The use of miniscrew as orthodontic anchorage in correction of maxillary protrusion with occlusal cant, spaced arch, and midline deviation without surgery

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This report describes the use of the miniscrew as orthodontic anchorage in maxillary protrusion with a spaced arch and midline deviation in a 16-year-old female patient. In cases with midline deviation, a cant in the maxillary occlusal plane is often observed. Thus, the authors used the miniscrew to control the vertical dimension, thereby flattening the maxillary occlusal plane, and to close and retract the incisors to improve her convex profile. Effective incisor intrusion to correct the deep overbite was also observed. In addition, functional evaluation by a 6-degrees-of-freedom jaw movement recording system was performed. Significant improvement in the jaw movement was observed during maximum opening and lateral excursion during the retention phase. The authors suggest that miniscrews are effective in correcting midline deviation due to maxillary occlusal cant and intrusion and retraction of incisors, and may result in favorable functional movement of the jaw. ORTHODONTICS (CHIC) 2013;14:e156–e167. doi: 10.11607/ortho.867

Key words: occlusal cant, maxillary protrusion, midline discrepancy, spaced arch, miniscrew

In recent years, miniscrews have been used to correct various types of malocclusion. The use of the miniscrew has been proven to be useful in correcting discrepancy and problems in the anteroposterior dimension, including severe Class III¹,² and III cases,³ and also in the vertical dimension, such as in open bite⁴,⁵ and deep bite cases.⁶,⁷ Correction of occlusal cant by the use of miniscrews with⁸,⁹ or without¹⁰ surgery is also reported in Class III cases. In Class III cases with a canted occlusal plane, the use of miniscrews in the maxilla to correct the cant may result in surgery in a single arch instead of maxillomandibular surgery.⁸,⁹ Occlusal cant is observed not only in Class III cases but also in Class II cases. In Class II cases, if adequate correction of the occlusal cant is achieved by the use of the miniscrew, orthognathic surgery could be avoided. However, there has been no report of correcting the occlusal cant using the miniscrew in Class II cases without surgery in the past.
Space management is extremely important in correcting a spaced arch with a midline deviation. In order to correct the midline, asymmetric space closure is required. Furthermore, in order to correct the convex profile and increased overjet, distalization of molars is also needed; otherwise, extraction of premolars would be indicated. With conventional orthodontic treatment methods, headgear, intraoral appliances, and elastics are used to reinforce anchorage and to distalize molars.\textsuperscript{11,12} However, headgear and elastics require patient cooperation, and with the use of intraoral appliances reciprocal force is inevitable, resulting in loss of anchorage compared with miniscrews.\textsuperscript{1,13} In correcting midline deviation, anchorage is crucial, especially on the contralateral side. Thus, precise control in orthodontic force to close the space is necessary. Moreover, without the use of miniscrews, canine retraction prior to incisor retraction is necessary for anchorage, which may result in additional treatment time. With the use of miniscrews, en masse retraction is possible and may result in shorter treatment time. However, there has been no study that reports the use of miniscrews in correcting the spaced arch with midline deviation.

In cases with a canted occlusal plane, midline deviation is often observed. Generally, the mandibular midline deviates to the side to which the occlusal plane is tilted. In these cases, functional problems such as asymmetric and restricted movement of the condyle is often observed and may lead to temporomandibular joint disorder.\textsuperscript{8} By flattening the cant of occlusal plane, mandibular deviation should be corrected, which may lead to improvement of jaw function. However, no study has functionally evaluated the effect of correcting the canted occlusal plane by the miniscrew. Moreover, occlusal force and/or occlusal area tends to decrease right after the debonding, and during the retention phase settling is known to occur, resulting in increase in the occlusal force and occlusal area.\textsuperscript{14} Therefore, we performed functional evaluation at the time of initial debonding and 1 year after the retention, assessing the functional change.

In this report, we demonstrate the use of miniscrews as an anchorage that effectively facilitated orthodontic treatment in correcting a canted occlusal plane, midline deviation, spaced arch, deep overbite, and convex profile. Furthermore, functional evaluation was performed during the retention phase to observe the change in the functional aspect.

