMOLAR EXTRACTION**

The patient was a 19-year-old woman diagnosed with facial asymmetry to the left side and a skeletal Class I jaw relationship. Her facial asymmetry pattern...
FIGURE 3 (cont’d). The stone casts D, E, before and F, G, after model surgery. [The amount of 3-dimensional movement on the lower anterior teeth is presented in Table 1, patient 1.]

<table>
<thead>
<tr>
<th>Pt. No.</th>
<th>Direction</th>
<th>Problem Lists</th>
<th>Treatment Planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anteroposterior</td>
<td>Proclined lower anterior teeth (IMPA 94°, LI to MnOP 59°)</td>
<td>Retroclination of incisors (5°) with minimum risk in thin symphysis, asymmetric retraction of lower canines (left 6.4 mm; right 5.8 mm)</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Extruded lower anterior teeth, 3 different occlusal planes (anterior, posterior on left, posterior on right)</td>
<td>Parallel intrusion of anterior teeth (1.8 mm) as reference of differential posterior level</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>Discrepancy between dental arch and basal bone of mandible (mandibular dental midline deviated to right 2.8 mm from menton)</td>
<td>Rotation of anterior segment to make accordance with basal arch curvature and midline coincidence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lateral movement (2.3 mm) to left side on both canines</td>
</tr>
<tr>
<td>2</td>
<td>Anteroposterior</td>
<td>Retroclined lower anterior teeth (IMPA 76.5°, LI to MnOP 74°)</td>
<td>Proclination of incisors (10°) without thinning labial cortex</td>
</tr>
<tr>
<td></td>
<td>Vertical</td>
<td>Extruded lower anterior teeth, canted incisal plane, and different canine levels</td>
<td>Leveling occlusal plane by differential intrusion (2.29 mm intrusion on lower left canine; 1.46 mm intrusion on lower right canine)</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Abbreviations: IMPA, lower incisor to mandibular plane angle; LI to MnOP, lower incisor to mandibular occlusal plane angle; Pt. No., patient number.
FIGURE 4. A to C, Photographs before anterior decompensation using segmental osteotomy (ADSO). D to F, Photographs 2 weeks after ADSO. (Fig 4 continued on next page.)

was combined with the roll and translation types on a 3-dimensional CBCT image (Fig 2). We observed canting of the maxilla, with the left side higher than the right by 4.1 mm in the first molar and 1.6 mm in the canine region.

The mandible deviated to the left on the frontal view and had yaw on the axial view. The inclination and length of the mandibular ramus and the body height differed on each side. The menton deviated to the left by 18.5 mm from the mid-sagittal plane (facial midline), and the lower dental midline deviated to the right by 2.8 mm from the menton (mandibular midline).

The intraoral examination showed a Class III molar relationship on the right and Class II on the left owing to the mandibular yaw. A crossbite was present on the left side, in both the anterior and the posterior region.
FIGURE 5 (cont’d). A to D, Post-treatment photographs and radiographs of patient 1. (Fig 5 continued on next page.)

Transverse compensation was apparent in the molar region. Mild crowding was present in both arches, and the arch length discrepancy was $-3.8$ on the upper and $-2.7$ mm on the lower. The proclined maxillary and mandibular incisors were seen (upper incisor to Frankfort horizontal [FH] plane [U1-FH]: $126.5^\circ$ and lower incisor to mandibular plane [IMPA]: $94.0^\circ$). Three different occlusal planes were present on the lower arch: anterior, left posterior, and right posterior (Fig 3B). For this, 3-dimensional elimination of the dental decompensation on the mandibular arch was needed to achieve sufficient correction of orthognathic surgery to improve the facial asymmetry. First, we considered conventional extraction of the premolars and strategic space closure using a different anchorage value between the left and right sides. However, using conventional preoperative orthodontic treatment had limitations, including the anatomic limits posed by the thin alveolar bone and a discrepancy between the mandibular alveolar and basal bones. In addition, premature contact and interdigitation caused by the cross bite could disturb the tooth movement. Therefore, we considered performing an ADSO on the mandibular arch.

