Long-term development of malocclusion traits in orthodontically treated and untreated subjects

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Introduction: The purposes of this study were to analyze long-term changes in malocclusion traits and to compare the development in orthodontically treated and untreated subjects. Methods: The sample comprised 308 adolescents in the intermediate, late mixed, or early permanent dentition who were examined clinically at the ages of 8 to 17 years and again 25 years later. The treated subgroup of 58 subjects had received orthodontic treatment with fixed or removable appliances or both. All subjects had a full complement of teeth, except a subgroup of 19 who had premolar extractions as a part of their orthodontic treatment plan. Results: The prevalence of maxillary overjet was significantly reduced in the untreated group and the treated subgroups. The prevalence of distal molar occlusion was significantly reduced in the subgroup treated without extractions. Comparison of treated and untreated groups in terms of changes over time showed that development was significantly more favorable in all treatment categories regarding maxillary overjet, and in the non-extraction category regarding distal molar occlusion. Subjects treated without extractions had less favorable development than did untreated subjects regarding molar crossbite. Conclusions: The long-term benefit of orthodontic treatment, with or without extractions, was confirmed regarding maxillary overjet, and the lasting effect of nonextraction treatment was confirmed regarding the distal molar relationship. The pattern of changes in treated and untreated subjects indicated that long-term development and individual variation can to some extent conceal the effects of a brief orthodontic intervention. (Am J Orthod Dentofacial Orthop 2010;138:277-84)
development of overbite and overjet in treated deepbite patients and a control group of untreated subjects with normal occlusion.21

Some aspects of posttreatment and postretention changes have been made clear in these studies, but the search for a cause-and-effect relationship has been mostly unrewarding. The factors that can obscure the etiology of relapse include individual variations, as shown by Little et al.18 in their landmark study, the confounding effects of normal aging processes discussed by Thilander,2 and the general lack of experimental research with randomization and proper control groups.

In this study, we compared changes in treated and untreated subjects in an attempt to describe the long-term net effect of orthodontic intervention on 4 important occlusal traits. However, because the subjects could not logically be randomly assigned to the respective groups, the orthodontic problems were more prevalent in the treated group initially, necessitating caution in this comparison.

MATERIAL AND METHODS

In 1972 and 1973, an epidemiologic study of malocclusion and dental, skeletal, and sexual maturation was conducted on a random sample of 1641 children attending primary schools in Reykjavik, Iceland.22 The same subjects were contacted again later and asked to participate in a second round of the study. The new survey included a questionnaire described elsewhere and a repetition of the previous clinical examinations.23 Panoramic radiographs (Orthopantomograph, Siemens, Bensheim, Germany) were also taken at the second visit, and the radiographic data were matched to the simultaneous clinical examination and all discrepancies resolved. The second survey was carried out with 832 subjects in 1998, approximately 25 years after the first examination.24

All subjects with congenitally missing teeth and those who had prematurely lost permanent teeth were excluded, keeping the focus on the occlusal development in orthodontically treated vs untreated subjects undisturbed from untimely tooth loss.

To eliminate the least mature of the initial group, we also excluded those who were in the early mixed dentition at the initial examination (T1), classified as dental stage (DS) 1 by Björk et al.5 This reduced the group in the second survey (T2) to a longitudinal sample of 308 subjects. This sample was then split into 3 subgroups of 250 untreated subjects, 39 subjects treated without extractions, and 19 subjects treated orthodontically with extractions of premolars. The subgroup of 19 comprised 9 subjects with maxillary premolar extractions only and 10 with 4 premolar extractions. Because this combination impaired uniformity and obscured developmental changes, we omitted the extraction group of 19 in comparisons regarding molar relationships.

Sex, age, initial DS, and treatment categories of the treated and untreated subjects are described in Table I. DS 4 refers to those with all permanent teeth mesial to the first molars fully erupted, DS 3 to those in the late mixed dentition, and DS 2 to those in the intermediate mixed dentition with all permanent incisors fully erupted.

The following traits were recorded: overjet of 6 to 9 mm and 9 mm and over, overbite of 5 to 7 mm and 7 mm and over, crossbite on at least 1 molar, and mesial and distal first-molar occlusion deviating by a half-cusp width or more from normal.

Most of the treated subjects were treated after T1, but, in a few cases, when treatment was already started at T1, the initial records from the orthodontic offices were used.

The selection process therefore resulted in a sample of 308 subjects who had been examined in the intermediate, late mixed, or early permanent dentition and again approximately 25 years later at the age of 33 to 44 years.

