

Mandibular Symphyseal Distraction Osteogenesis Using a Bone-Supported Distractor

Mehmet Bayram^a; Mete Özer^b; Alper Alkan^c

ABSTRACT

Increases in mandibular width by symphyseal distraction osteogenesis have recently been shown to be an acceptable and stable treatment option for transverse deficiencies. This case report presents the application of symphyseal distraction osteogenesis for increasing mandibular width using a bone-supported distractor as part of the orthodontic treatment of a 14-year-old male with a tapered shaped mandible and severe mandibular anterior crowding.

KEY WORDS: Symphyseal distraction; Bone-supported distractor; Mandibular widening; Mandibular anterior crowding

INTRODUCTION

Distraction osteogenesis (DO) is the biologic process of new bone formation between bone segments that are gradually separated by incremental traction.¹ The traction generates tension on the skeletal and surrounding soft tissue structures, which stimulates new bone formation parallel to the vector of distraction.² DO was introduced in the beginning of the 20th century and popularized by Ilizarov^{1,2} in the 1960s.³

Maxillary and mandibular transverse skeletal deficiencies are common clinical problems associated with narrow basal and dentoalveolar bones. In comparison with maxillary deficiencies,^{4,5} diagnosis and treatment of mandibular transverse deficiencies have received little attention. The conventional approaches for correcting mandibular crowding are extraction of teeth, dentoalveolar expansion, and interproximal enamel reduction. Whereas conventional approaches can resolve the problem, treatment of transverse discrepancies with mandibular expansion or incisor protrusion has been shown to be unpredictable and could result

in relapse and undesirable side effects in the long term.⁶⁻⁸

Mandibular symphyseal distraction osteogenesis (MSDO) is an alternative approach to correct mandibular transverse deficiencies and anterior dental crowding.^{3,9} Guerrero⁹ pioneered the use of rapid surgical mandibular expansion for correcting mandibular transverse discrepancies. Although a number of clinical studies,¹⁰⁻¹³ case reports,¹⁴⁻¹⁶ biomechanical studies,^{17,18} and technical reports¹⁹ have been published describing the use and effects of MSDO with different types of appliances, there is still a lack of sufficient knowledge regarding the application and effects of bone-supported distractors.

This case report presents the application of MSDO using a bone-supported distractor and evaluates the results of mandibular widening and orthodontic treatment in a patient who presented with severe mandibular anterior crowding and anterior transverse mandibular deficiency.

CASE REPORT

Diagnosis

The patient was a healthy 14-year-old boy whose chief complaint was crowded teeth in the mandible. Clinical examination revealed normal jaw function with no signs of temporomandibular dysfunction. His gingival health was moderate, and radiographs did not reveal any periodontal disease or other pathology. Pretreatment facial photographs showed a convex profile with mild anteroposterior chin deficiency, mildly protrusive lips, and facial symmetry with competent lips (Figure 1). The maxillary dental midline was co-

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Figure 1. Pretreatment facial photographs.

incident with the soft tissue facial midline; the mandibular dental midline was 2.0 mm to the right of the facial midline. The patient had a Class I molar relationship on both sides, 10 mm of overjet, and a 75% overbite (Figure 2). The dental cast analysis showed 2 mm of maxillary arch length deficiency, 10.5 mm of mandibular arch length deficiency localized in the anterior region, a slightly accentuated curve of Spee, and no Bolton tooth size discrepancy. Additionally, both arches were constricted from posterior to anterior as tapered arch forms.

The panoramic radiograph showed a complete permanent dentition, with erupting second molars and unerupted third molars. There was a root canal filling and a heavy amalgam filling in the mandibular right first molar and a root-canal filling with an endodontic pin and composite in the maxillary left central incisor. Furthermore, it was observed that the maxillary right first molar had been extracted (Figure 3). The lateral cephalometric radiograph indicated that the maxillary and

mandibular incisors were in protrusive positions on their respective apical bases. There was a moderate skeletal Class II discrepancy, with an ANB angle of 7.5° . The maxilla was located in a slightly retruded position relative to the cranial base, with an SNA angle of 77° . The mandible was located in a severely retruded position in relation to the cranial base, with an SNB angle of 69.5° . With a mandibular plane angle (sella-nasion/gonion-gnathion [S-N/Go-Gn]) of 44.0° , the patient demonstrated a high-angle skeletal pattern (Table 1). Pretreatment posteroanterior cephalometric measurements showed that the mandibular (biantegonial) and mandibular intercanine widths were less than the Turkish adult norms.²⁰ Pretreatment mandibular and intercanine widths were 80 mm and 23 mm, respectively (Table 2).