CASE REPORT

A 16-year-old female patient visited the outpatient clinic of our university hospital with a chief complaint of protruded maxilla and spaced arch (Fig 1). She had a convex profile (maxillomandibular dentoalveolar protrusion) and an asymmetric frontal view (mandible shifted to the right side), with strain on the mentalis. Cephalometric analysis showed a skeletal Class II jaw relationship (ANB: 7.3 degrees) with an average mandibular plane angle (MP-SN: 31.9 degrees). Increased axial inclination of the maxillary (U1-SN: 116.9 degrees) and mandibular (L1-MP: 98.1 degrees) incisors was observed (Fig 2 and Table 1). There was approximately 4 mm of occlusal cant according to the posteroanterior cephalometric radiograph (Fig 3). The maxillary dental midline was shifted 2 mm to the left side from the facial midline. The mandibular midline was also shifted 2 mm to the right side from the facial midline. Furthermore, the cephalometric radiograph taken in the rest position revealed that there was approximately 3 to 4 mm of opening at the posterior teeth (see Fig 2b). The clinical examination found Class I canine and molar relationships on both sides and spacing in the maxilla (+8.0 mm) and in the mandible (+2.5 mm). Overbite was 5.0 mm with the mandibular incisors biting the maxillary palatal gingiva, and
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overjet was 9.5 mm. The patient was diagnosed with skeletal Class II, Angle Class I maxillary protrusion with canted occlusal plane, spaced arch, and deep overbite.

Fig 1  Pretreatment facial and intraoral photographs.

Fig 2  (a) Pretreatment cephalometric radiograph. (b) Cephalometric radiograph taken during treatment. Notice the 3- to 4-mm bite opening at rest (arrow). (c) Pretreatment panoramic radiograph. The floor of the maxillary sinus was close to the roots of first molar and second premolar on the right side (arrow).
Table 1  Summary of cephalometric analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>Difference</th>
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<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angular (degrees)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SNA</td>
<td>81.5 3.3</td>
<td>86.2</td>
<td>84.5</td>
<td>–1.7</td>
</tr>
<tr>
<td>SNB</td>
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<td>78.1</td>
<td>–0.9</td>
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<tr>
<td>ANB</td>
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<td>7.3</td>
<td>6.4</td>
<td>–0.9</td>
</tr>
<tr>
<td>MP-SN</td>
<td>34.5 6.1</td>
<td>31.9</td>
<td>32.9</td>
<td>1.0</td>
</tr>
<tr>
<td>U1-SN</td>
<td>106.0 7.5</td>
<td>116.9</td>
<td>101.3</td>
<td>–15.6</td>
</tr>
<tr>
<td>L1-MP</td>
<td>95.2 6.2</td>
<td>98.1</td>
<td>94.6</td>
<td>–3.5</td>
</tr>
<tr>
<td>L1-FH</td>
<td>56.7 7.8</td>
<td>55.8</td>
<td>58.3</td>
<td>2.5</td>
</tr>
<tr>
<td>IIA</td>
<td>124.2 8.6</td>
<td>113.1</td>
<td>131.3</td>
<td>18.2</td>
</tr>
<tr>
<td>OP</td>
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<td>14.6</td>
<td>16.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Linear (mm)</td>
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<tr>
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<td>74.2</td>
<td>75.3</td>
<td>1.1</td>
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<tr>
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<td>123.8</td>
<td>126.3</td>
<td>2.5</td>
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<td>Me-NF</td>
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<td>68.4</td>
<td>70.6</td>
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<tr>
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<td>24.4</td>
<td>25.4</td>
<td>1.0</td>
</tr>
<tr>
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<td>32.9</td>
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<td>1.0</td>
</tr>
<tr>
<td>Overjet</td>
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<td>9.5</td>
<td>3.3</td>
<td>–6.2</td>
</tr>
<tr>
<td>Overbite</td>
<td>3.3 1.7</td>
<td>5.0</td>
<td>3.3</td>
<td>–1.7</td>
</tr>
</tbody>
</table>