The T1 registration was done by an author (T.E.M.). He was also in charge of the T2 examination, when the registrations were done by a qualified hygienist, after training and calibration between the 2 of them. The registrations were carried out with a measuring instrument designed specifically to record malocclusion with the comprehensive method of Björk et al.5 The marking lines on the instrument are easily readable and limited to those that categorize the malocclusion traits in question. Since the examiner at T2 did not know the treatment history of the subjects, any systematic or interexaminer bias would have affected to the same degree both treated and untreated subjects, the groups that were compared in the study. The registration interval of the examinations was approximately 25 years after the initial examination (T1) and repeated until the age of 33 to 44 years. The T2 examination was done by the same examiner as the T1 examination.

The subject characteristics at T1 and T2 are described in Table I.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age range at T1 (y)</th>
<th>Mean age at T1 (y)</th>
<th>DS 1 at T1</th>
<th>DS 2 at T1</th>
<th>DS 3 at T1</th>
<th>DS 4 at T1</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
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<tr>
<td>untreated</td>
<td>7-17</td>
<td>11.8</td>
<td>125</td>
<td>26</td>
<td>99</td>
<td>26</td>
<td>160</td>
<td>90</td>
</tr>
<tr>
<td>Nonextraction</td>
<td>8-17</td>
<td>10.7</td>
<td>8-17</td>
<td>6</td>
<td>26</td>
<td>6</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Extraction</td>
<td>9-17</td>
<td>10.7</td>
<td>8-15</td>
<td>10</td>
<td>135</td>
<td>7</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>total</td>
<td>7-17</td>
<td>11.6</td>
<td>138</td>
<td>35</td>
<td>135</td>
<td>138</td>
<td>196</td>
<td>112</td>
</tr>
</tbody>
</table>

In 1998 and 1973, an epidemiologic study of malocclusion and dental, skeletal, and sexual maturation was conducted on a random sample of 1641 children attending primary schools in Reykjavik, Iceland.22 The same subjects were contacted again later and asked to participate in a second round of the study. The new survey included a questionnaire described elsewhere and a repetition of the previous clinical examinations.23 Panoramic radiographs (Orthopantomograph, Siemens, Bensheim, Germany) were also taken at the second visit, and the radiographic data were matched to the simultaneous clinical examination and all discrepancies resolved. The second survey was carried out with 832 subjects in 1998, approximately 25 years after the first examination.24

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method has been tested positively for intraexaminer and interexaminer reliability and has been used in a number of studies dealing with epidemiology and development of occlusion.

Statistical analysis

The data were analyzed with SPSS software (version 15.0, SPSS Sweden AB, Kista, Sweden). Incisor relationship was expressed as grade 1 and grade 2 anomalies, and molar relationship as unilateral and bilateral anomalies. The Wilcoxon signed rank test was used to analyze change over time in each group, and the Mann Whitney U test to analyze differences between groups. P values below 0.05 were considered statistically significant.

RESULTS

Prevalence of malocclusion traits at T1 and T2 in the untreated group and the treated group and subgroups is described in Table II. The Figure illustrates strong general reduction of overjet, reduced prevalence of distal molar relationship, moderately reduced prevalence of overbite, and some increase in the prevalence of crossbite.

Table III compares the untreated group of 250 subjects with each treated subgroup. All malocclusion traits had a higher prevalence in the treated group of 58 subjects at T1: significantly for overjet, distal molar occlusion, and molar crossbite. At T2, the untreated subjects had a lower prevalence of crossbite than did the nonextraction treated group.

Table IV describes the development of the treated groups, by using development in the untreated group as the baseline. The statistical analysis shows that, in both the extraction and nonextraction treatment categories, the development of overjet was significantly more favorable than in the untreated subjects. Nonextraction treatment affected distal molar relationship favorably, and molar crossbite developed adversely in the nonextraction treated group.

### Table II. Incisor and first molar relationships at T1 and T2 in untreated and treated subjects

<table>
<thead>
<tr>
<th></th>
<th>No orthodontic treatment n = 250</th>
<th>Nonextraction treatment n = 39</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
</tr>
<tr>
<td>Overjet 6-9 mm</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Overjet ≥9 mm</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Deepbite 5-7 mm</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Deepbite ≥7 mm</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Distal occlusion unilateral</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>Distal occlusion bilateral</td>
<td>23</td>
<td>16</td>
</tr>
<tr>
<td>Mesial occlusion unilateral</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Mesial occlusion bilateral</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Molar crossbite unilateral</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Molar crossbite bilateral</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Any orthodontic treatment n = 58

