Malocclusion in children at 3 and 7 years of age: a longitudinal study

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Summary
The aim of this longitudinal study was to compare the prevalence of malocclusion at age three and seven years in a sample of children, exploring the hypothesis that prevalence of malocclusion is higher at 3 than at 7 years of age and may be influenced by sucking habits. The study sample comprised 386 children (199 girls and 187 boys), aged 3 years at study start, sourced from three Public Dental Service (PDS) clinics in Sweden. Malocclusion was diagnosed by clinical examination, using a specific protocol. Data on allergy, traumatic injuries, sucking habits and breathing pattern including nocturnal breathing disturbances were obtained by means of a questionnaire answered by child and parent in conjunction with the initial and final clinical examination. The overall prevalence of malocclusion decreased significantly, from 70 to 58 % (p < 0.0001): predominantly anterior open bite, excessive overjet and Class III malocclusion. Although high rates of spontaneous correction were also noted for deep bite, Class II malocclusion and posterior and anterior crossbites, new cases developed at almost the same rate; thus the prevalence was unchanged at the end of the observation period. Anterior open bite and posterior crossbite were the only conditions showing significant associations with sucking habits.

The results confirm the hypothesis of higher prevalence of malocclusion at three years of age and clearly support the strategy of deferring orthodontic correction of malocclusion until the mixed dentition stage.
INTRODUCTION
At 3 years of age the prevalence of malocclusion is as high as 66-70% (Kohler and Holst, 1973; Dimberg et al., 2010). Among preschool children, the most common conditions are anterior open bite, excessive overjet, Class II malocclusions and posterior crossbite (Kohler and Holst, 1973; Thilander and Myrberg, 1973; Ravn, 1976; Holm, 1978; Svedmyr, 1979; Warren et al., 2005; Dimberg et al., 2010).

Some malocclusions are more prone than others to persist during the development of the occlusion, and it is claimed that a full Class II malocclusion in the primary dentition is never self-correcting in growing children (Holm, 1978, Bishara et al., 1988). Moreover, maxillary protrusion is established early in the primary dentition and remains unmodified in the transition to the mixed dentition (Antonini, 2005). Other conditions undergo spontaneous correction: the prevalence of anterior open bite decreases from 51% in the primary dentition to 4% in the mixed and early permanent dentitions (Holm, 1978; Duncan et al., 2008). Klocke et al. (2002) also reported spontaneous correction of most cases of anterior open bite between the ages of 5 and 12 years. With respect to posterior crossbite, the results of studies to date are contradictory, with reports of spontaneous correction ranging from 17 to 45% (Thilander and Lennartsson, 1984; Lindner, 1989; Kurol and Berglund, 1992; Tscill et al., 1997).

The prevalence of sucking habits in 3-year olds ranges from 66 to 88% (Kohler and Holst, 1973; Holm, 1978; Svedmyr, 1979; Modeer et al., 1982; Dimberg et al., 2010) and is implicated in the development of anterior open bite, Class II malocclusion and posterior crossbite (Kohler and Holst, 1973; Ravn, 1976; Holm, 1978; Svedmyr, 1979; Warren et al., 2005; Dimberg et al., 2010). Persistence of the condition in the mixed dentition may be determined by the age at which the sucking habit is discontinued. Allergy, mouth-breathing, snoring, and nocturnal breathing disturbances also have potentially negative effects on the developing dentition (Vázquez-Nava F et al., 2006; Góis et al., 2008; Souki et al., 2009; Zicari et al., 2009).

It is obvious that determining the factors involved in the development of the occlusion during the transitional period from the primary to the permanent dentition requires knowledge and experience on the part of the clinician. Early treatment of a malocclusion might be unnecessary, if spontaneous correction occurs during the transition from the primary to the mixed dentition.

The prevalence of malocclusion and spontaneous correction has been studied with inconsistent results which are difficult to interpret (Thilander et al., 1984; Kurol and Berglund, 1992; Tscill et al., 1997). Longitudinal studies covering the period of transition from the primary to the early mixed dentition would contribute to our understanding of occlusal development over time and how and if early malocclusions self-correct.