The treatment plan included rapid palatal expansion to correct the maxillary constriction and mandibular midline DO to relieve the anterior crowding, followed by nonextraction fixed orthodontic treatment.



Figure 2. Pretreatment intraoral photographs.

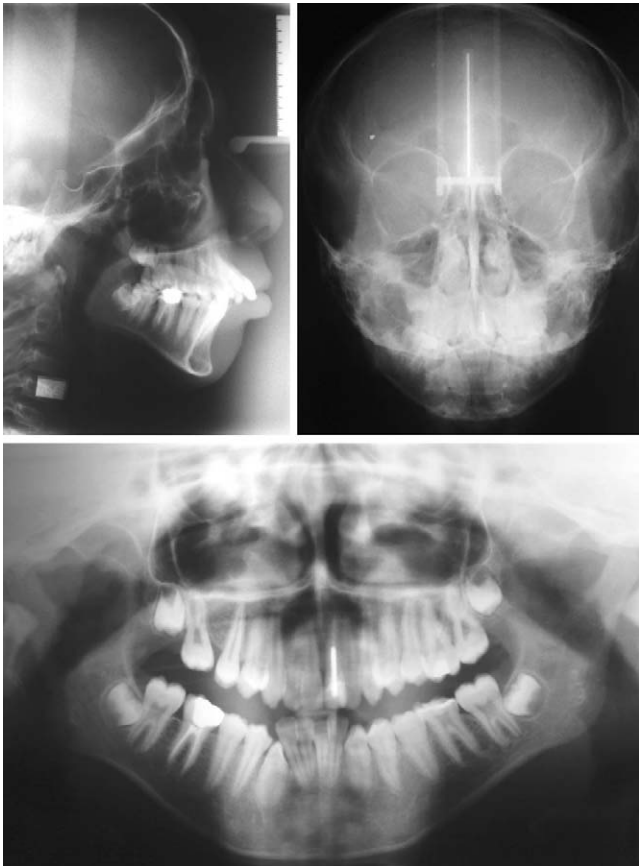


Figure 3. Pretreatment panoramic, lateral cephalometric, and posteroanterior radiographs of the patient.

Treatment Progress

The transverse constriction of the maxilla was treated by rapid palatal expansion. The amounts of transverse deficiency of the mandible and mandibular length deficiency were also taken into consideration during the rapid palatal expansion. The maxillary first premolars and first molars were banded, and a hyrax appliance was fabricated to correct the narrowness of the maxilla. The bonded appliance was turned one half turn per day (a quarter turn in the morning and a quarter turn in the evening). After 20 days, the desired expansion (10 mm) was achieved, and a screw was fixed in place for retention (Figure 4A,B).

One week later, a midsymphyseal osteotomy was performed under local anesthesia and sedation as described by Guerrero et al.¹⁰ A horizontal incision was made 5 to 7 mm labial to the depth of the vestibular sulcus, from canine to canine, and the muscle was reflected. The soft tissue above the incision was carefully elevated between the central incisors to provide access for the superior portion of the osteotomy. The inferior portion of the mental symphysis was sectioned vertically with a reciprocating saw. A small interdental osteotome was used with light tapping pressure to

