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OCCLUSAL AND DENTOFACIAL CHARACTERISTICS OF THE DECIDUOUS DENTITION AND TREATMENT EFFECTS OF THE ERUPTION GUIDANCE APPLIANCE IN THE EARLY MIXED DENTITION

by

Katri Keski-Nisula

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From the Department of Oral Development and Orthodontics, Institute of Dentistry, University of Turku, and Vaasa Central Hospital, Vaasa, Finland

Supervised by Professor Juha Varrela
Department of Oral Development and Orthodontics
Institute of Dentistry
University of Turku
Turku, Finland

Reviewed by Professor Jan Huggare
Department of Orthodontics
Institute of Odontology
Karolinska Institutet
Huddinge, Sweden

and PhD Tuomo Heikkinen
Department of Oral Development and Orthodontics
Institute of Dentistry
University of Oulu
Oulu, Finland

Opponent Professor Pertti Pirttiniemi
Department of Oral Development and Orthodontics
Institute of Dentistry
University of Oulu
Oulu, Finland

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to my Family

ABSTRACT

Katri Keski-Nisula

Occlusal and dentofacial characteristics of the deciduous dentition and treatment effects of the eruption guidance appliance in the early mixed dentition

Department of Oral Development and Orthodontics, Institute of Dentistry, University of Turku and Vaasa Central Hospital, Vaasa, Finland
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The aim of this investigation was to analyze the dental occlusion in the deciduous dentition, and the effects of orthodontic treatment carried out in the early mixed dentition with the eruption guidance appliance.

The deciduous occlusion and craniofacial morphology of 486 children (244 girls and 242 boys) were investigated at the onset of the mixed dentition period (mean age 5.1 years, range 4.0-7.8 years). Treatment in the treatment group and follow-up in the control group were started when the first deciduous incisor was exfoliated (T1) and ended when all permanent incisors and first molars were fully erupted (T2). The mean age of the children was 5.1 years (SD 0.5) at T1 and 8.4 years (SD 0.5) at T2. Treatment was carried out with the eruption guidance appliance. Occlusal changes that took place in 167 children were compared with those of 104 untreated control children. Pre- and post-treatment cephalometric radiographs were taken, and the craniofacial morphology of 115 consecutively treated children was compared with that of 104 control children.

The prevalence of malocclusion in the deciduous dentition was 68% or 93% depending on how the cut-off value between the acceptable and non-acceptable occlusal characteristic was defined. The early dentofacial features of children with distal occlusion, large overjet and deepbite differed from those with normal occlusion. However, the skeletal pattern of these three malocclusions showed considerable similarity each being characterized by a retrusive mandible, small maxillo-mandibular difference, convex profile, retrusive lower incisors, and large interincisal angle. In the treatment group, overjet and overbite decreased significantly from T1 to T2. Following treatment, a tooth-to-tooth contact was found in 99% of the treated children but only in 24% of the controls. A Class I molar relationship was observed in 90% of the children in the treatment group, and in 48% in the control group. Good alignment of the incisors was observed in 98% of the treated children, whereas upper crowding was found in 32% and lower crowding in 47% of the controls. A significant difference between the groups was found in the mandibular length, midfacial length and maxillo-mandibular differential. The occlusal correction, brought about by the eruption guidance appliance, was achieved mainly through changes in the dentoalveolar region of the mandible. In addition, the appliance seemed to enhance the growth of the mandible.

Treatment in the early mixed dentition using the eruption guidance appliance is an effective method to normalize occlusion and reduce further need of orthodontic treatment. Only few spontaneous corrective changes can be expected without active intervention.

Key words: early orthodontic treatment, treatment need, deciduous dentition, mixed dentition, removable appliance, eruption guidance appliances, cephalometrics, malocclusions

TIIVISTELMÄ

Katri Keski-Nisula

Purennan sekä kasvojen piirteet maitohampaistovaiheessa ja purennanohjaimen hoitovaikutukset hampaiston ensimmäisessä vaihduntavaiheessa

