Protraction of mandibular second and third molars into missing first molar spaces for a patient with an anterior open bite and anterior spacing

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In a young woman, aged 18 years 8 months, who had an anterior open bite and anterior spacing, the right and left mandibular first molar extraction spaces were closed by protraction of the second and third molars without reciprocal retraction of the incisors and the premolars. The amounts of protraction for the second molars were 12 mm on the right side and 11 mm on the left side. Two miniscrews were inserted into the mesiobuccal side of the edentulous spaces, and 2 more screws were inserted into the anterior sites after removing previous miniscrews. In addition, 4 miniscrews were inserted into the buccal and palatal sides between the first and second maxillary molars to intrude the maxillary posterior teeth, which had extruded into the missing mandibular spaces. Careful biomechanical consideration was used to prevent extrusion of the molars and worsening of the anterior open bite from protraction of the posterior teeth. Ultimately, the anterior open bite was corrected by both intrusion of the maxillary molars and extrusion of the maxillary anterior teeth. Excellent occlusion and correction of the anterior open bite were achieved without tipping, rotation of the posterior teeth, or other problems. The right mandibular third molar, which had been impacted at the beginning of treatment, erupted into the second molar space and functioned properly. At the 1-year follow-up examination, the patient had a slight anterior open bite, but closure of the first molar extraction spaces was well maintained. (Am J Orthod Dentofacial Orthop 2012;141:783-95)

When a mandibular first molar is lost, orthodontic replacement with second and third molars would be an excellent treatment option if success were guaranteed. Stepovich 1 presented the possibilities of these methods without severe complications, such as root resorption and tipping of adjacent teeth. At that time, however, the space was closed mostly by reciprocal movement of the anterior and posterior teeth, because no temporary skeletal anchorage devices were available. Roberts et al 2,3 used endosseous implants placed in the retromolar area to close missing first molar spaces by mesial movement of the mandibular molars. In recent years, orthodontic miniscrews, which are more convenient, simple, and cheaper than endosseous implants, have been used widely. Kyung et al 4 reported a 9-mm mesial movement of mandibular second molars, and Nagaraj et al 5 reported an 8-mm movement using miniscrews to close bilateral missing mandibular first molar spaces. Kravitz and Jolley 6 discussed problems, such as buccal proclination, during mandibular molar protraction with miniscrews.

Treatment is difficult when pure protraction of the second and third molars is required without retraction of the anterior and premolar teeth. In addition, treatment would be more complicated if the patient had an anterior open bite and long edentulous spaces.

Our patient was missing both mandibular first molars, and the maxillary first molars had extruded into the edentulous mandibular spaces. In addition, the patient had an anterior open bite. Protraction of the mandibular second molars was necessary, since there was no protrusion or crowding of the anterior teeth.

After treatment, good occlusion and the correction of the anterior open bite were achieved. The amounts of

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protraction of the mandibular second and third molars were 12 mm on the right side and 11 mm on the left side.

**DIAGNOSIS AND ETIOLOGY**

A young woman, aged 18 years 8 months, sought an orthodontic evaluation with chief complaints of an anterior open bite and spacing. She also wanted to close the missing mandibular first molar spaces by orthodontic tooth movement, if possible. The right and left mandibular first molars had been extracted 4 months previously, because of severe caries.

The patient had a straight profile with a slightly protruded chin. Vertically, she had a long face with a high gonial angle. No remarkable facial asymmetry was seen (Fig 1). Intraorally, she had anterior spacing in the mandibular arch, an anterior open bite (−1.0 mm of overbite), and an end-to-end incisor relationship (0.0 mm of overjet). Both mandibular first molars were missing. The dental casts showed that the lengths of the mandibular edentulous spaces were 11.5 mm on right side and 10.5 mm on the left side (Fig 2). The right and left maxillary first molars had extruded into the missing mandibular first molar edentulous sites. Without intrusion of these maxillary molars, protraction of the mandibular second molars would be difficult because of their potential contact against the maxillary molars.

The maxillary dental midline was coincident with the facial midline, and the mandibular dental midline was deviated 1.0 mm to the left. The canines exhibited a mild Class II occlusion, especially on the right side. To achieve a Class I occlusal relationship, the second molars would need to be protracted beyond the first molar extraction sites.

