Follow-up study of functional and morphological malocclusion trait changes from 3 to 12 years of age

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SUMMARY The aim of this study was to evaluate morphological and functional malocclusion trait changes in 3- to 12-year-old children and to determine whether such functional traits at the 3, 4, and 5 years of age correlated with malocclusion severity score at 12 years of age.

Two hundred and sixty-seven children (132 boys, 135 girls) were randomly selected for a follow-up study from a previous cohort of 560 subjects. Functional and morphological traits were clinically assessed. Five functional malocclusion traits: mouth breathing, atypical swallowing, thumb, pacifier sucking, and bottle feeding were assessed and evaluated. Intra-arch assessment involved measurements of incisor crowding, rotation of incisors, and axial inclination of the teeth. For inter-arch measurements, overbite, anterior open bite, overjet, reverse overjet, anterior crossbite, and buccal segment relationships were recorded. The weighted sum of recorded occlusal traits thus represented the total malocclusion severity score.

The median morphological malocclusion severity score was almost the same at 3 and 12 years of age, while functional malocclusion decreased. Sucking habits (finger- or dummy-sucking, bottle feeding) until 5 years of age were statistically significantly correlated with an atypical swallowing pattern from 6 to 9 years (Spearman \( r = 0.178, P = 0.017 \)), which in turn was statistically significantly correlated with the morphological malocclusion severity score (Spearman \( r = 0.185, P = 0.042 \)) at 12 years of age.

At an early age, the morphological severity score is related to the stage of dental development, while at a later period, malocclusion severity score is also the result of incorrect orofacial functions at an early stage of dental development.

Introduction

Today’s emphasis on preventive orthodontic care necessitates rational planning of orthodontic preventive measures on a population basis among children, even in the early stage of dental development. This need highlights the importance of screening methods and epidemiological studies in order to obtain knowledge of the prevalence of malocclusion and the need for orthodontic treatment (Thilander et al., 2001; Ovsenik et al., 2004).

Malocclusion assessment methods differ not only according to various morphological (Baume et al., 1974; Eismann, 1974, 1977; Cons et al., 1986; Brook and Shaw, 1989; Espeland et al., 1992; Daniels and Richmond, 2000) or functional (Summers, 1971; Lundström, 1977; Brook and Shaw, 1989; Ovsenik and Primožič, 2007) occlusal trait recordings and measurements, but also to the stage of dental development. Most malocclusion assessment methods were designed for use in the permanent dentition period (Baume et al., 1974; Eismann, 1974, 1977; Cons et al., 1986; Brook and Shaw, 1989; Ovsenik and Primožič, 2007), only the Occlusal Index (Summers, 1971) was designed for all developmental stages of the dentition.

With the increasing interest in the early detection and treatment of malocclusions and a corresponding emphasis on preventive procedures, it would be beneficial to collect information on patients at younger ages (Farčnik et al., 1985, 1988; Trotman and Elsbach, 1996; Tschill et al., 1997; Thilander et al., 2001; Ovsenik et al., 2004). Treatment of some malocclusions should be started in the primary and early mixed dentition stages, as it is generally believed that the status of the primary occlusion affects the development of the permanent occlusion (Farčnik et al., 1985, 1988; Kurol and Berglund, 1992; Trotman and Elsbach, 1996; Ovsenik et al., 2004; Kurol, 2006; Proffit, 2006).

Posterior crossbites have been reported to be one of the most prevalent malocclusions of the primary dentition in Caucasian children, and if left untreated, may lead to craniofacial asymmetry (Pirttiniemi et al., 1990; Kurol and Berglund, 1992; Sonnesen et al., 2001; Thilander and Lennartsson, 2002; Ovsenik et al., 2004). It has also been suggested that the later these crossbite malocclusions are treated, the greater the risk of damage to the temporomandibular joint (Pirttiniemi et al., 1990; Sonnesen et al., 2001; Kurol, 2006).

