Outcome and long-term stability of an early orthodontic treatment strategy in public health care

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SUMMARY Our aim was to evaluate the long-term treatment outcome of a systematically applied orthodontic screening and early treatment strategy in a public dental health care system, with special reference to occlusal stability at least 5 years post-retention. The subjects (N = 68) belonged to one age cohort born in a Finnish rural municipality (N = 85), and they were regularly followed from 8 to 20 years. Persons with malocclusions were screened and treated according to pre-planned protocol. Treatment need was assessed according to the Dental Health Component of the Index of Orthodontic Treatment Need, and treatment outcome using the peer assessment rating (PAR) Index and Little's Index of Irregularity. Eighty-two per cent of the treated participants were out of retention (mean 6.9 years post-retention) at age 20. Definite treatment need in the study population decreased from 37% to 3%. In the treated group, the mean PAR improvement decreased from 65% to 63% from age 15 to 20 years. The mean irregularity score for the mandibular incisors was 4.0 [standard deviation (SD) 2.4] and for maxillary incisors 3.7 (SD 2.1) with no significant difference between treated and not treated subjects. The results suggest that definite need for orthodontic treatment may be predominantly eliminated from the target population with a systematically implemented treatment strategy focusing on early treatment with simple appliances. Emphasis on early timing of treatments may have contributed to the good long-term stability of treatment results.

Introduction
The correct timing of orthodontic treatment is under continuous discussion. The present evidence supports early treatment of patients with functional anterior or posterior crossbites (Pirttiniemi et al., 1990; Hesse et al., 1997), marked overjet including trauma risk (Nguyen et al., 1999; Årtun et al., 2005), and class III malocclusion (Westwood et al., 2003; de Toffol et al., 2008). Regarding class II treatment, most studies have found no benefits in early treatment compared with later treatment in the adolescence (Tulloch et al., 2004; Harrison et al., 2007; O’Brien et al., 2009). However, early treatment was reported to reduce the difficulty and necessity of phase 2 treatment in class II (King et al., 1999). Early headgear treatment has also been shown to have a long-term positive effect on crowding by producing wider and longer dental arches (Pirttiniemi et al., 2005). Long treatment times following an early start have generally been considered as a major disadvantage (Hsieh et al., 2005; Pirttiniemi et al., 2005). Considering the large individual variation in growth and dental development and lack of conclusive evidence between different treatment strategies, the optimal time of starting orthodontic treatment should always be decided individually for each patient (Tulloch et al., 1998; King et al., 1999).

Functionally good and aesthetically acceptable occlusion to all children and adolescents is the goal of free-of-charge orthodontic treatment in the municipal dental health care system in Finland. This mission implies that, in adulthood, the level of orthodontic treatment need should be equally low both in the treated and also in the non-treated part of the population.

Uniformly agreed treatment need criteria are required to ensure that all children and adolescents who fulfil the criteria have access to treatment. In areas, where orthodontic manpower in the public health care is limited, new orthodontic strategies based on early start of treatment with technically simple appliances have been introduced to meet the demands (Kerosuo et al., 2008; Keski-Nisula et al., 2008). Usually, these strategies aim to offer an alternative to fixed appliances so that experienced general practitioners can be involved in the treatments under the supervision of an orthodontist.
In a Norwegian population group, interceptive orthodontic treatment was found effective for improving malocclusion in children in their early mixed dentition compared with untreated controls, but it did not produce finished quality results (King and Brudvik, 2010). Early treatment has typically been seen as an interceptive treatment, preliminary to subsequent obligatory fixed appliances (Gianelly, 1995; Tulloch et al., 2004). However, a systematic early treatment strategy with simple appliances as the primary treatment modality has been shown to lead in acceptable results (Väkiparta et al., 2005; Kerosuo et al., 2008).

The evidence from follow-up studies has established that treatment results tend to relapse in the long term, after the retainers are removed (Little et al., 1988; Birkeland et al., 1997). Data on the long-term outcome and stability of early treatment orthodontic strategies is so far scarce, but a tendency to better long-term outcome has been reported in treatments started in the mixed dentition than in the permanent dentitions (Dugoni et al., 1995; Haruki and Little, 1998).

The aim of this study was to evaluate the long-term treatment outcome of a systematically applied orthodontic screening and early treatment strategy in one age cohort in public dental health care, with special attention on occlusal stability more than 5 years post-retention.