Table 1. Pretreatment and Posttreatment Cephalometric Measurements

	Pre-treatment	Post-treatment
Skeletal analysis		
S-N-A (°)	77.0	77.0
S-N-B (°)	69.5	72.0
A-N-B (°)	7.5	5.0
Mandibular plane angle (S-N/Go-Gn) (°)	44.0	44.0
Anterior facial height (N-Me) (mm)	115.0	119.0
Posterior facial height (S-Go) (mm)	64.0	67.5
Face height ratio (%)	55.6	56.7
Wits appraisal (AO/BO) (mm)	5.0	−1.0
Dental analysis		
Maxillary incisor to A-Pg (mm)	15.0	12.0
Maxillary incisor to N-A (°)	34.0	24.0
Maxillary incisor to ANS-PNS (°)	124.0	113.0
Mandibular incisor to A-Pg (mm)	4.0	6.0
Mandibular incisor to N-B (°)	31.0	33.0
IMPA (Tweed) (°)	97.0	102.0
Overjet (mm)	10.0	2.5
Overbite (mm)	5.0	2.0
Soft tissue analysis		
Upper lip to E-line (mm)	3.0	−2.0
Lower lip to E-line (mm)	8.0	2.0
Nasolabial angle (°)	107.5	108.5

Table 2. Changes in Widths, as Measured on Posteroanterior Radiographs During Different Phases of Treatment

Width (mm)	Pre-treatment	Post-distraction	Post-treatment
Bicondylar	113	112	112
Bigonion	95	95	96
Biantegonion	80	84	85
Mandibular intermolar	56	63	60
Mandibular intercanine	23	32	28

complete the interdental osteotomy between the root tips of the central incisors, with care taken to avoid injury to the teeth.

Immediately after the osteotomy, a bone-supported distractor (Medartis, Modus MDO 2.0, Basel, Switzerland) was adjusted and tested for expansion (Figure 5). During a 7-day latency period, the patient was prescribed antibiotics and used a 0.012% chlorhexidine rinse. After the latency period, the distraction process was started at a rate of 1 mm, done twice daily. The mandible was widened approximately 10 mm (Figure 4C,D and Figures 6 and 7). A soft diet was prescribed for 4 weeks. A 3-month consolidation period followed, during which no tooth movement was attempted. At the end of the consolidation period, the distractor was removed under local anesthesia.

After the consolidation period, orthodontic treatment was initiated. Preadjusted appliances (0.022 × 0.028-

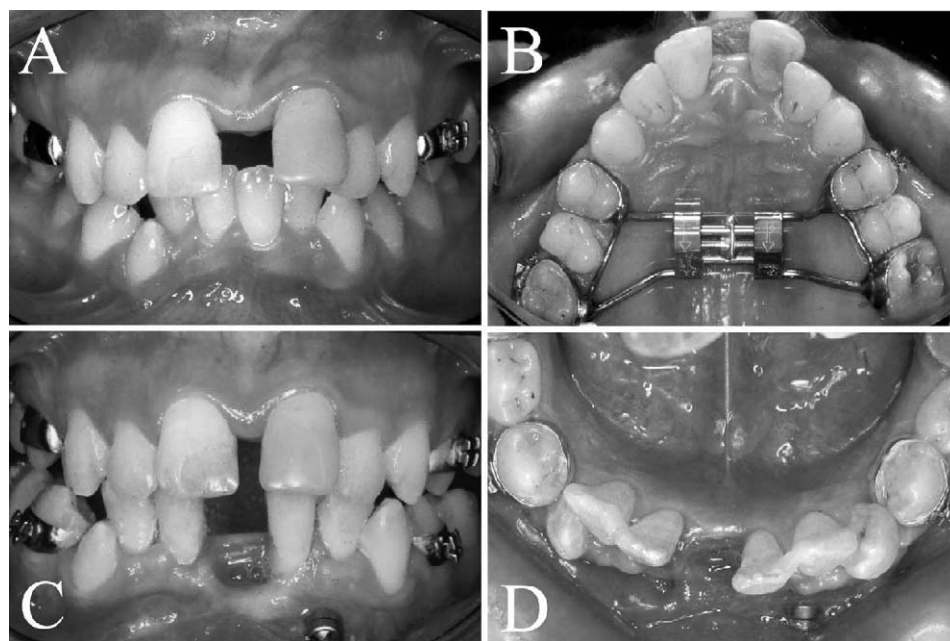


Figure 4. Clinical views after rapid palatal expansion (A,B) and after MSDO (C,D).

inch) were placed in both arches for leveling and alignment. Space closure proceeded with stainless steel wires and sliding mechanics. Power chains were used to close the distraction space. The orthodontic appliances were removed after active treatment was completed (Figures 8 through 10). A maxillary removable Hawley retainer and a mandibular fixed lingual retainer were constructed for the patient and delivered after debonding. Throughout the treatment period, the patient was extremely cooperative. The postdistraction phase of treatment lasted 8 months, resulting in a total treatment time of 12 months (Figure 11).