Besides heredity, deleterious habits, impaired nasal breathing, and atypical swallowing are considered to be important factors in the aetiology of malocclusion (Melsen et al., 1979; Behlfelt et al., 1989; Kurol and Berglund, 1992; Larsson et al., 1992; Korpar et al., 1994; Øgaard et al., 1994; Thilander and Lennartsson, 2002). It has, therefore, been considered important to treat incorrect orofacial functions and functional malocclusions as early as possible.
(Kloehn, 1948; Farčnik et al., 1986, 1988; Kurol and Berglund, 1992; Thilander and Lennartsson, 2002; Ovsenik et al., 2004; Kurol, 2006).

With this background in mind of clinical problems and possible later negative consequences, it would be of interest to assess orofacial functions and functional malocclusion traits in preventive orthodontic treatment planning (Farčnik et al., 1985, 1988; Kurol and Berglund, 1992).

The role of sucking habits in the aetiology of malocclusions has been investigated by Melsen et al. (1979), Larsson (2000), and Øgaard et al. (1994). These studies were cross-sectional and concentrated mostly on the effects of prolonged sucking habits, indicating that irreversible malocclusions were produced if the sucking persisted beyond 4 years of age (Lindsten et al., 1996).

There have been no reported studies on the effect of incorrect orofacial functions on the development of occlusion and morphological malocclusion severity score.

Therefore, the aim of this research was to assess functional and morphological malocclusion trait changes of the orofacial region from 3 to 12 years of age and to determine how early functional malocclusion traits correlate with malocclusion severity score at 12 years of age.

Subjects and methods

The research was part of a longitudinal study (Farčnik et al., 1986). A cohort of 560 children was included, from which 267 children (132 boys, 135 girls) from 3 to 12 years of age were selected at random for a follow-up study. Recordings and measurements of five functional and 10 morphological occlusal traits were registered yearly using the method of Farčnik et al. (1988).

Functional malocclusion traits were registered during clinical examination and the mode of breathing determined with an airflow instrument (Farčnik and Rudel, 1987) that registers the difference in airflow temperature through the mouth or nose in subjects with an incompetent lip seal, thus distinguishing mouth breathing from an incompetent lip seal (Figure 1).

A modification of the method suggested by Melsen et al. (1979) was used to determine swallowing so that tongue-thrust and teeth-apart swallowing were registered as a single functional malocclusion trait category. The assessment of swallowing pattern was carried out while the children were swallowing small amounts of water. First, the mandibular movements and perioral muscle contractions were observed during swallowing. Then the examiners palpated the temporalis and the masseter muscles while the patient produced an ‘unconscious’ swallow, as this may deviate from the swallow on command.

Information on a subject’s deleterious habits such as finger- or dummy-sucking and bottle feeding was recorded through parental interview. Each child was clinically examined by three independent examiners and the consensus opinion was accepted. Alginate impressions of the maxillary and mandibular arches and wax bite registrations were obtained annually for each child. All models were assessed by a single examiner (MO), calibrated in the use of the method. Intra-arch assessment involved determination of incisor crowding and rotations. For inter-arch measurements, overbite, anterior open bite, overjet, reverse overjet, anterior crossbite, and buccal segment relationships were recorded. For each set of morphological measurements, registrations were carried out using a metric ruler (Zürcher model, Dentaurum 042-751, Ispringen, Germany) accurate to 1/10 mm.

All morphological traits, recorded and measured, were weighted and scored against a scoring table (Figure 2). The weighted sum of recorded occlusal traits thus represented the total malocclusion severity score. The overall malocclusion scores according to Farčnik et al. (1985, 1988) were categorized in terms of mild (1–15), moderate (16–40), severe (41–65), and very severe (over 66) malocclusion. Treatment need in the present study was defined as a total malocclusion severity score over 15 (Farčnik et al., 1986).

For statistical analysis, the Statistical Package for Social Sciences, Windows version 13 (SPSS Inc., Chicago, Illinois, USA) was used.

Results

For any longitudinal investigation, it is inevitable that patients drop out during the study period. For statistical correctness, it is necessary to verify that these dropouts occur at random. Figure 3 shows how the children in the study, some of whom dropped out but then returned, were transferred from the treatment need group to the no treatment need group and vice versa. For example, there were 110 children in the no treatment need group and 105 children needing treatment at 6 years of age. During the next year, 14 children left the study from the no treatment need group and nine from the treatment need group; the malocclusion severity score worsened in 25 children but improved in 31 subjects. Additionally, 19 children who dropped out at 6 years of age returned. Thirteen were then
categorized as requiring no treatment and six as requiring treatment. As a result, at 7 years of age, 115 children were in the no treatment need group and 96 in the treatment need group.