We selected ADSO, using the extraction space of the mandibular first premolars for anteroposterior, vertical, and transverse decompensation of the lower anterior teeth (Table 1, Fig 3A,B). The lower anterior teeth were to be retroclined by $5^\circ$ and intruded by $1.8$ mm parallel to a reference of the differential posterior occlusal level. The anterior segment would be rotated to facilitate accordance with the basal arch yaw, including midline decompensation using the extraction space. A model surgery using a 3-dimensional model analyzer was performed on a dental cast before proceeding with the ADSO (Fig 3C to G).

At 6 months after bonding, the lower ADSO was performed with the patient under local anesthesia. The mandibular incisors were retroclined and parallel intruded to level the occlusal plane and then moved to the left to coordinate the dental midline with the mandibular midline (Fig 4). After the lower ADSO was completed, the arches were leveled further, and space closure was performed. Transverse molar decompensation was attained using a bite plane and intermaxillary elastics. At the end of the preoperative orthodontic treatment, dental decompensation on both arches had been achieved successfully. The basal bone on the maxilla and the mandible coordinated with its dental parts.

At 9 months after the ADSO, we performed a maxillary Le Fort I osteotomy, upper anterior segmental...
FIGURE 6. A to D, Pretreatment photographs and radiographs of patient 2. (Fig 6 continued on next page.)

osteotomy, mandibular bilateral sagittal split ramus osteotomy, and mandibular angle shaving with titanium miniplate fixation (Osteomed LP, Osteomed Corp) to correct the facial asymmetry. Subsequently, postoperative orthodontic treatment was undertaken for 10 months for finishing and detailing the occlusion. The total treatment period was 26 months, and the post-treatment photographs indicated successful results (Fig 5). The facial asymmetry and lateral profile had dramatically improved and a Class I relationship with an ideal overbite and overjet were achieved. The facial midline coincided with the dental midline on the maxillary and mandibular arches.

CASE 2: VERTICAL AND INCLINATION CORRECTION OF THE ANTERIOR SEGMENT WITHOUT EXTRACTION OF PREMOLARS

The patient was a 19-year-old woman complaining of facial asymmetry. She had a prognathic chin and was diagnosed with facial asymmetry to the left side and a skeletal Class III jaw relationship (retruded maxilla and protruded mandible). She had a hyperdivergent vertical pattern, and the mandibular plane angle was steep on the lateral cephalogram (Fig 6). Her facial asymmetry pattern was a translation type on the 3-dimensional CBCT image. The mandible deviated to the left by 4.5 mm from the mid-sagittal plane (facial midline) on the frontal view and had anterior yaw on the axial view.

We observed both an anterior cross bite and a Class III molar relationship on both sides. A deep curve of Spee (COS) on the lower arch with extruded lower anterior teeth was present. The lower right canine was less extruded than the lower left canine because of occlusal contacts with the opposite teeth, resulting in different canine levels. The inclination of the maxillary central incisors was proclined, and the inclination of mandibular central incisors was retroclined (U1-FH 121.0°; IMPA 76.5°).

We selected ADSO for dental decompensation of the lower arch. Conventional preoperative orthodontic treatment would have required a long treatment time and had several limitations, including a thin and elongated symphysis and thin periotype. Furthermore, conventional intrusion mechanics require long treatment periods and can cause problems, including labial cortex resorption and gingival recession. Additionally, proclination of the lower anterior teeth is difficult because of the force exerted by the lower lip.
The treatment plan was designed to 3-dimensionally correct the compensation of the lower arch (Table 1; Fig 7A,B). Therefore, we selected ADSO, using the inter-radicular spaces between the mandibular canines and first premolars for anteroposterior and vertical decompensation of the lower anterior teeth. The lower anterior teeth would be proclined by $10^\circ$ and intruded differentially for correction of the incisal canting. The lower left canine would be intruded by 0.83 mm more than the lower right canine (2.29-mm intrusion on the lower left canine; 1.46 mm on the lower right canine). Before undertaking ADSO, we performed a model surgery using the 3-dimensional model analyzer on a dental cast (Fig 7D to G).

