Relapse of anterior crowding in patients treated with extraction and nonextraction of premolars

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Introduction: The purpose of this study was to evaluate long-term stability of incisor crowding in orthodontic patients treated with and without premolar extractions. Methods: Dental casts and cephalometric records of 98 patients were evaluated before treatment (T1), at posttreatment (T2), and at postretention (T3). Half of the patients had been treated with extractions, and half were treated nonextraction. Results: Irregularity, as measured by the irregularity index, decreased 5.51 mm in the extraction group and 2.38 mm in the nonextraction group. Mandibular incisor irregularity increased 0.97 mm in the extraction group and 0.99 mm in the nonextraction group, respectively, in the postretention period. Maxillary incisor irregularity relapse was smaller than mandibular incisor relapse for both groups. Intercanine width expanded during treatment. At T3, mandibular intercanine width decreased in both groups, but the differences were not statistically significant. At T3, intermolar width was stable, arch depth decreased, overbite and overjet slightly increased, SN mandibular plane angle decreased, and incisor positions in both groups tended to return to T1 values. Clinically acceptable stability was obtained. Conclusions: With the exception of the interincisal angle, no statistically significant differences were recorded between the extraction and nonextraction groups from T2 to T3. No statistically significant correlations were found between any variables studied and mandibular incisor irregularity at T1, T2, and T3. (Am J Orthod Dentofacial Orthop 2006;129:775-84)

A major goal of orthodontic treatment is to achieve long-term stability of posttreatment occlusion. Several investigators have evaluated treatment results and long-term posttreatment stability of orthodontically treated malocclusions.1–5 The stability of aligned teeth is variable and largely unpredictable. This variability might be due to severity and type of malocclusion, treatment approach, patient cooperation, or growth and adaptability of the hard and soft tissues.6

Premolar extraction to permit alignment of crowded teeth has been an accepted procedure for decades and continues to be a common treatment modality for patients with crowded arches. However, mandibular incisors suffer from relapse and crowding despite their retraction during extraction treatment. Because of changing concepts of facial soft-tissue profile esthetics and late growth changes, the trend in orthodontics has been toward nonextraction treatment. The question thus arises as to which treatment procedure is most helpful in achieving long-term stability.

Previous long-term studies on relapse of anterior crowding have most often evaluated patients treated with extraction.2,3,7–11 Different results might be seen in the relapse patterns of patients treated without extractions12–19 or by comparing extraction and nonextraction groups.4,20–27

Many theories have been proposed and controversies exist about the cause of relapse. Protrusion and final position of the mandibular incisors might influence the stability of orthodontic treatment. The pretreatment position of the mandibular incisors is the best guide for their labiolingual position of stability.7,28 Nance29 asserted that flaring the mandibular incisors is never a successful treatment technique. Brodie30 studied nonextraction orthodontic patients, and Cole31 studied extraction patients; both concluded that the axial inclination of teeth disturbed by orthodontic treatment tends to return to pretreatment conditions. Weinberg and Sadowsky16 reported that the protrusion of mandibular incisors can predispose them to relapse. On the other hand, Freitas et al19 reported that final mandibular incisor inclination and linear protrusion do not influence crowding relapse. Schulaf et al32 reported that the mandibular incisor anteroposterior position relative to various cephalometric values had no relationship to postretention crowding of mandibular incisors.
Investigators found that the most frequent cause of mandibular incisor instability was expansion of intercanine width during treatment.\(^{18,23,25}\) It has been reported that stable results can be gained only when mandibular intercanine width is maintained.\(^{14,25,33}\) Yet it has also been shown that maintenance of the pretreatment intercanine distance during treatment does not guarantee stability of the mandibular incisors’ alignment.\(^{19,24}\) Arch-length decrease in the postretention stage might cause incisor crowding. Kahl-Nieke et al\(^ {22}\) and Årtun et al\(^ {27}\) reported that arch-length increase is associated with crowding relapse.

Another factor might be that postadolescent growth of the jaws affects stability and influences orthodontic treatment results over the long term. Sampson\(^ {34}\) and Vaden et al\(^ {10}\) reported that growth rotation is greater in the mandible than in the maxilla, and that might be a factor in the higher incidence of mandibular crowding.

