Long-term stability of anterior open-bite treatment by intrusion of maxillary posterior teeth

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Introduction: Anterior open bite results from the combined influences of skeletal, dental, functional, and habitual factors. The long-term stability of anterior open bite corrected with absolute anchorage has not been thoroughly investigated. The purpose of this study was to examine the long-term stability of anterior open-bite correction with intrusion of the maxillary posterior teeth. Methods: Nine adults with anterior open bite were treated by intrusion of the maxillary posterior teeth. Lateral cephalographs were taken immediately before and after treatment, 1 year posttreatment, and 3 years posttreatment to evaluate the postintrusion stability of the maxillary posterior teeth. Results: On average, the maxillary first molars were intruded by 2.39 mm (P < 0.01) during treatment and erupted by 0.45 mm (P < 0.05) at the 3-year follow-up, for a relapse rate of 22.88%. Eighty percent of the total relapse of the intruded maxillary first molars occurred during the first year of retention. Incisal overbite increased by a mean of 5.56 mm (P < 0.001) during treatment and decreased by a mean of 1.20 mm (P < 0.05) by the end of the 3-year follow-up period, for a relapse rate of 17.00%. Incisal overbite significantly relapsed during the first year of retention (P < 0.05) but did not exhibit significant recurrence between the 1-year and 3-year follow-ups. Conclusions: Most relapse occurred during the first year of retention. Thus, it is reasonable to conclude that the application of an appropriate retention method during this period clearly enhances the long-term stability of the treatment. (Am J Orthod Dentofacial Orthop 2010;138:396.e1-396.e9)
open bite by intruding the mandibular molars, but they did not report the long-term stability of the treatment after their last report of a 30% relapse rate at 1 year post-treatment. Lee and Park used miniscrew implants to intrude the maxillary molars and reported a 10.36% relapse rate for the intruded molars and an 18.1% relapse of overbite at 1 year posttreatment.

Because there has not been a substantial report on the long-term stability of treating anterior open bite with absolute anchorage, we evaluated the 3-year post-treatment stability of anterior open bite in adults treated by orthodontic intrusion of the posterior teeth with miniscrew implants.

**MATERIAL AND METHODS**

Our study participants were selected from the archives of the Department of Orthodontics, Dental Hospital of Yonsei University College of Dentistry in Seoul, Korea. Patients who were treated with miniscrew implants to intrude the maxillary posterior teeth and followed for at least 3 years of the retention period were selected according to the following criteria: (1) diagnosed with incisal open bite (incisor overbite: $< -1.0$ mm), (2) high SN-MP angle ($> 40^\circ$), and (3) skeletal Class I or Class II discrepancy (anteroposteriorly).

Nine patients (1 man, 8 women) met these criteria and were included in the study. Three of these patients had premolar extractions. The mean age at the beginning of treatment was 23.7 years (range, 18.3-31.1 years), and the mean treatment period was 28.8 months (range, 18-37 months). The mean period during which the miniscrew implants were applied was 5.4 months (range, 3-9 months), and the mean retention period was 41 months (range, 36-51 months). All patients were given lingual fixed retainers; the extraction patients applied them between the premolars, and the nonextraction patients applied them between the canines. In addition, they were also given the usual circumferential retainers for retention; the retainers were applied on both the maxilla and the mandible for the entire day during the first 6 months after treatment and only at night after that.

Two methods were used for intrusion of the maxillary molars. The first method was miniscrew implants placed on the buccal and palatal sides, between the roots of the maxillary second premolar and first molar, and between the roots of the maxillary first and second molars. After a 1 to 2 week period, an intrusive force was directly applied on the molars with elastomeric chains (Fig 1, A and B).

The second method was the placement of miniscrew implants on the buccal side only, between the roots of the maxillary second premolar and first molar, and between the roots of the maxillary first and second molars. Rigid transpalatal arches were placed before applying an intrusive force to prevent buccal tipping of the teeth (Fig 1, C and D).

Lateral cephalographs were taken at the Department of Radiology, Dental Hospital of Yonsei University College of Dentistry by using Cranex (Soredex Orion corp, Helsinki, Finland) and stored in digital imaging and communications in medicine (DICOM) file format in the picture archiving communication system (PACS; Infinitt Co, Ltd, Seoul, Korea). The PACS digitizes and manages radiographic images from individual hospitals.