Subjects and methods

This was a prospective intervention study where the subjects were regularly examined from 8 to 15 years of age, and subjects with malocclusions were identified and treated according to pre-planned criteria and protocol. At the age of 20, all subjects were recalled for the final follow-up examination.

Subjects

The subjects consisted of one age cohort, i.e. all children born in 1987 (N = 89) and living in a rural municipality in western Finland (Väkiparta et al., 2005). In the examination at age 15, the number of subjects was 85. For the follow-up examination at the age of 20 years, an invitation letter was sent to all 85 participants. Those who did not show up after the first invitation were recontacted by telephone. Sixty-eight subjects attended the 20-year examination.

Methods

Occlusal indices/measurements on casts. The Dental Health Component (DHC) of the Index of Orthodontic Treatment Need (IOTN; Brook and Shaw, 1989) was used to assess treatment need. DHC grades 1−2 represented no/slight need, DHC grade 3 moderate/borderline need, and DHC grades 4–5 definite need for treatment. As modifications of DHC, crossbites in primary molars and canines were also recorded. Overjet and overbite were not recorded if permanent incisors were not fully erupted.

Peer assessment rating (PAR) index was used to assess the change in occlusion (Richmond et al., 1992). PAR score 0 indicates ideal occlusal alignment, and higher scores (rarely beyond 45) indicate the level of irregularity. All PAR scores were weighted with the British weighing factors. PAR reduction (pre-treatment PAR − post-treatment PAR) greater than 70% = ‘greatly improved’, from 70% to 30% = ‘improved’, and reduction less than 30% = ‘not improved or worse’.

To describe crowding/displacement of upper and lower anterior teeth and to analyze stability of occlusion, Little’s Index of Irregularity (LII) was measured at 15 and 20 years of age (Little, 1975). The linear distance from anatomic contact point to adjacent anatomic contact point of mandibular anterior teeth was measured, and the sum of five measurements = the irregularity index. The index was applied similarly also on the maxillary anterior teeth. The LII was scored only in the subjects who had no orthodontic or retaining appliances at ages 15 and 20 years.

Intercanine width was measured as the distance between right and left canine across distal anatomic contact points of the canines in both jaws separately. Arch length was measured as the distance from the mesial contact point of the first molar to the midline contact point of the central incisors, the sum of left and right distances representing the arch length (Harradine et al., 1998).

The LII and the linear measurements were made by one examiner (KH) on casts with a sharp-pointed digital vernier caliper.

Study protocol

The protocol was reviewed and approved by the Board of the Federation of Municipalities of Kokkola. All subjects were examined at the ages of 8, 10, 12, and 15 years. An informed consent was obtained from the parent of each subject. The follow-up examination was done at the age of 20 years. Dental casts with bite registered in centric relation were obtained from every subject at all examination ages, irrespective of their treatment need. The specialist orthodontist (MV) assessed the subjects’ treatment needs on the casts. The mean age was 8.3 years (SD 0.35) at the first examination and 20.3 years (SD 0.35) at the last examination.

After the first examination at age 8, orthodontic treatment was started for the subjects with definite treatment need (DHC 4–5) who were considered to benefit from early treatment. Malocclusions in this category included crossbite (anterior or lateral), increased overjet (greater than 6 mm), deep overbite with palatal contact, and severe crowding. DHC 4–5 was also an indication for starting treatment in later examinations. Occlusal indices were not assessed for subjects undergoing active treatment.
The consultant specialist made all treatment plans based on the clinical records, casts and radiographs. Two experienced general practitioners carried out the orthodontic treatments according to the consultant’s plan. Quad helix was preferred for the correction of posterior crossbite and headgear was generally used to correct distal sagittal relationships. Lingual and palatal arches were used for space maintaining. Multi-bonded fixed appliances were not used before the 12-year examination, after which subjects needing fixed appliances were treated by the specialist.

Data analysis

The data were analyzed in SPSS for Windows 14.0. Pearson’s chi square test was used to test the differences between groups. Pearson’s correlation test was used for testing correlations between two variables. The change in treatment need was tested with non-parametric-related sample’s Wilcoxon signed-rank test. P-values smaller than 0.05 were considered significant.

