Effectiveness of interceptive orthodontic treatment in reducing malocclusions

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Introduction: In this retrospective cohort study of the effectiveness of interceptive orthodontic treatment, we compared patients receiving interceptive orthodontic treatment with untreated control subjects. Methods: Models were scored by using the index of complexity, outcome and need (ICON). Control models (n = 113) were archival and were selected based on malocclusion in the early mixed dentition and no orthodontic treatment during the subsequent 2 years. The patients (n = 133) were in the mixed dentition and consecutively treated in the University of Bergen orthodontic clinic. Initial ages were 9.4 years (± 1.4) for the treated group and 9.3 years (± 0.8) for the control group. The treatment took a mean of 27.2 months (± 16.3) for the patients; the control group was observed for a mean of 24.4 months (± 3.6). Subject Groups were matched for age, need, complexity, duration, and all ICON components except spacing (P <0.006) and crossbite (P <0.000).

Results: ICON scores decreased after treatment by 38.8% (P <0.0001) from 54.9 (± 16.6) to 33.6 (± 16.1). The controls were unchanged, with ICON scores of 54.0 (± 14.8) and 54.2 (± 16.9). Improvement grades were different (P <0.0001), with most controls categorized as “not improved or worse” (89.4%), whereas only 36.1% of the treated group were in that category. However, there were increases in the “minimal,” “moderate,” and “substantial” improvement categories for the treated subjects (22.6%, 21.1%, and 17.3%, respectively). The controls did not change in any ICON component and worsened in crowding (P <0.007), whereas the patients improved in esthetics, crowding, crossbite, and overbite (P <0.007). Conclusions: These results indicate that interceptive orthodontic treatment is effective for improving malocclusion but does not produce finished-quality results. (Am J Orthod Dentofacial Orthop 2010;137:18-25)

Interceptive and preventive orthodontic procedures are relatively simple and inexpensive treatment approaches that target developing malocclusions during the mixed dentition. Orthodontists perceive these as useful ways to reduce the severity of malocclusions,1 improve a patient’s self-image, eliminate destructive habits, facilitate normal tooth eruption, and improve some growth patterns.2 Because of this, some have advocated their wider use as public health measures aimed at reducing the burden of malocclusion in underserved populations3 and as a strategy for increasing access to orthodontic treatment when resources are limited.1

Available evidence suggests that patients at risk for severe malocclusion can readily be identified in the mixed dentition, and that the burden of these malocclusions in this age group is substantial (about 25%-30%). In 1 study, patients at risk for future orthodontic problems were identified in 28% of those examined, and most of the developing malocclusions were judged to be suitable for interceptive orthodontic treatment.4 A similar study found that about 27% of the children examined in a large Nigerian sample needed some form of interceptive orthodontic treatment.5 A third study of children screened in a community dental clinic at ages 9 and 11 years also found that one-third would benefit from interceptive orthodontic treatment.5

Although interceptive orthodontic procedures often do not produce finished orthodontic results without a second phase of treatment in the permanent dentition, several studies have suggested that systematically planned interceptive treatment in the mixed dentition might contribute to a significant reduction in treatment need between the ages of 8 and 12 years, often producing results so that further need can be categorized as elective. In a Finnish study, the need was reduced significantly from ages 8 to 12 in a small group receiving interceptive treatment.6 In a similar study, 94% of the children receiving interceptive treatment in a community health clinic were judged to have completely successful results, with only 2% showing deterioration.5

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Using the peer assessment rating (PAR) \(^7\) and the index of complexity, outcome and need (ICON) \(^8\), the authors of another study reported significant reductions in malocclusion severity after early treatment in both Medicaid and privately financed patients, with comparable results in both groups. \(^9\) In addition, about two thirds of those patients changed from a “medically necessary” category, as judged by the handicapping biolinguinal deviation index \(^10\) to “elective” after mixed dentition orthodontic intervention. \(^11\)