Hampaiston kehitys- ja oikomisoppi, Hammaslääketieteen laitos, Turun yliopisto ja Vaasan Keskussairaala, Vaasa
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Tutkimuksessa tarkasteltiin purentavirheiden esiintymistä maitohampaistossa ja purennan-ohjaimella suoritetun oikomishoidon vaikutuksia purentaan ensimmäisen vaihduntavaiheen aikana. 486 lapsen (244 tyttöä ja 242 poikaa) purenta ja leukojen rakenne analysoitiin hampaiston ensimmäisen vaihduntavaiheen alussa (keski-ikä 5,1 vuotta, vaihteluväli 4,0–7,8 vuotta). Oikomishoito ja kontrolliryhmän seuranta aloitettiin, kun ensimmäinen maitoinkisiivi irtosi (T1) ja lopetettiin, kun kaikki pysyvät etuhampaat ja ensimmäiset pysyvät poskihampaat olivat puhjenneet purentaan (T2). Lasten keski-ikä oli 5,1 vuotta (SD 0,5) T1-vaiheessa ja 8,4 vuotta (SD 0,5) T2-vaiheessa. Hoitokojeena käytettiin purennanohjainta. Purennassa tapahtuneita muutoksia tarkasteltiin 167 lapsen hoito-ryhmässä ja 104 lapsen kontrolli-ryhmässä. Lateraalikallokuvien avulla tutkittiin leukojen rakenteissa tapahtuneita muutoksia 115 hoidetulla lapsella ja 104 kontrollilapsella.

Virhepurennan esiintyvyys maitohampaistossa oli 68 % tai 93 % riippuen virhepurennaksi määritellyistä purennan piirteistä. Virhepurentaryhmän skeletaaliset piirteet olivat keskenään samankaltaisia. Normaalipurentaiseen verrattuna alaleuka oli retrusiivisempi, ylä- ja alaleuan pituuksien suhde pienempi, profiili kuperampi, alaetuhampaat pystymmät sekä ylä- ja alaetuhampaiden välinen kulma suurempi. Hoitoryhmässä horisontaalinen ja vertikaalinen ylipurenta pienentyivät hoidon aikana merkittävästi. T2-vaiheessa hoito- ja kontrolliryhmän välillä oli useita merkitseviä eroja. Etualue oli hammaskantoinen 99 %:lla hoitoryhmän lapsista ja 24 %:lla kontrollilapsista. 90 %:lla hoidetuista ja 48 %:lla kontrolleista poskihampaat olivat ideaalisuhteessa. Hoitoryhmän lapsista 98 %:lla ala- ja yläetuhampaat olivat tasaisessa rivissä, kun verrokkiryhmän lapsista 32 %:lla oli ahtautta yläetualueella ja 47 %:lla alaetualueella. Ryhmien välillä oli merkittävä ero alaleuan ja keskikasvojen pituudessa sekä niiden keskinäisessä suhteessa. Purennanohjaimen vaikutukset rajoittuivat pääasiassa alaleuan hampaiston ja hammaslisäkkeen alueelle. Hoito lisäsi merkittävästi alaleuan kasvua.

Purennanohjaimella ensimmäisen vaihdunnan aikana suoritettu oikomishoito ohjaa tehokkaasti hampaiden puhkeamista ideaalipurentaan ja vähentää jatkohoidon tarvetta hampaiston myöhäisimmissä kehitysvaiheissa. Vain muutamia purentaa korjaavia muutoksia on odotettavissa purennan kehittymisen myötä ilman aktiivista hoitoa.

Avainsanat: Oikominen, varhaishoito, hoidon tarve, maitohampaisto, ensimmäinen vaihduntavaihe, purentavirhe, irtokoje, purennanohjain, kefalometria

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which will be referred to by their Roman numerals (I–IV).

I. Keski-Nisula K, Lehto R, Lusa V, Keski-Nisula L, Varrela J. Occurrence of malocclusion and need of orthodontic treatment in early mixed dentition. Am J Orthod Dentofacial Orthop 2003;124:631-638.

II. Keski-Nisula K, Keski-Nisula L, Mäkelä P, Mäki-Torkko T, Varrela J. Dentofacial features of children with distal occlusions, large overjets and deepbites in the early mixed dentition. Am J Orthod Dentofacial Orthop 2006;13:292-299.

III. Keski-Nisula K, Hernesniemi R, Heiskanen M, Keski-Nisula L, Varrela J. Orthodontic intervention in the early mixed dentition: A prospective, controlled study on the effects of the eruption guidance appliance. Am J Orthod Dentofacial Orthop 2008;133:254-260.

IV. Keski-Nisula K; Keski-Nisula L; Salo H; Voipio K, Varrela J. Dentofacial Changes after Orthodontic Intervention with Eruption Guidance Appliance in the Early Mixed Dentition. Angle Orthod 2008;78:324-331.