Method error

The intraexaminer reliability of DHC was substantial ($\kappa = 0.76$) and has been published in Väkiparta et al. (2005). The intraclass correlation coefficient between the examiner’s (MV) duplicate PAR assessments was 0.96 [95% confidence interval (CI) 0.92–0.98], and that between the examiner and the calibrating specialist (KH) was 0.97 (0.94–0.99). The duplicate examination procedures have been published in detail in Kerosuo et al. (2008).

For evaluating the intraexaminer consistency of the LII and the linear measurements, the same author (KH) remeasured 15 pairs of models with an interval of 3 months or more between the measurements. The intraclass correlation coefficient of the repeated measurements ranged between 0.991–0.998, indicating almost perfect agreement.

Results

Eighty per cent of the invited subjects (68/85) attended the 20-year examination. The treatment rate in the entire age cohort ($n = 85$) at age 20 was 54%. No significant difference was found between the attendants and dropouts regarding orthodontic treatment experience ($P = 0.664$) and need for treatment according to DHC ($P = 0.884$) at age 15.

Orthodontic treatment need and outcome

Definite need for orthodontic treatment (DHC 4–5) among the participants decreased from 37% at age 8 to 3% at age 20 (Figure 1). The majority (78%) had no treatment need at age 20 (DHC 1–2), and the distribution of treatment need did not differ between the treated and untreated participants ($P = 0.231$). From age 15 to 20, in 69% of the subjects (47/68), treatment need stayed the same; in 15 individuals, treatment need decreased; and in five individuals, it increased during that interval (Figure 2). Two treatments were discontinued by mutual agreement because of non-compliance of the patients, and one participant with definite treatment need due to crowding (DHC 4–5) declined the treatment offer. By the age of 20 years, four subjects had received treatment outside the protocol (with DHC score less than 4–5).

The mean weighted PAR scores of the treated and not treated participants at age 20 were 7.3 (SD 6.6) and 5.5 (SD 3.9), respectively, and the difference was not statistically significant ($P = 0.097$). In the treated subjects the mean PAR improvement was 63%, and the mean post-treatment PAR score showed minimal change from 15 to 20 years (Table 1). Eighty-four per cent of the subjects were either greatly improved or improved, and 16% showed no improvement or had changed to worse (Table 1).
The mean LII score for the mandibular incisors at age 20 was 4.1 (SD 2.4) and for maxillary incisors 3.7 (SD 2.1), with no significant difference between treated and not treated subjects.

Treatments

Thirty out of 38 treated subjects (79%) had received the entire treatment with one or more than one simple appliances such as quad helix, headgear, and functional appliances. In five of the treated subjects cross-elastics was the only active treatment. Fixed appliances were involved in 21% (8/38) of treatments.

In the 20-year examination, 82% of the treated participants were in post-retention stage with the mean post-retention time of 6.9 years (range from 2.3 to 13.0 years). Six subjects (16%) had retainers, and one subject was still in treatment.

Long-term stability of the dental arches in the subjects with more than 5 years post-retention

Sixty per cent of the treated subjects (22/37) had been out of retention more than 5 years. All except one of them were treated with only simple appliances, and the mean age at treatment start was 8.7 years (SD 2.3). The mean post-retention time among this group was 8.4 years (SD 2.4).

Among the subjects with more than 5 years post-retention, the mean PAR score increased from 5.8 (SD 5.1) to 6.6 (SD 4.6) and the mean PAR improvement decreased from 66 to 62%. Among the non-treated subjects the corresponding change in the mean PAR score was from 6.6 (SD 5.4) to 5.5 (SD 3.9) between 15 to 20 years of age. The change in the mandibular incisor irregularity of the treated subjects varied individually from −0.4 to +3.2 mm, and the change was similar to that found in the non-treated subjects during the same time interval (Table 2). More than 1mm increase in the mandibular incisor irregularity was seen in 23% of the treated and in 21% of the non-treated participants. The width and the length of the dental arches had typically slightly decreased in both treated and non-treated participants from 15 to 20 years. The changes in the arch width varied from −1.6 to 1.1 mm. The range in the arch length was greater, from −1.0 to 5.9 mm (Table 2). No correlation was found between the changes in the intercanine distance and changes in the incisor irregularity in the mandible ($r = −0.082$, $P = 0.557$) or in the maxilla ($r = −0.041$, $P = 0.774$).

### Table 1

Peer assessment rating (PAR) improvement (%) among the treated subjects ($N = 37$).

