Prevalence of dental features that indicate a need for early orthodontic treatment

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SUMMARY The aim of the study was to establish the prevalence of dental features that indicate a need for early orthodontic treatment (EOT). A group of schoolchildren in the mixed dentition stage (7–11 years old) (n = 432) was clinically screened for indications for EOT. Over 1/3 of the youngsters (34.7 per cent) presented at least one of the indications for EOT: anterior and posterior crossbites (including edge to edge occlusion) were found in 9.5 and 23.3 per cent, respectively; Angle Class III was found in 3 per cent; increased overjet (>7 mm) prevailed in 3.7 per cent and was significantly related to risk for dental trauma (P = 0.001); while oral habits were practiced by 10.9 per cent, open bite was found only in 6.5 per cent, both predominantly among girls (P = 0.006 and P = 0.012, respectively); impinging overbite was present in 5.2 per cent, mainly in boys (P = 0.006); crowding >5 mm was found in 6.9 per cent for the maxilla and in 6 per cent for the mandible. Loss of tooth material affecting tooth position was found in 15.3 per cent. Normal occlusal relationships were found in 10.9 per cent only. The findings indicate that almost 1/3 of the examined children in the mixed dentition stage require EOT. Sexual dimorphism was demonstrated for several occlusal features.

Introduction

Early orthodontic treatment (EOT) is a controversial treatment modality. Some studies find no clear evidence of its benefit (Pancherz, 2002; Profitt and Tulloch, 2002; Hsieh et al., 2005), while other studies support early treatment under certain circumstances, such as posterior crossbite (McNamara, 2002; Primozic et al., 2011), Class III malocclusion (Baccetti et al., 2000; Mitani, 2002), crowding (Gianelly, 2002; Little, 2002), or tooth eruption disturbances (Becker, 2002; Kurol, 2002; Armi et al., 2011). Recently, it has been established that early (interceptive) treatment could be an effective strategy for moving patients’ treatment from the medically necessary category to elective (Jolley et al., 2010), with overjet and alignment being the most readily corrected malocclusions at this stage.

A basic research study of the relationship between degree of malocclusion and occlusal interference in mice suggests that ‘early improvement of occlusal interference that promotes malocclusion could prevent the malocclusion from becoming more severe in growing patients, even if they have genetic factors of malocclusion’ (Tsukamoto et al., 2010).

It was the aim of this study to find out the prevalence of various occlusal features in a population of school children, in the mixed dentition stage, in Jerusalem.

Subjects and methods

A total of 432 school students in the mixed dentition stage, 7–11 years of age, were examined in four elementary schools in Jerusalem. The study was approved by an Institutional Review Board and informed consent was obtained from the parents for the participating minors. A purposive cluster sample was used to reflect the distribution of various social sectors within the population of Jerusalem. The examinees were also divided by gender: 210 girls (48.6 per cent) and 222 boys (51.4 per cent).

Inclusion criteria

Inclusion criteria were: 1. Only children who presented an informed consent signed by their parents were examined. 2. Mixed dentition stage. Children with full deciduous or full permanent dentitions were not included in the study. 3. No previous orthodontic treatment. However, for two of the children who already underwent EOT, pre-treatment clinical examination notes were received from their orthodontists and used in this study.

Following two calibration sessions, every youngster was examined by one of the three orthodontists participating in the study, in the nurse’s room or in a quiet classroom, under natural or artificial illumination using a dental mirror, tongue blade, and a millimetric ruler. No roentgenograms, study casts, and previous written records were used except for the two children who underwent orthodontic treatment. The measurements were performed to the nearest 0.5 mm. A specially designed form was filled for each examinee, based on clinical examination and questioning. It included information on the dental developmental stage, molar and canine relationships, overjet and overbite, Angle classification (including Class II subdivision: unilateral Class II relationship), upper and lower midlines, anterior and posterior crossbite, infraocclusion, crowding/spacing (visible distance
between adjacent teeth), ectopic eruption, habits (such as sucking or nail biting), facial symmetry, and history of trauma.