The cephalometric radiographs taken before the introduction of PACS were scanned by using Diagnostic Pro Plus (Vidar Systems, Herndon, Va), corrected for their measurements, and uploaded to the PACS to be included in the study.

The cephalographs were taken with conventional radiography at the initial evaluation (T1), after treatment (T2), 1 year after treatment (T3), and 3 years after treatment (T4). The cephalographs were traced through the midpoints between the right and left structures, and the measurements were corrected by considering a 110% magnification rate. Cephalometric landmarks, reference planes (Fig 2), and cephalometric variables (Table I) were selected based on commonly used analyses.

**Statistical analysis**

The lateral cephalographs stored in the PACS in DICOM file format were analyzed by using V-ceph software (version 3.5, CyberMed, Seoul, Korea) to measure the landmarks and reference points.

In an effort to maintain consistency, all cephalometric measurements and analyses were done by 1 examiner (M.-S.B.). Once a week, a number of reference points were randomly selected to remeasure and reanalyze the dimensions with paired $t$ tests to verify and reduce systematic errors.

The Shapiro-Wilks test was used to verify normal distribution, the paired $t$ test to compare variables at T1 and T2, 1-way repeated-measures analysis of variance (ANOVA) to compare the values at T2, T3, and T4, and the Pearson correlation analysis to examine their correlations.

**RESULTS**

The mean measurements for selected cephalometric variables from the T1 evaluation to T4 are shown in Tables I and II, and the correlation coefficients between the variables are presented in Tables III, IV, and V.
In regard to the skeletal changes after treatment, significant changes occurred from intrusion of the posterior teeth. The mean vertical distance between the maxillary posterior teeth and palatal plane was reduced by 2.39 mm ($P < 0.01$), which in turn decreased the ANB angle difference by 0.66° ($P < 0.05$), the SN-GoMe angle by 2.03° ($P < 0.01$), and the anterior facial height by 2.53 mm ($P < 0.01$) as pogonion moved forward and upward and the vertical reference place-pogonion increased by 2.40 mm ($P < 0.05$) (Tables I and II). In the dental changes, the mean overbite values at T1 and T2 were –3.91 and 1.65 mm, respectively; there was a mean bite closure of 5.56 mm ($P < 0.001$).

Among the skeletal changes during retention periods, the SNPog angle decreased by 0.86° ($P < 0.05$), the FMA angle increased by 0.69° ($P < 0.05$), and the vertical reference place-pogonion length decreased by 1.37 mm ($P < 0.05$) by the end of 3 years (T4-T2). However, at 1 year posttreatment (T3-T2), no significant skeletal changes were observed other than a 0.46° decrease in the SNPog angle ($P < 0.05$). Between the end of the first year and the third year of retention (T4-T3), no significant change was observed in any skeletal parameters.

As for dental changes, overbite decreased by an average of 0.99 mm ($P < 0.05$) during the first year of retention but did not significantly decrease thereafter. By T4, overbite decreased by an average of 1.20 mm ($P < 0.05$). The vertical distance between the maxillary molars and the palatal plane significantly increased by 0.45 mm ($P < 0.05$) after 3 years (Tables I and II). The vertical distance between the maxillary anterior teeth and the palatal plane significantly increased by 0.33 mm ($P < 0.05$) between T4 and T3.

While analyzing the correlations between variables, we verified that overbite correction was induced by the forward and upward rotation of the mandible after intrusion at the posterior teeth. The changes after treatment, compared with before treatment (T2-T1), of the SNPog ($P < 0.05$), SN-MP ($P < 0.05$), and SNB angles ($P < 0.05$) all were highly correlated with the change in overbite. The SNPog angle also was highly correlated with hard-tissue pogonion ($P < 0.01$), suggesting that the change in the SNPog angle during treatment was caused by the forward and upward displacement of pogonion (Table III).

Analyzing the correlations between the severity of the initial condition and the amount of relapse, we found no significant correlation between initial overbite,
mandibular plane angle, or lower anterior facial height and the amount of relapse (Table IV).

The correlation between the extent of the correction achieved by the treatment and the extent of relapse after 3 years of retention was also examined. The extent of intrusion performed on the maxillary posterior teeth did not highly correlate with the extent of relapse, whereas the extent of overbite correction showed a significant correlation with relapse (Table V).