Treatment objectives were to correct the lip protrusion, spaced arch, deep overbite, and occlusal cant; establish an ideal profile; and achieve an adequate functional Class I occlusion. We planned to use miniscrews in the maxilla for anchorage to close and retract the incisors, flatten the occlusal plane, and distalize the maxillary molars. Since there was 3 to 4 mm of opening at rest position, extrusion of the molars was indicated. Thus, we planned to intrude the maxillary right molars to create a reciprocal force that would result in extrusion of the maxillary left molars. After intrusion of the maxillary right molars, vertical elastics would be used to extrude the mandibular molars from the maxillary miniscrew to close the maxillomandibular space. In addition, maxillary incisors were planned for intrusion using a power chain attached from the miniscrew to a hook.
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The treatment sequence of the present case was as follows:

1. Leveling and alignment of the maxilla and mandible
2. Insertion of the miniscrew in the maxilla
3. Transpalatal arch in the maxilla (Fig 4a)
4. Intrusion of the maxillary right segment (Figs 4b and 4c)
5. Use of elastics to extrude the right mandibular molars from the maxillary miniscrew (Fig 4d)
6. Retraction of the maxillary arch after the correction of the occlusal cant, especially on the right side to correct midline deviation of the maxilla (Figs 4e to 4g)
7. Intrusion of the maxillary incisors (Fig 5a)
8. Detailing (continue to retract maxillary anterior to the right to correct midline and maintain intrusion of the incisors) (Figs 5b to 5d)
9. Retention

Fig 4 Illustrations and intraoral photos of mechanics used in this case. A transpalatal arch was set in the maxilla (a), followed by intrusion (arrow in b) of the right posterior segment by the ligature wire (arrow in c) to the miniscrew (b and c). (d) After intrusion of the right segment, extrusion of the mandibular posterior segment was achieved by power chain (arrow) attached to the maxillary miniscrew. (e to g) Space closure and the anterior retraction was done by the power chain attached from the miniscrew to the hook.
Since her chief complaint was protruded upper and lower lips, the first alternative was edgewise treatment with extraction of first premolars. However, since she had a significant amount of space in the maxilla, we decided that extraction was not necessary to correct the profile if maximum anchorage was possible. Moreover, extracting the mandibular premolars may have rendered the vertical control difficult because of the increased overbite.

The second alternative was the use of headgear and Nance palatal arch with intermaxillary elastics. However, headgear and intermaxillary elastics require patient cooperation, and the use of intermaxillary elastics tends to extrude molars and results in clockwise rotation of the mandible. Since she had incompetent lips, clockwise rotation of the mandible would exacerbate the strain on the mentalis.

After a preadjusted edgewise appliance with 0.018-inch slots was placed, miniscrews (6 mm long, 1.3 mm in diameter; Absoanchor, Dentos) were placed in the maxilla between the left second premolar and first molar and between the right first and second premolar. The reason for placing the miniscrew between premolars on the right side was because radiographic evaluation revealed that the floor of the maxillary sinus was close to the roots of first molar and second premolar (see Fig 2c). Miniscrews were implanted through a self-tapping method with the patient under local anesthesia. After leveling the canted occlusal plane, 150 g of retracting force by a nickel titanium coil spring (Sentalloy closing coil spring, GAC) was applied from the miniscrew to the hook between the lateral incisor and the canine attached to the wire. Space closure, correction of the midline by flattening the occlusal plane, and incisor intrusion was done in 11 months. Miniscrews were stable during treatment and were removed under topical anesthesia. After debonding and debanding, circumferential retainers were placed in both arches. Total active treatment time was 20 months.
A well-aligned dentition and harmonious facial balance were obtained (Fig 6). The facial profile was improved by retracting the maxillary incisors. Muscle strain of the mentalis disappeared. The asymmetric facial appearance also has been improved. Canine and molar Class I relationships were achieved with adequate overjet and overbite after the space closure and retraction of the maxillary teeth. Furthermore, the occlusal cant was flattened, midline deviation was corrected, and the maxillary and mandibular dental midlines corresponded (Fig 7).