At 5 months after bonding, the lower ADSO was performed with the patient under local anesthesia, with sufficient space between the canine and the first premolar acquired before surgery (Fig 7C). The mandibular incisors were proclined and intruded to correct the deep COS and level the occlusal plane (Fig 8). After the lower ADSO was completed, the patient underwent preoperative orthodontic treatment. The teeth in both arches were moved to positions where the basal bone firmly supported them, making it possible for surgical correction of the maxilla and mandible.

At 6 months after the ADSO, we performed a Le Fort I osteotomy, upper anterior segmental osteotomy, mandibular bilateral sagittal split ramus osteotomy, and reduction genioplasty with titanium miniplate fixation to correct the jaw deformities. Subsequently, the arch coordination and interdigitation were adjusted for 11 months, and the orthodontic appliances were removed. The total treatment period was 24 months, and the post-treatment photographs showed successful results.

**FIGURE 7.** A, B, Three-dimensional compensation of the lower dentition. ([Fig 7 continued on next page.])

(Fig 9), including dramatic improvement of the facial asymmetry and protruded chin and favorable interdigitation between the maxillary and mandibular teeth.

**Discussion**

These 2 cases illustrate the versatility of ADSO for patients with severe facial asymmetry. It can
FIGURE 7 (cont’d). E, before and F, after model surgery. (Fig 7 continued on next page.)

effectively correct the anterior dentoalveolar yaw (patient 1) and the vertical position and inclination of the anterior teeth (patient 2). In both patients, sufficient elimination of anterior compensation using the ADSO guaranteed successful improvement of the facial asymmetry and stabilization of occlusion after orthognathic surgery.

It is important to perform an accurate evaluation of the mandibular asymmetry when planning to use ADSO. A 2-dimensional posteroanterior cephalometric radiograph cannot provide enough information, either for identifying the causes of asymmetry or for determining a suitable treatment plan, even with the aid of lateral and submentovertex projections. However, using reconstructed 3-dimensional CT images decreases the errors caused by magnification and distortion and allows for quantitative measurements of the anatomic structures of interest. A few studies have been reported on the classification of mandibular asymmetry by roll, pitch, yaw, or their combination using 3-dimensional CT data. Accurate planning of ADSO is possible with evaluation of the mandibular asymmetry using 3-dimensional CT data, followed by model surgery using the 3-dimensional model analyzer.

The several characteristics of transverse dental compensation in patients with facial asymmetry include lower occlusal planes slanted significantly upward to the mandibular shifted side; significant differences in the COS between the mandibular shifted and nonshifted sides because of a significantly small COS on the mandibular nonshifted side; and significant asymmetry of the mandibular dental arch due to lateral deviation of the canine. In some cases of severe facial asymmetry, however, the compensation pattern of the anterior teeth will not correspond with the skeletal asymmetry owing to interdigitation and/or lip pressure.

The elimination of extreme dental compensation using conventional orthodontic treatment can require a long treatment period and can also have anatomic and mechanical limitations. Particularly with the mandibular incisors, incomplete preoperative decompensation has several possible causes, including inadequate labial bone to allow sufficient movement of the mandibular incisors, lower lip muscle resistance, interdigitation of the upper teeth, and poor patient compliance with intraoral elastic traction.

Patients with severe facial deformity often present with extreme dental compensation to maintain normal interarch positioning under abnormal jaw relationships, which can lead to thinning of the alveolar bone and deterioration of the periodontal tissue, reflecting compensation for the skeletal pattern of the jaws. Lee et al have suggested that in patients...
with mandibular prognathism, alveolar bone loss or fenestration is more common in the anterior mandibular teeth before treatment. In addition, Chung et al\textsuperscript{15} found that the width of the symphyseal region and the alveolar height were significantly lower in patients with open bite than in those with a negative overjet.