As for relapse rates, 22.88% of the vertical distance between the maxillary molar and palatal plane and 17.00% of the overbite relapsed after 3 years of retention (Table VI).

DISCUSSION

Umemori et al and Sugawara et al reported on patients with anterior open bite treated by intruding the mandibular molars with the skeletal anchorage system, and Sugawara et al reported a relapse rate about 30% at 1 year posttreatment. However, those patients with anterior open bite also had skeletal problems that were mostly caused by an excessive vertical growth tendency of the maxillary posterior area; it would be a more fundamental approach to correct the condition by intruding the maxillary molars. For this reason, we intended to evaluate the long-term stability of maxillary molar intrusion treatment of patients with anterior open bite.

Before the study, reference planes from which we could accurately assess the changes had to be defined. In many previous studies evaluating the posttreatment stability of anterior open bite, the direct distance between the maxillary and mandibular incisors on lateral cephalographs was measured to quantify the extent of the overbite. Concerns arose that various examiners were defining overbite differently and applying different methods to measure it; such interexaminer differences were causing significantly different results.

In more recent studies on anterior open bite, overbite and overjet values were determined mostly by using calipers to measure the interincisal distances in reference to the nasion-menton line. However, when treating these patients with posterior intrusion, the reference line was altered because of the accompanying skeletal changes and the counterclockwise rotation of the mandible. Therefore, in this study, we determined new reference planes in reference to the constant sella-nasion plane: the horizontal reference plane and vertical reference plane (Fig 2).

To correct anterior open bite, 2 methods were used to intrude the maxillary posterior teeth (Fig 1). There was no significant difference between the 2 methods in regard to the extent of intrusion achieved.

As the posterior teeth were intruded, concurrent skeletal changes occurred; counterclockwise rotation of the mandible occurred toward the closing of the bite, which in turn induced forward and upward displacement of B-point and pogonion, as well as a reduction in the ANB difference, the mandibular plane angle, and the anterior facial height (Table II). In patients with skeletal Class II tendency, correction to a skeletal Class I relationship was achieved by the changes. These results agree with previous studies that found that intrusion of the posterior teeth with skeletal anchorage induced counterclockwise rotation of the mandible and, as a consequence, corrected the anteroposterior intermaxillary relationship.
Although posterior intrusion promotes the necessary skeletal changes to enhance the patient’s dentofacial esthetics, the conventional method of anterior extrusion is limited to dentoalveolar changes and has fewer effects on facial appearance. For this reason, one can reasonably conclude that the posterior intrusion method is a more suitable way to nonsurgically correct an anterior open bite.

In this study, we followed the posttreatment skeletal changes for 3 years and observed significant relapses for a number of variables (Table II). After the relapsed eruption of the maxillary molars, the mandible subsequently rotated clockwise toward the open bite, pogonion rotated downward and backward, and anterior facial height increased. Surprisingly, we also observed significant eruption of the maxillary anterior teeth between the end of the first year and the third year of retention (T4-T3); this consequently deepened the bite. This eruption compensated for the relapse of the posterior teeth, as well as the overbite and skeletal parameters. Such results are consistent with the study of Sugawara et al., who reported that relapse of intruded molars does not directly influence the posttreatment skeletal and overbite changes.

The overall pattern of relapse observed in this study was similar to that of surgical treatment. Downward

### Table I. Cephalometric variables before treatment (T1), after treatment (T2), 1 year after treatment (T3), and 3 years after treatment (T4)