Evidence from the literature indicates many variables and conflicting points of view. The intent of this study was to search for associations between cephalometric and dental-cast parameters that might be clinically useful predictors of posttreatment alignment of incisors.

**MATERIAL AND METHODS**

The sample consisted of complete records (dental casts and cephalometric radiographs) of 98 patients from 3 time periods: pretreatment (T1), at the end of active treatment (T2), and at postretention (T3). The group was equally divided into nonextraction and extraction groups. The nonextraction group (n = 49) included 19 males and 30 females, mean ages 14 years 1 month at T1, 16 years 3 months at T2, and 20 years 11 months at T3. The mean treatment time was 1 year 9 months, and the mean postretention time was 4 years 8 months. The extraction group (n = 49) also included 19 males and 30 females, with mean ages of 12 years 11 months at T1, 14 years 8 months at T2, and 19 years 7 months at T3. The mean treatment time was 2 years 2 months, and the mean postretention time was 4 years 11 months.

In the extraction group, the maxillary and mandibular first premolars were extracted. All patients evaluated in this study had pretreatment malocclusions of Angle Class I or Class II Division I. There were 28 Class I and 21 Class II Division I patients in each group. All patients were treated with edgewise mechanics and achieved acceptable posttreatment results, both maxillary and mandibular arches were retained with Hawley retainers; the postretention period was at least 2 years. None of the subjects had congenitally missing permanent teeth or was treated with rapid palatal expansion.

**Analysis of dental casts**

Dental casts were measured by 1 investigator (A.E.E.) on the mandibular and maxillary dental casts, to the nearest 0.01 mm with a digital caliper. The following measurements were obtained for each set of casts. All measurements were linear.

1. Incisor irregularity: the sum, in millimeters, of the 5 distances between the anatomic contacts from the mesial aspect of the left canine through the mesial aspect of the right canine according to the method described by Little.\(^ {35}\)

2. Canine-canine width: distance between crown tips of the right and left canines. In some cases, this value could not be measured at T1 because the permanent canines were not yet erupted (Fig 1, A). In the extraction group, 46 maxillary intercanine widths and 48 mandibular intercanine widths and, in the nonextraction group, 47 maxillary intercanine widths and 49 mandibular intercanine widths were measured. In the extraction group, intercanine widths of only 4 patients and, in the nonextraction patients group, intercanine widths of only 2 patients were not measured.

3. First premolar-first premolar width: distance between the central fossae of the first premolars in both jaws (Fig 1, B).
4. Second premolar-second premolar width: distance between the central fossae of the second premolars in both jaws (Fig 1, C).

5. First molar-first molar width: distance between the central fossae of the first molars in both jaws (Fig 1, D).

6. Arch depth: perpendicular length from the midpoint between the maxillary and mandibular central incisors to the line drawn between the mesial anatomic contact points of the first molars (Fig 1, E).

7. Overjet: distance parallel to the occlusal plane from the incisal edges of the most labial maxillary to the most labial mandibular central incisor recorded in millimeters.

8. Overbite: amount of vertical incisal overlap of the maxillary and mandibular central incisors recorded in millimeters.

Analysis of lateral cephalometric radiographs

To analyze the lateral cephalometric radiographs, the 16 cephalometric landmarks shown in Figure 2 were located, and 4 angular and 5 millimetric variables were measured (Fig 3). The measurements were made by 1 investigator (A.E.E.). The cephalograms were traced and digitized with the Dentofacial Planner digitizing pad (Dentofacial Software Inc, Toronto, Canada), and the information was stored and analyzed on a computer.

The cephalometric landmarks were 1, porion; 2, sella; 3, nasion; 4, orbitale; 5, A-point; 6, M-point; 7, posterior nasal spine; 8, maxillary incisor apex point; 9, maxillary incisor tip point; 10, mandibular incisor tip point; 11, mandibular incisor apex point; 12, B-point; 13, pogonion; 14, menton; 15, gonion; and 16, articular.

Maxillary Point M, representing the midpoint of the premaxilla in the midsagittal plane, was located on the tracings according to the superior anterior, and the palatal outlines of the premaxilla and the midpoint were identified with concentric circles to find the circle that best fit the premaxilla or the outlines of the premaxilla. This point was used in drawing the palatal plane.