<table>
<thead>
<tr>
<th>Mean PAR score (SD)</th>
<th>Mean PAR improvement %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before treatment</td>
<td>20.8 (9.4)</td>
</tr>
<tr>
<td>At age 15</td>
<td>8.1 (7.2)</td>
</tr>
<tr>
<td>At age 20</td>
<td>7.3 (6.6)</td>
</tr>
<tr>
<td>PAR improvement %*</td>
<td>N (%)</td>
</tr>
<tr>
<td>&lt;30</td>
<td>6 (16)</td>
</tr>
<tr>
<td>30–70</td>
<td>12 (32)</td>
</tr>
<tr>
<td>&gt;70</td>
<td>19 (52)</td>
</tr>
<tr>
<td>Total</td>
<td>37 (100)</td>
</tr>
</tbody>
</table>


The subject in treatment at age 20 was excluded. SD, standard deviation.

### Table 2

Changes in Little’s Irregularity Index (LII), arch width and arch length (mm) from 15 to 20 years of age according to orthodontic treatment experience.

<table>
<thead>
<tr>
<th>Maxilla</th>
<th>Mandible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment ($N = 22$)</td>
<td>No treatment ($N = 29$)</td>
</tr>
<tr>
<td>LII change 15–20 yr</td>
<td>N (%)</td>
</tr>
<tr>
<td>Decrease</td>
<td>8 (36)</td>
</tr>
<tr>
<td>Increase 0–1 mm</td>
<td>13 (59)</td>
</tr>
<tr>
<td>Increase &gt;1 mm</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Intercanine distance change</td>
<td>N (%)</td>
</tr>
<tr>
<td>Decrease &gt;1 mm</td>
<td>3 (14)</td>
</tr>
<tr>
<td>Decrease 0–1 mm</td>
<td>17 (77)</td>
</tr>
<tr>
<td>Increase</td>
<td>2 (9)</td>
</tr>
<tr>
<td>Change in arch length</td>
<td>N (%)</td>
</tr>
<tr>
<td>Decrease &gt;1 mm</td>
<td>10 (45)</td>
</tr>
<tr>
<td>Decrease 0–1 mm</td>
<td>11 (50)</td>
</tr>
<tr>
<td>Increase</td>
<td>2 (9)</td>
</tr>
</tbody>
</table>

All treated subjects had finished their treatment and retention before age 15 (post-retention time > 5 years).
Discussion

The original sample included one age cohort, i.e. all 8-year olds of a rural municipality. The high long-term participation rate shows that the subjects were engaged to the study, considering that at the time of the last examination they were adults and many of them had moved away from the area. Those who didn’t attend the 20-year examination did not differ from the participants as to treatment experience or treatment need at the age of 15 years, indicating that the present results represent the whole age cohort.

In principle, Finnish children and adolescents with orthodontic problems are entitled to free-of-cost orthodontic treatment. In practice, in many health centres, the specialist manpower in orthodontics is limited (Pietilä et al., 2009a). In the health centre of our study the orthodontist’s main focus was in organization of the treatment strategy, patient selection, and treatment planning, while two experienced general practitioners implemented the majority of treatments under the supervision of the orthodontist. Our results suggest that definite need for orthodontic treatment could predominantly be eliminated from the target population by using mainly simple orthodontic appliances, with the emphasis in early screening and treatment. The number of participants who had no treatment need doubled during the 12-year study period. At the end of the study, at age 20, the occlusions, as evaluated with the DHC, PAR and Little’s Irregularity indices, showed no significant differences between the treated and non-treated groups. This indicates that the level of orthodontic treatment need was as low in the treated as in non-treated population groups and shows that the principle of equality was fulfilled in the free-of-charge orthodontic care. Of the two participants, who were left with definite treatment need, one had declined the treatment offer and the other had been through a long, yet unsuccessful open bite treatment.

In the original treatment protocol, strict screening criteria were applied, and definite treatment need (DHC 4–5) was required before access to free treatment. Knowing the limitations of the IOTN index especially in the mixed dentition, the DHC was modified by including crossbites of primary molars and canines in the index to improve the comparability of the index in different dental stages. When the treatment was started, the goal was a good occlusion with minimum residual treatment need left. Moderate crowding and/or somewhat increased overjet (up to 6 mm) were typical reasons for falling into the moderate/optional treatment need category, which did not qualify for treatment. During the 12 years of the study, it appeared that four subjects had nevertheless received treatment with lower treatment need criteria than decided in the protocol. Compromising the protocol may be explained by various human factors which are commonly involved in long-lasting clinical studies. These exceptions have however slightly increased the treatment rate in our sample. Our treatment rate of 54% among 20-year olds is in accordance with a recent Finnish study, where 50% of 16- to 18-year-old Finnish population had received orthodontic treatment in public health care (Pietilä et al., 2009b).

