論文題名
Long-term evaluation of early versus late orthodontic treatment of crowded first premolar extraction cases

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A long-term evaluation of early versus late orthodontic treatment of crowded first premolar extraction cases

ABSTRACT

The purpose of this study was to evaluate the differences in the long-term craniofacial pattern of orthodontically induced changes between early orthodontic treatment (mixed dentition) and late orthodontic treatment (permanent dentition). Cephalometric radiographs were evaluated before treatment, after treatment, and at minimum of 10 years after retention for an early orthodontic treatment group of 28 and a late orthodontic treatment group of 28. All were categorized as either Angle Class I and Class II malocclusion at pre-treatment and had received routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraction. There were no significant differences between these groups at pre-treatment and post-treatment except linear measurements according to age difference. Irregularity index at pretreatment had a statistical significant correction with the change of gonial angle during the treatment period and the change of occlusal plane angle during the treatment period. Decreasing the gonial angle and occlusal plane angle during the treatment period may indicate to improve long-term stability.

INTRODUCTION

Long-term stability of orthodontic treatment is one of the most important concerns of orthodontists and patients. In 1960 Richard Riedel stated, "Retention is and will continue to be a problem of treatment." This sage admonition drives our search for understanding and improved treatment methods. Early orthodontic treatment has been advocated because it may not only correct the occlusion but also may promote normal development of the dentition. Proper arch form and dental relationships in the mixed dentition may lessen the need for additional orthodontic treatment. Objectives in
mixed dentition orthodontic therapy could include correction of dental arch irregularities, occlusion and jaw relation abnormalities, and functional interference, but does this improve stability? There have been a number of studies to evaluate long term stability, but no study to describe skeletal changes when comparing early versus late orthodontic treatment of first premolar extraction cases. This study investigated these differences by using cephalometric radiographs of patients who had been out of retention a minimum of 10 years.

MATERIALS AND METHODS
The sample consisted of diagnostic records for 80 patients who ware categorized as either Angle Class I, Class II division 1, or Class II division 2 malocclusion at pretreatment. These cases had been selected and were submitted to the Department of Orthodontics, University of Washington and from faculty practices in the Seattle area. All cases had pretreatment radiographs (moderate irregularity, severe irregularity, or very severe irregularity) of mandibular and maxillary anterior and no spacing in the anterior dentition. Patients with anterior overbite and/or posterior crossbites were not included in this study. Patients were divided into two groups according to the time of the initial orthodontic mechanical treatment (Table 1).

<table>
<thead>
<tr>
<th>Early (mixed dentition) orthodontic treatment group</th>
<th>Late (orthodontic treatment group)</th>
</tr>
</thead>
</table>
| (Sella's dental stage III C21) or after (n=56) | All permanent teeth anterior to second permanent molars had erupted prior to any treatment. Extraction or first premolars was accomplished and active treatment immediately began. All cases of Class II division 1 and Class II division 2 involved headgear therapy to the maxillary arch. In some of the cases, a maxillary arch bar plate was used for overbite reduction. Each patient had complete records including dental casts and cephalometric radiographs at three time periods (Table 1): pretreatment (T1), at the end of active treatment (T2), and minimum of 10 years after removal of retainers (T3). All patients had undergone routine edgewise orthodontic treatment that included maxillary and mandibular first premolar extraction. All four premolars were extracted either just before or soon after (within five months) the start of initial treatment. Treatment was followed by a variable period of retention, typically 1 to 3 years of a removable upper arch retainer and a lower arch canine to canine fixed retainer. No case received a "silkon plate" (interproximal supragingival fibroplasty) in an effort to avoid postretention rotation change. To be considered a part of the sample, a clinically acceptable result at the end of active treatment had to have been achieved and at postretention there had to be a full complement of teeth excluding extracted first premolars.

The average postretention period was 15 years for both the early and late orthodontic treatment groups. There was no statistically significant difference in posttreatment period between early and late orthodontic treatment groups.

Measurements on cephalometric radiographs
To reduce examiner bias in the current study, each cephalometric radiograph was numbered and measured in random order via a computer-generated list. Pretreatment (T1), posttreatment (T2) and postretention (T3) lateral cephalometric radiographs were traced on acetate film using a 0.5-mm lead pencil by the same trained dentist. Cephalometric landmarks were digitized with the Nacasonic Digitizer (Nacasonic Corp., Montgomeryville, Pa., USA). Using the Macintosh Quick Ceph Program (Quick Ceph Systems, San Diego, Calif., USA), the following twenty angular and eleven linear measurements were calculated:

Angular measurements:
- SNA°
- SNB°
- ANB°
- Upper to NA°
- Lower to NB°
- Occlusal plane angle°
- Interincisal angle°
- FMJ°
- FMIA°
- IMPA°
- Saddle angle°
- Articular angle°

Linear measurements:
- GoS
- Upper Gonsal angle°
- Lower Gonsal angle°
- Liner measurements:
- Upper 1 to NA°
- Lower 1 to NB°
- Wits appositional°
- Anterior cranial base°
- Posterior cranial base°
- Ramales height°
- Mandibular body length°
- Posterior facial height°
- Anterior facial height°
- Convexity°
- ANS-Me dull°

