Combined maxillary and mandibular midline and mandibular ramus distraction osteogenesis for treatment of a Class II patient with implants as orthodontic anchorage

Ichiro Takahashi, Hiroshi Kawamura, and Teruko Takano-Yamamoto
Sendai, Japan

This case report describes the treatment of a woman with severe mandibular retrusion and maxillomandibular transverse deficiency. Her malocclusion was characterized by a large overjet, a deep overbite, and a V-shaped dental arch, and she had a skeletal Class II profile. Treatment included combined maxillary and mandibular midline expansion, maxillary downward repositioning, and mandibular ramus lengthening with distraction osteogenesis with implants as orthodontic anchorage. During the postdistraction orthodontic treatment period, some skeletal relapse occurred. Implants provided absolute orthodontic anchorage to overcome the unexpected skeletal changes. Combined orthodontic treatment with implants for anchorage and distraction osteogenesis successfully expanded the maxilla and the mandible and corrected the mandibular deficiency. Two-year follow-up records show a morphologically and functionally stable result. (Am J Orthod Dentofacial Orthop 2010;137:412-23)

Distraction osteogenesis (DO) is recognized as a major option in the treatment of maxillofacial deformities with vertical, transverse, anteroposterior mandibular, or maxillary deficiencies in growing and adult patients. Since mandibular DO was first described in 1992 by McCarthy et al., applications of distraction osteogenesis have been developed for various maxillofacial deformities. Mandibular symphyseal distraction osteogenesis (MSDO), mandibular body and ramus lengthening, the rigid external distraction system, maxillary advancement with an internal distraction device, and alveolar distraction osteogenesis have all been developed by using various unique distraction devices. Combining devices has enabled the correction of complex maxillofacial deficiencies. The advantages of DO, when compared with bilateral sagittal split ramus osteotomy (SSRO), are gradual lengthening of the bones with lengthening of surrounding soft tissues such as muscles, tendons, and fibrous connective tissues; gradual advancement or transverse expansion of the mandible with minimal influence on temporomandibular joint (TMJ) conditions, lengthened alveolar bone providing space for aligning teeth; and reduction of skeletal relapse after application. However, DO is still rapidly developing in orthodontic treatment, and scientific and clinical evidence needs to be integrated.

On the other hand, the use of implants as orthodontic anchorage is becoming a popular, stable, and safe treatment option for various malocclusions. It provides an immobile anchor for tooth movement such as distalization of molars, intrusion of whole dental arches including molars, and simultaneous distalization and intrusion of molars. It can also be used for intermaxillary fixation after orthognathic surgery. Many types of miniscrews and miniplates have been developed for these approaches over the past 10 years and applied to various malocclusions.

In this case report, we demonstrate combined treatment of DO and absolute orthodontic anchorage using implants in an adult Class II patient with a retrognathic profile.

DIAGNOSIS AND ETIOLOGY
The patient was a Japanese woman (aged 39 years 1 month) with a chief complaint of maxillary protrusion.
Her medical history was normal. She had a convex facial profile, a gummy smile, and hypertonicity of the mentalis muscle during closing of the lips. She had a severe Class II malocclusion with 12.0 mm of overjet, and she was missing the maxillary right first premolar and a mandibular left first molar. The periodontal parameters were acceptable for orthodontic treatment. The probing depth of all teeth was less than 3.0 mm, and no bleeding on probing was recorded at the initial examination. Functionally, her TMJs had no symptoms; however, anterior guidance was nonexistent.

The facial photographs indicated a convex facial appearance, a protruded upper lip, overexposure of the maxillary incisors, a gummy smile, and a large interlabial gap (Fig 1). The dental casts showed severe maxillary protrusion with large overjet, deep overbite, and transverse deficiency with narrow dental arches (Fig 2). The molar relationship was Angle Class II on both
sides, and a lateral crossbite was found in the left second premolar region. Her panoramic radiograph showed that she was missing all third molars except for the mandibular left one, in addition to a maxillary right first premolar and a mandibular left first molar as described above (Fig 3).

