Original Article

Microscrew Anchorage in Skeletal Anterior Open-bite Treatment
Chunlei Xuna; Xianglong Zengb; Xing Wangc

ABSTRACT
Objective: To evaluate the effectiveness of miniscrew anchorage for intrusion of the posterior dentoalveolar region to correct skeletal open bite.

Materials and Methods: The study was comprised of 12 patients (aged 14.3 to 27.2 years; mean 18.7 years) with anterior open bites. All the patients presented a Class II skeletal pattern and excessive posterior growth. Self-drilling miniscrew implants were inserted into the posterior midpalatal area and the buccal alveolar bone between the lower molars. A transpalatal and a lingual arch were used to maintain the molars on each side in order to avoid overrotation during intrusion. A force of 150 g was applied to the microscrews on each side to intrude the posterior teeth. Lateral cephalograms of all 12 patients were taken preintrusion and immediately after completion of the intrusion. The cephalometric films were measured and compared.

Results: The results showed that the anterior open bites in 12 patients were all corrected in a mean of 6.8 months. Overbite increased by a mean of 4.2 mm ($P < .001$), from 2.2 mm in preintrusion to 2.0 mm in postintrusion. The maxillary and mandibular first molars were intruded for an average of 1.8 mm ($P < .001$) and 1.2 mm ($P < .001$), respectively. The mandibular plane angle was reduced by 2.3° ($P < .001$), which led to a counterclockwise rotation of the mandible with a significant decrease in the anterior facial heights (mean of 1.8 mm; $P < .001$).

Conclusion: Miniscrew anchorage has the advantages of being a simpler procedure, being minimally invasive, and requiring minimal patient cooperation.

KEY WORDS: Orthodontic anchorage; Microscrew anchorage

INTRODUCTION
Skeletal anterior open bite is a complicated malocclusion characterized mainly by overgrowth of the maxillary and mandibular posterior dentoalveolar heights, resulting in a longer vertical facial dimension and a steeper mandibular plane.1,2 It is difficult to decrease the heights of posterior dentoalveolar regions in the treatment of anterior open bite. Many methods have been introduced to intrude the posterior teeth, such as passive bite blocks,3 active bite blocks with magnets4,5 or springs,6 high-pull headgear,7 fixed appliances, and vertical elastics.8–11 However, these traditional techniques often cannot intrude the molars, especially in adult patients. Thus, surgical impaction of the maxilla is often the only way to obtain counterclockwise rotation of the mandible and a reduction of anterior facial height in adult patients with severe skeletal open bite.12

Specially-designed implants,13–15 miniscrews,16–21 and miniplates22–26 have been developed recently to obtain a stationary anchorage source. Several studies23–26 have reported the successful treatment of anterior open bite by intruding the mandibular or maxillary molars with miniplate anchorage. However, the surgical procedure of miniplate placement is relatively complicated.

Compared with the miniplate, the microscrew implant has the advantages of lower cost, simpler inser-
tion, the absence of a surgical procedure, and more varied implanting areas available. The purpose of this study was to investigate the effectiveness of microscrew anchorage in treatment of the skeletal anterior open bite.

MATERIALS AND METHODS

Patient Selection

Twelve patients, ranging from 14.3 to 27.2 years of age (mean 18.7 years), were included in the study. Selection criteria for the study were:

a. Patient’s growth completed or primarily completed;
b. Long-face pattern with anterior open bite and mild Class II skeletal relation;
c. Nonacceptance of orthognathic surgery;
d. Patient had previously received premolar or molar extraction.

In 11 patients, microscrews were inserted after the teeth had been aligned and the extraction space closed, while the overbite remained negative. In only one case, with extraction of first molars, microscrews were inserted before the space was closed. Lateral cephalograms of 12 patients were taken preintrusion and immediately after completion of intrusion.

All patients and/or their parents had been informed about the purpose of the study, the advantages of intrusion treatment using microscrew anchorage, and the possible complications, and had signed an informed consent.