According to Tulloch et al. (2004), post-treatment PAR scores between 6–10 could be regarded as satisfactory treatment outcome, and our mean post-treatment/post-retention PAR score (7.3) fits in this frame. It is also in line with mean post-treatment PAR scores reported by several earlier studies (Al-Yami et al., 1999; Dickens et al., 2008; Fleming et al., 2010).

Our mean PAR improvement percentage (63%) was however somewhat less than the over 70% reductions reported generally after treatments with full fixed appliances (Birkeland et al., 1997; Dickens et al., 2008; Fleming et al., 2010). The initial PAR score is known as the best predictor of PAR improvement, and high pre-treatment PAR scores typically favour higher PAR improvement. Since the PAR index scores only permanent teeth, it gives generally lower scores in the early mixed than in the permanent dentition, irrespective of obvious treatment need (Firestone et al., 1999; Pangrazio-Kulbersh et al., 1999). The relatively low mean pre-treatment PAR score in our study reflects our early treatment protocol, where the majority of subjects were scored in the early mixed dentition, and it is likely to have affected our mean PAR improvement percentage in comparison to other studies (Birkeland et al., 1997; Al-Yami et al., 1999; Fleming et al., 2010).

Mandibular incisor irregularity up to 3.5 mm has been considered minimal and hence clinically acceptable (Little et al., 1988). In a sample consisting of first premolar extraction cases, only 30% of patients were found acceptable 10 years post-retention. The corresponding figure in our sample including both treated and non-treated subjects was 46%, indicating that irregularity of mandibular incisors to a varying clinically relevant degree was a rather common finding at age 20.

Treatment stability more than 5 years post-retention

In this study, the long-term treatment outcome, as evaluated with the PAR index, seemed more stable compared with previous reports 5 years post-retention (Birkeland et al., 1997; Al-Yami et al., 1999). The change in the mean PAR score was minimal, less than one point, which can be considered clinically insignificant. The decrease in the mean PAR improvement was also slight, from 66 to 62%, compared with earlier reported changes in PAR improvement from 67 to 49% (Al-Yami et al., 1999) and from 77 to 64% (Birkeland et al., 1997). Al-Yami et al. reported also a marked increase from 8.5 to 13.6 in the mean PAR score 5 years post-retention. A potential explanation for the stability may be the early implementation of the treatments in our study. Premolar extraction
treatments were found to be more stable when started in the mixed dentition than those started later in the permanent dentition (Haruki and Little, 1998). Also, Dugoni et al. (1995) suggested that treatments performed only with a passive lingual arch in the early mixed dentition were as effective in reducing anterior crowding in long-term as treatments with fixed appliances, with good stability 5 years post-retention. Early maxillary expansion with a quad helix and/or headgear was common practice in this study and could have potentiated optimal transversal growth of the maxilla. The use of a passive lingual arch may also have contributed to maintaining the space in the mandible during the occlusal development, thus promoting the post-treatment stability. Early establishment of the occlusion by guiding the teeth into correct positions all from the beginning has been previously suggested to improve treatment stability in the long term (Reitan, 1969; Bergersen, 1988).

Previous evidence indicates that after the orthodontic treatment the greatest relapse occurs during the first 2 years post-retention, and it slows down after 5 years post-retention, except lower anterior irregularity, which typically continues to increase even after 10 years post-retention (Al Yami et al., 1999; Little, 1988, 1990). In our study, the changes in the incisor irregularity and mandibular width in subjects who had been out of retention more than 5 years were rather similar to changes occurring in the non-treated group between 15 and 20 years, suggesting that the long-term post-retention changes in our study may have been mainly physiologically changes.

Our results suggest that definite need for orthodontic treatment can be predominantly eliminated from the target population with a systematically implemented treatment strategy focusing on early treatment with simple appliances. Emphasis on early timing of treatments may have contributed to the good long-term stability of treatment results.

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