The reproducibility of the measurements was assessed by the statistically analyzing the differences between double measurements taken at least two weeks apart on 15 cephalometric radiographs selected at random. The error of the method was calculated from the equation:

\[ \text{error} = \sqrt{\text{SSD}^2 / \text{N}^2} \]

where SSD is the difference between duplicate measurements and N is the number of double measurements. The error was calculated for each of the cephalometric measurements. The method did not ex-
Data analysis

The means and standard deviations were calculated for each parameter and statistical analysis was performed by using standard methods. Groups were compared by unpaired Student's t-test for independent groups, and the significance of changes across time was determined by paired Student's t-test for paired data. Association between variables was evaluated by the Pearson product-moment correlation coefficient, discriminant analysis, and a multiple linear regression analysis.

RESULTS

Measurement of cephalometric radiograph

Mean measurement values are listed in Table 2. For angular measurement, at pretreatment (T1), there were statistically significant differences between the groups on Upper incisor to NA angle, Lower incisor to NB angle, Interincisal angle, FMIA and Upper Gonial angle. At pretreatment, the average patient included in the sample of late treated group had a more proclined maxillary and mandibular incisors. However, there were no statistically significant differences between groups at posttreatment (T2) and postorthodontic (T3). For linear measurement, at pretreatment there were statistically significant differences between groups on all linear measured values except Wits appraisal and Convexity. However, there were no statistically significant differences between groups at posttreatment period (T2) and postorthodontic period (T3).

Treatment (T1-T2), posttreatment (T2-T3) and overall (T1-T3) changes are listed in Table 3. During the treatment period (T1-T2), there were significant differences in changes on SNA, ANB, Upper to NA angle. Occlusal plane angle, Interincisal angle, FMIA, Articular angle and Gonial angle between early and late groups. In linear measurement during the treatment period (T1-T2), there were statistical significant differences of change on all linear measured values except Wits appraisal. However, during the post-treatment period (T2-T3), there was no statistical significant difference of changes except the change of Mandibular body length between early and late groups. During the overall period (T1-T3), there were the same tendencies of the change as during the treatment period (T1-T2). There were no statistical significant difference of change on Lower 1 to NB angle and FMA during the treatment period (T1-T2), but there were significant statistical differences of changes on Lower 1 to NB angle and FMA during the overall period (T1-T3).

Treatment and posttreatment changes which were compared with zero are listed in Table 4. During the treatment period (T1-T2), the angular measures of SNA, ANB and Upper Gonial angle, and the linear measure of Lower 1 to NB and Wits appraisal indicated significant treatment decreasing in both early and late groups. The angular measures of Gonial angle indicated significant decreasing only in the early group. The other way, the angular measures of Upper 1 to NA angle, Lower 1 to NB angle indicated significant treatment decreasing only in the late group. The linear measurement of skeletal values in early group indicated significant growth increasing.
However, in the late group, there was no significant growth increasing in Posterior cranial base in the treatment period, and the linear measurement of Upper 1 to NA (mm) indicated significant treatment decreasing only in the late group. During the posttreatment period (T2-T3), the angular measures of FMA and Lower Gonial angle indicated significantly decreasing. The linear measurement of all values indicate significant increasing in both early and late groups. However, the angular measures of Occlusal plane angle and Gonial angle indicated significant decreasing only in the early group and the linear measurement of Wits appraisal indicated significant increasing only in the late group respectively.

In assessing the other cephalometric parameters, some clinically useful correlations were found. A weak association existed between the change of Gonial angle from pretreatment and posttreatment (T1-T3) and Mandibular body length at pretreatment (T1) (r=0.49), and Ramus height at pretreatment (T1) (r=0.32). A weak association existed between the change of Occlusal plane angle from pretreatment and posttreatment (T1-T3) and Wits appraisal at pretreatment (T1) (r=0.48). A moderate negative association existed between the change of Occlusal plane angle from pretreatment and posttreatment (T1-T3) and the change of SNA from pretreatment and posttreatment (T1-T3) (r=0.59), and the change of Upper incisal to NA angle from pretreatment and posttreatment (T2-T3) (r=0.59).

**Associations cephalometric radiographs and study models**

In assessing the parameters of study models at posttreatment (T3) and cephalometric parameters, some clinically useful correlations were found. A weak association existed between the irregularity index at posttreatment (T3) and Gonial angle during the treatment period (T1-T2) (r=0.31), the irregularity index at posttreatment (T3) and Occlusal plane angle during the treatment period (T1-T2) (r=0.32), between the irregularity index at posttreatment (T3) and ANB at posttreatment (T2) (r=0.33). ANB at posttreatment (T3) had a statistically significant correlation with Convexity, ANB, Wits appraisal and Overjet at pretreatment (T1) (Table 6).
Table 7 Pearson's correlation coefficient (r-value) between ANB at posttretament (T2) and other tested variables.