Surgical Procedure of Microscrew Insertion

Under local infiltration anesthesia, a 3- to 4-mm vertical incision was made on the mandibular alveolar mucosa between the first and second molars. A self-drilling titanium alloy microscrew (1.6 mm in diameter and 7 mm in length) was inserted into the buccal alveolar bone on each side. A 9-mm-long microscrew (1.6 mm in diameter) was inserted in the posterior midpalatal area corresponding to the upper first molar. The self-drilling microscrews could be inserted manually directly into the cortical bone with a specially-designed screwdriver. Flap gingival surgery and pilot drilling were not necessary, which greatly facilitated the procedure and diminished trauma. Microscrew removal was performed without local anesthesia on completion of treatment.

Orthodontic Treatment

All patients received orthodontic treatment with 0.022-inch preadjusted appliances and sliding mechanics. During intrusion treatment, the main arch wire used was a 0.019 × 0.025-inch rectangular stainless steel arch. A fixed transpalatal arch and lingual arch were attached to the upper and lower first molars and located 5 mm from the palatal or lingual tissues. Traction hooks were soldered onto the transpalatal arch close to the first molars. Two self-drilling microscrews were implanted in the buccal alveolar bone between the molars in the mandible and one in the posterior midpalatal area in the maxilla. Two weeks after implantation, the intrusion treatment was initiated. Nickel titanium coil springs were placed bilaterally in the maxillary arch between the microscrew and traction hooks on the transpalatal arch (Figure 1). Power chains were connected bilaterally between the miniscrew and main arch in the mandible (Figure 1). About 150 g force was applied on each side.

Assessment of Cephalometric Measurements

All cephalometric radiographs preintrusion and post-intrusion were traced with a sharp pencil. Tracings from images of bilateral landmarks were averaged to eliminate errors from head posture differences. A horizontal reference line was drawn 7° from the sella-nasion line, registered at sella, and served as a true horizontal line (TH line). A perpendicular line through sella served as a true vertical line (TV line). Nineteen measurements according to conventional cephalometric analysis were included (Figure 2).

To assess dental changes in the vertical and horizontal directions, landmark images of the screw head and palatal plane or mandibular plane were used as references to establish a coordinate system. Eight linear parameters were measured (U1-PP, U6-PP, U1-
The statistical analysis was performed with SPSS 10.0 (SPSS, Chicago, IL). The mean difference of each variable was examined with paired Student’s t-tests. All variables were measured at two different times by the same investigator to calculate the error of the method.

**RESULTS**

In this study, the method error did not exceed 0.3 mm for the linear variables and 0.4° for the angular variables.

The anterior open bite was closed after intrusion treatment in all cases. The mean time for intrusion treatment using miniscrew anchorage was 6.8 ± 1.1 months. Comparison of cephalometric measurements of preintrusion and postintrusion is shown in Tables 1 and 2.

**Dental Changes**

Maxillary first molars and mandibular first molars were intruded an average of 1.8 mm (P < .001) and 1.2 mm (P < .001), respectively. Upper incisors had a mean extrusion of 1.3 mm (P < .01) and a retroclination of 5.0 degrees (P < .01). The mean angle of the upper occlusal plane to the SN plane increased by 4.4 degrees (P < .001). This increase occurred because of the clockwise rotation of the maxillary dentition. The lower incisors were extruded an average of 1.3 mm (P < .001), and retroclined 1.4 degrees, but these amounts were not statistically significant. There was a mean overbite increase of 4.2 mm (P < .001) and a mean overjet decrease of 2.0 mm (P < .05).
Upper and lower molars and incisors had no statistically significant changes in the horizontal direction.

**Skeletal Changes**

The angles of mandibular plane to SN plane and palatal plane significantly decreased by averages of 2.3° (P < .001) and 2.5° (P < .001), respectively. The inclination of the palatal plane did not change. Anterior facial height and lower anterior facial height decreased by averages of 1.8 mm and 1.6 mm (P < .001). Posterior facial height decreased by 0.4 mm; this decrease was not statistically significant. No significant changes were observed with SNA. SNB increased a mean of 1.6 degrees (P < .001), and ANB decreased by 1.8 degrees (P < .001). B point moved a mean distance of 0.9 mm upward (P < .01) and 2.5 mm forward (P < .01).

**Soft Tissue Changes**

A mean decrease of 1.9° (P < .01) was noted in the angle of Ns-Sn-Pos, reflecting a dramatic improvement in the convex profile.