<table>
<thead>
<tr>
<th></th>
<th>Overjet 6-9 mm</th>
<th>Overjet ≥9 mm</th>
<th>Deepbite 5-7 mm</th>
<th>Deepbite ≥7 mm</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>14</td>
<td>7</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>24.1</td>
<td>12.1</td>
<td>13.8</td>
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<td>–12.1</td>
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<tr>
<td></td>
<td>0.000†</td>
<td></td>
<td>0.132</td>
<td>0.102</td>
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<tr>
<td></td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>52.6</td>
<td>15.8</td>
<td>15.8</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>5.3</td>
<td>0.0</td>
<td>5.3</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>–47.4</td>
<td>–15.8</td>
<td>–10.5</td>
<td>–5.3</td>
</tr>
<tr>
<td></td>
<td>0.001†</td>
<td></td>
<td>0.122</td>
<td>0.102</td>
</tr>
</tbody>
</table>

Significance level: *P <0.05, †P <0.01, ‡P <0.001.

T1-T2 difference within groups was analyzed with the Wilcoxon signed rank test. Negative signs for T1-T2 difference indicate reduced prevalence.
DISCUSSION

The quality of the orthodontic service might play a role in the long-term development. The treatment approaches in this study ranged from removable appliances to conventional fixed appliances and could have been compromised at times, but the orthodontic treatments were carried out exclusively by authorized specialists, educated in the United States and the Scandinavian countries. In most patients, nonextraction treatment included removable or functional appliances, whereas extraction treatment was associated with fixed appliances (Table I).

Most subjects received their treatment in the 1970s and early 1980s, mostly before the time of bonded retainers. Most studies referred to in this article also describe the development of occlusion unsupported by bonded retainers, important long-term aids that have later been used widely without serious side effects.  

The approach used in this study was selected to show substantial changes with clinical consequences, making a distinction between having and not having a certain anomaly. In most of the studies cited here, the findings were presented, conversely, in millimetric mean changes, ranges, and variations. When our results are compared with these varied studies, this difference should be considered.

Our approach was not intended to cover directly any aspects of subjective or objective treatment need. The results are, however, mostly in harmony with those of Stenvik et al., who found a definite reduction of

| Table III. Differences between treated groups and untreated group at T1 and T2 |
|---------------------------------|-----------------|----------------|-----------------|-----------------|-----------------|
|                                 | T1              |               | T2              |                 |                 |
|                                 | 39 vs 250       | 19 vs 250     | 58 vs 250       | 39 vs 250       | 19 vs 250       |
| Overjet ≥6 mm                   | 10.9            | 58.8          | 26.6            | −2.2            | 0.5             |
| Deepbite ≥5 mm                  | 3.0             | 8.7           | 4.8             | 4.0             | 3.5             |
| Distal occlusion                | 14.5            | 28.6          | 19.1            | −7.6            | NA              |
| Unilateral/bilateral            | 0.2             | 2.9           | 1.0             | 1.1             | NA              |
| Molar crossbite                 | 4.9             | 7.7           | 5.8             | 13.5            | NA              |
| Unilateral/bilateral            |                 |               |                 |                 |                 |
| Significance level: *P < 0.05; †P < 0.01; ‡P < 0.001; NA, not applicable. |

Differences between groups were analyzed with Mann Whitney U tests. Table III compares untreated and treated groups, using categories and data from Table II and the Figure. A negative sign indicates a lower prevalence in the treated group than in the untreated group.

professionally defined treatment needs from ages 12 to 20 years in treated subjects and a close to significant reduction also in untreated subjects.

All groups experienced a significant reduction in the prevalence of horizontal maxillary overjet from T1 to T2 (Table II, Fig), and the development was significantly more favorable in all treated groups (Table IV), leaving only 2 treated subjects with an excessive overjet at T2 (Fig).

These findings agree with a previous report by Feldmann et al. regarding reduction of overjet in untreated subjects, finding a small but statistically significant improvement of mean overjet in their longitudinal study of Class II Division 1 subjects with untreated deep overbite.

Bjork found, in a cephalometric study of a group of boys with overjet of 6 mm or more at age 12, that only 17 of 38 still had a 6-mm overjet at age 20. Other studies of untreated subjects covering various periods of late adolescence and adulthood comprise a mixture of normal and excessive overjet and present their findings in terms of mean changes and variations. Statistically significant decreases in overjet have been demonstrated in some studies, at least in males, although the more usual finding is a less definitive mean decrease, or a minimal change, or even a slight mean increase.

In treated subjects, the development of overjet has usually been described, irrespective of malocclusion type or treatment approach, as a significant net reduction, including either partial relapse or stability after treatment.
There was a tendency toward reduction in deep overbite in all groups, with no difference between treated and untreated subjects (Table II). This agrees with the general opinion that expects favorable development in untreated subjects, even with Class II deepbite malocclusion and a net reduction of bite depth also in treated subjects in spite of partial relapse.