Although the available data suggest that interceptive orthodontic treatment can be effective, no randomized clinical trials or large cohort studies have compared interceptive outcomes with no treatment in either the near or long term. This has been primarily due to the lack of suitable cohorts of untreated patients with malocclusions to serve as control subjects. During the 1970s, the orthodontic faculty at the University of Bergen in Norway collected orthodontic study casts biannually from many local school children. A substantial number of these children had orthodontic needs and were not treated during the mixed dentition. Thus, it was possible to collect an archival cohort of study casts of untreated subjects with excellent matching for malocclusions to serve as a contemporary sample of patients treated in an interceptive clinic. We hypothesized that interceptive orthodontic treatment would improve malocclusions with reductions in their complexity and need.

**MATERIAL AND METHODS**

This was a retrospective cohort design. Power calculations were based on a similar study with a 40% improvement in ICON scores after interceptive treatment. \(^9\) A sample size of 100 provided a power of 90% and an alpha of 0.05 for this level of difference in ICON scores. For the treated group, 133 patients with pre- and postinterceptive sets of dental casts were selected from consecutively treated patients who met our inclusion criteria and were treated in the orthodontic clinic at the University of Bergen by dental students supervised by orthodontic faculty members. Most of these patients were treated for dental misalignment, crowding or spacing, inversions, anterior open bite, and crossbite with various removable appliances. The control group, consisting of 113 patients with 2 sets of dental casts that also met the inclusion criteria, was randomly selected from departmental archives of biannual records of school children taken during the 1970s. Inclusion and exclusion criteria were initial casts in the early mixed dentition, final casts after interceptive orthodontic treatment but no later than the late mixed dentition (ie, final casts with a fully erupted permanent dentition mesial to the first molars were excluded), final casts for the control group who received no orthodontic treatment were taken 2 years after the first, initial casts showing a malocclusion suitable for funding under the Norwegian Social Security System as judged subjectively by an orthodontist (P.B.) experienced with these criteria, Scandinavian ethnicity, and no exclusion based on sex.

All casts were scored with the ICON by a calibrated examiner (G.J.K.) who was not blinded to group or time point. True blinding was not possible because the casts of the control group were easily recognizable because of their rough trimming, and the time points were obvious based on the stage of tooth development evident on the casts. The ICON scores overall occlusion and an aesthetic component of malocclusion on an interval scale, from 0 to 120 for the former and 0 to 10 for the latter. The higher the ICON score, the worse the malocclusion. The ICON has been validated based on the subjective judgments of 97 orthodontists from 9 countries on 240 initial and 98 treated dental casts. Created as a single measure of need, complexity, and outcome simultaneously, the ICON has 2 advantages over the more commonly used PAR as a dental outcome measure. \(^7,12\) It has an aesthetic component that is weighted highly by clinicians and valued by patients, and it has clear and internationally validated cut points for treatment need and outcome with categories for complexity and improvement. Five weighted parameters are scored and comprise the components of the ICON: dental esthetics, crossbite, anterior vertical relationship, maxillary crowding or spacing, and buccal segment anteroposterior relationship. The components were individually scored from dental casts and multiplied by their respective weights to yield a single summary ICON score. This final score was then used to determine initial need (ICON \(>43\)) and final outcome acceptability (ICON \(<31\)), and difference scores were used to determine improvement. According to the convention recommended by the developers of the ICON, improvement scores were calculated by subtracting 4 \(\times\) final scores from the initial scores. \(^8\) This permitted us to compare the improvement in our samples with the categories validated for the ICON. Intrarater reliability of the examiner was determined by using Dahlberg’s formula \(^13\) on 10 sets of models remeasured 2 weeks apart and was considered to be acceptable (4.1 ICON points).

Initial equivalence of the groups was assessed by using age, sex, and malocclusion characteristics. The latter consisted of weighted initial ICON scores and unweighted ICON component scores. Equivalence in ICON components was assessed by using multiple
unpaired t tests with Bonferroni adjustments for multiple comparisons. Since 7 tests were performed, the level of significance was set at \( P < 0.007 \) (ie, \( P < 0.05/7 \)).