A panoramic radiograph showed long edentulous spaces and a slight mesial tilt of the left second molar in the mandible. The right third molar was impacted, but the developing status was good (Fig 3). Lateral cephalometric analysis (Fig 4, Table) showed a mild skeletal Class III relationship (ANB angle, 3.0°; Wits appraisal,
Vertically, the patient showed a long facial tendency (FMA, SN-MP angle, and ANS-Me/N-ANS) with an anterior open bite. Soft-tissue analysis showed a slight protrusion of the lower lip (lower lip to E-line, 2.5 mm).

The functional assessment showed no remarkable discrepancy between centric occlusion and centric relation, and no apparent signs and symptoms of temporomandibular joint dysfunction. There were no other medical or dental problems.
TREATMENT OBJECTIVES

We planned to maintain the anteroposterior position of the maxillary incisors, since there was no significant facial profile problem, except for the slight protrusion of the lower lip. The main treatment objectives consisted of protracting the mandibular second and third molars to close the missing first molar spaces and to correct the anterior open bite. Mandibular anterior spacing would be closed by retraction of the incisors and protraction of the premolars, because the protraction was needed to improve the existing Class II canine relationship. Vertical facial height would be maintained, because of the original long-face tendency.

TREATMENT ALTERNATIVES

Spaces caused by missing mandibular first molars can be corrected by prosthetic bridges, dental implants, autotransplantation of third molars, or mesial orthodontic movement of second and third molars. Prosthetic bridges offer the advantage of short treatment time.

### Table. Summary of cephalometric analysis

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Normal</th>
<th>1 SD</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>1 year after retention</th>
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</thead>
<tbody>
<tr>
<td>Maxillomandibular relationships</td>
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<td></td>
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<td></td>
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<td>SNA (°)</td>
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<td>2.8</td>
<td>80.0</td>
<td>80.0</td>
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<td>SNB (°)</td>
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<td>2.7</td>
<td>77.0</td>
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<td>3.0</td>
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<td>3.0</td>
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<td>Wits appraisal (mm)</td>
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<td>2.6</td>
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<td>−5.0</td>
<td>−4.5</td>
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<tr>
<td>Vertical skeletal relationships</td>
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<tr>
<td>Mandibular plane to SN (°)</td>
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<td>42.5</td>
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<td>Gonial angle (°)</td>
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<tr>
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<td>IMPA (°)</td>
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<td>Interincisal angle (°)</td>
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<td>Soft tissues</td>
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<td>Upper lip to E-line (mm)</td>
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<td>0.86</td>
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<td>Lower lip to E-line (mm)</td>
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<td>0.56</td>
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</table>

![Fig 5. Labiolingual archwire to intrude the maxillary first molars (top row); after 3 months, sufficient intrusion was achieved (bottom row).](image-url)
but must be accompanied by significant tooth preparation. Dental implants permit conservation of tooth structure but require surgery. Autotransplantation also requires surgery, and successful transplantation cannot be guaranteed. To improve facial esthetics and skeletal discrepancies such as a protruded chin, orthognathic surgery might be another option.

Our patient finally chose orthodontic replacement, because she wanted to correct additional tooth-position problems, including anterior spacing and an anterior open bite. She also hoped to avoid surgical trauma. The patient rejected orthognathic surgery, because she did not want dramatic changes in facial appearance and extensive surgical trauma.

**TREATMENT PROGRESS**

First, a labiolingual wire (0.9 mm stainless steel) was attached to several other teeth to reinforce anchorage and intrude the maxillary right and left first molars with an elastic thread (Fig 5). This technique intruded the maxillary first molars that were initially extruded into the missing mandibular first molar spaces. Preadjusted edgewise appliances with 0.018-in slots were bonded to the mandibular teeth after the maxillary first molar was sufficiently intruded. After leveling and alignment, orthodontic miniscrews (6.0 mm long, 1.5 mm diameter; Orlus, Seoul, Korea) were placed into the mesiobuccal sides of both missing mandibular first molar spaces under local anesthesia (Fig 6). Two weeks after placement, an elastic module (force, 150 g) was connected from the miniscrews to the hook of the bracket attached to both the right and left second molars. A 0.016 × 0.022-in heat-treated stainless steel wire was used as a working wire, and the right and left mandibular second molars were protracted with sliding mechanics.