The aim of the present study was threefold: to follow a group of children and record occlusal status at ages 3 and 7 years in a cohort of Swedish children, with special reference to prevalence of malocclusion; to determine the frequency of spontaneous correction of malocclusion during the transition from the primary to the early mixed dentition, and thirdly to analyse the possible influence of sucking habits on the prevalence of malocclusion.

The hypothesis was that the prevalence of malocclusions is higher at age 3 than at age 7 and may be influenced by sucking habits.
MATERIAL AND METHODS
Subjects
The study sample was sourced from three Swedish Public Dental Service (PDS) clinics, each located in a small rural community of about 22,000 inhabitants. In 2003, these clinics had an enrolment of 597 3-year-old children. Forty subjects refused to participate in the study and 29 could not be contacted. Thus, 528 children presented for initial clinical examination in conjunction with the routine dental examination offered to every child in Sweden at 3 years of age. In order to reduce potential confounding factors such as ethnic differences and environmental conditions, 29 non-Scandinavian children were excluded. Four children with syndromes or developmental disorders were also excluded. Every child was given at least two opportunities to attend the examination, but 38 children refused, resulting in a final sample comprising 457 3-year-old subjects (223 boys and 234 girls), (Figure 1).

Figure 1. Flow-chart of the children in the study.
At the clinical examination at 3 years of age, uncooperative behaviour in a number of children precluded registration of sagittal occlusion or vertical relationships in 5 and 4 cases, respectively. Moreover, the overjet could not be measured in 18 children.

At the clinical examination at 7 years of age, 386 children (187 boys and 199 girls) participated. Thus, 71 (15%) of subjects were lost to the study: 30 children had left the district and 41 refused to participate (Figure1). Because of erupting permanent incisors, measurement of overjet was precluded in 14 children and measurement of overbite in 61.

No orthodontic treatment was undertaken in the interval between the two examinations. The Ethics committee of the Örebro Health Care region, Sweden approved the study protocol and informed consent form (2003-87/03).

**Clinical examination**

The examinations were undertaken by one experienced clinician (LD) between 2003 and 2009. The examinations, using a mouth-mirror and probe, followed a specific protocol. The methods of Björk et al., (1964) and Foster & Hamilton, (1969) served as guidelines for registration of malocclusion in centric occlusion. Radiographic examination was not included.

Data on allergy, traumatic injuries, sucking habits and breathing pattern, including nocturnal breathing disturbances, were collected by means of a questionnaire which the children, together with their parents, were asked to answer at the time of the 3 and 7-year examinations.

**Measures**

At 3 years of age the sagittal occlusion was determined by the relationship between the maxillary and mandibular primary canines and at 7 years of age, at the maxillary and mandibular primary canines and also at the first maxillary and mandibular permanent molars.

**Primary canines**

- Class I (Normal occlusion)
  The tip of the upper primary canine tooth is in the same vertical plane as the distal surface of the lower primary canine tooth
- Class II (Postnormal occlusion)
  The tip of the upper primary canine tooth is in anterior relationship to the distal surface of the lower primary canine tooth
- Class III (Prenormal occlusion)
  The tip of the upper primary canine tooth is in posterior relationship to the distal surface of the lower primary canine tooth

**First permanent molars**

- Class I (Normal occlusion)
  Normal, up to or equal to ½ cusp postnormal or prenormal relation.
- Class II (Postnormal occlusion)
  More than ½ cusp postnormal relation.
- Class III (Prenormal occlusion)
  More than ½ cusp prenormal relation.

- Overjet was measured at the most protruding maxillary incisor and was classified as normal in the range of 0-4 mm.
- Anterior crossbite was registered if one or more maxillary incisors occluded lingually to the mandibular incisors and checked for anterior shift in the retruded position.
- A deep bite was registered when more than 2/3 of the height of the mandibular incisors were covered by the maxillary incisors on full closure.
- A negative overlap in the vertical plane was recorded as an anterior open bite. Incisors in edge-to-edge relationship were not considered to be in open bite, nor was lack of overlap due to incomplete eruption of the incisors.
- Posterior crossbite and scissorsbite were recorded if at least two teeth were involved. They were also stratified as unilateral or bilateral and checked for lateral shift in the retruded position.