Cephalometric planes were drawn as shown in Figure 3, and the following measurements were made. To assess sagittal changes in jaw relationship, measurements were made from Points A and B to the vertical plane (VP), which was drawn perpendicular to the horizontal plane (7° to sella-nasion line) at sella.

1. VP to A point (mm): line formed perpendicular to the VP at A-point.
2. VP to B point (mm): line formed perpendicular to the VP at B-point.
3. Palatal plane to menton (mm): line formed perpendicular to the palatal plane at menton (lower face height).
4. Mandibular central incisor to NB (mm).
5. Pogonion to NB (mm).
6. Maxillary central incisor to SN angle.
7. Incisor-mandibular plane angle (IMPA).
8. Interincisal angle.
9. SN to mandibular plane angle.

The posttreatment cephalometric changes were used as predictor variables to test whether growth of any of the skeletal units after treatment was significantly associated with dental changes measured from the casts.

Method error

Twenty randomly selected orthodontic models were remeasured 1 month later to estimate the error of measurement. The paired *t* test for differences between the replications showed no statistically significant differences. These results indicated the reliability of the measurements.

To determine the error of tracing, digitizing, and measuring, 20 cephalograms were randomly selected, retraced, and redigitized by the same examiner 1 month after the initial procedure. The paired *t* test for differences between the replications showed statistically no significant differences and indicated the reliability of the measurements.

Statistical analysis

Means and standard deviations were calculated for the T1, T2, and T3 measurements and for the differences between the T1 and T2 measurements, and the T2 and T3 measurements. Analyses of the changes during treatment and postretention were performed separately. In each treatment group (extraction and nonextraction), a paired *t* test was used to determine whether a change was significantly different from 0. Differences between the treatment groups were tested by using analysis of variance with treatment and sex as factors. No significant influence by sex was found. The level of significance was predetermined at the 0.01 level of confidence. In addition, Pearson correlation coefficients were used to evaluate the association between the cast and cephalometric variables. All analyses were performed with software (version 8.1, SAS Institute, Cary, NC).

RESULTS

Tables I and II give the average changes from T1 to T2, and T2 to T3. Table III gives the statistical significance of differences between the extraction and nonextraction groups for the changes from T2 to T3. Of all the measurements, only interincisal angle showed a statistically significant difference during the postretention period in both groups.

Pearson correlation coefficients were used to determine whether there were simple pairwise correlations between the variables of this study. These estimates were obtained to assess mandibular incisor stability at T1, T2, and T3. No significant correlations (*r* > 0.7) were identified that would help predict postretention incisor irregularity.

Dental-cast data

Both groups showed statistically significant decreases in overjet with treatment. No significant postretention relapse occurred.

Overbite decreased 1.22 mm in the extraction group and 1.54 mm in the nonextraction group during the treatment period. These changes were statistically significant. However, statistically significant relapse occurred at T3 for both groups.

The extraction patients had higher irregularity index values than the nonextraction patients at T1. The irregularity index was 5.57 mm for mandibular teeth and 4.40 mm for maxillary teeth in the extraction group; this corresponds to moderate irregularity according to Little. In the nonextraction group, the irregularity indexes were 2.38 mm for the mandibular teeth and 1.94 mm for the maxillary teeth; this is minimal irregularity. Treatment produced a statistically significant decrease in maxillary and mandibular incisor irregularity in both groups, and mandibular incisor irregularity increased significantly—0.97 and 0.99 mm in the extraction and nonextraction groups, respectively—during the postretention period. Maxillary incisor irregularity increased less than mandibular incisor irregularity from T2 to T3, and these changes were not statistically significant.

In both groups, mandibular intercanine width increased significantly during treatment and decreased significantly at postretention.

After treatment, in the extraction group, the increase in maxillary intercanine width was not statistically significant, but the increase in the nonextraction group was significant. No statistically significant relapse occurred in maxillary intercanine width in either group.

At T2, premolar width decreased significantly in the extraction group in both jaws, but, in the nonextraction group, maxillary premolar width significantly increased, and mandibular premolar width showed a slight increase. At T3, the premolar width decreased in both groups.