**DISCUSSION**

Previous studies stated that the overeruption of posterior teeth contributes to the appearance of anterior open-bite malocclusion, and that intrusion of teeth is more stable than extrusion of teeth. Therefore, to achieve stable treatment results and improve esthetics for skeletal anterior open-bite patients, posterior dentoalveolar intrusion should be the correction goal.

Occlusal blocks with or without repelling magnets and high-pull headgear have been introduced to slow posterior growth and relatively intrude posterior teeth.

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**Table 1. Comparison of Preintrusion and Postintrusion Dental Measurements**

<table>
<thead>
<tr>
<th></th>
<th>Preintrusion</th>
<th>Postintrusion</th>
<th>Difference</th>
<th>P</th>
<th>Significance</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP/SN</td>
<td>20.1 1.9</td>
<td>24.5 3.6</td>
<td>4.4 1.9</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>U1/SN</td>
<td>111.2 5.0</td>
<td>106.2 8.5</td>
<td>-5.0 5.1</td>
<td>.006</td>
<td>**</td>
</tr>
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<td>L1/Mp</td>
<td>85.3 7.8</td>
<td>83.9 6.3</td>
<td>-1.4 3.3</td>
<td>.163</td>
<td>NS</td>
</tr>
<tr>
<td>L1/MP</td>
<td>32.2 1.9</td>
<td>33.5 2.5</td>
<td>1.3 1.0</td>
<td>.001</td>
<td>**</td>
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<td>U1-PP</td>
<td>46.3 2.7</td>
<td>47.6 3.1</td>
<td>1.3 0.8</td>
<td>.000</td>
<td>***</td>
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<tr>
<td>U6-PP</td>
<td>26.3 2.2</td>
<td>24.5 2.0</td>
<td>-1.8 0.7</td>
<td>.000</td>
<td>***</td>
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<tr>
<td>L6-MP</td>
<td>37.4 3.4</td>
<td>36.2 3.3</td>
<td>-1.2 0.8</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>U1-Ypp</td>
<td>33.3 3.1</td>
<td>32.9 3.3</td>
<td>-0.4 0.7</td>
<td>.082</td>
<td>NS</td>
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<td>U6-Ypp</td>
<td>27.9 3.5</td>
<td>27.3 3.8</td>
<td>-0.6 1.2</td>
<td>.087</td>
<td>NS</td>
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<tr>
<td>L1-Ymp</td>
<td>6.7 0.7</td>
<td>6.6 0.6</td>
<td>-0.1 0.4</td>
<td>.220</td>
<td>NS</td>
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<td>OB</td>
<td>-2.2 0.9</td>
<td>2.0 0.3</td>
<td>4.2 0.9</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>OJ</td>
<td>4.7 2.1</td>
<td>2.7 0.6</td>
<td>-2.0 2.2</td>
<td>.010</td>
<td>**</td>
</tr>
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</table>

* NS indicates not significant; * P < .05; ** P < .01; *** P < .001.