Special attention was given to the presence of caries with interproximal enamel breakdown, which affected tooth position. Examinees that presented with clinically visible interproximal caries that affected tooth position were referred to as ‘caries affected subgroup’ while the rest were in the ‘caries free subgroup.’ Consequently, the determination of Angle’s classification was performed in the ‘caries free’ subgroup only. Patients with Class I malocclusion, severe crowding (more than 5 mm in each jaw), normal overjet and overbite, and slightly convex profile were considered possible candidates for serial extractions.

Overjet of 7 mm and above was considered ‘severely increased.’ In the crossbite category, cases with at least one pair of teeth in crossbite as well as edge to edge relationship were recorded.

Treatment need

The need for orthodontic treatment was established in two ways: 1. Determination of the need for EOT based on the examiner’s clinical experience, the apparent severity of the malocclusion and by mental integration of the data of the examined patient, as performed by clinicians in everyday practice: At the end of each examination, every examiner subjectively determined the need for orthodontic treatment and entered her decision into the examination form. 2. Objective determination of the need for EOT was performed on the basis of the presence of at least one of the malocclusion features indicating EOT (AAO website). In addition, impinging overbite was considered as additional indication for early treatment.

Statistical methods

Sample size was calculated by the WINPEPI software (Abramson, 2004). This was based on the evaluation of a mean prevalence of 10% of the various malocclusion traits in the Israeli population. The occlusal features considered were posterior crossbite, anterior crossbite, increased overjet etc. The required sample size was 400 examinees.

Calibration

Twenty-five students were examined by two of the examiners (IB and YBB) and another 25 students by MS and YBB. Comparison of the results was performed by the Kappa test (SPSS 15.0, IBM Corp., New York, New York). Satisfactory calibration among the three examiners was obtained (Kappa values 0.63–1.00). For parameters like facial symmetry, for which lower Kappa values were attained, the examiners discussed the potentially asymmetric cases until agreement was achieved.

Intra-examiner reliability of each of the examiners was assessed by the Cronbach’s alpha test. The results ranged between 0.612 and 0.682 and indicated acceptable reliability.

Comparisons of subgroups were performed by the Chi-square test. P values below 0.05 were considered statistically significant.

Results

The distribution of the examinees by their dental development stage was as follows: 74.3 per cent were in the early and 25.7 per cent in the late mixed dentition stage.

Prevalence of indications for early treatment is presented in Table 1. Sexual dimorphism proved statistically significant for overbite, habits, posterior crossbite, posterior buccal crossbite and severe crowding, manifesting the need for serial extraction.

Comparison between carious free and carious affected subgroups for the distribution of the relevant parameters is presented in Tables 2 and 3.

In the sagittal dimension

No significant gender difference was found in the distribution of the various categories of Angle classification (P = 0.12). Normal occlusion was observed in 12.3 per cent of the examinees in the caries free subgroup (10.9 per cent of the total group of 432 examinees) (Table 4). No significant difference was found between ‘caries free’ and ‘caries affected’ subgroups regarding symmetry of molar relations; however, asymmetrical canine relationships were significantly more prevalent in the caries affected subgroup (Table 2).

Overjet

The mean overjet of the whole group was 3 ± 1.9 mm while for 73.4 percent of the examinees the overjet was within normal limit (0.5–4 mm). Severely increased overjet of 7 mm or more was found in 3.7 per cent of the examined children. Thirty-eight per cent of children with overjet larger or equal to 7 mm presented with traumatized incisors.

Table 1 Prevalence of features indicating early orthodontic treatment.