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1</th>
<th>SD</th>
<th>T2</th>
<th>SD</th>
<th>T3</th>
<th>SD</th>
<th>T4</th>
<th>SD</th>
</tr>
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<tbody>
<tr>
<td><strong>Skeletal</strong></td>
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<tr>
<td>ANB (°)</td>
<td>4.60</td>
<td>1.28</td>
<td>3.94</td>
<td>1.56</td>
<td>3.94</td>
<td>1.55</td>
<td>4.11</td>
<td>1.67</td>
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<td>FMA (°)</td>
<td>38.26</td>
<td>3.45</td>
<td>35.11</td>
<td>3.88</td>
<td>35.74</td>
<td>4.11</td>
<td>35.80</td>
<td>4.04</td>
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<tr>
<td>SN-GoMe (°)</td>
<td>45.44</td>
<td>4.11</td>
<td>43.41</td>
<td>4.41</td>
<td>43.68</td>
<td>4.88</td>
<td>43.98</td>
<td>4.76</td>
</tr>
<tr>
<td>SN-Pog (°)</td>
<td>76.08</td>
<td>3.57</td>
<td>77.18</td>
<td>3.79</td>
<td>76.71</td>
<td>4.10</td>
<td>76.31</td>
<td>4.04</td>
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<td>AFH (mm)</td>
<td>133.95</td>
<td>5.55</td>
<td>131.41</td>
<td>6.10</td>
<td>131.86</td>
<td>5.54</td>
<td>132.32</td>
<td>5.87</td>
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<td>VP-Pog (mm)</td>
<td>50.10</td>
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<td>52.50</td>
<td>8.54</td>
<td>51.75</td>
<td>9.55</td>
<td>51.13</td>
<td>9.13</td>
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<td>OB (mm)</td>
<td>−3.91</td>
<td>1.65</td>
<td>1.65</td>
<td>0.82</td>
<td>0.66</td>
<td>0.79</td>
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<td>OJ (mm)</td>
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<td>3.68</td>
<td>2.90</td>
<td>0.78</td>
<td>3.36</td>
<td>1.57</td>
<td>3.31</td>
<td>1.49</td>
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<td>IMPA (°)</td>
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<td>88.42</td>
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<td>88.89</td>
<td>5.31</td>
<td>88.97</td>
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<td>U6-PP (mm)</td>
<td>26.88</td>
<td>1.12</td>
<td>24.50</td>
<td>1.64</td>
<td>24.89</td>
<td>1.69</td>
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<td>1.68</td>
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<td>U1-PP (mm)</td>
<td>31.50</td>
<td>2.67</td>
<td>32.56</td>
<td>2.12</td>
<td>32.49</td>
<td>1.91</td>
<td>32.83</td>
<td>2.15</td>
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<tr>
<td>L1-MP (mm)</td>
<td>43.58</td>
<td>2.46</td>
<td>45.17</td>
<td>2.78</td>
<td>44.90</td>
<td>2.58</td>
<td>45.12</td>
<td>2.57</td>
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</tbody>
</table>