**Table 2. Comparison of Preintrusion and Postintrusion Skeletal and Soft Tissue Measurements**

<table>
<thead>
<tr>
<th></th>
<th>Preintrusion</th>
<th>Postintrusion</th>
<th>Difference</th>
<th>P</th>
<th>Significance</th>
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<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNA</td>
<td>79.7 3.1</td>
<td>79.4 3.1</td>
<td>-0.3 0.5</td>
<td>.108</td>
<td>NS</td>
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<td>SNB</td>
<td>73.6 3.2</td>
<td>75.2 3.1</td>
<td>1.6 0.7</td>
<td>.000</td>
<td>***</td>
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<tr>
<td>ANB</td>
<td>6.0 0.9</td>
<td>4.2 0.7</td>
<td>-1.8 0.9</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>MP/SN</td>
<td>45.6 5.8</td>
<td>43.3 5.1</td>
<td>-2.3 0.8</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>PP/SN</td>
<td>8.9 2.8</td>
<td>9.1 2.6</td>
<td>0.2 0.5</td>
<td>.228</td>
<td>NS</td>
</tr>
<tr>
<td>PP/MP</td>
<td>36.8 4.8</td>
<td>34.3 4.2</td>
<td>-2.5 0.9</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>Ar-Go-Me</td>
<td>131.8 4.7</td>
<td>130.8 5.1</td>
<td>-1.0 1.7</td>
<td>.062</td>
<td>NS</td>
</tr>
<tr>
<td>N-Me</td>
<td>139.2 5.1</td>
<td>137.4 4.8</td>
<td>-1.8 1.1</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>ANS-Me</td>
<td>82.2 3.8</td>
<td>80.6 3.4</td>
<td>-1.6 0.9</td>
<td>.000</td>
<td>***</td>
</tr>
<tr>
<td>S-Go</td>
<td>81.7 3.8</td>
<td>81.3 3.7</td>
<td>-0.4 1.0</td>
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<td>NS</td>
</tr>
<tr>
<td>Gn-Tv</td>
<td>128.7 4.6</td>
<td>127.8 4.9</td>
<td>-0.9 0.7</td>
<td>.001</td>
<td>**</td>
</tr>
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<td>A-Tv</td>
<td>62.5 5.8</td>
<td>62.6 6.3</td>
<td>0.1 0.9</td>
<td>.748</td>
<td>NS</td>
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<tr>
<td>B-Tv</td>
<td>48.4 8.2</td>
<td>50.9 7.7</td>
<td>2.5 2.6</td>
<td>.007</td>
<td>**</td>
</tr>
<tr>
<td>Ns-Sn-Pos</td>
<td>23.6 3.6</td>
<td>21.7 3.3</td>
<td>-1.9 1.4</td>
<td>.001</td>
<td>**</td>
</tr>
</tbody>
</table>

* NS indicates not significant; ** P < .01; *** P < .001.
Abdullatif and Keles introduced a modified full-coverage acrylic cap splint expander with headgear facebow to treat growing patients who had an anterior open bite because of excessive posterior dentoalveolar growth. It was reported that, in these young patients, open-bite closure, molar intrusion with no incisor extrusion, upper occlusal plane clockwise rotation, and mandibular plane angle reduction were all achieved.

Kim and Kim et al suggested extraction of the second or third molars and use of a multiloop edgewise archwire and anterior elastics to upright mesially tipped molars in open-bite correction. Chang and Moon’s study found that multiloop edgewise archwire technique could not really intrude the molars, but did indeed upright the molars. They pointed out that the uprighting of mesially tipped molars could improve the inclination of the maxillary or mandibular occlusal
plane, which greatly benefited the correction of an anterior open bite.

Some investigators\textsuperscript{11,32} applied upper accentuated-curve and lower reverse-curve nickel-titanium rectangular archwires instead of multiloop archwires to simplify the treatment of open-bite malocclusions. The results showed that the correction of open bites was attained mainly by extrusion of the lower incisors and uprighting of the upper incisors, without molar intrusion.

For more severe skeletal open-bite cases, especially for adults, orthognathic surgery was the only choice in the past. The skeletal orthodontic anchorage devices, such as dental implants,\textsuperscript{13–15} miniplates,\textsuperscript{16–21} and microscrews,\textsuperscript{22–24} have been developed recently, and these offer a new way to treat borderline cases. Umemori et al\textsuperscript{23} illustrated the use of titanium miniplates as anchorages to correct skeletal open-bite patients by intruding the lower posterior teeth. In two other studies, Sherwood et al\textsuperscript{25} and Erverdi et al\textsuperscript{24} demonstrated that skeletal open bites could be effectively treated by intrusion of the upper posterior dentoalveolar with miniplate anchorage placed in the zygomatic ridge. Their studies demonstrated that counterclockwise rotation of the mandible, reduction in anterior facial height, and clockwise rotation of the maxillary occlusal plane caused by the intrusion of posterior teeth had been achieved. Our study demonstrated that microscrew anchorage is an effective technique in skeletal open-bite treatment that is much simpler and minimizes the invasiveness of surgical procedure.

Orthodontic treatment for most open-bite cases requires extraction of either premolars or molars. Different extractions could require different treatment. Therefore, it is critical to take cephalometric films preintrusion and immediately after intrusion treatment so that pure intrusion effects of the microscrew will be detected.