During protraction, the anterior open bite worsened slightly because of posterior occlusal interference by...
the extruded mandibular second molars (Fig 7). We also observed mesial rotation of the mandibular molars, especially on the right side. To solve these problems, we changed the mechanics: (1) bands were removed from the second molars, and brackets were directly bonded onto the more mesial side of the second molars, and new brackets were bonded to both right and left third molars; (2) long buccal hooks were attached to the second molar brackets to protract the molars through their centers of resistance; and (3) the initial 2 miniscrews were removed before impeding the mesial movement of the second molars, even though the spaces were not completely closed.

Fig 8. The initial 2 miniscrews (mandibular) were removed, and 2 additional screws were placed between the mandibular first premolar and canine on the buccal side. Two other miniscrews were placed in the buccal side between the maxillary first and second molars to intrude them. During this time, both maxillary third molars were extracted simultaneously, and a transpalatal arch was attached to the lingual side of the maxillary molars to prevent buccal flaring.

Fig 9. Miniscrews were inserted into the palatal side to prevent buccal flaring of the maxillary molars. Complete closure of the missing first molar spaces can be seen, and there was no rotation of the molars.
Two additional miniscrews (6.0 mm long, 1.5 mm in diameter; Biomaterials Korea, Seoul, Korea) were placed on the buccal side between the mandibular first premolars and canines to help complete the protraction of the second molars. Two miniscrews (8.0 mm long, 1.5 mm in diameter; Biomaterials Korea) were placed into the buccal side between the maxillary first and second molars to correct the anterior open bite by intrusion of the maxillary molars. During this time, both the right and left maxillary third molars were extracted, and a transpalatal arch was attached to the palatal side of the maxillary molars to prevent buccal proclination (Fig 8). Two weeks after miniscrew insertion, protraction of the mandibular molars and intrusion of the maxillary molars were begun by using an elastic module and thread.

The anterior open bite improved as treatment progressed. Despite the use of the transpalatal arch, some proclination of the maxillary molars occurred, so 2 additional miniscrews (10.0 mm long, 1.5 mm in diameter; Biomaterials Korea) were inserted into the palatal side between the maxillary first and second molars to provide additional intrusive force from that side (Fig 9). A total of 8 miniscrews were used. Greater intrusion of the maxillary molars was achieved by using both the palatal and buccal sides. Consequently, the anterior open bite improved.

After finishing and detailing, the brackets and the miniscrews were removed. Active treatment time was 50 months. A 0.0175-in twisted-wire fixed retainer was attached onto the lingual surfaces of the anterior teeth in both arches immediately after debonding. Hawley retainers were also used in both arches.

**TREATMENT RESULTS**

All of the original treatment objectives were achieved. The maxillary and mandibular arches were well aligned and coordinated without midline deviations. Normal overbite and overjet were achieved (Fig 10). The final models showed favorable Class I molar and canine...
relationships and excellent intercuspation (Fig 11). Good functional occlusion was seen from the lingual aspect of the posttreatment dental cast. The edentulous spaces in the mandibular arch were completely closed by protraction of the second and third molars.

The premolars and the canines also moved slightly mesially; this helped to improve the Class II canine relationship seen at the beginning of treatment. As a result, the amount of mesial movement of the mandibular second
and third molars became greater than the span of the original missing spaces (12 and 11 mm on the right and left sides, respectively, compared with the original 11.5 and 10.5 mm). The mandibular anterior spacing was corrected both by retraction of the mandibular incisors and protraction of the mandibular premolars. The mesially tipped mandibular second molars were uprighted. The posttreatment panoramic radiograph showed good root parallelism (Fig 12). There was no remarkable root resorption. All teeth showed good alveolar bone height. The probing depths were 2.0 to 2.5 mm around the mandibular second and third molars. Posttreatment cephalogram and superimposed tracing shows the mesial movement of the second and third molar (Figs 13 and 14).

