Apical root resorption in orthodontic patients with en-masse maxillary anterior retraction and intrusion with miniscrews

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Introduction: The purposes of this retrospective study were to investigate the apical root resorption of maxillary incisors in orthodontic patients with en-masse maxillary anterior retraction and intrusion with miniscrews and the factors disposing a patient to apical root resorption. Methods: Fifty adult patients with maxillary protrusion were included; 30 were treated with miniscrews and extraction of the maxillary first premolars (group I), and 20 were treated with extraction of the maxillary first premolars (group II). For each patient, periapical films of the maxillary incisors and lateral cephalometric radiographs were taken before and after treatment to evaluate apical root resorption and cephalometric measurements. The intergroup differences were analyzed with the Student t test and the correlations between apical root resorption and cephalometric measurements were analyzed by the Pearson correlation. Results: The apical root resorption values were 16.0% to 20.0% (2.5-2.8 mm) in group I and 13.4% to 14.4% (2.1-2.3 mm) of the original root length in group II. Group I had significantly more severe Class II jaw discrepancy (ANB, 7.1° ± 1.9°) than did group II (ANB, 3.2° ± 2.9°). The amount of maxillary en-masse anterior retraction (8.2 ± 2.4 mm), the duration of treatment (28.3 ± 7.3 months), and apical root resorption of maxillary lateral incisors were significantly greater in group I than in group II. Apical root resorption of the maxillary central incisors was significantly correlated to the duration of treatment but not to the amount of en-masse retraction, intrusion, or palatal tipping of maxillary incisors. Conclusions: Miniscrew anchorage allows for more maxillary en-masse anterior retraction in patients with severe Class II cases. But the time needed for the greater amount of maxillary en-masse anterior retraction with miniscrew anchorage is longer and might dispose the patient to more apical root resorption. (Am J Orthod Dentofacial Orthop 2010;137:207-12)

The growing demand for orthodontic treatment methods that require minimal compliance and maximal anchorage control, particularly by adults, has led to the expansion of implant technology. Miniscrews have been introduced as temporary anchorage devices for various purposes: canine retraction, anterior retraction, en-masse anterior retraction, molar uprighting, distalization, and protraction. They have the advantages of smaller size, more implant sites and indications, simpler placement surgically and connection orthodontically, short or even no waiting period, no need for laboratory work, easier removal after treatment, and lower cost than implants, onplants, and miniplates.

Without a limit in anchorage, we can now move teeth farther, position the maxillary or mandibular incisors in ideal positions and inclinations, and intrude the incisors farther with miniscrews. Nevertheless, the roots of maxillary or mandibular incisors would travel farther through the dentoalveolus, and treatment could also be longer than with conventional approaches. All of these are considered predisposing factors for apical root resorption. However, apical root resorption in patients with miniscrew anchorage has not been studied thoroughly yet.

The purposes of this retrospective study were to study the apical root resorption of maxillary incisors in orthodontic patients with en-masse maxillary anterior retraction and intrusion with miniscrews and the factors disposing them to apical root resorption.

MATERIAL AND METHODS

Fifty adults who had their maxillary first premolars extracted and en-masse maxillary anterior retraction and intrusion of their maxillary dentoalveolar
protrusion, and had clear and readable pretreatment (T1) and posttreatment (T2) periapical and lateral cephalometric radiographs were selected from our database (Table I). They had no medical history of asthma, hypothyroidism, or maxillofacial trauma, and no dental history of root canal treatment of the maxillary incisors or previous orthodontic treatment. Thirty patients were treated with miniscrew anchorage and extraction of the maxillary first premolars (group I), and 20 were treated with extraction of the maxillary first premolars without miniscrew anchorage (group II). The group II patients were treated before orthodontic miniscrews were available. The miniscrews were the Lin/Liou orthodontic mini anchor system (Mondeal Medical System GMBH, Tuttingen, Germany). The size was 2 mm in diameter and 9 mm in length (Fig 1). The miniscrews were placed in the infrapygomatic crest of the maxilla.5

The appliances and mechanisms for the en-masse maxillary anterior retraction and intrusion are described in Figure 2. They were the same for all patients and performed by the same orthodontist (P.M.H.C.). The forces were 250 g for en-masse anterior retraction and 100 g for intrusion.

The T1 and T2 cephalometric radiographs were traced and superimposed on the anterior cranial base and best fitted on the cranial vault.15 A horizontal reference line (x-axis) through sella was constructed anteriorly 7° to the sella-nasion line, and a perpendicular line through sella to the horizontal reference line was constructed as the vertical reference line (y-axis). The root shortening of the maxillary incisor at T2 from apical root resorption returned to its root length at T1 by superimposing its crown contour at T2 with the crown contour at T1.