Previous studies dealing with mixed or normal samples of untreated subjects reported general reductions of overbite,3,12,32 even statistically significant,5,30 at least in fully grown men.31 Untreated subjects with deepbite will develop favorably according to Feldmann et al,4 who found, in their longitudinal study of Class II Division 1 untreated deep overbite patients, small but statistically significant improvements of mean overbite. Bjo¨rk8 also found a general decrease in overbite with advancing age but emphasized the importance of individual variations.

Others found varied patterns in overbite changes,6,9 general stability of bite depth,11 or even a tendency toward increased deepbite from late adolescence to adulthood33 or in adulthood.10

In treated subjects, according to studies of various malocclusion and treatment categories, significant net reductions of bite depth have been reported through treatment, retention, and postretention, in spite of partial19,35,36 or even statistically significant postretention relapse.16,18,20,21,34

There was a clear reduction in the prevalence of distal molar occlusion from T1 to T2 in untreated subjects and a significant reduction in the nonextraction subgroup (Table II).

Distal occlusion was more prevalent in the treated groups than in the untreated group at T1, but slightly less prevalent than in the nonextraction treatment subgroup at T2 (Table III). The reduction of prevalence in the nonextraction group was significant (Table II) and significantly more favorable than in the untreated group (Table IV).

Feldmann et al4 also found a small but significant mean improvement in untreated Class II Division 1 deepbite subjects. Uhde et al16 found some tendency toward a Class II relationship posttreatment but generally a stable molar relationship sagittally in Class I and Class II extraction and nonextraction patients. Others have reported similar findings in Class II Division 2 patients.35

The number of subjects with a mesial molar relationship in the treated group was too low for any conclusions, but in both groups there was some increase in the prevalence of mesial molar occlusion (Table II). An increase in mesial molar relationship might not be unexpected, considering the effect of prolonged mandibular growth on the sagittal molar relationship.

The general increase in crossbite prevalence found in this study was probably caused by changes in maxillary transversal dimensions or the development of sagittal jaw relationships, rather than by changes in mandibular intermolar arch width, which are usually small. An increased prevalence of molar crossbites has been reported in relation to dental stages throughout the late mixed dentition,22 in a long-term study by Hong et al,30 and also with advancing age in an extensive cross-sectional survey in the United States.13 Schu¨tz-Fransson et al21 found that arch width development was essentially the same in treated and untreated controls, i.e., continuous decreases in maxillary and mandibular width.

Molar crossbite was significantly more frequent at T1 in the treated subgroups than in the untreated group (Table III), developed less favorably, and was at T2 significantly more prevalent than in the untreated group.
(Tables II and III, Fig). Less favorable development in the nonextraction treated group (Table IV) might indicate either poor stability of crossbite treatment or that this group had a stronger Class III growth vector than did the untreated group.

Most previous studies on transversal development in untreated subjects were not concerned with crossbites per se, but focused on maxillary and mandibular arch widths individually. Sinclair and Little found a small decrease in mandibular arch width in females, and other researchers found some constriction in both arches, whereas others reported, controversially, significant increases in arch widths in adults.

Most studies and reviews on patients treated with maxillary expansion concluded that, in spite of some relapse postretention, there will be a net gain in transversal dimensions of the maxilla. Changes in maxillary arch width after other treatments varied from stability to some constriction or relapse.

This study covered an extended period of time including active skeletal and dental development in adolescents and more subtle changes in adults. Within this frame, the pattern of long-term developmental changes seems to be generally similar in treated and untreated subjects. Changes in muscular balance, with strength of perioral musculature gradually increasing and exceeding lingual pressure from the tongue, might in both groups result in reduced arch length and lower prevalence of overjet. Another main force of influence seems to be prolonged forward movement of the mandible relative to the maxilla, influencing incisor relationships, reducing the prevalence of distal molar relationships, and increasing molar crossbites and mesial molar occlusions.

CONCLUSIONS

1. The long-term benefits of orthodontic treatment were confirmed regarding maxillary overjet and of nonextraction treatment regarding distal molar relationships.
2. In both treated and untreated subjects, some increase in the prevalence of mesial molar occlusion and crossbite can be expected.
3. The treated and untreated groups had similar patterns of development, as judged from the shift over time in the presence or absence of malocclusion traits, indicating that long-term development and individual variations might to some extent conceal the effects of a brief orthodontic intervention.

We thank Drs Sigurjon Arnlaugsson and Eirikur Orn Arnarson for their contributions to data collection for this study.

REFERENCES