A stainless steel ruler was used to measure overbite and overjet to an accuracy of 0.5 mm.

**Questionnaire**

The questionnaire comprised the following questions.

1. Has your child ever had a sucking habit?
   Response options: Yes  No
2. Is the habit ongoing?
   Response options: Yes  No
3. Has the habit ceased?
   Response options: Yes  No
   If yes, at what age did the sucking habit cease?
4. What kind of sucking habit did your child have?
   Response options: Dummy, finger/thumb, other objects.
5. Estimate the duration rate of sucking habit during a day!
   Response options: Night+day (>16 hours), night (8-16 hours), part of night+day (< 8 hours).
6. Does your child normally breathe with an open mouth?
   Response options: Yes  No
7. Does your child snore while sleeping?
   Response options: Yes  No
   If yes: every night  sometimes
8. Does your child have nocturnal breathing interruptions during sleep?
   Response options: Yes  No
9. Does your child have any allergy?
   Response options: Yes  No
   If yes, has the allergy been confirmed by tests?
   Response options: Yes  No
10. Has your child suffered any dental trauma?
    Response options: Yes  No
    If yes,
    a. When did the injury occur?
    b. Which tooth/teeth were involved?
    c. Has there been more than one incident of dental trauma?
    d. How was the dental trauma treated?
    Response options:
    Expectancy
    Grinding of the tooth/teeth
    Extraction of the tooth/teeth
Statistical analysis
All data were analysed using the SPSS version 17.0. When analysing dependent data, i.e. comparison of the same children at two different times, the McNemar’s test was used. Chi-square analysis was used for analysis of binary variables and Odds ratio (OR) with a 95% confidence interval (CI) was calculated to measure the strength of associations for binary variables. Each sagittal, vertical and transverse malocclusion was dichotomized in contrast with others and correlated with sucking habits. Differences in probabilities of less than 5% (p<0.05) were considered to be statistically significant.

RESULTS
The sample was tested for homogeneity by analysis of participants and nonparticipants with respect to gender, sucking habits, breathing disturbances or types of malocclusion. At 3 years of age more boys than girls were found with sucking habits (p=0.015; OR=1.7) or nocturnal breathing disturbances in the nonparticipant group (p=0.040; OR=3.6). At 7 years of age, posterior crossbite (p=0.023; OR=1.87) was more prevalent in girls than in boys. Deep bite was more prevalent in boys than in girls (p=0.006; OR=10.7). At age 7 years, no other significant gender-related differences in the study variables were disclosed. The data for both genders were therefore pooled for analysis.

Prevalence
Malocclusions
One or more malocclusions were diagnosed in 70% of the children at 3 years of age, compared with 58% at age 7 (p<0.0001). Two or more malocclusions were diagnosed in 18% at age 3 and in 8% at age 7 (p<0.0001).

The prevalence of anterior open bite, excessive overjet and Class III malocclusions decreased significantly from age 3 to 7 years (Table 1). For other specific malocclusions the prevalence remained relatively constant throughout the observation period (Table 1).

Among the cases of anterior crossbite, 30% had an anterior shift and 71% of posterior crossbites showed lateral shift at 7 years of age.

Spontaneous correction
During the observation period, spontaneous correction was observed in all types of malocclusion and also new malocclusions developed (Table 2). In cases of Class III malocclusion, excessive overjet and anterior open bite, the rate of spontaneous correction was significantly greater than the development of new malocclusions (Table 2). However, with respect to Class II malocclusion, anterior crossbite, deep bite, and posterior crossbite, the rates of spontaneous correction and the development of new malocclusions were similar.
Table 1. Prevalence of different types of malocclusion, overjet and overbite at 3 and 7 years of age.