The T1 and T2 cephalometric tracings and periapical films with a ruler (Fig 3) were scanned into a computer, calibrated, and measured in a 1:1 ratio with ImageJ software (version 1.37, National Institutes of Health, Bethesda, Md, http://rsb.info.nih.gov/ij/) for (1) maxillary incisor proclination (1-SN), SNA, SNB, and ANB angles at T1; (2) amount of anterior retraction (horizontal distance to the y-axis) and intrusion (vertical distance to the x-axis) of the incisor tip and root apex from T1 to T2; (3) palatal tipping of the maxillary incisors (1-SN-T1-2) from T1 to T2; and (4) on the periapical films, apical root resorption of the maxillary central and lateral incisors from T1 to T2.

Apical root resorption of the maxillary incisors from T1 to T2 was measured as length and percentage of shortening of the original root length at T1 by the following16: apical root resorption (mm) = C1/C2 (R1 – R2); apical root resorption (%) = C1/C2 (R1 – R2)/R1 (C1, T1 radiographic incisor crown length; C2, T2 radiographic crown length; R1, T1 radiographic root length; R2, T2 radiographic root length).

### Statistical analysis

Ten periapical and cephalometric radiographs were randomly selected for the study of method errors. The maxillary right central incisor crown lengths on the periapical films and the lengths of SN on the cephalometric radiographs were measured again 2 months later and analyzed with paired t tests (P < 0.05) for systemic errors, and analyzed with the formula \( \sqrt{\sum D^2/N} \) for measurement errors,17 where \( D \) is the difference between repeated measurements and \( N \) is the number of repeated measurements.

The intergroup differences of the cephalometric measurements, duration of treatment, and apical root resorption were analyzed with the Student t test (P < 0.05). Their correlations (groups I and II combined) were analyzed with the Pearson correlation (P < 0.05).

### RESULTS

The systemic error of cephalometric measurement was 0.21 mm (P = 0.092), and its measurement error
was 0.10 mm. The systematic error of apical root resorption measurement was –0.27 mm (P = 0.079), and its measurement error was 0.10 mm.

The pretreatment 1-SN and SNA values were similar between the groups. SNB at T1 was significantly less, and ANB was significantly greater in group I than in group II (Table II).

The amounts of en-masse anterior retraction of the maxillary incisor tip and root apex in group I were significantly greater than in group II. The duration of treatment of group I was significantly longer than in group II. However, the amount of intrusion of the maxillary incisor tip or root apex, and 1-SN-T1-2 were not significantly different between the groups (Table III).

Apical root resorption of the maxillary central incisors was not significantly different between the groups, but apical root resorption of the maxillary lateral incisors was significantly greater in group I than in group II (Table IV).

The apical root resorption of the maxillary right central or lateral incisors was not significantly different from that on the left in both groups; therefore, the 2 sides were combined for the Pearson correlation analysis. The amounts of maxillary en-masse anterior retraction, intrusion, and palatal tipping were not significantly correlated to apical root resorption. The duration of treatment was significantly correlated to apical root resorption of the maxillary central incisors but not the lateral incisors (Table V).

**DISCUSSION**

Although the amounts of pretreatment maxillary dentoalveolar protrusion were similar, group I had significantly more severe mandibular retrognathism than did group II. This explained why the patients in group I were treated with extraction of the maxillary
treated without miniscrew anchorage.18,19,22-28

The severity of apical root resorption was directly correlated to duration of treatment,12,31-35,38 although some,

first premolars and miniscrew anchorage, and why they had significantly more maxillary en-masse anterior retraction. This proved that miniscrew anchorage, because of no anchorage loss and more extraction space available, allows for greater orthodontic tooth movement in more severe patients. However, on the other hand, the treatment duration needed for the greater amount of en-masse anterior retraction in group I was also significantly longer.

Maxillary incisors of patients treated without miniscrew anchorage have been reported to be more vulnerable to apical root resorption than other teeth.11,18-21

Table III. Intergroup comparison (Student t test) of the treatment results after en-masse maxillary anterior retraction and intrusion (T1-T2)

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retraction at incisor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tip (mm)</td>
<td>8.2 ± 2.4</td>
<td>6.5 ± 2.1</td>
<td>0.013*</td>
</tr>
<tr>
<td>Intrusion at incisor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tip (mm)</td>
<td>0.4 ± 2.0</td>
<td>0.0 ± 1.6</td>
<td>0.459</td>
</tr>
<tr>
<td>Retraction at root apex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>apx (mm)</td>
<td>3.0 ± 2.7</td>
<td>1.3 ± 1.6</td>
<td>0.018*</td>
</tr>
<tr>
<td>Intrusion at root apex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>apx (mm)</td>
<td>2.7 ± 1.8</td>
<td>2.5 ± 1.4</td>
<td>0.709</td>
</tr>
<tr>
<td>1-SN-T1-2 (°)</td>
<td>14.4 ± 10.0</td>
<td>13.9 ± 7.5</td>
<td>0.856</td>
</tr>
<tr>
<td>Duration of treatment</td>
<td>28.3 ± 7.3</td>
<td>22.7 ± 5.0</td>
<td>0.003†</td>
</tr>
</tbody>
</table>

*P <0.05; †P <0.01.