The maxillary incisors were retracted and extruded, which contributed to correcting the anterior open bite, but this increased the amount of visible gingivae when smiling. Gingival recontouring of the maxillary incisor area was recommended at the time of debonding. However, the patient rejected this option. The intrusion of the maxillary molars was another constituent for the correction of the open bite. There was no significant change in the facial profile with no increase in facial height. The lower lip was slightly retracted; this helped to improve the Class III profile. The changes in the upper lip and chin were minimal during treatment.

Wire fixed retainers were attached to the lingual aspect of each tooth from the right to the left canines in both arches. The patient wore a Hawley retainer for 15 hours per day for the first 2 months, followed by another 10 months of nighttime wear. After 1 year of retention, there was a slight relapse of the anterior open bite, but the amount was minimal. The mandibular edentulous spaces did not reopen. Comparison of the posttreatment and 1-year retention facial photos and cephalograms showed only minor dental and skeletal changes (Figs 15-18; Table).

**DISCUSSION**

Recently, there have been more reports about orthodontic protraction of the second and third molars into missing first molar spaces.\(^4^\)\(^-^\)\(^6^\) Compared with other cases previously reported, our patient is different in several ways. First, the edentulous spans were longer (11.5 and 10.5 mm). Second, the edentulous spaces were closed entirely by protraction of the second and third molars. In addition, the canines and the premolars were also protracted to correct the Class II canine relationships. As a result, the final amounts of mesial movement of the second and third molars were 12.0 and 11.0 mm on right and left sides, respectively.
The more the molars move, the greater the risk of complications.

During the movement of a tooth over a long distance, tipping is a big concern. To prevent mesial tipping, a heat-treated \(0.016 \times 0.022\)-in stainless steel wire was inserted and changed at every visit. Long buccal hooks attached to the second molar brackets were also used to protract the teeth through their centers of resistance. Other special devices, such as a molar uprighting spring, were not used. Some tipping of the left mandibular second molar occurred in the later stages of protraction; this was easily solved by rebonding the brackets with angulation control. The final and 1-year retention panoramic radiographs showed good root parallelism (Figs 12 and 16). Stepovich \(^1\) also demonstrated that posterior mandibular edentulous spaces could be closed without tipping.

When protracting molars, mesial rotation of the protracted teeth might occur, creating a posterior cross-bite. \(^6\) Kyung et al \(^4\) connected the right and left mandibular second molars with a rigid lingual arch and protracted the molars from a lingually placed miniscrew to prevent mesial rotation during protraction. However, the lingual arch might not only cause discomfort to the patient, but also interfere with any further movement of the molars. In addition, the lingual arch...
should be remade when it touches the lingual side of the anterior teeth. Lingual placement of a miniscrew is difficult, because of poor visibility and accessibility. Nagaraj et al.\textsuperscript{5} prevented rotation of the molars with an elastic chain from the lingual side of the molars to a button on the canine. Kravits and Jolley\textsuperscript{6} recommended the use of a sliding band with a lingual arch. In our patient, this problem was minimized by placing an antirotation bend in the posterior portion of the archwire. Despite our efforts, a slight mesial rotation occurred on the right second molar during protraction (Fig 7). Therefore, we removed the bands and bonded the brackets toward the mesial sides of the teeth. At debonding, there were no rotations or crossbites of the second and third molars (Figs 10 and 11).

The third different feature was that this patient had an anterior open bite and a long face before treatment. Jung and Kim\textsuperscript{8} demonstrated some different biomechanics in the skeletal anchorage system. The entire arch rotates around the center of rotation of the dentition in the miniscrew retraction system. Therefore, when posterior teeth are protracted, the molars would be extruded, and an anterior open bite would worsen. To solve these problems, the following methods were used. First, a long hook was attached to the second molar brackets to put the protracting force near the center of rotation. Second, the replacement miniscrews were inserted into more anterior and deeper sites at the later stage of the protraction (Fig 8), when the second molars were able to meet the initial miniscrews before complete closure of the edentulous space. Deeper positioning of the miniscrews helped to prevent extrusion and tipping of the second molars during protraction (Fig 19). Third, the maxillary molar intrusion was achieved by miniscrews (Fig 9). Usually, intrusion of the maxillary molars causes extrusion of the mandibular molars and vice versa. Sugawara et al.\textsuperscript{9} reported maxillary molar extrusion during mandibular molar intrusion. This phenomenon also occurred in our patient. The mandibular molar extrusion shown in Figure 14 was caused by both protraction and counteraction during the maxillary molar intrusion. The result would have been better if there had been a treatment to inhibit the extrusion of the mandibular molars such as miniscrew insertion.