Cephalometric analysis indicated that she had a skeletal Class II jaw deformity (Fig 4). The ANB angle was $8.0^\circ$, and the Wits appraisal was $6.3$ mm. The SNA angle of $80.1^\circ$ reflected a normally positioned maxilla, and the SNB angle of $72.1^\circ$ indicated mandibular deficiency. Her mandibular plane angle to the SN plane (MP-SN) was $49.5^\circ$; this was steeper than that typical of Japanese women. In addition to these skeletal problems, she had labially proclined and extruded maxillary incisors and extruded mandibular incisors with a deep curve of Spee. The linear and angular cephalometric measurements are given in the Table. The following problems needed to be resolved: (1) skeletal Class II anteroposterior jaw relationship, (2) steep mandibular plane angle, (3) narrow maxillary and mandibular dental arch, (4) gummy smile with large interlabial gap and tooth exposure, (5) bilateral Angle Class II molar relationships, (6) large overjet, (7) excessive mandibular incisor height and deep overbite, (8) lateral crossbite at the left first premolar, and (9) labial proclination of the maxillary incisors.

**TREATMENT OBJECTIVES**

Because the patient was concerned about her facial esthetics, treatment options were considered to correct the mandibular deficiency. The severe skeletal Class II deformity directed the orthognathic surgery. To solve the problems above, the treatment objectives for this patient were the following: (1) correct the imbalanced
Class II anteroposterior jaw relationship; (2) coordinate the widths of the dental arches; (3) reduce the steep mandibular plane angle; (4) reduce the deep overbite; (5) improve the gummy smile, the large interlabial gap, and tooth exposure; (6) correct the molar relationship; (7) reduce the overjet; (8) decrease mandibular incisor height; (9) correct the lateral crossbite on the left side; and (10) improve the inclination of the maxillary incisors.

A 2-dimensional visualization of the treatment goals for the patient on the cephalometric tracing is shown in Figure 4. Five millimeters of maxillary impaction, 7 mm of advancement of the mandible, 5 mm of advancement of the chin, and height reduction of the symphysis were planned.

The 7 mm of planned mandibular advancement was on the borderline between bilateral SSRO or DO. Without making the space to align and intrude the anterior teeth by MSDO and maxillary midline DO, extraction of the premolars would be needed. By using implants as orthodontic anchorage from the beginning of treatment, tooth-bearing alveolar bone generated by DO could be used as available alveolar bone. In addition, because widening of the dental arches was also needed, we decided to use a combination of MSDO, maxillary midline DO, and mandibular ramus and body DO to achieve the treatment goals in one-time surgical intervention without tooth extractions. The following treatment was planned to achieve these treatment objectives: (1) bilateral mandibular ramus and body DO to simultaneously increase the ramus height and body length, and reduce the mandibular plane angle; (2) MSDO and maxillary midline DO to coordinate the arch widths and partially obtain space to retract the maxillary incisors and intrude the mandibular incisors; (3) impaction of the maxilla to reduce the anterior maxillary incisor height; (4) genioplasty to improve the retruded chin and reduce incisor height; (5) retraction and retroclination of the maxillary incisors to reduce overjet by using implants as orthodontic anchorage; and (6) flattening the deep curve of Spee and intruding the mandibular incisors to reduce mandibular incisor height.

TREATMENT ALTERNATIVES

Because the patient’s main concern was related to facial esthetics, treatment options were considered to correct the mandibular deficiency. Her severe Class II skeletal relationship required orthognathic surgery. Bilateral SSRO and LeFort I osteotomy or a combination of mandibular ramus and body DO, MSDO, and maxillary midline DO were considered as treatment options. DO can provide bone regeneration to increase the available arch length for tooth alignment at the beginning of combined orthodontic and orthognathic surgical treatment, whereas bilateral SSRO cannot provide this effect. In addition, since midline DO can enlarge the oral cavity, we selected DO as the primary option in her treatment.