The present study agrees with the results of Erverdi et al\textsuperscript{24} The upper and lower molars achieved intrusions of 1.8 and 1.2 mm respectively in a mean of 6.8 months of treatment. The anterior teeth extruded without anterior elastics, which was a beneficial movement for open-bite closure. The mandibular plane angle also had a significant decrease (mean 2.3°) caused by molar intrusion. All these treatment results contributed to the 4.2-mm increase in anterior overbite. The option of intruding posterior teeth with microscrew anchorage can be expected to achieve a good, stable result in skeletal open-bite treatment.

The counterclockwise rotation of the mandible because of molar intrusion also brings significant changes in skeletal pattern and soft tissue profile. The anterior facial height decreased by 1.8 mm and the ANB angle by 1.8°, with an upward and forward movement of B point. The soft-tissue facial convex angle had a significant reduction (mean of 1.9°). These skeletal and soft tissue changes could greatly improve the esthetics of skeletal open-bite in nongrowing patients—a result that cannot be achieved with traditional orthodontic techniques.

With respect to the fact that intrusive forces mounted on microscrews were applied directly to the lingual side of the upper molars and buccal side of the lower molars, some measures should be taken to prevent the molars from overrotating lingually or buccally during intrusion. Thus, a stiff rectangular stainless steel archwire (0.019 × 0.025 inches) was used. The application of transpalatal and lingual arches was also necessary to maintain the position of the molars on each side. The distance of the transpalatal and lingual arches from the soft tissues was more than 5 mm, in order to avoid impingement during the intrusion process. The intrusion force was about 150 g, which is one third of that used by Sugavara.\textsuperscript{33} At the completion of the intrusion treatment, no significant root resorption was found in any of the eight patients.

Demonstration Reports

\textbf{Case report 1.} A 16-year-old male with the chief complaint of an anterior open bite asked for orthodontic treatment (Figures 4 through 8). The patient presented with a convex long-face profile and retrognathic...
Figure 8. Posttreatment facial and intraoral photographs (case 1).

Figure 9. Pretreatment facial and intraoral photographs (case 2).
mandible. The patient also had incompetent lips while relaxing. The intraoral examination showed a broad open bite to the second molars and a slight crowding in the upper and lower dental arch. The anterior open bite was 8 mm and the molar and canine relationships were slightly Class II. Both lower first molars had extensive fillings with composite resin. The patient refused orthognathic surgery.

The treatment plan was extraction of 36 and 46 with microscrew anchorage to intrude the posterior dentoalveolar region. After 7 months of intrusion treatment, the anterior open bite was corrected and 2.0 mm of overbite was achieved. The total treatment duration was 15 months. Normal anterior overbite and overjet were achieved. Pre intrusion and post intrusion cephalometric comparison indicated significant intrusion of posterior teeth and counterclockwise rotation of the mandible. The mandibular plane angle decreased by 5.0° and the convex long-face profile showed obvious improvements.

Case report 2. An 18-year-old female complained of an inability to close the anterior teeth and asked for orthodontic treatment (Figures 9 through 13). The patient presented with a long-face profile and retrognathic mandible. The intraoral examination revealed open bite forward from the first molars and moderate crowding in the upper and lower dental arches. The anterior open bite was 6 mm and the molar relationship was slightly Class III. The patient refused orthognathic surgery.

The treatment plan was extraction of 15, 25, 34, and 44. The patient's open bite remained 2.5 mm open after the teeth were aligned and the extraction space closed. Microscrew anchorage was then used to intrude the posterior dentoalveolar area. After 7 months of intrusion treatment, 2.0 mm of overbite was achieved. The mandibular plane angle was reduced by 3.0 degrees and an obvious improvement of facial appearance had been achieved.

CONCLUSIONS

- Microscrews can provide a stable skeletal anchor to achieve molar intrusion.
Skeletal open bite can be effectively corrected by this orthodontic treatment option without orthognathic surgery, especially in nongrowing potential borderline surgery patients.

The microscrew anchorage technique introduced in this study has the obvious advantages that it is a simpler and less invasive procedure and requires minimal patient cooperation.

ACKNOWLEDGMENT

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