Treatment Results

By the end of treatment, the mandibular anterior crowding and maxillary constriction had been successfully corrected. The overjet was eliminated, and the overbite was corrected to approximately 25%. A favorable occlusal outcome was achieved, with acceptable intercuspation, and the patient's soft tissue profile was more balanced. The patient had no symptoms of temporomandibular dysfunction at the end of active treatment.

Although the maxillary incisors were uprighted during treatment, the mandibular incisors were still in a protrusive position relative to their apical base. The maxillary incisor inclination (maxillary incisor to ANS-PNS) was reduced from a pretreatment angle of 124° to a posttreatment angle of 113°. However, the mandibular incisor inclination (IMPA) increased from a pretreatment angle of 97° to a posttreatment angle of 102°. While the SNB angle had increased by the end

of treatment, SNA and mandibular plane angle (S-N/Go-Gn) maintained their pretreatment values (Table 1, Figure 12A).

The patient's mandibular intercanine width had increased from 23 mm at baseline to 32 mm just after distraction, but it had decreased to 28 mm by the end of treatment. The pretreatment mandibular intermolar width (56 mm) was also increased (to 63 mm) after distraction and it had decreased to 60 mm by the end of treatment. It was observed that MSDO had less effect on the condylar and gonial areas than on the anterior part of the mandible, as is apparent when viewed in the transverse plane (Table 2, Figure 12B). Additionally, the postdistraction posteroanterior radiograph demonstrated nearly parallel distraction at the skeletal basal bone and the alveolar bone (Figure 7C).

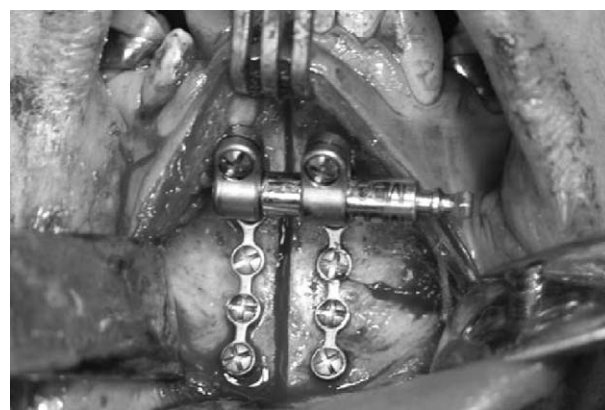


Figure 5. The bone-supported distractor and osteotomy design used.

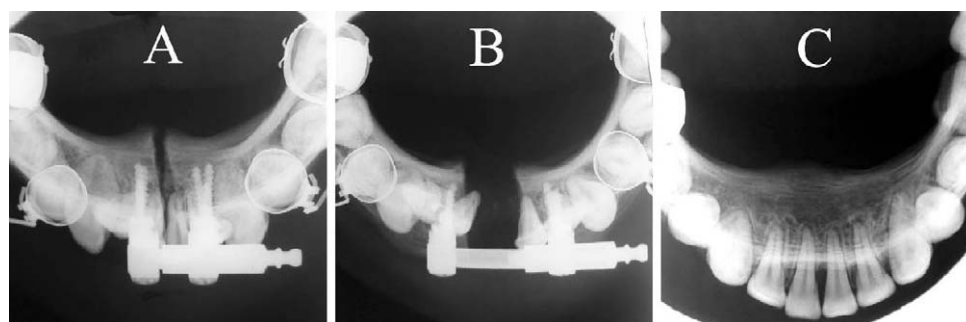


Figure 6. Occlusal radiographs of the mandible. (A) Immediately after surgery. (B) After completion of distraction. (C) After orthodontic treatment.