Limitations exist to tooth movement within the alveolar bone. If elimination of dental compensation on the anterior teeth with thin symphyses is performed without considering these anatomic limits, it can decentralize the teeth from the alveolar bone envelope, causing gingival recession, abnormal teeth mobility, severe root resorption, and bone dehiscence or fenestrations.\textsuperscript{6} Several methods have been used to overcome these anatomic limits. Corticotomy is an alternative approach that facilitates tooth movement by minimizing the periodontal complication using regional acceleratory phenomenon (RAP). Although it helps bone remodeling, RAP still requires

\textbf{FIGURE 8.} A to C, Photographs before anterior decompensation using segmental osteotomy (ADSO). D to F, Photographs 3 weeks after ADSO. (Fig 8 continued on next page.)

conventional orthodontic mechanics and only lasts for 3 to 4 months. Wilcko et al introduced a 1-stage, surgically facilitated, rapid orthodontic technique with alveolar augmentation to decrease the treatment times with correction of pre-existing bony dehiscence and fenestration. From that study, Ahn et al introduced the augmented corticotomy, which provides effective decompensation of the mandibular incisors in skeletal Class III patients while maintaining the labial bone thickness, with no periodontal side-effects. However, in 40% of the subjects in their study, the greatest increase in alveolar thickness was at the level of B-point, with no increase in the alveolar crest height because of the downward movement of the bone graft materials. This could lead to poor regeneration of the alveolar crest, because this is a critical area for decompensation of the lower anterior teeth. Despite these efforts, sufficient tooth movement cannot be achieved in many cases because of other factors, including neuromuscular function, bite force, and mechanical limits. In patients with strong masticatory muscles, it is more difficult to achieve extrusion of the teeth during COS leveling. Various methods to induce incisor decompensation have been reported, including temporary skeletal anchorage devices and intermaxillary elastics for selective tooth movement. An occlusal separation device, such as a bite plane, is needed to avoid premature occlusal contact with the opposite teeth. Sekiya et al presented a case in which the preoperative orthodontic treatment of a patient with severe facial asymmetry achieved sufficient elimination of transverse dental compensation using asymmetric extraction. However, none of these approaches could overcome more complex problems, such as asymmetric arches, the limitations of orthodontic mechanics, and the long treatment times.

As an alternative, segmental osteotomy can be an effective method for anterior decompensation. Anterior subapical mandibular surgery was first described by Köle and was mainly applied to patients with an anterior open-bite and deep-bite. This surgery was frequently used to correct vertical problems, but it could also advance or retract a dentoalveolar segment. Macintosh was the first to describe total subapical mandibular surgery, which involves moving the total mandibular dentoalveolus in an anterior, posterior, or superior direction. Because ADSO is performed with the patient under local anesthesia, the patient’s burden for a surgical operation can decrease.

The complications of ADSO are similar to those of conventional segmental surgery. The sequelae of insufficient vascularity after segmental surgery can include loss of tooth vitality, periodontal defects, tooth loss, and total segment loss. However, most of these adverse effects were reported to occur on the maxilla when Le Fort I osteotomies were performed in multiple segments. Several factors should be considered for the ADSO to be successful: 1) the surgical design for 3-dimensional movement of the bone segment; 2) the importance of the blood supply to preserve vitality in the tooth-bone segments (horizontal osteotomy is performed ≥5 mm below the root apex); and 3) the anatomic structures surrounding the operation site, including the root structures, individual teeth length, and proximity of inferior mental foramen (located near the mandibular second premolars). Particularly for nonextraction cases, control of the angulation of the adjacent teeth must be...
FIGURE 9. A to D, Post-treatment photographs and radiographs of patient 2. (Fig 9 continued on next page.)

performed before performing ADSO, because at least 1.5 mm of space is needed for the vertical osteotomy line. This is shown in our second patient (Fig 7C).

In conclusion, to obtain sufficient correction of facial asymmetry using orthognathic surgery, precise and sufficient dental decompensation during preoperative orthodontic treatment is needed. The ADSO can quickly eliminate the anterior compensation and move the teeth to their proper positions such that the basal bone supports them beyond the anatomic limits. Precise evaluation and diagnosis using 3-dimensional CT data should be performed to prevent unnecessary surgical procedures.

References