TREATMENT PROGRESS

Fixed prostheses for the maxillary right first premolar and mandibular left first molar were removed. Fixed appliances (0.022 × 0.028-in preadjusted edgewise) were placed, and segmented passive wires (0.019 × 0.026-in heat-treated heavy wires) were set in each quadrant of both dental arches. In the treatment plan, all DO procedures were to be performed before orthodontic tooth movement because the space created by bone regeneration was needed to align and level the dental arch. Bilateral osteotomy at the angle of the mandible, mandibular symphyseal osteotomy with genioplasty, and maxillary midline osteotomy with LeFort I osteotomy were performed with an intraoral approach. The anterior part of the maxilla was impacted and wired to the piriform edge. Intraoral distraction devices were placed, spanning the osteotomized sites at the mandibular angles and symphysis (Fig 5). Bone-borne intraoral devices (Leibinger, Freiburg, Germany) were placed at the mandibular angle, and a bone- and tooth-borne...
distraction device (Leibinger) was fixed to the symphyseal osteotomy site. Both arches were fixed on the right and left with a resin-made occlusal splint. This distracted the maxillary midline as the mandibular distraction device was activated. Similarly, intermaxillary fixation transferred the distraction force from the distractor placed on the angle of the mandible to the maxillary bones, thereby inducing downward movement of the posterior maxilla. Wiring beside the anterior nasal spine was fixed to maintain the level of the anterior maxilla during distraction.

After a latency period of 7 days, distraction was started by activating the devices twice a day at the rate of 1.0 mm per day. Distraction was continued until a 10-mm distraction gap was obtained at the mandibular angle and a 5.0-mm gap was produced at the maxillary midline (Fig 6, A and B). Bone plates (Leibinger) were fixed on the bilateral mandibular body and zygomatic buttress simultaneously during the surgical placement of distraction devices for creating implant anchorage.

The distraction devices were maintained until the 5-month consolidation period was completed. Immediately after distraction, backward movement of the condyles in the glenoid fossa was found; this could have caused TMJ pain (Fig 6, C-F). When the distractors were removed, since the consolidation of the distraction gap in the right mandibular angle was incomplete, a bone plate was placed spanning the distraction gap to fix the proximal and distal segments (Fig 7). To prevent root resorption of the teeth, postdistraction

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**Fig 6.** A and B, Lateral cephalometric and panoramic x-rays taken after distraction; C-F, Schüller method of x-ray photography of the TMJ at the beginning (C and E) and end (D and F) of distraction indicates the posterior displacement of the condyle in the glenoid fossa.

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**Fig 7.** Panoramic x-ray immediately after removal of the distractor. Distraction gap on right ramus was rigidly fixed by using a bone plate.
orthodontic treatment was started after 5 months of consolidation.\textsuperscript{18,19}

After the distractors were removed, postoperative orthodontic treatment was started by using bone plates as anchorage. By fixing the canines to bone plates implanted as anchors, the maxillary incisors were retracted by using the space made by the maxillary midline DO (Fig 8). The space made at the symphysis was used for intrusion of the mandibular incisors and flattening the curve of Spee. The anteroposterior relationship of the maxillary and mandibular dental arches was adjusted, and the maxillary incisors were retroclined and moved lingually to achieve the treatment goal. As the treatment progressed, some skeletal relapse was observed (Figs 9 and 10). To overcome this, the maxillary dental arch was totally distalized to adjust the anteroposterior dental relationship. The spaces for missing teeth were adjusted to suitable sizes for later prosthetic treatment. After removing all fixed appliances, the bone plates for absolute anchorage were removed, the maxillary right premolar region was restored by dental implants, and the mandibular left molar was restored by using a bridge with a shorter span than that used before treatment.

TMJ dysfunction symptoms appeared during distraction. The patient particularly suffered from pain during jaw opening and closing. The mandibular condyles showed slight resorption after the DO treatment. The symptoms gradually lessened after the DO and during orthodontic treatment, and disappeared altogether at debonding.

**TREATMENT RESULTS**

The skeletal Class II facial profile was improved by combined mandibular ramus and body and mandibular symphyseal distraction osteogenesis (Figs 9-11). The large interlabial gap and exposure of the maxillary incisors were both reduced, and the gummy smile was improved (Fig 11). Although the mandibular body was lengthened by 10 mm immediately after distraction, 3 mm of relapse was observed during orthodontic treatment (Fig 10). In this patient, the expected 7 mm of advancement was mostly achieved by the end of active orthodontic treatment. Changes in linear and angular cephalometric measurements and comparisons with Japanese norms after treatment are given in the Table.\textsuperscript{20} Relapse in the mandibular body length and total mandibular length was observed 1 to 2 years after removal of the distraction devices by the time of debonding. The 3-mm relapse at the chin (Fig 10) was related to shortening of the mandibular body length as indicated (Table 1). Most linear and angular measurements in the Table were stable 2 years after debonding.