<table>
<thead>
<tr>
<th>variable</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonial angle</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>ANB</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.41</td>
<td>0.14  **</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.50</td>
<td>0.25   ***</td>
</tr>
<tr>
<td>Anterior occlusal angle</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>ANB</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Anterior occlusal angle</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>ANB</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>Anterior occlusal angle</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>ANB</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
</tbody>
</table>

Other tested variables were excluded data at T2 and T3.

Table 8 Pearson's correlation coefficient (r-value) between Mandibular body length at posttretament (T3) and other tested variables.

<table>
<thead>
<tr>
<th>variable</th>
<th>r</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Mandibular body length</td>
<td>0.54</td>
<td>0.29  ***</td>
</tr>
<tr>
<td>(Arch length)</td>
<td>0.50</td>
<td>0.25   ***</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.43</td>
<td>0.18  **</td>
</tr>
<tr>
<td>Gonial angle</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>ANB</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Anterior occlusal angle</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>ANB</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.30</td>
<td>0.20   ***</td>
</tr>
<tr>
<td>Anterior cranial base length</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>Anterior occlusal angle</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>ANB</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
<tr>
<td>Convexity</td>
<td>0.29</td>
<td>0.08   *</td>
</tr>
</tbody>
</table>

Other tested variables were excluded data at T2 and T3.

The ANB correction was primarily due to the decrease of SNA, indicated that the maxilla may be maintained or displaced slightly posteriorly by the effect of a face-bow in Class II patients. The decrease of SNA in the early group indicated significant greater treatment decreasing than the late group. However, there was no significant difference of SNA between early and late groups during the treatment period (T1-T2) and overall period (T1-T3). Consequently, the angular measurement of ANB in the early group indicated greater treatment effect than the late group. During the posttreatment period (T2-T3), there was no significant difference in change of ANB among both groups (Table 3).

Most of the differences of the linear measurements between early and late groups in the treatment period (T1-T2) and the overall period (T1-T3) were probably due to the differences of the growth and development by the age at pretreatment (T1). This is the reason that there was no statistical significant difference of the linear measurements between early and late groups in the posttreatment period (T2-T3) except mandibular body length (Table 3).

The post-treatment changes in cephalometric radiographs were indicated that the maxilla maintained or displaced slightly posteriorly during the posttreatment period (T2-T3) only in the early group. With appraisal for posttreatment changes
indicated significant increase only in the late group. It was a very interesting finding because the Wits appraisal in the early group was stable but that in late group showed relapse.

Irregularity index at postretention (T3) had a statistical significant relationship with the change of Gonial angle during the treatment period (Table 6). Irregularity index at postretention (T3) had a statistical significant relationship with the change of occlusal plane angle during the treatment period (T1-T2). The results of the regression analyses suggested that the decreasing of Gonial angle and occlusal plane angle during the treatment period were significant predictors for the amount of incisor crowding at postretention (T3).

These interesting findings in the current study suggest that we should make an effort to reduce Gonial angle and occlusal plane angle during the treatment period to improve long-term stability.

ANB at postretention (T2) had a statistically significant correlation with the change of FMA, occlusal plane angle and Gonial angle during the posttreatment (T2-T3) and with the change of occlusal plane angle during the treatment period (T1-T2). These correlations indicated that counter clockwise rotation of the mandible was due to the small ANB at postretention. We could confirm the general clinical impression that a reduction in mandibular plane angle is associated with decrease of ANB. ANB at postretention (T3) had a statistically significant negative correlation with the change of Anterior cranial base during the treatment period (T1-T2) and posttreatment period (T2-T3) (Table 7). These correlations were confirmed that the smaller ANB was due to the anterior N point in general.

Finally, in our previous study, the patient's age at treatment (T1) had a significant negative correlation with deviation of midline at postretention (T3) and the change of Irregularity index during the posttreatment period (T2-T3) and a significant correlation with Irregularity index at postretention (T3). These significant correlation between the patient's age and relapse of model analyses were indicated the advantage of early orthodontic treatment. The current study, it is very interesting finding between the patient's age at treatment (T1) and Mandibular body length at postretention (T3) (Table 8). The younger age of treatment was the shorter Mandible at treatment (T1), while the younger age of treatment was the longer Mandible at postretention (T3). Thus, observed the patient's age at treatment time (T1) with other treated variables indicated the advantage of early orthodontic treatment of crowded first premolar extraction cases in Angle's Class I and Class II malocclusion (Table 9).

It is the goal of early treatment to minimize or eliminate skeletal, dental-occlusal and muscular problems by the end of the transition to the permanent dentition. At this time, it is hoped that skeletal imbalances and functional imbalances have been resolved easier than the permanent dentition. However, each sample demonstrates the marked variation. In clinically, we sometimes have been experienced that early intervention does not change appreciably the environment for dental-occlusal development. These concerns also must be considered when evaluating treatment options and we must recognize the importance of total diagnosis in early dentition.

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2) Haruki, T., Little, R. M. : Early versus late treatment of crowded first premolar extraction cases