Cephalometric superimposition showed that the ANB angle was decreased from 7.3 to 6.4 degrees. Maxillary incisors were retracted approximately 7.0 mm, and U1-SN changed from 116.9 to 101.3 degrees (Fig 8). Maxillary incisors were also intruded approximately 3.0 mm. Mandibular incisors were retracted, and L1-MP changed from 98.1 to 94.6 degrees and intruded about 2.0 mm. The interincisal angle increased from 113.1 to 131.3 degrees. The mandibular plane angle increased from 31.9 to 32.9 degrees and slightly rotated in a clockwise direction (see Table 1).

In addition, since midline deviation was observed pretreatment, we examined the jaw movement using a 6-degrees-of-freedom jaw movement recording system (Gnathohexagraph system version 1.31, Ono Sokki) at the time of initial
debonding and 1 year after (Table 2). For comparison, Japanese standards of jaw movement for an adult female are also shown in Table 2. After 1 year, during the maximum opening, mandibular deviation was seen to be significantly improved from a horizontal view in both sides of the condyle. In lateral movement, asymmetric incisor movement on the left side was also improved. In maximum anterior movement, improvement in symmetric movement of both condyles was observed from a sagittal condyle view. Furthermore, the occlusal contact area was increased from 7.62 to 14.5 mm², and the occlusal force increased from 461 to 548 N during the 10-month retention phase.
DISCUSSION

Correction of the canted occlusal plane and midline deviation

Initially, a significant amount of midline deviation was observed. An asymmetric appearance was also observed in the frontal facial photograph. The maxillary dental midline was shifted 1 to 2 mm to the right of the facial midline, and the mandibular midline was shifted 2 mm to the left of the facial midline. We diagnosed that the midline deviation of the mandible was due to the cant of the occlusal plane in the maxilla. Therefore, we planned to correct the midline deviation by retracting the maxillary right segment and by leveling the occlusal cant using a miniscrew. In correcting the occlusal cant, the decision regarding whether intrusion and/or extrusion of molars is required should be carefully assessed. Generally, with an increased mandibular plane angle, intrusion of molars on one side is preferable. It is known that the mandibular rest position serves as a reference position for restoration of the vertical dimension during prosthetic reconstruction and as a guideline for orthodontic treatment procedures.16,17 The cephalometric method is known to be reliable in registering the rest position.18,19 In this case, since there was 3 to 4 mm of space between the maxilla and mandible in the rest position and a decreased mandibular plane angle was observed, we planned to extrude on one side (left molars) and intrude on the other side (right molars) to flatten the occlusal plane. We also thought that using the reciprocal force of the contralateral molar would accelerate the duration of leveling the occlusal cant compared with intruding or extruding one side of the arch. As a result, it took only 4 months to level the canted occlusal plane. Thus, we conclude that miniscrews are useful devices in leveling the cant of the occlusal plane without surgical intervention.

*Note that there was a significant reduction in the difference in the amount of right and left mandibular movement.
Correction of the convex profile and spaced arch

In the present case, one of the main problems and the patient’s chief complaint was the convex profile. Generally, extraction is preferable in order to retract the anterior teeth and change the profile. In this case, approximately 8.0 mm of space was present in the maxilla. Thus, we decided to not extract the teeth and use all of the space to retract the anterior teeth. It was known that maximum anchorage would be essential to retract the incisors. With conventional orthodontic treatment, headgear and an intraoral appliance such as the Nance holding arch would be required in this case. However, the use of headgear depends mainly on patient cooperation, and the Nance appliance is known to result in reduced hygiene under the acrylic resin button, causing inflammation of soft tissue. Therefore, we decided to use miniscrews to maximize the retraction of the anterior teeth.

In this case, no anchorage loss was observed in the maxillary molars. Since we planned to retract the incisors, not only closure of the space but also molar distalization was planned to improve the convex profile and to correct the Class II canine relationship on the right side. Thus, slight distal movement of the right molars was observed in the superimposition of the cephalometric tracings. This distal movement of molars by the use of miniscrews has been reported previously. Since the initial right molar relationship was Class I, it was finished as slightly Class III posttreatment. However, in Asian patients, since there is a Bolton discrepancy (wide maxillary anterior teeth), we prefer to finish in a slight Class III rather than Class I molar relationship. This results in a Class I canine relationship. Therefore, we conclude that the use of miniscrews is very effective in spaced arch malocclusion.