Another important concern is the size of the edentulous ridge. The edentulous alveolar ridge might undergo resorption with time after extraction of the teeth.\textsuperscript{10} This problem could complicate tooth movement. It could take more time for orthodontic movement, and the narrow ridge could cause root dehiscence, resorption, or other periodontal problems. The best timing of extraction is just before mesial traction. Leveling and alignment of the teeth should be finished before traction in sliding mechanics. In our patient, the mandibular right and left first molars were extracted at another clinic 4 months before our orthodontic treatment. Hence, the leveling and alignment could not be achieved before extraction. Yet, the relatively short latent period between extraction and protraction might have allowed for good treatment results without the side effects mentioned earlier.

In the beginning of the treatment, the mandibular right third molar had a developing root and was completely covered with soft tissue. If the space for mesial movement of the third molar were created orthodontically, then the development and emergence of the tooth might be promoted.\textsuperscript{11,12} In our patient, only leveling and alignment were performed on the anterior segment of the mandibular dentition during the initial stages. At that time, there was little change in the third molar (Fig 6). After 6 months of protraction of the second molar, the crown of the third molar emerged into the oral cavity (Fig 7). In the final stage of treatment, the third molar was fully erupted and resembled a second molar (Figs 10 and 11). The complete exposure of the third molar might decrease the possibility of infection from plaque accumulation, the biggest problem of impacted third molars.

The total treatment time was long (50 months). Closure of the long edentulous span could have caused the long treatment time, but trial errors were also part of the reason. In the later stages of treatment, tipping and mesial rotation of the second molars required rebonding of the brackets. If the brackets had been well positioned at

![Image](image_url)
first, considering these factors, the length of the treatment would have been shorter.

The patient had a slight relapse of the anterior open bite 1 year after appliance removal (Figs 17 and 18). This relapse was due to a slight extrusion of the maxillary molar during the retention phase; this was verified by superimposition of the posttreatment and retention tracings (Fig 18). Sugawara et al previously reported a relapse rate of 27.2% to 30.3% at 1 year after debonding. Relapse rates after molar intrusion are more than that of other tooth movements such as mesiodistal movement or rotation for several reasons: (1) other types of tooth movement are characterized by the formation of new bone, which inhibits relapse after tooth movement, but new bone cannot be formed after molar intrusion; and (2) apical periodontal tissues reorganize more slowly than tissues in other sites. To prevent relapse after intrusion, Ohtani recommended long mechanical retention periods of more than 16 weeks. In our patient, if traction treatment for maxillary molar intrusion had been applied for a longer time, relapse of the intruding molar might have been reduced.

Relapse can also occur after orthognathic surgical treatment of an anterior open bite. Bailey et al and Proffit et al reported various relapses after superior repositioning of the maxilla by LeFort I osteotomy that were observed during long-term follow-ups. It is difficult to predict the maintenance of vertical closure over the long term, because there are many contributing factors and numerous types of relapses.

As mentioned previously, there are several options for treating missing mandibular first molars. Autotransplantation is a good option, when it is important to conserve the teeth and their innate periodontal structure, and is favorable because it does not require the use of artificial materials. However, the transplantation procedure can result in surgical trauma, root resorption, ankylosis,
and infection, and the success rate of the procedure varies.18-20 Of the other feasible methods, orthodontic replacement of missing first molars with posterior teeth does not produce surgical trauma except during miniscrew insertion. Furthermore, if a patient also desires orthodontic treatment for other problems, the additional treatment time required is minimal, and the extra financial burden associated with installation of a bridge or an implant becomes unnecessary. In this sense, protraction of posterior teeth into edentulous spaces might be called "orthodontic transplantation." This type of treatment could become more popular with the development of temporary anchorage devices. The analysis of this case might broaden the scope of possibilities for this type of treatment.

CONCLUSIONS

Bilateral orthodontic traction of the mandibular second and third molars into the mandibular first molar edentulous spaces was possible without retracting the anterior teeth in a complicated case with an anterior open bite and large edentulous spans.

REFERENCES