<table>
<thead>
<tr>
<th>Early treatment indications</th>
<th>Total, N = 432</th>
<th>Boys, N = 210</th>
<th>Girls, N = 222</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posterior crossbite (P.C.)</td>
<td>101 23.3</td>
<td>40 2.3</td>
<td>61 14.1</td>
<td>0.008</td>
</tr>
<tr>
<td>P.C. with functional shift</td>
<td>37 8.6</td>
<td>16 3.7</td>
<td>21 4.9</td>
<td>0.3</td>
</tr>
<tr>
<td>Anterior crossbite</td>
<td>41 9.5</td>
<td>23 5.3</td>
<td>18 4.2</td>
<td>0.153</td>
</tr>
<tr>
<td>Oral habits</td>
<td>47 10.9</td>
<td>16 3.7</td>
<td>31 7.2</td>
<td>0.012</td>
</tr>
<tr>
<td>Open bite</td>
<td>24 5.6</td>
<td>8 1.9</td>
<td>16 4.3</td>
<td>0.006</td>
</tr>
<tr>
<td>Impinging overbite</td>
<td>19 5.2</td>
<td>15 3.5</td>
<td>4 1.1</td>
<td>0.006</td>
</tr>
<tr>
<td>Overjet ≥ 7 mm</td>
<td>16 3.7</td>
<td>8 1.8</td>
<td>8 1.8</td>
<td>0.979</td>
</tr>
<tr>
<td>Angle Class III</td>
<td>13 3.0</td>
<td>6 1.4</td>
<td>7 1.6</td>
<td>0.178</td>
</tr>
<tr>
<td>Class I, severe crowding</td>
<td>7 1.6</td>
<td>1 0.2</td>
<td>6 1.4</td>
<td>0.048</td>
</tr>
<tr>
<td>Posterior buccal crossbite</td>
<td>5 1.2</td>
<td>0 0.0</td>
<td>5 1.2</td>
<td>0.021</td>
</tr>
<tr>
<td>Ectopic eruption of first molar</td>
<td>4 0.9</td>
<td>2 0.45</td>
<td>2 0.45</td>
<td>0.955</td>
</tr>
<tr>
<td>Infraocclusion &gt; 5 mm</td>
<td>3 0.7</td>
<td>3 0.7</td>
<td>0 0</td>
<td>0.091</td>
</tr>
</tbody>
</table>
Comparison of the distribution of the relevant parameters in the caries free and caries affected subgroups.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Caries-free</th>
<th></th>
<th>Caries-affected</th>
<th></th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total**</td>
<td>N***</td>
<td>%</td>
<td>Total*</td>
<td>N***</td>
</tr>
<tr>
<td>Molar relationship</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symmetrical</td>
<td>363</td>
<td>264</td>
<td>72.7</td>
<td>65</td>
<td>41</td>
</tr>
<tr>
<td>Asymmetrical</td>
<td>99</td>
<td></td>
<td>27.3</td>
<td>24</td>
<td></td>
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<tr>
<td>Canine relationship</td>
<td>352</td>
<td>268</td>
<td>76.1</td>
<td>57</td>
<td>38</td>
</tr>
<tr>
<td>Symmetrical</td>
<td>84</td>
<td></td>
<td>23.9</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Asymmetrical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enlarged overjet (&gt;4 mm)</td>
<td></td>
<td>174</td>
<td>23.6</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>188</td>
<td>20.2</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>Enlarged overbite (&gt;3.5 mm)</td>
<td></td>
<td>160</td>
<td>8.1</td>
<td>32</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>168</td>
<td>8.8</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>Upper midline deviation</td>
<td>364</td>
<td>32</td>
<td>25.6</td>
<td>66</td>
<td>14</td>
</tr>
<tr>
<td>Lower midline deviation</td>
<td>366</td>
<td>141</td>
<td>38.5</td>
<td>66</td>
<td>37</td>
</tr>
<tr>
<td>Dental</td>
<td>366</td>
<td>56</td>
<td>15.3</td>
<td>66</td>
<td>28</td>
</tr>
<tr>
<td>Skeletal/functional</td>
<td>366</td>
<td>85</td>
<td>23.2</td>
<td>66</td>
<td>9</td>
</tr>
<tr>
<td>Anterior crossbite</td>
<td>363</td>
<td>31</td>
<td>8.5</td>
<td>65</td>
<td>10</td>
</tr>
<tr>
<td>Posterior crossbite</td>
<td>366</td>
<td>80</td>
<td>21.9</td>
<td>66</td>
<td>21</td>
</tr>
</tbody>
</table>

*Owing to incomplete information in some cases, the total will not always add up to 432.
**Number of recordable individuals.
***Number of positive findings.