Because of multiple comparisons, it is not unusual to find few statistically significant differences, i.e. among 7- and 8-year-old children, there were more dropouts from the no treatment need group than from the treatment need group, and also there were more children with an improved morphological severity score. Overall, there was a visible shift towards an improved better occlusion, which could not be attributed to the different dropout rates in the two groups.

With the exception of 3 years of age, the morphological malocclusion severity score was almost the same throughout growth and development, median scores ranging from 11 to 15. The highest malocclusion severity score (median score 20) was found at 3 years of age, probably due to an anterior open bite resulting from deleterious sucking and feeding habits. The morphological malocclusion severity score in the need for treatment categories was present at 3 years of age in 50 per cent of the examined children and remained stable throughout growth and development (Table 1). Functional malocclusion traits were present at 3 years of age in almost all children, but showed a tendency to decrease towards the end of the mixed dentition period (from 85.4 to 37.3 per cent, Table 1).

Functional malocclusion traits had the highest value at 3 years of age and showed a tendency to diminish towards 12 years. Mouth breathing was approximately constant, regardless of age, and was present in 28 per cent of the examined children, while an atypical swallowing pattern decreased from 55 per cent in 3-year-old children to 24 per cent at 12 years of age. Deleterious sucking habits diminished completely towards the end of the primary dentition phase, at 5–6 years of age. Only thumb sucking was still present in
nearly the same percentage of children at 3–8 years of age (Figure 4).

The results (Figure 5) showed that sucking behaviour (finger- or dummy-sucking, bottle feeding) that persisted at 5 years of age was statistically significant for an atypical swallowing pattern at 6–9 years of age ($r = 0.178$, $P = 0.017$).

An atypical swallowing pattern at 6–9 years was significantly correlated with morphological malocclusion severity score at 12 years of age (Figure 6).

**Discussion**

In order to assess malocclusion severity on a population basis among children during early dental development in preventive orthodontic treatment planning, the Eismann (1974) index was modified for the mixed and primary dentitions by Farčnik et al. (1985, 1988), adding numerical assessment of functional malocclusion traits. Numerical estimation of functional symptoms was clinically evaluated in Slovenia and used in a study to determine interceptive orthodontic treatment results (Korpar et al., 1994). The morphological traits of malocclusion are well defined and the method was found to be easy, valid, and reliable for use in the early stages of dental development.

The prevalence of malocclusion, as well as the treatment need, should be studied longitudinally (Linder-Aronson, 1979; Farčnik et al., 1986; Heikinheimo et al., 1987; Trottman and Elsbach, 1996; Thilander et al., 2001). The growth and development of the jaws and dentition may have an unknown effect on an individual’s orthodontic treatment need, thus longitudinal studies could also clarify the question of treatment timing (Heikinheimo et al., 1987).

The present longitudinal study demonstrated how functional and morphological traits of malocclusion changed during growth and development. The very small number of children with an ideal occlusion at 3 years of age was the most significant finding. The results showed that in 50 per cent of the examined children, a morphological malocclusion severity score from mild to severe was present at 3 years of age and increased towards the end of the mixed dentition period (Table 1). Such a high prevalence of malocclusion is in agreement with the study of Thilander et al. (2001), using other classification methods. Due to the specific approach in quantitative malocclusion assessment in an early developmental dentition stage, it was not possible to compare the findings with the results of similar investigations since most previous studies in the primary dentition were qualitative in nature and quantitative assessment of functional malocclusion traits was not taken into account (Trottman and Elsbach, 1996; Tschill et al., 1997; Thilander et al., 2001).