Maxillary and mandibular intermolar width decreased significantly in the extraction group at T2 and
remained stable at T3. In the nonextraction group, this width slightly expanded during treatment; it was not statistically significant and increased slightly during postretention period.

In the extraction group, maxillary and mandibular arch depth decreased during treatment (T2) and continued to decrease at T3. These changes were statistically significant. In the nonextraction group, the increase in mandibular arch depth during treatment was not statistically significant, but, in the maxillary arch, only a small insignificant decrease was recorded. At the post-retention period (T2 to T3), statistically significant decreases occurred for the maxillary and mandibular arch depths in both groups.

**Cephalometric data**

Anteroposterior mandibular and maxillary growth measured from vertical plane to Points A and B showed that the increases were not statistically significant from T1 to T2 in both groups. At T3, statistically significant increases occurred for maxillary and mandibular growth in both groups.

Lower anterior face height increased during treatment and continued to increase at T2 for both groups. These changes were statistically significant.

In both groups, SN/MP angle was stable during treatment (T2), but the decrease at T3 was statistically significant.

The mandibular incisor axial inclination showed differences between the 2 groups at the 3 times. During T2, a statistically insignificant decrease occurred in IMPA in the extraction group. During the same period, this angle increased significantly in the nonextraction group. At T3, a small insignificant increase in IMPA in the extraction group was reported. In the nonextraction group, it decreased, and this reduction was statistically significant. Mandibular central incisor to NB measurements decreased in accordance with the decrease in IMPA in the extraction group and increased in accordance with the increase in IMPA in the nonextraction group. The mandibular incisors in nonextraction group proclined with treatment (T2) and then retroclined at T3. In the extraction group, the mandibular incisors retroclined with treatment (T2) and then proclined to a lesser degree from T2 to T3. The changes were statistically significant at T2 but insignificant at T3 in both groups.
In the extraction group, the maxillary incisors retroclined with treatment and then proclined to a lesser degree from T2 to T3. The changes in the extraction group at T2 were statistically significant, but the changes at T3 were not significant. In the nonextraction group, the maxillary incisors proclined with treatment (T2), and a small degree of retroclination occurred at T3. These changes were not statistically significant.

In the nonextraction group, because of the proclination of the mandibular and maxillary incisors, the interincisal angle decreased significantly with treatment, and these proclined teeth uprighted from T2 to T3 with significant increases in interincisal angles. In the extraction group, the interincisal angle significantly increased with treatment and stayed stable from T2 to T3. This was the only change between the groups that was statistically significant at T3 (Table III).

**DISCUSSION**

Based on the results of this study, ideal orthodontic treatment should achieve long-term stability of incisor alignment. Controversy exists as to which treatment decision—extraction or nonextraction—will lead to this stability. It is therefore important to investigate long-term changes in the dentitions of patients treated with both treatment regimens.

There was an age difference of 1 year 2 months at T1 between the extraction and nonextraction groups. Based on age at T1, most subjects in the sample were experiencing or were on the verge of the pubertal spurt. However, after orthodontic treatment (approximately 2 years), no statistically significant differences attributable to skeletal growth changes were recorded.

The average incisor irregularity index was smaller in the nonextraction than in the extraction group. Both groups showed improvement with treatment. This should be obvious for extraction and nonextraction treatment decisions. Observation at T3 did not relate to the pretreatment incisor irregularity or crowding of incisors. In agreement with Little et al.,

12 we found no correlation in the postretention increase in irregularity with the severity of crowding before treatment.