The large overjet and deep overbite were improved by orthodontic treatment after the DO, and a good static occlusion was obtained by the time of debonding (Fig 12). The treatment goals set at the beginning of the treatment were achieved, except for a greater retroclination of the maxillary incisors than planned (Table). Adequate intercuspatation was achieved during static occlusal contact. A circumferential retainer was used in the maxillary arch, and a flexible multistrand wire was bonded on the 6 mandibular anterior teeth.

Fig 8. Intraoral photographs immediately after removal of the distractors. Treatment was then started by using implanted bone plates (arrowheads) tied to a hook of canine brackets. Note the expanded dental arches.
The edentulous sites were treated after debonding. At the patient’s request, the maxillary right premolar was restored with a dental implant, and the mandibular left first molar region was reconstructed with a bridge (Fig 13). Two years after active treatment, static occlusion was maintained (Figs 14-16), and the patient was satisfied with both the esthetic and functional results.

**DISCUSSION**

Distraction osteogenesis was developed to lengthen long bones that load mechanical compressive stress from the surrounding soft tissues and muscular functions. Although DO has been applied to the maxillofacial skeleton to lengthen the mandible and is expected to eventually substitute for conventional orthognathic surgery, it is not yet largely accepted as a primary option for treatment because of the complexity of the procedures, the patient’s burden, and weak scientific evidence for application. Many basic studies with animals, however, have demonstrated that DO could be a better treatment option than conventional orthognathic surgery for complex craniofacial deformities when increased length and width of the bones are needed.

DO can actually enlarge the oral cavity and regenerate bone on which to align the teeth. Our patient shows that DO can improve many complicated problems.

Although some previous studies claim that DO is advantageous over SSRO for TMJ symptoms, several unfavorable symptoms occurred in this patient, including joint pain and a decrease in the amount of maximum jaw opening. These symptoms could also occur in patients undergoing mandibular advancement with bilateral SSRO. Age might have caused these unfavorable TMJ effects of DO. However, the TMJ symptoms, including pain and restricted mouth opening, all improved after removal of the appliances. Some previous clinical and animal studies also demonstrated a certain risk for condylar resorption or TMJ disorders, but these effects were transient and reversible.

Even after 5 months of consolidation, bone regeneration in the right distraction gap was immature, whereas
other distraction gaps had mature bone. Therefore, bone fixation with a bone plate was needed on the mandibular right ramus when the distractors were removed. As shown in the literature, although patient age could be a factor causing delay of maturation of the regenerated bone, other factors such as right-left asymmetry in the amount or orientation of the distraction or thin bony gaps found immediately after placing the distractors might cause uneven mechanical stability in the distraction gap; this could result in uneven maturation of regenerated bone.\(^{12}\) Eventually, however, sufficient bone formation was observed, and good mechanical stability was obtained.

The skeletal relapse was mainly observed during 1 to 2 years of postdistraction orthodontic treatment as described above. In this patient, backward movement of the chin could have been caused by relapse in mandibular body length rather than in ramus height. Thus, skeletal relapse during the treatment could be caused by the tension from the soft tissues. A previous study indicated that the mandibular plane angle was related to the amount of the skeletal relapse.\(^{7}\) In that study, patients with MP-SN angles larger than 38° had greater relapse at Point B than those with shallower mandibular plane angles after 1 year of follow-up. In our patient, since the MP-SN was 48.8° initially, some relapse was expected during postdistraction orthodontic treatment and was observed. Although the long-term stability of the distracted facial bones is still unclear, this patient has a stable anteroposterior relationship of total mandibular length, mandibular ramus height, and mandibular body length 2 years after active orthodontic treatment. Thus, it could be considered that the skeletal relapse after distraction occurs 1 to 2 years after distraction, and skeletal morphology becomes stable thereafter.