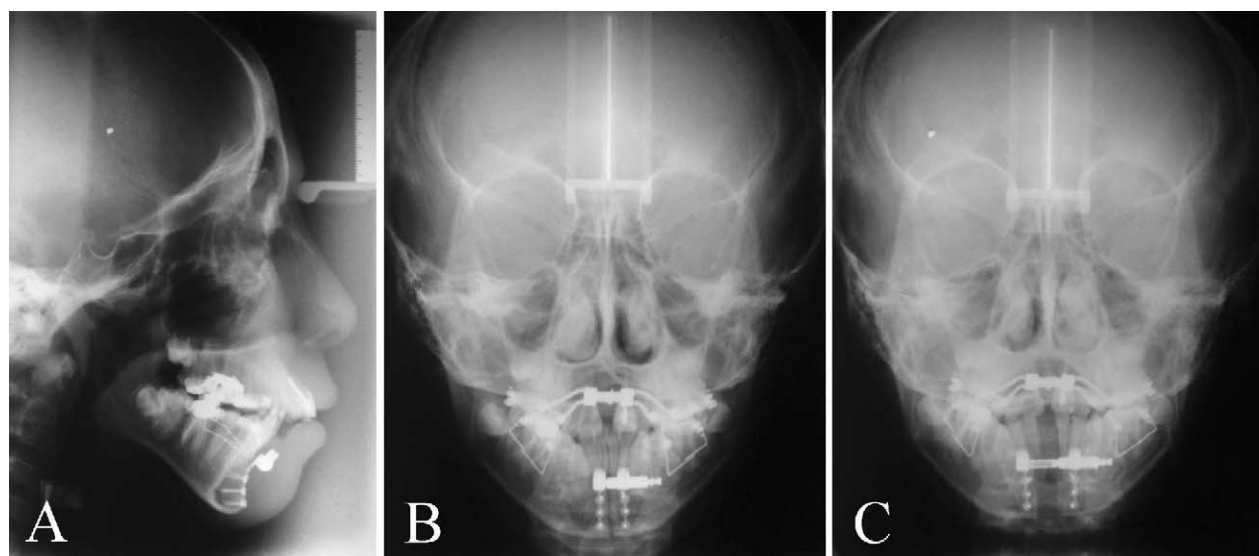


Figure 7. (A) Lateral radiologic view of the distractor. (B,C) Posteroanterior radiographs of the patient immediately after surgery and after completion of the distraction phase, showing that parallel distraction of basal and alveolar bone has occurred.



Figure 8. Posttreatment facial photographs.



Figure 9. Posttreatment intraoral photographs.

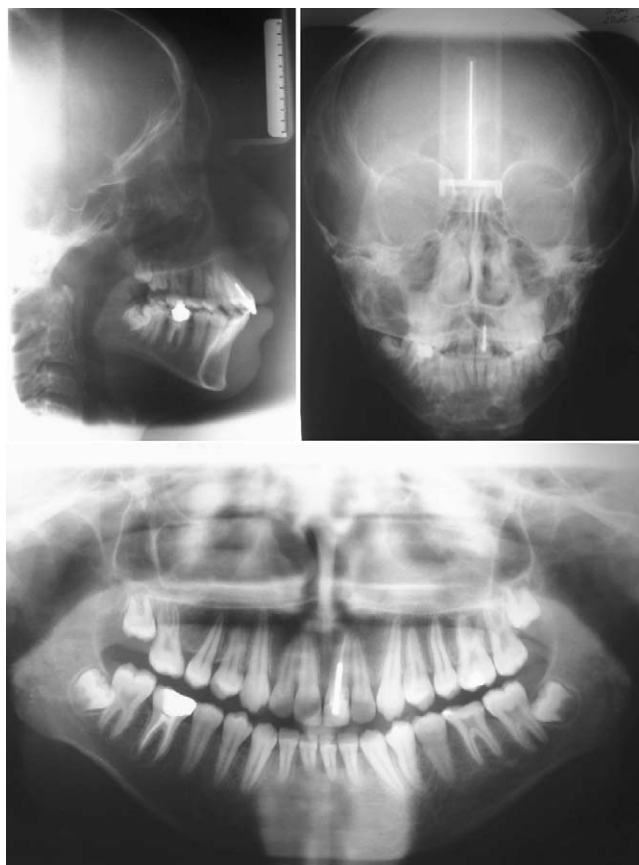


Figure 10. Posttreatment panoramic, lateral cephalometric, and posteroanterior radiographs.