ICON scores were compared between groups and at the 2 time points with 2-way analysis of variance (ANOVA) and post-hoc comparisons with the Kruskal-Wallis test if \( P < 0.05 \). Initial need was determined by using the weighted ICON score threshold of \( >43 \), and end-of-study acceptability was determined with the \( <31 \) threshold. The prevalences of subjects in the initial complexity grades and improvement categories were also calculated, and these distributions were compared between groups by using the chi-square statistic. Unweighted ICON component scores were compared between initial and final casts, and differences were assessed with multiple t tests with Bonferroni adjustments and significance set at \( P < 0.007 \).

**RESULTS**

Initially, the subjects in the interceptive and control groups had mean chronological ages of 9.4 years (±1.4) and 9.3 years (±0.8), respectively (Table I). These were not different. However, although the treated group was about equally divided by sex (51.6% female), the control group was predominantly male (31.8% female). The untreated controls had

### Table I. Initial comparison of groups

<table>
<thead>
<tr>
<th></th>
<th>Interceptive</th>
<th>Control</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y) (SD)</td>
<td>9.4 (1.4)</td>
<td>9.3 (0.8)</td>
<td>0.590</td>
</tr>
<tr>
<td>Female (%)</td>
<td>51.6</td>
<td>31.8</td>
<td>0.017</td>
</tr>
<tr>
<td>Mean ICON (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unweighted components</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esthetics (1-10)</td>
<td>5.3 (1.8)</td>
<td>5.2 (1.7)</td>
<td>0.469</td>
</tr>
<tr>
<td>Crowding (0-5)</td>
<td>0.6 (1.3)</td>
<td>0.4 (1.6)</td>
<td>0.414</td>
</tr>
<tr>
<td>Spacing (0-5)</td>
<td>0.2 (0.5)</td>
<td>0.4 (0.7)</td>
<td>0.006</td>
</tr>
<tr>
<td>Crossbite (0-1)</td>
<td>0.6 (0.5)</td>
<td>0.2 (0.4)</td>
<td>0.000</td>
</tr>
<tr>
<td>Open bite (0-4)</td>
<td>0.3 (1.0)</td>
<td>0.2 (0.6)</td>
<td>0.277</td>
</tr>
<tr>
<td>Overbite (0-3)</td>
<td>0.6 (0.8)</td>
<td>1.0 (0.9)</td>
<td>0.008</td>
</tr>
<tr>
<td>Buccal AP (0-2)</td>
<td>1.1 (0.8)</td>
<td>1.2 (0.5)</td>
<td>0.500</td>
</tr>
</tbody>
</table>

**AP:** Anteroposterior relationship

sets of casts averaged 27.2 months (±16.3) in the treated group and 24.4 months (±3.6) in the control; these were not different. At the second time point, the mean ICON scores were 33.6 (±16.1) for the treated group and 54.2 (±16.9) for the untreated control. This represented a 38.8% improvement for the former (\( P < 0.0001 \)) and no change for the latter. Based on the ICON acceptability cut point of \( <31 \), both groups would be judged unacceptable, but the treated cohort was borderline.

The distributions of the initial complexity grades (Fig 1) were not different between the groups (chi-square: \( P = 0.186 \)). Figure 2 gives a comparison of the distributions of improvement grades between the 2 groups. The difference between these was highly significant (chi-square, \( P < 0.0001 \)). Whereas most subjects were categorized as “not improved or worse” in the untreated control group (89.4%), the treated group had 36.1% in that category. This reduction was reflected by roughly equivalent increases in the “minimal,” “moderate,” and “substantial” improvement categories for the treated subjects (22.6%, 21.1%, and 17.3%, respectively) compared with the controls (7.9%, 1.8%, and 0.9%, respectively).