The high frequency of deleterious sucking habits at 3 years of age (83 per cent had used dummies, 9 per cent

![Figure 3](https://example.com/f3.png)

**Figure 3** Classification of malocclusion scores into grades of severity classified according to treatment need.

| Table 1 Median value of morphological malocclusion score and number and percentage of children with functional malocclusion traits. |
|---|---|---|---|
| Age in years | No. of children | Median Children with a score >15 (treatment need) | Children with functional traits |
| 3 | 267 | 20 | 156 (58%) 228 (85.4%) |
| 4 | 267 | 13 | 129 (48.3%) 174 (65.2%) |
| 5 | 241 | 12 | 105 (43.6%) 139 (57.7%) |
| 6 | 215 | 14 | 105 (48.8%) 128 (59.5%) |
| 7 | 211 | 14 | 96 (45.5%) 87 (41.2%) |
| 8 | 198 | 11 | 71 (35.9%) 80 (40.4%) |
| 9 | 198 | 11 | 83 (41.9%) 81 (40.9%) |
| 10 | 137 | 15 | 70 (51.1%) 53 (38.7%) |
| 11 | 136 | 13 | 62 (45.6%) 65 (47.8%) |
| 12 | 134 | 14 | 66 (49.3%) 50 (37.3%) |
had sucked their thumb, but only 8 per cent had no history of non-nutritive sucking) was in agreement with the findings of others (Melsen et al., 1979; Øgaard et al., 1994; Larsson, 2000). However, their results were cross-sectional and concentrated mostly on the effects of prolonged sucking habits indicating irreversible malocclusions. Fifty per cent of the 3-year-old children in the present study were still bottle fed, which is in agreement with some Scandinavian studies (Modéer et al., 1982; Øgaard et al., 1994; Lindsten et al., 1996; Larsson, 2000) that found that the use of dummies by young children has increased over the past decades, as well as the tendency to prolong the habit (Figure 4). Sucking behaviour has long been recognized to affect occlusion and dental arch characteristics and children with sucking habits are more likely to develop an anterior open bite, excessive overjet, distal occlusion, and a posterior crossbite (Warren and Bishara, 2002).

Prof (1986) believed that the role of atypical swallowing in the aetiology of malocclusion was overestimated, while Melsen et al. (1979) established that previous sucking habits had no significant influence on the type of swallow, but children with sucking habits had significantly more distal, mesial occlusion and crossbites.

In this study, an atypical swallowing pattern was present in half of the examined children at 3 years of age, changed significantly after 6 years, but was still present in 25 per cent at 12 years of age (Figure 4). Melsen et al. (1979) reported that an atypical swallowing pattern was present in 25–30 per cent of 9 year olds, confirming the results of the present study (Figure 4).

Sucking habits, even of a short duration, must be considered to have a direct influence on the developing occlusion, as well as an indirect effect due to a change in swallowing pattern. Therefore, on the basis of previously reported data and the findings of the present study, sucking habits must be considered a factor of major influence in the aetiology of malocclusions and a causative factor for the higher malocclusion severity score at the end of the mixed dentition period.

Preventive and early treatment in orthodontics is still the subject of debate and controversy regarding cost-effectiveness in the analysis of functional and psychosocial benefits (Tschill et al., 1997; Kurol, 2006; Proffit, 2006). Viazis (1995), Kurol (2006), Ngan (2006) and Proffit (2006) considered that the ideal time for treatment is in the late mixed dentition period, while others (Thilander et al., 1984; Farčnik et al., 1988; Korpar et al., 1994; Trottmann and Elsbach, 1996; Tschill et al., 1997; Thilander et al., 2001; Ovsenik et al., 2004) concluded that early orthodontic treatment would be beneficial and desirable, especially to enhance skeletal and dental development and to correct habits, function, and malocclusion in their early stages, especially transverse discrepancies which may lead to temporomandibular joint problems or facial asymmetry (Franchi et al., 2004; Kurol, 2006; Proffit, 2006).
Therefore, in preventive orthodontic treatment planning, malocclusion severity score should be based on the assessment of functional malocclusion traits, because they are caused by deleterious sucking and feeding habits in the early period of orofacial development.

Conclusions
On the basis of the results, the following conclusions can be drawn:

1. The morphological malocclusion severity score is almost the same throughout growth and development, while the functional malocclusion score significantly decreases.

2. In early dental development, the morphological severity score is related to the stage of dental development, while at a later period, the malocclusion severity score is also the result of incorrect orofacial functions at an early stage of dental development.

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