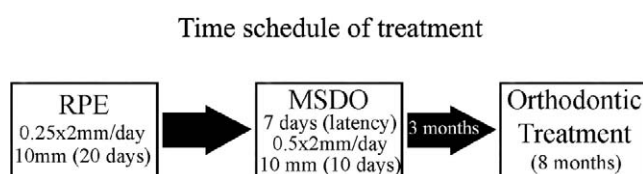


Figure 11. Timeline of treatment.

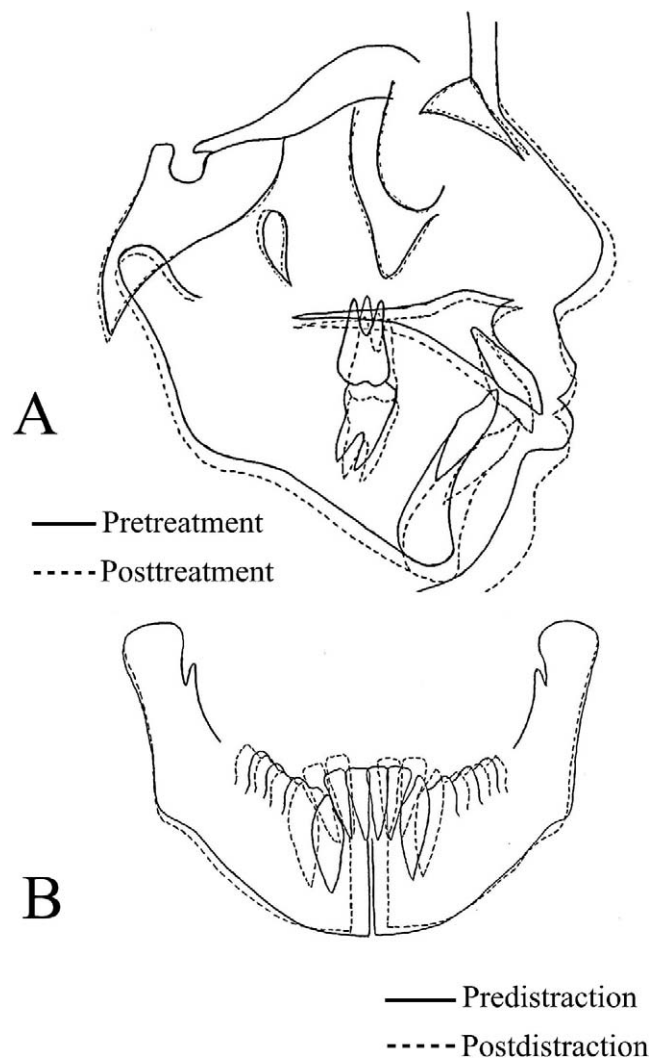


Figure 12. (A) Superimposition of pretreatment and posttreatment lateral cephalometric tracings. (B) Superimposition of mandibular tracings on predistractor and postdistractor posteroanterior radiographs.

DISCUSSION

The principal indication for widening the mandible is absolute transverse mandibular deficiency. Transverse mandibular deficiencies, such as excessively narrow or tapered arch form, dental crowding, and tipped teeth, require correction of the deformity in the transverse plane.^{18,21} Attention to transverse deficiencies is vital in planning treatment for patients who require an increase in the lateral dimensions of the mandible or maxilla.²¹ DO holds great potential to correct transverse mandibular deficiencies. Guerrero⁹ pioneered the use of mandibular midsymphyseal DO, calling it "surgical rapid mandibular expansion."