At T3, maxillary alignment was stable, but the mandibular incisors relapsed an average of 1 mm in both groups. This was considered a minimal relapse by Little,

35 and it was smaller than the results of other
Table III. Comparison of changes at postretention (T3-T2) between extraction and nonextraction groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Extraction</th>
<th></th>
<th></th>
<th></th>
<th>Nonextraction</th>
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<tbody>
<tr>
<td></td>
<td>D</td>
<td>P</td>
<td>SD</td>
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<td>D</td>
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<td>P</td>
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<td>Cast analysis</td>
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<td></td>
</tr>
<tr>
<td>1. Overjet (mm)</td>
<td>0.34</td>
<td>NS</td>
<td>1.04</td>
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<td>0.4</td>
<td>NS</td>
<td>1.27</td>
<td>NS</td>
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<tr>
<td>2. Overbite (mm)</td>
<td>0.45</td>
<td>S</td>
<td>1.05</td>
<td></td>
<td>0.41</td>
<td>S</td>
<td>0.85</td>
<td>NS</td>
</tr>
<tr>
<td>3. Mand incisor irregularity</td>
<td>0.97</td>
<td>S</td>
<td>1.4</td>
<td></td>
<td>0.99</td>
<td>S</td>
<td>1.16</td>
<td>NS</td>
</tr>
<tr>
<td>4. Mand 3-3 width (mm)</td>
<td>−0.79</td>
<td>S</td>
<td>0.97</td>
<td></td>
<td>−0.48</td>
<td>S</td>
<td>0.78</td>
<td>NS</td>
</tr>
<tr>
<td>5. Mand 4-4 width (mm)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td>−0.31</td>
<td>NS</td>
<td>1.02</td>
<td>—</td>
</tr>
<tr>
<td>6. Mand 5-5 width (mm)</td>
<td>−0.21</td>
<td>NS</td>
<td>1.07</td>
<td></td>
<td>−0.35</td>
<td>NS</td>
<td>0.97</td>
<td>NS</td>
</tr>
<tr>
<td>7. Mand 6-6 width (mm)</td>
<td>0.10</td>
<td>NS</td>
<td>1.13</td>
<td></td>
<td>0.13</td>
<td>NS</td>
<td>0.97</td>
<td>NS</td>
</tr>
<tr>
<td>8. Mand arch length (mm)</td>
<td>−0.67</td>
<td>S</td>
<td>0.6</td>
<td></td>
<td>−1.13</td>
<td>S</td>
<td>0.91</td>
<td>NS</td>
</tr>
<tr>
<td>9. Max incisor irregularity</td>
<td>0.19</td>
<td>NS</td>
<td>0.48</td>
<td></td>
<td>0.12</td>
<td>NS</td>
<td>0.47</td>
<td>NS</td>
</tr>
<tr>
<td>10. Max 3-3 width (mm)</td>
<td>−0.24</td>
<td>NS</td>
<td>0.84</td>
<td></td>
<td>−0.09</td>
<td>NS</td>
<td>0.84</td>
<td>NS</td>
</tr>
<tr>
<td>11. Max 4-4 width (mm)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td>−0.33</td>
<td>NS</td>
<td>0.86</td>
<td>NS</td>
</tr>
<tr>
<td>12. Max 5-5 width (mm)</td>
<td>−0.22</td>
<td>NS</td>
<td>1.11</td>
<td></td>
<td>−0.15</td>
<td>NS</td>
<td>0.85</td>
<td>NS</td>
</tr>
<tr>
<td>13. Max 6-6 width (mm)</td>
<td>0.01</td>
<td>NS</td>
<td>1.18</td>
<td></td>
<td>0.37</td>
<td>NS</td>
<td>0.93</td>
<td>NS</td>
</tr>
<tr>
<td>14. Max arch length (mm)</td>
<td>−0.49</td>
<td>S</td>
<td>0.64</td>
<td></td>
<td>−0.69</td>
<td>S</td>
<td>0.76</td>
<td>NS</td>
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<tr>
<td>Lateral cephalometric analysis</td>
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<td></td>
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<tr>
<td>15. VP to A (mm)</td>
<td>1.29</td>
<td>S</td>
<td>2.13</td>
<td></td>
<td>1.40</td>
<td>S</td>
<td>3.02</td>
<td>NS</td>
</tr>
<tr>
<td>16. VP to B (mm)</td>
<td>2.07</td>
<td>S</td>
<td>3.42</td>
<td></td>
<td>2.13</td>
<td>S</td>
<td>4.57</td>
<td>NS</td>
</tr>
<tr>
<td>17. Lower face height (mm)</td>
<td>1.02</td>
<td>S</td>
<td>2.06</td>
<td></td>
<td>2.70</td>
<td>S</td>
<td>2.82</td>
<td>NS</td>
</tr>
<tr>
<td>18. SN-MP angle (°)</td>
<td>−1.46</td>
<td>S</td>
<td>1.97</td>
<td></td>
<td>−1.57</td>
<td>S</td>
<td>2.20</td>
<td>NS</td>
</tr>
<tr>
<td>19. Max 1/SN angle (°)</td>
<td>1.36</td>
<td>NS</td>
<td>5.07</td>
<td></td>
<td>−0.32</td>
<td>NS</td>
<td>3.85</td>
<td>NS</td>
</tr>
<tr>
<td>20. IMPA (°)</td>
<td>0.26</td>
<td>NS</td>
<td>3.52</td>
<td></td>
<td>−2.78</td>
<td>S</td>
<td>4.47</td>
<td>NS</td>
</tr>
<tr>
<td>21. Interincisal angle (°)</td>
<td>−0.16</td>
<td>NS</td>
<td>5.98</td>
<td></td>
<td>4.67</td>
<td>S</td>
<td>6.70</td>
<td>S</td>
</tr>
<tr>
<td>22. Mand 1 to NB distance (mm)</td>
<td>0.11</td>
<td>NS</td>
<td>0.70</td>
<td></td>
<td>−0.32</td>
<td>NS</td>
<td>0.86</td>
<td>NS</td>
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<tr>
<td>23. PgNB distance (mm)</td>
<td>0.58</td>
<td>S</td>
<td>0.70</td>
<td></td>
<td>0.47</td>
<td>S</td>
<td>0.76</td>
<td>NS</td>
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</table>