<table>
<thead>
<tr>
<th>Variables</th>
<th>3 years of age</th>
<th></th>
<th>7 years of age</th>
<th></th>
<th>$P$ for difference between ages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample size</td>
<td>Prevalence</td>
<td>Sample size</td>
<td>Prevalence</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$n$</td>
<td>$%$</td>
<td>$n$</td>
<td>$%$</td>
<td></td>
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<td>Sagittal relationship</td>
<td>452</td>
<td>386</td>
<td>66</td>
<td>296</td>
<td>67</td>
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<tr>
<td>Class I</td>
<td>26</td>
<td>116</td>
<td>28</td>
<td>107</td>
<td>0.614</td>
</tr>
<tr>
<td>Class II</td>
<td>9</td>
<td>40</td>
<td>5</td>
<td>21</td>
<td>0.024</td>
</tr>
<tr>
<td>Class III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overjet</td>
<td>439</td>
<td>372</td>
<td>23</td>
<td>99</td>
<td>17</td>
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<tr>
<td>Excessive overjet (&gt;4 mm)</td>
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<td></td>
<td></td>
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<tr>
<td>Anterior open bite (&lt;0 mm)</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>0.687</td>
</tr>
<tr>
<td>Vertical relationship</td>
<td>453</td>
<td>325</td>
<td>50</td>
<td>226</td>
<td>10</td>
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<tr>
<td>Overbite</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Anterior open bite (&lt;0)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep bite (&gt;2/3)</td>
<td>6</td>
<td>29</td>
<td>3</td>
<td>11</td>
<td>0.152</td>
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<tr>
<td>Transverse relationship</td>
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<td>386</td>
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<td>60</td>
<td>14</td>
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<tr>
<td>Bilateral crossbite</td>
<td>6</td>
<td>29</td>
<td>3</td>
<td>11</td>
<td>0.003</td>
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<tr>
<td>Scissors bite</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
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</table>
Chi-square was used. *P*-value with the null hypothesis indicates that there is no difference between spontaneous correction and new cases of malocclusions among children between 3 and 7 years of age.

**Sucking habits**
The prevalence of sucking habits decreased from 66% to 4% (*p*<0.0001) between 3 and 7 years of age. Almost all those reporting a persistent sucking habit at age 7 years were thumb or finger suckers.

**The influence of sucking habits**
During the observation period, the odds ratios for developing anterior open bite or posterior crossbite were significantly higher for those children who had or had had a sucking habit than for those who had never had a sucking habit (Table 3).

Compared with finger or thumb suckers, children with a dummy sucking habit and anterior open bite (*p*<0.0001) or excessive overjet (*p*=0.002) had a spontaneous correction rate, significantly higher than the rate of development of new malocclusions.
Breathing disturbances and allergy
During the observation period, the prevalence of mouth-breathing decreased from 19 to 8% (p<0.0001).

The reported prevalence of snoring was relatively constant at age 3 and 7 years: 9% and 10% respectively.

At 3 years of age, 6% were experiencing nightly nocturnal breathing disturbances; at 7 years of age the prevalence had decreased to 2 % (p=0.007). Most (16 out of 25) had undergone abrasion/tonsillectomy between the ages of 3 and 7 years and post-operatively, nocturnal breathing disturbances had ceased in 15.

The prevalence of allergy at 7 years of age was 12%.

The influence of breathing disturbances and allergy
Associations were found between snoring and posterior crossbite (OR=2.28; p=0.003) as well as between allergy and Class II malocclusion (OR=3.19; p=0.001). Only a weak association was found between mouth-breathing and anterior open bite (OR=2.13; p=0.05) In addition, an interdependence was found between mouth-breathing and allergy (OR=1.78; p=0.045) and finally between mouth-breathing and snoring (OR=4.56; p<0.0001).

Traumatic injury
Thirty-four per cent (132 of 386) of the 7-year-old children had experienced dental trauma, while 4% (6 of 386) reported injury to a permanent incisor. The mean age for the first incident of dental trauma was 4.1 years. For those who had experienced a second incident the average age was 5.4 years. The prevalence was no higher among children with excessive overjet than those with normal overjet (p=0.101).

In cases of traumatic injury to the teeth, most common was expectancy (no treatment), 87%. In 8% of the children, traumatized primary incisors were extracted and in 5% the primary incisors were ground.