In previous clinical studies^{3,10} with tooth-supported distraction devices, disproportionate displacement patterns that result in a larger gap in the alveolar area than in the basal area have been observed. Disproportionate patterns have also been demonstrated with tooth-supported appliances in animal models.^{21,22} As noted, animal studies have shown that lateral movement of bone segments and dental tipping do not match, ie, the teeth moved approximately twice as far as the bone segments when tooth-supported DO devices were used.²³ Regardless of its cause, a disproportionate gap represents potential problems, because expanded alveolar bone, when not supported by basal bone, may be unstable and add to the risk of relapse.^{24,25} In contrast, Weil et al¹³ claimed that the distraction gap showed sagittal symmetry in all of their subjects after midsymphyseal mandibular widening with tooth-supported distraction devices attached to the mandibular first premolars and molars. On the other hand, bone-supported or tooth/bone-supported expansion devices have a greater potential to obtain proportionate movement than tooth-supported devices, so that more stable results can be expected.^{11,12}

The location of the distractor and orientation of vector of distraction are of fundamental importance because they might influence the shape of the distraction gap. Theoretically, if the force is applied near the center of resistance of the mandible, the distraction will produce pure translation of the bone segments and the distraction gap will have parallel margins. However, if the force is applied above the center of resistance of the mandible, rotation of the two bone segments might be expected, resulting in a disproportionately larger gap in the alveolar area than in the basal area.^{3,18} Başçiftçi et al¹⁸ claimed that a tooth/bone-supported or bone-supported distractor, placed on the mandibular anterior surface slightly above the apex of the mandibular incisors, would cause parallel expansion of the mandible.

Theoretically, MSDO should produce greater increases in the width of the anterior part of the man-

dible than in the posterior part. Del Santo et al³ claimed that when using a tooth-supported distractor, the greatest widening would be achieved at the symphyseal region, and the widening effect would gradually decrease from anterior to posterior.

Devices for symphyseal widening are classified as intraoral or extraoral.¹⁰ Because of esthetic desires, intraoral devices are often used, and these are divided into three categories: tooth-supported, hybrid, and bone-supported.²⁶ The advantages of the bone-supported device are that the same amount of expansion should occur at the basal and alveolar areas. In contrast, the disadvantages of bone-supported devices are the necessity of a second operation to remove the device, a longer operation time, and additional cost.

In the literature, rapid palatal expansion was applied before the application of mandibular midline DO in some studies.^{3,10,13,27,28} In the same way, before the application of MSDO, rapid palatal expansion was carried out in the present case. The amount of mandibular anterior crowding, maxillary and mandibular arch shape, expansion requirements of the maxilla, and coordination of both arches were taken into consideration during the present treatment plan.

In clinical orthodontics, reestablishment of the occlusion by movement of teeth into the new bone formed after DO is at the forefront of research. Cope and Samchukov²⁹ presented histologic and histomorphometric observations of bone formation during a consolidation period after mandibular DO. In a pilot study, Liou et al³⁰ showed that a tooth could be moved into regenerated bone, even early in the consolidation period. In an experimental study, Nakamoto et al³¹ determined that the rate of movement was much faster when the teeth were moved into immature new bone, as opposed to mature areas. However, severe root resorption also occurred, probably because of the greater force used and the greater bone remodeling activity in the immature bone. They recommended against the application of heavy forces and early orthodontic tooth movement when teeth are moved through new bone to avoid tipping and severe root resorption. In the light of these experimental studies, in the present case, tooth movement into the distraction space was begun after the consolidation period was completed.

Anteroposterior evaluation of the effects of MSDO indicated that the greatest widening was at the symphyseal region, and the widening effect gradually decreased from anterior to posterior. The present radiographic results confirmed that symphyseal distraction using a bone-supported device was proportional, and intercanine width increased more than intermolar width. Viewed occlusally, the width of the mandibular bone at the symphyseal region increased remarkably,

whereas the ramal and gonial regions of the mandible and the condyle showed minimal displacement. Our results showed that postdistraction orthodontic treatment largely resolved the crowding by moving teeth into the newly formed bone in the distraction gap. Some proclination of the mandibular incisors and some gingival recession at the mandibular central incisors region occurred as side effects in this case.

CONCLUSION

- a. MSDO with a bone-supported distractor can produce a greater transverse increase in the anterior part of the mandible than in the posterior part.
- b. MSDO with the bone-supported distractor has a greater potential for parallel movement of the segments in the vertical plane.
- c. Adequate mandibular basal and dentoalveolar bone expansion for relief of crowding may be achieved by MSDO using a bone-supported distractor.

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