### Table II. Mean changes in the cephalometric variables at different time intervals

<table>
<thead>
<tr>
<th>Variable</th>
<th>ΔT2-T1</th>
<th>SD</th>
<th>Sig</th>
<th>ΔT3-T2</th>
<th>SD</th>
<th>Sig</th>
<th>ΔT4-T3</th>
<th>SD</th>
<th>Sig</th>
<th>ΔT4-T2</th>
<th>SD</th>
<th>Sig</th>
</tr>
</thead>
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<tr>
<td><strong>Skeletal</strong></td>
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<tr>
<td>ΔANB (°)</td>
<td>−0.66</td>
<td>0.79</td>
<td>*</td>
<td>0.00</td>
<td>0.70</td>
<td>NS</td>
<td>0.17</td>
<td>0.71</td>
<td>NS</td>
<td>0.17</td>
<td>0.71</td>
<td>NS</td>
</tr>
<tr>
<td>ΔSN-GoMe (°)</td>
<td>−2.03</td>
<td>1.59</td>
<td>†</td>
<td>0.27</td>
<td>1.14</td>
<td>NS</td>
<td>0.31</td>
<td>1.33</td>
<td>NS</td>
<td>0.57</td>
<td>1.46</td>
<td>NS</td>
</tr>
<tr>
<td>ΔSN-Pog (°)</td>
<td>1.10</td>
<td>0.94</td>
<td>†</td>
<td>−0.46</td>
<td>0.56</td>
<td>*</td>
<td>−0.40</td>
<td>0.72</td>
<td>NS</td>
<td>−0.86</td>
<td>0.92</td>
<td>*</td>
</tr>
<tr>
<td>ΔFMA (°)</td>
<td>−3.16</td>
<td>1.81</td>
<td>†</td>
<td>0.64</td>
<td>1.41</td>
<td>NS</td>
<td>0.05</td>
<td>0.86</td>
<td>NS</td>
<td>0.69</td>
<td>0.88</td>
<td>*</td>
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<tr>
<td>ΔAFH (mm)</td>
<td>−2.53</td>
<td>1.90</td>
<td>†</td>
<td>0.44</td>
<td>0.89</td>
<td>NS</td>
<td>0.46</td>
<td>0.80</td>
<td>NS</td>
<td>0.90</td>
<td>1.21</td>
<td>NS</td>
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<tr>
<td>ΔVP-Pog (mm)</td>
<td>2.40</td>
<td>2.32</td>
<td>*</td>
<td>−0.75</td>
<td>1.29</td>
<td>NS</td>
<td>−0.62</td>
<td>1.02</td>
<td>NS</td>
<td>−1.37</td>
<td>1.59</td>
<td>*</td>
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<tr>
<td><strong>Dental</strong></td>
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</tr>
<tr>
<td>ΔOB (mm)</td>
<td>5.56</td>
<td>1.94</td>
<td>†</td>
<td>−0.99</td>
<td>1.05</td>
<td>*</td>
<td>−0.21</td>
<td>0.55</td>
<td>NS</td>
<td>−1.20</td>
<td>1.44</td>
<td>*</td>
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<td>ΔIMPA (°)</td>
<td>−0.66</td>
<td>7.34</td>
<td>NS</td>
<td>0.47</td>
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<td>NS</td>
<td>0.55</td>
<td>2.39</td>
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<tr>
<td>ΔU6-PP (mm)</td>
<td>−2.39</td>
<td>1.76</td>
<td>†</td>
<td>0.40</td>
<td>0.59</td>
<td>NS</td>
<td>0.05</td>
<td>0.35</td>
<td>NS</td>
<td>0.45</td>
<td>0.46</td>
<td>*</td>
</tr>
<tr>
<td>ΔU1-PP (mm)</td>
<td>1.05</td>
<td>1.40</td>
<td>*</td>
<td>−0.07</td>
<td>0.49</td>
<td>NS</td>
<td>0.33</td>
<td>0.34</td>
<td>*</td>
<td>0.27</td>
<td>0.49</td>
<td>NS</td>
</tr>
<tr>
<td>ΔL1-MP (mm)</td>
<td>1.59</td>
<td>2.10</td>
<td>NS</td>
<td>−0.27</td>
<td>0.81</td>
<td>NS</td>
<td>0.22</td>
<td>0.58</td>
<td>NS</td>
<td>−0.04</td>
<td>0.58</td>
<td>NS</td>
</tr>
</tbody>
</table>

*ΔT2-T1*, change from initial evaluation to immediately after treatment; *ΔT3-T2*, change during the first year of retention; *ΔT4-T3*, change after the first year to the end of 3 years of retention; *ΔT4-T2*, change during the entire 3 years of retention; Sig, significance; NS, not significant.

*P < 0.05; †P < 0.01; ‡P < 0.001.

Negative values represent decreases during treatment; positive values represent increases during treatment.
displacement of the posterior nasal spine, eruption of the maxillary molars, and downward and backward rotation of the mandible resembled the relapse events after orthognathic surgery.\textsuperscript{1,2,11} Such events after surgery are thought to be a physiologic adaptation of adjacent muscles and soft tissues to the altered skeletal structures.\textsuperscript{2,12}

As for dental changes before and after treatment, the incisal overbite deepened after posterior intrusion as intended, but we also found a significant amount of extrusion on the maxillary anterior teeth during treatment that aided in deepening the overbite (Table II). Because the amount of overbite correction did not significantly correlate with posterior intrusion (Table III), we confirmed that both posterior intrusion and anterior extrusion contributed to the improvement in the anterior overbite. In addition, there was no significant difference between groups treated with and without premolar extractions, in terms of the amounts of extrusion of maxillary anterior teeth and overbite correction.

Although the intruded maxillary molars and overbite significantly relapsed throughout the 3 years of retention, most relapse occurred during the first year of retention (Table II, Fig 3). A significant amount of overbite relapse and over 80% of the total relapse of the maxillary molars occurred during this first year. The 2 values showed recurrence, even between the end of the first year and the third year (T4-T3), but it was not significant. Taken together, these results suggest that, if an effective retention method is applied during the first year of retention, we could prevent the relapse and significantly improve the long-term stability of the treatment.