X: Mean, D: mean of differences; P: significance; S: P value < .01; NS: nonsignificant.


studies. This was probably because the postretention observation period was longer in their studies. There is a tendency for increases in mandibular anterior crowding with time. In contrast, Ludwig reported that all incisor relapse occurs within a year or after retention ends. Gardner and Chaconas noted that 1 year was ample time for any relapse to occur. Rossouw et al and Årtun et al also reported no significant difference between groups. In contrast, Uhde et al and Paquette et al stated that nonextraction patients had greater relapses. Kahl-Nieke et al reported that the extraction group had more relapse than the nonextraction sample.

Intercanine width expanded with treatment, but at T3, mandibular intercanine width relapsed in both groups. Mandibular intercanine width increased by averages of 1.13 mm in the extraction sample and 0.74 mm in the nonextraction sample with treatment. Our results are comparable with those of Paquette et al, Luppanapornlarp and Johnston, Uhde et al, and BeGole et al. According to Gianelly, this slightly larger increase in patients treated with premolar extractions might reflect lateral movement as the canines are moved distally into the premolar sites. Similar to the findings of Årtun et al, we found no significant intergroup differences at T3. Maxillary intercanine width was more stable than that of the mandible from T2 to T3. Bishara et al reported similar results. We found no correlation between the increase in incisor irregularity and the decrease in intercanine width. This finding agrees with previous reports.

With treatment, intermolar width responded differently in the extraction and the nonextraction patients. In the nonextraction patients, intermolar width increased as a result of treatment, with a slight increase during the postretention period. In the extraction patients, intermolar width decreased during treatment and slightly increased at postretention. At postretention, both groups showed similar changes. The intergroup differences were not statistically significant. Premolar extractions resulted in forward movement of the molars into a narrower part of the alveolar trough; this resulted in narrowing of the intermolar width. We saw only small changes at T3; this supported the concept of stability of intermolar width.

Second premolar width for the extraction patients showed a decrease with treatment and an additional slight decrease at postretention. In the nonextraction group, the small width increase with treatment reversed
slightly at postretention. The average changes between the 2 groups were not statistically significant; this was similar to the observation of Gardner and Chaconas.20

There was a statistically significant decrease in arch depth from T2 to T3 in both groups. It had no correlation to the uprighting of the incisors and incisor irregularity.

The increase in overbite was statistically significant from T2 to T3. This finding agrees with previous studies.2,10,46 Overbite increase at postretention is reported to be related to the amount reduced during treatment, with only 30% to 50% of the correction is retained.2,7,27 It was about 27% in our sample.