Table IV. Intergroup comparison (Student t test) of apical root resorption after en-masse maxillary anterior retraction and intrusion (T1-T2)

<table>
<thead>
<tr>
<th>Maxillary incisor</th>
<th>Group I</th>
<th>Group II</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right lateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>20.0 ± 7.3</td>
<td>14.4 ± 7.3</td>
<td>0.017*</td>
</tr>
<tr>
<td>(mm)</td>
<td>2.7 ± 1.0</td>
<td>2.1 ± 1.4</td>
<td></td>
</tr>
<tr>
<td>Left lateral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>19.6 ± 6.6</td>
<td>14.4 ± 8.5</td>
<td>0.030*</td>
</tr>
<tr>
<td>(mm)</td>
<td>2.8 ± 1.0</td>
<td>2.3 ± 1.7</td>
<td></td>
</tr>
<tr>
<td>Right central</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>16.8 ± 8.8</td>
<td>13.6 ± 7.6</td>
<td>0.197</td>
</tr>
<tr>
<td>(mm)</td>
<td>2.5 ± 1.4</td>
<td>2.1 ± 1.5</td>
<td></td>
</tr>
<tr>
<td>Left central</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(%)</td>
<td>16.0 ± 9.2</td>
<td>13.4 ± 7.3</td>
<td>0.299</td>
</tr>
<tr>
<td>(mm)</td>
<td>2.5 ± 1.5</td>
<td>2.1 ± 1.3</td>
<td></td>
</tr>
</tbody>
</table>

*P <0.05.

Regardless of the statistical results, the apical root resorption of the maxillary lateral incisors was greater than that of the maxillary central incisors in both groups, and the apical root resorption of the maxillary lateral incisors in group I was significantly more than in group II. This could be because the appliances that we used for intrusion of the maxillary incisors were placed on the archwire between the maxillary canine and lateral incisor. Although the intrusive force was the same in the intrusion appliances, the force directed to the maxillary lateral incisors would be heavier than to the maxillary central incisors. The consequence could be greater apical root resorption in the maxillary lateral incisors than in the central incisors. Another explanation is that the maxillary lateral incisors are inherently more vulnerable to apical root resorption than the maxillary central incisors,8,29,30 although there is some disagreement with this statement.7,11,31,32,33 Unfortunately, we could not differentiate between these factors in this study.

Our main concern in this study was whether the miniscrew anchorage that enables greater tooth movement but causes longer treatment time in more severe cases would trigger more apical root resorption. It has been shown that the greater the tooth movement, the more apical resorption.8,10,30,34-38

Intrusive movement and force are also thought to cause apical root resorption.12,30,39 The severity of apical root resorption was directly correlated to duration of treatment,12,31-35,38 although some,
on the other hand, did not support this finding.\textsuperscript{10,40,41} Apical root resorption is caused by many factors.

In this study, the appliances and forces for retraction and intrusion were controlled the same way in all patients, except for those with the most severe Class II mandibular retrognathism and miniscrew anchorage. Miniscrews were used for greater tooth movement in more severe Class II cases, and, therefore, treatment was also longer. Our results showed that apical root resorption in the maxillary incisors was not significantly correlated to the amounts of maxillary en-masse anterior retraction, intrusion, and palatal tipping, but apical root resorption of the maxillary central incisors was significantly correlated to duration of treatment. The explanation of this is that tooth movement was a combination of retraction, palatal tipping, and intrusion of the maxillary incisors, and the length of treatment is the summation of many factors—amounts of retraction, intrusion, and palatal tipping of the maxillary incisors and the other teeth.

Periapical radiographs can only detect apical root resorption after a certain amount of root shortening.\textsuperscript{42} Furthermore, radiographs show only the phenomenon but not the causes of apical root resorption. The underlying factors disposing a patient to apical root resorption from orthodontic tooth movement are biologic rather than radiographic.\textsuperscript{43,44,45} The factor of time could be a summation of all factors disposing a patient to apical root resorption during orthodontic tooth movement.

**CONCLUSIONS**

Miniscrew anchorage allows for greater maxillary en-masse anterior retraction in severe Class II cases. But the time needed for this greater retraction with miniscrew anchorage would be longer and dispose the patient to more apical root resorption.

**REFERENCES**