In order to treat this case with a conventional orthodontic treatment method, Class II elastics would have been essential to correct the full Class II canine relationship (maxillary canine occluding between the mandibular lateral incisor and canine) into a Class I relationship. The use of Class II elastics would extrude the mandibular molars and result in clockwise rotation of the mandible. We suggest that distalization of the molars allowed correction of the Class II canine relationship and maxillary midline deviation using miniscrews. Furthermore, with the conventional method, not only elastics but also the use of intraoral appliances, open coil, and wire bending such as loops and tip-back bends to cancel reciprocal force may have been required to treat this case. With the use of the miniscrew, no complex wire bending is needed, and by simply changing the amount of force of the closed coil attached from the miniscrew to the hook, distalization of molars and correction of the midline was possible.

Incisor control

With conventional orthodontic treatment, canine retraction prior to incisor retraction would be necessary to prevent anchorage loss in this case. This may take additional time to close the space and retract the anterior segment. Since en masse retraction is possible without the loss of anchorage in miniscrew cases, shorter treatment time is indicated. In this case, we started retracting the anterior teeth (incisors) as we retracted the canine from the miniscrew. It took only 11 months to close the space, correct the midline, retract the anterior segments, and to intrude the incisors. Sequential space closure and retraction may be achieved in shorter duration with the use of a miniscrew compared with conventional methods in cases with protruded spaced arch malocclusion. As a result, a significant amount of incisor retraction was possible without patient cooperation.

Miniscrews are also known to be effective in controlling the vertical dimension. In this case, correction of deep overbite was necessary by extruding the molars or by intruding the incisors. However, strain on the mentalis was observed from the initial facial photograph; therefore, intrusion of incisors rather
than extrusion of molars was preferable. Thus, at the later stage of anterior retraction, we changed the short hook to a long hook in order to intrude the incisors. Superimposition indicated approximately 3 mm of intrusion of the maxillary incisors, and we suggest that adequate incisor control resulted from using the miniscrew as anchorage in this case. From the cephalometric superimposition, even with the use of miniscrews on the maxilla, slight mandibular molar extrusion was observed. However, vertical growth of the mandible helped minimize the clockwise rotation. Thus, in order to control the vertical dimension, miniscrews may have also been needed in the mandible.

**Functional evaluation**

There has been no study that functionally evaluated the effect of correcting the canted occlusal plane using miniscrews. In this case, since a significant amount of space was present in the arch, there was a concern with regard to the stability of occlusion during the retention phase. Furthermore, since we have corrected the midline deviation, the stability of jaw movement was also a concern in this case. Thus, jaw movement was carefully evaluated using a 6-degrees-of-freedom jaw movement recording system during the retention phase. As a result, significant improvement of the jaw movement was observed during the retention phase. In particular, shifting of the mandible (to the right side) at the condyle completely disappeared, and asymmetric incisor movement during lateral movement as well as asymmetry of the right and left condyle movement during maximum anterior movement was also improved. We suggest that the improvement of jaw movement is the result of the flattened occlusal cant that resulted in the correction of midline deviation. Occlusal contact and occlusal force also increased during the retention phase, which is consistent with past reports. Throughout the retention period, the increase in occlusal contact area and occlusal force may suggest an ideal occlusal relationship, perhaps indicating a stable functional occlusion. Therefore, we suggest that the present orthodontic treatment resulted in not only improvement of occlusion and esthetics, but also functional jaw movement. Orthodontic treatment evaluation is mainly morphologic and static, but the functional and dynamic aspect should be evaluated as well. The findings suggest that a 6-degrees-of-freedom jaw movement recording system may be useful for evaluating functional change after orthodontic treatment such as correcting the cant of the occlusal plane.

**CONCLUSIONS**

Miniscrews are useful devices in retracting the anterior segment by en masse space closure with the correction of deep overbite and flattening the occlusal cant, resulting in the correction of the midline deviation without complex wire bending and therefore in a shorter retraction period compared with conventional orthodontic methods. Furthermore, correction of the canted occlusal plane resulted in not only static but also dynamic functional improvement in this study. We suggest that the miniscrew is the most effective method for avoiding surgery in the correction of cases with a canted occlusal plane.
REFERENCES