Improvements in the various ICON categories are shown in Figures 3 and 4. The untreated controls had no improvement in any component and a statistically significant worsening of maxillary crowding (\( P = 0.007 \)). In contrast, the treated sample showed statistically highly significant improvements in the esthetic and crossbite components (\( P < 0.0001 \)), with significant improvements in the maxillary-crowding and open-bite components (0.001 < \( P < 0.007 \)).

**DISCUSSION**

This study supports the hypothesis that a systematic program of interceptive orthodontic treatment during the mixed dentition is more effective than doing nothing to improve malocclusions over the near term. This finding supports other studies that have reported similar improvements but has the added advantage of including
an untreated cohort with similar initial malocclusions to address spontaneous improvement or worsening during the transition from the deciduous to the permanent dentition.\textsuperscript{5,6,9,11} The untreated control group in this study showed little change in overall ICON scores with most subjects in the ICON “not improved or worse” category. This finding clearly supports the conclusion that these malocclusions do not change in any significant ways during the mixed dentition without intervention. Conversely, the treated group had far fewer patients in this “not improved or worse” category but increases in the “minimal,” “moderate,” and

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{Percent of subjects in the ICON initial complexity categories: easy, <29; mild, 29-50; moderate, 51-63; difficult, 64-77; very difficult, >77. Interceptive and control distributions were not different based on the chi-square statistic.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{Percent of subjects in the ICON improvement categories: improvement scores = initial ICON score $- 4 \times$ final ICON score. Greatly improved, $>-1$; substantially improved, $-25$ to $-1$; moderately improved, $-53$ to $-26$; minimally improved, $-85$ to $-54$; not improved or worse, $<-85$. Based on the chi-square statistic, the interceptive and control distributions were highly significantly different ($P < 0.0001$).}
\end{figure}
“substantial” improvement categories, suggesting that interceptive treatment improves malocclusions to varying degrees. However, few patients in either group were in the “greatly improved” category, supporting the hypothesis that interceptive orthodontic treatments often require further treatment in the permanent dentition.

When we considered the various components of malocclusion, the untreated group experienced no
improvement in any category and a statistically significant worsening of maxillary crowding, whereas the treated group had improvements in esthetics, crossbite, maxillary crowding, and anterior open bite. The deterioration in maxillary crowding in the untreated sample during the mixed dentition might have been caused by a loss of arch perimeter caused by caries, since this archival sample subjectively appeared to have more interproximal caries, restorations, and early loss of deciduous teeth than did the more contemporary treated sample. This suggestion is supported by Norwegian studies reporting declines in caries incidence during the interval covered by the 2 groups in this study, with the extensive use of fluoride-based preventive programs cited as the major factor contributing to the decline during the late 1960s and early 1970s.

This comparison did not consider the long-term stability of interceptive orthodontic corrections. Without such a comparison, it is impossible to know the extent to which these partial corrections have any lasting benefit, or how they compare over the long term with comprehensive treatment. Preferably, a randomized controlled trial designed to compare interceptive with comprehensive treatment over the long term would be required, but such a study has not yet been reported. Randomized controlled trials designed to examine 1-phase vs 2-phase treatment of Class II malocclusions indicate that early intervention has a short-term benefit over no treatment but offers no advantage over 1-phase treatment at adolescence. However, these studies did not have groups receiving only phase-1 treatment, so they could not address the long-term stability of early treatment alone. Because interceptive orthodontic treatment has limited goals aimed at reducing, rather than eliminating, features of malocclusion, it is considered to be partial treatment by most orthodontists; our data support that conclusion. If producing an ideal occlusion lessens the risk of relapse as some contend, one might predict that comprehensive treatment would have greater stability. However, the question of how the quality of outcome influences posttreatment stability is debatable, with some evidence suggesting that, over the long term, excellent results tend to deteriorate, whereas average results tend to improve.