Comparison between the caries free (n = 366) and caries affected (n = 66) subgroups for crowding/spacing condition.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Caries-free</th>
<th>Caries-affected</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Maxilla</td>
<td>366</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>No crowding/no spacing</td>
<td>107</td>
<td>29.2</td>
<td>14</td>
</tr>
<tr>
<td>Crowding</td>
<td>139</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td>Spacing</td>
<td>120</td>
<td>32.8</td>
<td>14</td>
</tr>
<tr>
<td>Mandible</td>
<td>366</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>No crowding/no spacing</td>
<td>100</td>
<td>27.3</td>
<td>13</td>
</tr>
<tr>
<td>Crowding</td>
<td>196</td>
<td>53.6</td>
<td>44</td>
</tr>
<tr>
<td>Spacing</td>
<td>70</td>
<td>19.1</td>
<td>9</td>
</tr>
</tbody>
</table>

*Owing to incomplete information in some cases the total will not always add up to 432.

The distribution of midline deviation and posterior crossbite is presented in Table 2. The frequency of dental midline deviation in the upper and lower jaws was higher in the caries affected subgroup. When an attempt was made to differentiate between dental and other types of lower midline deviations, it was found that within the caries affected subgroup, in 43.3 per cent of the cases, the deviation was of dental origin, while in the caries free subgroup, dental deviation prevailed in 15.3 per cent only (P = 0.001). Within the examinees with facial asymmetry (n = 57), 71.9 per cent showed lower midline deviation (P < 0.001). In most of the cases, the chin and the lower midline deviated to the same side (P < 0.001).
**Posterior crossbite**

Posterior crossbite and/or edge to edge relationships of at least one pair of teeth were diagnosed in 23.3 per cent of the examined children. Of these, 13 per cent (56) presented with posterior crossbite of more than one pair of teeth. Posterior crossbite with functional shift was found in 37 children (8.6 per cent) (Table 1). Among the children with facial asymmetry, 40.3 per cent demonstrated posterior crossbite. No correlation between habits and posterior crossbite was found \((P = 0.556)\).

In the vertical dimension

**Overbite.** The mean overbite for the overall group was \(2 \pm 1.6\) mm, significantly \((P = 0.001)\) deeper in boys (mean of 2.3 mm) than in girls (mean of 1.7 mm). Deep overbite of over 4 mm and impinging overbite were also more predominant in boys \((P < 0.001)\) and \(P = 0.006\), respectively. Anterior open bite was found in 4.3 per cent of the girls and 2.2 per cent of the boys \((P = 0.006)\).

**Posterior open bite.** In 1.6 and 1.9 per cent of the children, the first permanent molars and the canines, respectively, were in an open bite relationship. Due to the very low number of children with posterior open bite, no further statistical evaluation was pursued.

**Infraoccluded teeth**

The prevalence of at least one infraoccluded tooth in the total sample was 22 per cent \((n = 95)\). This phenomenon was observed significantly more in the younger age group \((7–9\) years of age) \((P = 0.009)\), mainly among girls \((P = 0.027)\). Severe infraocclusion of more than 5 mm was encountered in five teeth, in three boys \(2.9\) per cent of the total number of infraoccluded teeth. The most frequently infraoccluded tooth was the lower second primary molar.

**Other occlusal features**

Crowding evaluated as exceeding 5 mm was found in 6.9 per cent for the upper jaw and 6 per cent for the lower jaw in the total sample. Severe crowding of both jaws in Class I cases was found in 1.6 per cent.