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**Fig 11.** Facial photographs at debonding. Facial esthetics, gummy smile, and large interlabial gaps were improved.

**Table 1.** Lateral cephalometric measurements

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>Japanese norms</th>
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<tbody>
<tr>
<td>SNA</td>
<td>79.8°</td>
<td>80.2°</td>
<td>81.3°</td>
<td>79.1°</td>
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<td>SNB</td>
<td>73.3°</td>
<td>76.5°</td>
<td>78.3°</td>
<td>73.6°</td>
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<td>ANB</td>
<td>6.4°</td>
<td>3.8°</td>
<td>3.0°</td>
<td>5.5°</td>
<td>5.4°</td>
<td>2.8°</td>
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<tr>
<td>Upper incisor to SN</td>
<td>117.4°</td>
<td>114.6°</td>
<td>113.9°</td>
<td>94.4°</td>
<td>96.1°</td>
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<tr>
<td>IMPA</td>
<td>98.0°</td>
<td>92.6°</td>
<td>95.6°</td>
<td>91.8°</td>
<td>93.5°</td>
<td>94.3°</td>
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<td>Occlusal plane to SN</td>
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<td>14.7°</td>
<td>16.2°</td>
<td>20.7°</td>
<td>18.9°</td>
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<td>Mandibular plane to SN</td>
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<td>43.6°</td>
<td>45.0°</td>
<td>45.7°</td>
<td>45.7°</td>
<td>37.1°</td>
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<td>Wits appraisal</td>
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<td>2.9 mm</td>
<td>–0.7 mm</td>
<td>1.8 mm</td>
<td>2.1 mm</td>
<td>—</td>
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<tr>
<td>Go-Me</td>
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<td>73.7 mm</td>
<td>70.8 mm</td>
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<td>Ar-Go</td>
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<td>44.8 mm</td>
<td>43.8 mm</td>
<td>44.0 mm</td>
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<td>Ar-ME</td>
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<td>110.7 mm</td>
<td>107.0 mm</td>
<td>108.1 mm</td>
<td>103.0 mm</td>
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*T1, Initial; T2, immediately after distraction; T3, removal of distractors; T4, at debonding; T5, 2 years after debonding.*
The large overjet and deep overbite were both improved by orthodontic treatment after DO, and good static occlusion was established by the end of the treatment. Regenerated bone made by distraction was used to retract the maxillary and mandibular incisors. Since tooth movement into actively remodeled bone caused root resorption in previous studies, we waited for 3 months to move teeth into the distraction gap. Consequently, the large tooth exposure and interlabial gap seen initially were improved by the incisor retraction. The treatment goals set at the beginning of the treatment were achieved. Because of the skeletal relapse of the mandible during and after consolidation, the whole maxillary dental arch was distalized more than planned.
The maxillary incisors were therefore tipped lingually to compensate for the anteroposterior jaw relationship during orthodontic treatment after DO by using implants as orthodontic anchorage. Although we used implanted bone plates for anchorage, because the amount of distalization of the maxillary dental arch did not exceed 2 to 3 mm, mini-implants such as screws could also be used for this tooth movement.\cite{16,17} The inclination of the maxillary incisors was still acceptable when compared with Japanese standards. Whereas DO can be a powerful modality to improve complicated skeletal deformities such as in this patient, because of some skeletal relapse, orthodontic treatment with implants as orthodontic anchorage contributed to overcoming those problems and obtaining a stable and well-balanced occlusion.

**CONCLUSIONS**

We presented a patient with complex skeletal problems treated by combined DO and orthodontic treatment using implants for anchorage. The results were acceptable, and the patient was satisfied with the treatment outcome. The combination of DO and implants as orthodontic anchorage is a powerful modality to improve patients with severe skeletal Class II problems.

We thank the clinicians who assisted in the treatment of this patient in the Divisions of Orthodontics and Dentofacial Orthopedics and Maxillofacial Surgery, Tohoku University Graduate School of Dentistry, Sendai, Japan.
1. Ilizarov GA, Lediaev VI, Shitin VP. The course of compact bone reparative regeneration in distraction osteosynthesis under different conditions of bone fragment fixation (experimental study). Eksp Khir Anesteziol 1969;14:3-12.