The comparison groups were well matched with respect to the main outcomes for testing the hypothesis: age, need, complexity, and treatment duration. However, there were some lack of comparability in less relevant features that might reflect clinician and patient biases in favor of early treatment for some population subgroups and malocclusions as well as differences in dental health between the years covered by the 2 groups. Comparison of initial complexity data suggests slightly more mild-to-moderate malocclusions in the control group and more difficult-to-very-difficult cases in the treated group. This seems reasonable, since one expects that there would be parental pressure to begin treatment early for children with more significant impairments. Since mixed dentition treatment was an exclusion criterion for the control group in this study, some subjects with the most severe problems requiring early treatment might have been excluded from the control sample. This also might explain the curious finding of more boys in the control sample, since demand for orthodontic treatment is known to be higher for girls.

Matching also was generally good with respect to the various components of malocclusion with differences only in more maxillary spacing and fewer crossbites in the controls. Many clinicians, including the orthodontic faculty at the University of Bergen, treat crossbites during the mixed dentition because younger patients are thought to respond better to treatment; early treatment also prevents the risk of asymmetric facial growth and gingival damage. Despite recent reports that do not strongly support many of these beliefs, this practice is common worldwide. This could explain why these patients were found less frequently in our untreated sample. A greater amount of initial maxillary spacing in the untreated sample might reflect greater incisor flaring in this group. The tendency for higher overbite scores in this group further supports this interpretation. Despite good matching on several important criteria for testing the main hypothesis, the failure to achieve perfect matching in all categories examined is a limitation of this study, since some of these might be confounders in data interpretation.

The wider use of interceptive orthodontic treatment has been proposed as a public health measure for reducing the burden of malocclusions in developing countries and for increasing access to orthodontic services for underserved populations (low-income, ethnic minorities, and geographically isolated subgroups). The rationale for this derives from the hypothesis that orthodontists can more readily provide shorter, simpler interceptive and preventive treatments to low-income families compared with the alternative of more expensive and longer comprehensive treatments. Cost-effectiveness analyses are necessary to demonstrate the economic value of this strategy compared with comprehensive treatment in the permanent dentition. A Finnish study found that the cost was lower in 1-stage treatments started in the permanent dentition compared with 2-stage treatments started in the mixed dentition. However, no studies have compared mixed dentition interceptive treatment alone vs comprehensive permanent dentition treatment alone. Nevertheless, data from...
a decision analysis designed to evaluate potential savings by reducing the proportion of children offered free orthodontic treatment through the National Health Service in Denmark suggest that this reduction actually results in increased consumption of resources overall. This finding lends support to the idea that a comprehensive strategy designed to increase access to interceptive orthodontic services might be more cost-effective overall than the competing one of focusing primarily on comprehensive treatment in the permanent dentition for the most difficult malocclusions.

The use of the ICON as the measure of the effectiveness of interceptive orthodontic treatment ignores possible psychological and quality-of-life benefits that can be derived from these approaches. These factors are often cited as justifications for orthodontic treatment. This study supported the effectiveness of interceptive treatments at improving esthetics but did not address quality of life. According to several reports in the literature, the decision to seek orthodontic care is based on the desire to improve dental esthetics, self-esteem, and social acceptance, not necessarily on the degree of malocclusion severity. In a study evaluating the psychosocial effects of early treatment, self-concept improved, and negative social experiences declined, suggesting that improved self-esteem might be an important benefit of interceptive orthodontic treatment.

The unweighted ICON component data seem to suggest that some types of interceptive treatments are more effective than others. This is lost in the summary ICON data, when the weightings are applied, and the contributions from the individual components are masked. In the ICON validation, certain component scores (eg, esthetics) were weighted much more highly by the experts than others. Therefore, these components tend to drive the summary results. Also, the ICON scores components of malocclusion, not the effectiveness of certain treatment approaches. For the latter, it would be more appropriate to actually measure the various features of malocclusion that are addressed by certain types of interceptive treatment (eg, overjet by headgear).

CONCLUSIONS

1. Interceptive orthodontic treatment initially improves malocclusions with reductions in complexity and need compared with doing nothing.
2. Interceptive orthodontic treatment often requires follow-up treatment in the permanent dentition.

We thank Kirsten Thunold for collecting the study models in the untreated control sample.

REFERENCES