Many studies have emphasized the importance of proper retention after orthodontic treatment. To achieve good stability, one must pay great attention to the collaborative influence of the tongue and the soft tissues around the mouth. Any causative factor should be detected by meticulous examination of the patient and thoroughly eliminated as part of the treatment; otherwise, it will counteract the bite closure. Continuously monitoring these factors during the retention period is also essential to prevent them from reappearing.\textsuperscript{1,13-15}

Furthermore, having these surrounding structures adapt and maintain a functional balance with the reformed skeletal and occlusal relationships is important in achieving excellent stability.\textsuperscript{3,16,17} Along these lines, Kondo and Aoba,\textsuperscript{13} Kondo,\textsuperscript{14} and Arai and Kondo\textsuperscript{15} reported that maintaining myofunctional therapy after its application for open-bite correction helps significantly to enhance the long-term stability of the treatment.

Although one can never overemphasize the importance of retention after orthodontic treatment, an effective method of retention after intrusion treatment has not

\begin{table}[h]
\centering
\caption{Correlation coefficients between cephalometric variables (T2-T1)}
\begin{tabular}{llll}
\hline
Variable 1 & Variable 2 & R & P & Sig (2-tailed) \\
\hline
U6-PP & FMA & 0.56 & 0.120 & NS \\
U6-PP & OB & 0.02 & 0.963 & NS \\
OB & SNPog & 0.70 & 0.036 & \* \\
OB & SN-MP & 0.74 & 0.022 & \* \\
OB & SNB & 0.71 & 0.046 & \* \\
SNB & SNPog & 0.97 & 0.000 & \* \\
SNB & SN-MP & 0.79 & 0.011 & \* \\
VP-Pog & SNPog & 0.84 & 0.005 & \* \\
VP-Pog & SN-MP & 0.50 & 0.175 & NS \\
VP-Pog & SNB & 0.83 & 0.006 & \* \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Correlation coefficients between pretreatment measurements (T1) and changes in overbite (OB: T4-T2)}
\begin{tabular}{llll}
\hline
Variable 1 (T1) & Variable 2 (T4-T2) & R & P & Sig (2-tailed) \\
\hline
OB & OB & 0.448 & 0.226 & NS \\
SN-MP & OB & 0.243 & 0.529 & NS \\
LAFH & OB & 0.092 & 0.815 & NS \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Correlation coefficients between T2-T1 variables and T4-T2 variables}
\begin{tabular}{llll}
\hline
Variable 1 (T2-T1) & Variable 2 (T4-T2) & R & P & Sig (2-tailed) \\
\hline
U6-PP & U6-PP & 0.602 & 0.086 & NS \\
OB & OB & 0.674 & 0.023 & \* \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Relapse rate of U6-PP and overbite (OB)}
\begin{tabular}{ll}
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Variable & Relapse rate (\%) \\
\hline
U6-PP (mm) & 22.88 \\
OB (mm) & 17.00 \\
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\end{tabular}
\end{table}

$T_1$, before treatment; $T_2$, after treatment; $R$, Pearson correlation coefficient; Sig, significance; NS, not significant.

*P <0.05; †P <0.01; ‡P <0.001.
been introduced. Even in our study, the intruded maxillary molars had significant amounts of relapse during the entire 3 years of retention. A tooth displaced intrusively is much less stable than one displaced either mesiodistally or rotationally; a reason is that there is really no effective way to retain an intruded tooth.18-20 Beckmann and Segner21 suggested the use of Hawley removable appliances to enhance the stability of orthodontic treatments, but they are inadequate for preventing relapse of intruded posterior teeth.

Although it was not used in this study, we have devised our own retention appliance to solve this problem and effectively retain intruded molars. The appliance was designed to be aided by the miniscrew implants used to intrude the maxillary molars. After we achieved molar intrusion with these implants, we made sure that they were well maintained for further use. Then, we fabricated the so-called active retainer, which is a clear retention appliance with buttons attached to the buccal side of the maxillary molar positions to provide sites where they can hook to miniscrew implants with elastics (Fig 4). This appliance is expected to effectively prevent the eruption of intruded maxillary molars.

The importance of these results is that they provide the basis to emphasize the importance of posttreatment retention, especially during the first year after treatment. Subsequent studies might further elaborate on this point by analyzing the relapse patterns in patients treated with and without retainers during this period.