**Dentofacial trauma.** About a quarter of the total sample showed some signs of dentofacial injury: 46 \((10.6\) per cent) presented with at least one injured incisor while 6.7 per cent presented with submental scar. A significant correlation was found between enlarged overjet and signs of dentofacial trauma \((P = 0.001)\) (Figure 1).

**Habits**

Clinical evidence to the practice of oral habit, supported by affirmative answer to questioning, was found in 10.9 per cent of the total sample, with an almost double frequency among girls \((31:16, P = 0.012)\).

**Ectopic eruption.** Four examinees \((0.9\) per cent) presented with ectopic eruption of the first permanent molars.

**Evaluation of treatment need**

Almost 31 per cent of the total group \((30.6\) per cent) was in need of EOT based on the subjective judgment approach. According to the objective determination, 34.7 per cent of the examinees showed a need for EOT. Comparison of these two approaches revealed sensitivity of 81.1 per cent and specificity of 85.7 per cent.

**Discussion**

Two partitions of the examinees were attempted: by gender and by the effect of caries. We found posterior crossbite, habit practicing, and open bite more prevalent in females, similarly to Celikoglu et al. (2010) and Ben-Bassat et al. (1997).

Caries was the other predominant factor to affect occlusal relationships (Tables 2 and 3). The Angle’s classification rendered only 12.3 per cent of normal occlusion in the caries free subgroup. Low percentages were recorded previously also by others (Thilander et al., 2001; Schopf, 2003), but radically different evaluations exist as well (El-Mangoury and Mostafa, 1990). The reason for this discrepancy may lie not only in ethnic diversity but also in the difference in definitions of normal occlusion. The distribution of malocclusion types found in this study (Table 4) is similar to the findings of previous population surveys in Israel (Rosenzweig, 1961; Krzypow et al., 1975; Shano, 1986; Ben-Bassat et al., 1997) and very close to that recorded in Italy (Perillo et al., 2010).

The higher prevalence of asymmetrical canine relationships in the caries affected subgroup (Table 2) could be explained by possible unilateral extractions or interproximal carious lesions in the anterior region, affecting more the canine relations. As expected, dental midline deviations were associated with caries.

However, in cases in which the lower midline deviation was not associated with caries, it prevailed in children with some degree of facial asymmetry, suggesting a possible skeletal asymmetry.

Severely increased overjet \((>7\) mm) was found in 3.7 per cent only. This relatively small portion of the examined group compared to the USA (McLaine and Proffit, 1989) \((9.4\) per cent) is nevertheless important from the standpoint of the risk of trauma, since a positive significant correlation was found between these two phenomena (Figure 1). The significant correlation \((P = 0.001)\) confirms the findings of others (Bastone et al., 2000; Brin et al., 2000; Ben-Bassat et al., 2001; Sgan-Cohen et al., 2005). Thus, this fraction of the population deserves orthodontic attention at an early age if the percentage of traumatically affected incisors is to be reduced.
The high prevalence of posterior crossbite and/or edge to edge relationships of at least one tooth was possibly due to the inclusion of cases with edge to edge relations (3.5 per cent) and crossbite of only one pair of teeth (5.1 per cent). An identical prevalence was found in Sweden among children in the deciduous dentition (Kurol and Berglund, 1992) and a similar prevalence was found in a young population in Slovenia (Ovsenik, 2009). The higher prevalence in the present study, compared to a previous study of the Israeli population (Ben-Bassat et al., 1997), can be attributed to the increasing numbers of mouth breathers in contemporary population (Nunes and Di Francesco, 2010). In spite of the fact that habit practice and posterior crossbite were more prevalent among girls, no statistical association between these parameters could be demonstrated. Lindsten et al. (2001) noted a secular increase in the transverse incompetence between the maxillary and mandibular arches, as was also pointed out by Brin et al. (1998) for the Israeli population. It should be noted that 8.6 per cent of the examinees with posterior crossbite exhibited also a functional shift, which is considered an important indication for EOT, in order to prevent the transformation of a functional shift to a skeletal one. Close examination of Table 2 reveals that posterior crossbite was significantly more prevalent among the children affected by caries, who also exhibited significantly more crowded maxillary dentitions, probably due to caries and/or early extractions. These in turn could result in mesial migration accompanied by mesio-palatal rotation (especially of the first permanent molars) and finally in an edge to edge or crossbite relationships.