There was no change in SN/MP from T1 to T2 in the nonextraction group and only a small decrease in the extraction group. The latter might be due to extraction of premolars, mesialization of premolars, and mandibular rotation. However, there were significant decreases in both groups. These decreases might be due to growth changes as reported by Nanda.47 Nanda and Nanda48 also stated that any posttreatment skeletal changes can attenuate, exaggerate, or maintain the dentoskeletal relationship.

Sakuda et al49 and Freitas et al19 reported that the degree of relapse in crowding was related to facial patterns. Our sample was mostly average based on the mandibular plane and lower anterior face height. We found no correlation between growth pattern and crowding of relapse.

The mandibular incisor axial inclination showed differences between the 2 groups. At the end of active treatment, the mandibular incisors were more upright in the extraction group and more proclined in the nonextraction group. During postretention, in the extraction group, the uprighted teeth showed a slight proclination, and, in the nonextraction group, the incisors were retroclined. There was a tendency for the mandibular incisors to rebound, especially in patients with increased axial inclinations. These findings could be interpreted to support the contention of Blake and Bidy50 that the initial position of the mandibular incisors is the best guide for their stable labiobuccal position. Several investigators noted a rebound effect for displaced incisors.18,51-53 In the nonextraction group, the interincisal angle significantly decreased with treatment, and, because of the rebound of the incisors’ position, this angle significantly increased at T3. In the extraction group, the maxillary and mandibular teeth were uprighted during treatment, and the interincisal angle was more stable in the extraction group at T3. The results showed no positive correlation with final mandibular incisor inclination and crowding relapse.

The postretention irregularity index was not significantly correlated to any measured variables or changes in the measurements through time. This corroborated the results of Little et al,2 who reported that no descriptive characteristics, such as Angle class, length of retention, age at start of treatment, or sex, and none of the measured variables, such as initial or end of active treatment alignment, overbite, overjet, arch width, or arch length, were of value in predicting the long-term result.

The success of orthodontic treatment is judged by the long-term stability of the results. In this study, both extraction and nonextraction treatments showed exceptionally good stability. However, the nonextraction patients started with minimal anterior irregularity, whereas the extraction patients had moderate crowding. Our results should not be interpreted as endorsing nonextraction treatment for patients with moderate to severe crowding. The decision for nonextraction or extraction depends on the clinician’s diagnosis and the treatment plan. From these results, all that we can say is that the outcome of treatment and the postretention stability were similar in both groups. We referred to the mean data, and individual patients might behave differently. The parameters observed at T2 and T3 remained within clinically acceptable stable limits. The minimal changes noticed in incisor alignment could be ascribed to natural changes.25,54 It is assumed that, if the teeth are, irrespective of the type of treatment, correctly placed, the finished dentition will be reasonably stable. But human dentition is in a dynamic state, continually changing throughout life. The degree of relapse is confounded by the normal events of growth and aging that invariably follow treatment. Considerable craniofacial alterations occur beyond 17 years of age and are accompanied by compensatory changes in the dentition. Orthodontists have little control over these biologic processes. Patients and their parents must be informed, at the start of treatment, of the expected long-term changes in tooth positions. If orthodontists and their patients desire stable treatment outcomes, retention should be a lifelong process for which the patient assumes responsibility.

CONCLUSIONS

1. In this study, stability was exceptionally good.
2. Only the interincisal angle showed a significant difference between the extraction and nonextraction groups at T3.
3. There were no statistically significant correlations between any variables studied and mandibular incisor irregularity at T1, T2, or T3. No predictor of clinical value was found.
4. Minimal incisor crowding occurred at T3. The relapse patterns were similar for the extraction and nonextraction treatment modalities.
5. Intercanine width increased with treatment and relapsed during T3 in both groups.
6. Intermolar width was stable during T3 in the extraction and nonextraction patients.
7. In both groups, arch depth decreased at T3.
8. Overjet and overbite decreased with treatment, and a small relapse was seen in both groups.
9. SN/MP angle decreased from T2 to T3 in both groups.
10. Lower anterior face height increased during treatment in both groups and continued to increase in T3, as part of the normal growth process.

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REFERENCES