DISCUSSION
The results of this study clearly support the hypothesis that the prevalence of malocclusion is higher at 3 than at 7 years of age. Moreover, despite the relatively constant prevalence of some types of malocclusion from 3 to 7 years of age, changes occurred at the individual level, not only because of spontaneous correction, but also because of the development of new malocclusions at a similar rate.

Similar findings have been reported earlier with respect to posterior crossbite (Thilander and Lennartsson, 1984; Kurol and Berglund, 1992), stimulating debate about the question of early treatment, i.e. in the primary dentition, with claims that early treatment should be avoided because of the high rate of spontaneous correction and the poor success rate for grinding therapy. The present results are in accordance with previous findings and support the strategy of deferring orthodontic intervention until the mixed dentition stage. Instead, the focus at age 3 should be on observation of occlusal development, growth and tooth eruption and information to parents about the undesirable consequences of persistent sucking habits or functional disturbances.
It was noteworthy that the influence of sucking habits on the occlusion was significant at 3 years of age, while at 7 years of age, sucking habits were associated with anterior open bite and posterior crossbite. Anterior open bite may also be caused by tongue thrust; if persistent this habits it may prevent spontaneous correction of the open bite. With respect to posterior crossbite, normalisation of tongue position is usually a prerequisite for spontaneous correction. A sucking habit may change the swallowing pattern which has been found as an important factor in the etiology for posterior crossbite development (Ovsenik et al, 2007; Ovsenik, 2009). Thus, even if the sucking habit ceased several years ago, persistence of abnormal tongue position or pressure will prevent spontaneous correction of the malocclusion. Unfortunately, tongue pressure, tongue position or swallowing pattern were not evaluated in this study.

The results also showed that in children with anterior open bite or excessive overjet, spontaneous correction was less frequent among thumb or finger suckers than among dummy suckers. This can probably be explained by the fact that as children get older, periods of dummy sucking decrease, whereas in thumb or finger suckers the habit is often prolonged, even during waking hours. Moreover, finger suckers tend to cease the habit later in life than dummy suckers (Larsson, 1986; Larsson, 1987; Bishara et al., 2006; Duncan et al., 2008; Dimberg et al., 2010).

It was noteworthy that the results also disclosed that allergy, mouth breathing or snoring had a potential effect on occlusion as early as in the primary or early mixed dentition stages, supporting earlier studies (Vázquez-Nava F et al., 2006; Góis et al., 2008; Souki et al., 2009). However, it should be borne in mind that the reported associations are bivariate and may not be confirmed by multivariate analysis. Therefore, further studies are warranted on even larger populations, in order to allow multivariate analysis and thereby disclosure of any such associations.

The 34% prevalence of dental trauma in the 7-year-old children is within the reported range of 18 to 39% for children aged 7 to 15 years (Forsberg and Tedestam, 1990; Caravalho et al., 1998; Robson et al., 2009).

Two important advantages of the present study are the longitudinal design and the fact that none of the subjects underwent orthodontic treatment during the study period. However, a drawback inherent in the longitudinal study design is the unavoidable loss of some subjects over time. In the present study, attrition was relatively low and within acceptable limits (15%). Analysis disclosed only minor differences between the study sample and subjects who failed to complete the study.

CONCLUSIONS

In this study, comparing dental occlusal conditions of children observed longitudinally at 3 and 7 years, the following conclusions were reached.

1. Between the ages of 3 and 7 years, the overall prevalence of malocclusion decreased significantly, from 70 to 58%. This decrease in overall prevalence was attributable primarily to spontaneous correction of anterior open bite, excessive overjet and Class III malocclusion.
2. Although high rates of spontaneous correction were also recorded for deep bite, Class II malocclusion and posterior and anterior crossbite, new malocclusions developed at almost the same rates, resulting in unchanged prevalence at the end of the observation period.

3. There was a significant association between sucking habits and anterior open bite and posterior crossbite.

4. Spontaneous correction of anterior open bite and excessive overjet was less frequent among thumb or finger suckers than among dummy suckers.

5. Allergy, mouth-breathing and snoring had potentially negative effects on the occlusion.

6. The results clearly support clinical guidelines recommending deferral of orthodontic treatment of malocclusion diagnosed in the primary dentition until transition to the mixed dentition stage.

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