The mean overbite of the total group was within normal limits, while in the boys subgroup, it was significantly deeper than in girls, confirming previous findings in the Israeli (Ben-Bassat et al., 1997) and other populations (El-Mangoury and Mostafa, 1990). The prevalence of open bite was similar to findings in the Canadian population (Karaiskos et al., 2005). The higher prevalence of this feature among girls ($P = 0.006$) may be related to the more frequent habit practising by them.

Infraoccluded teeth were found in 22 per cent of the total group, which is a higher prevalence than the 14.3 per cent found by Kurol (1981) in his epidemiological study. However, in another study of the Israeli population (Koyumdjiski-Kaye and Steigman, 1982), similar prevalence was encountered (24.8 per cent). Genetic predisposition has been suggested for the occurrence of infraocclusion (Shalish et al., 2010), thus it can be speculated that it is the ethnic variability that is responsible for the relatively high prevalence of infraoccluded teeth in the Israeli population compared to other nationalities. A higher frequency of infraoccluded deciduous molars was also encountered among younger girls. The significant distinction between the younger (7 up to 9 years of age) and older (9 years of age and above) subgroup for this phenomenon can be explained by the fact that most infraoccluded teeth shed with time (Kurol and Thilander, 1984) and their prevalence is lower in the older age group.

The information about crowding relates to possible need of interception or EOT, as crowding is one of the indications for arch length preservation (Gianelly, 2002; AAO website) or in extreme cases serial extractions commenced in the mixed dentition stage (Boley, 2002).

Ectopic eruption of the first permanent molar was found in almost 1 per cent of the examinees, which was lower than the 5.9 per cent found in Sweden (Josefsson et al., 2007). Baccetti (2000) found association between ectopic eruption and other dental anomalies. We could not examine a possible correlation between these phenomena since we did not have roentgenograms at our disposal.

The subjective evaluation of the need for early treatment indicated that 30.6 per cent of the examined children were in need of EOT. On the other hand, the objective determination denoted that 34.7% of the total group needed EOT. This concordance between the two values is reflected by the high sensitivity and specificity obtained in the statistical workup. The somewhat higher percentage found in the second determination may be explained by the presence of a slight degree of malocclusion (i.e. edge to edge of one pair of teeth without functional shift), which the orthodontist decided was not indicative for EOT, but was included in the EOT by the ‘objective’ determination. These results correspond well with those of Chestnutt et al. (2006), who found that 35 per cent of 12 years old in the UK deserved orthodontic treatment when evaluated using the modified IOTN. A somewhat higher need of 39.5 per cent was recorded in Sweden (Josefsson et al., 2007), while a lower prevalence was recorded in southern Italy (Perillo et al., 2010).

The findings of the present study denote a considerable prevalence of occlusal characteristics in the mixed dentition stage, which deserve early orthodontic attention. As these features are not self-correcting, EOT of these malocclusions is expected to establish normal oral function and prevent adverse growth patterns and dental trauma. Thus, population screening at this stage is recommended.

**Conclusions**

1. Almost 1/3 of the examined children in Jerusalem between the ages 7–11 years exhibited dental features indicating EOT.
2. Enlarged overjet statistically correlated with the occurrence of dental trauma.
3. Sexual dimorphism was demonstrated for some occlusal features.
4. Population screening at the mixed dentition stage is recommended.

**Funding**

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