In analyzing the correlations between cephalometric variables, we verified that overbite correction was mainly attained by forward and upward rotation of the mandible. There was also forward and upward displacement of pogonion as the SN-Pog angle increased during treatment (Table III). There was no significant correlation between the amounts of posterior intrusion and overbite correction, indicating that other components, such as eruption of the anterior teeth, also contributed to the deepening bite.

Researchers have attempted to develop indexes to predict the stability of open-bite treatments by observing the relationships among such cephalometric variables. Beckmann and Segner21 reported that patients with severe open bite and a large mandibular plane angle and anterior facial height tend to have relatively low posttreatment stability. Janson et al22,23 and de Freitas et al24 concluded that the severity of pretreatment conditions greatly affects the stability after extraction treatment. On the other hand, Lopez-Gavito et al25 asserted that there is not 1 indicator to help predict the posttreatment stability and reported that no pretreatment value in their study strongly correlated with the extent of relapse after treatment. Remmers et al10 also reported that no pretreatment variable can serve as an indicator of stability and that it is impossible to predict the success and stability of open-bite treatment beforehand. The results of our study were consistent with these reports; initial overbite, mandibular plane angle, anterior facial height, and all other pretreatment values did not correlate with the extent of relapse on incisal overbite (Table IV). However, in regard to the correlation between overbite change after treatment and overbite relapse 3 years posttreatment, the results did not agree with previous reports, including the precedent study by Lee et al5; only the change in overbite significantly correlated with the extent of relapse (Table V).
correlation suggests that overbite relapse was proportional to overbite correction achieved during treatment. Therefore, a practitioner might plan to overcorrect the overbite because of the estimated relapse of the overbite correction. This approach would allow the patient to end up with the targeted correction even after a certain amount of relapse.

In the study by Lee et al,5 relapse occurred in 10.36% of intruded maxillary molars and 18.10% of overbites by 1 year posttreatment. These results show relatively high posttreatment stability compared with that reported by Sugawara et al,4 whose open-bite patients were treated with intrusion of the mandibular molars and experienced relapse in 30% of the intruded molars. In our study, relapse occurred in 22.88% of the intruded maxillary molars and 17.00% of overbites by 3 years posttreatment (Table VI). Inversely, these relapse rates give success rates of 77.12% for maxillary molar intrusion and 83.00% for overbite correction. Comparing these success rates with those of orthognathic surgery of anterior open-bite patients, Denison et al5 reported a 79% success rate at 3 years posttreatment, Hoppenreis et al20 reported 81% success at 5 years posttreatment, Lo and Shapiro27 reported 75% success at 5 years posttreatment, and Proffit et al2 reported 88% success at 5 years posttreatment. Huang9 also asserted that the overall success rate of orthognathic surgery is approximately 75% to 88%. Although not involving surgery, the success rate from this study had little disparity from surgical approaches, providing a strong basis for applying the orthodontic posterior intrusion method for correcting patients with mild to moderate skeletal anterior open bite.

Many studies evaluating the stability of anterior open-bite treatments point out that their studies were limited by small sample groups, short retention and follow-up periods, and no control groups. Because our study also had these limitations, future prospective studies are expected to further support these results by including more patients and longer retention periods, and by using quantitative methods to assess the treatment results.

CONCLUSIONS

The purpose of this study was to evaluate the long-term stability of anterior open-bite treatment in adults
treated by orthodontic intrusion of the maxillary posterior teeth. This evaluation was performed by measuring the posttreatment changes of selected parameters and the extent of relapse after more than 3 years. The following conclusions can be drawn:

1. Skeletally, counterclockwise rotation of the mandible occurs after treatment and, in turn, improves skeletal Class II malocclusion tendencies to skeletal Class I.
2. More than 80% of relapse of the intruded maxillary first molars occurs during the first year of retention.
3. A significant amount of overbite relapse occurs at the end of the first year of retention, but not between the end of the first year and the third year.
4. There was no correlation between initial amount of open bite, mandibular plane angle, or lower anterior facial height and posttreatment overbite relapse. However, there was a significant correlation between the amount of overbite correction achieved by the treatment and the extent of relapse.

If an appropriate retention method is applied during the first year, considering the initial skeletal configuration, muscle force, and influence of the tongue and soft tissues, it would effectively enhance the long-term stability of anterior open-bite treatment.

REFERENCES