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1. INTRODUCTION

Opinions on the optimal timing of orthodontic treatment vary greatly among clinicians and researchers. The College of Diplomats of the American Board of Orthodontics held workshop discussions on early treatment during their meeting in 1997, concluding that almost all types of malocclusions could benefit from the early treatment (Bishara et al. 1998). On the other hand, it has been suggested that the best time for orthodontic treatment would be in early permanent dentition (Gianelly 1995, Proffit 2002). The opinions of orthodontists concerning the timing of treatment are largely based on clinical experience. Only few well-controlled studies have been carried out, and these have covered only a fraction of the treatment modalities that are available in orthodontics. Further studies are needed before there is full understanding of the advantages and disadvantages of early orthodontic treatment.

Because of the variation in children's growth patterns and growth potential, an individualized approach is usually favored in orthodontic therapy. However, investigations have been carried out testing the effects of more generalized interceptive measures (Al Nimri and Richardson 2000, Väkiparta et al. 2005). In Finland, the health care system provides free dental care up to 18 years of age. This gives a unique opportunity, on a population basis, to monitor the occlusal development and provide treatment at any chosen time. Financial pressures, as well as the desire to give treatment to all children in need, have encouraged orthodontists to develop novel solutions (Pulkkinen and Pulli 1991, Pietilä 1998). Most of these have included treatment carried out with orthopedic and/or functional appliances in the early mixed dentition.

The prefabricated eruption guidance appliance has become increasingly popular among the Finnish orthodontists who favor comprehensive early treatment (Pietilä et al. 2004). This appliance can be used to guide the erupting teeth into their correct positions on the dental arches. Furthermore, many types of malocclusion such as Class II relationship, crowding, excess overjet, deepbite, openbite and buccal crossbite (scissors bite) can be treated simultaneously with the eruption guidance appliance (Methenitou et al. 1990). Good results are reported from orthodontic clinics in Finland that have used the eruption guidance appliance in early treatment, but no controlled studies have been published before the present investigation.

The series of studies summarized here analyzed the occlusal and dentofacial features and orthodontic treatment need at the interface between the deciduous and early mixed dentition. In addition, they investigated the effects of orthodontic treatment carried out with the eruption guidance appliance, on the occlusal and skeletal development in the early mixed dentition.

2. REVIEW OF THE LITERATURE

2.1 Occurrence of malocclusion in the deciduous and early mixed dentition

Only few epidemiological or age cohort studies have been carried out to investigate the occurrence of malocclusions in the deciduous dentition. Heikinheimo and Salmi (1987b) studied occlusal features in an entire age cohort of 184 five-year-old children in a Finnish health center. Their results showed that a cross-bite of the anterior or lateral segment occurred in 16%, a scissors bite in 1%, an open bite in 0.6%, a persistent sucking habit in 2 %, and a severe Class II bite in 0.6%, a milder Class II bite or a Class II tendency in 14%, and crowding in 9% of the children. Tschill et al. (1997) studied occlusal characteristics in the deciduous dentition of 407 boys and 380 girls aged 4-6 years. They found that 24% of the children were lacking adequate space in the upper anterior segment, 16% had a lateral crossbite, 6% an excessive overjet of 6 mm or more, 26% a Class II relationship, and 37% an anterior open bite.

In the British study by Foster and Hamilton (1969), 100 children aged from 2.5 to 3 years were investigated. When all children who had either a unilateral or bilateral Class II relationship were taken into account, the frequency of distal step was 39%, and that of a Class II canine relationship 59%. They also reported that 37% of the children were lacking contact between the upper and lower incisors. In 20% of the children the lower incisors were biting into the palatal gingiva. The percentage of children with an overjet exceeding 2 mm was 72%. It should be noted, however, that the frequencies of the Angle classes cannot be directly compared to those found in other studies because Foster and Hamilton (1969) equaled a flush terminal plane with a Class I, and a mesial step with a Class III, relationship, thereby applying a classification that has not been commonly used elsewhere.

Stahl and Grabowski (2003) made an epidemiologic study of 8864 preschool and school-aged children of whom 1225 were in the deciduous dentition stage (mean age 4.5 years) and 7639 in the mixed dentition stage (mean age 8.9 years). Their findings indicated that a crossbite with a midline discrepancy was significantly more frequent in the deciduous dentition than in the mixed dentition. Similarly, an anterior open was more common in the deciduous dentition.

Thilander et al. (1984) found a posterior cross-bite in 10% of 1046 four-year-old children. In Finland, the prevalence of a posterior crossbite in the deciduous dentition increased from 3% in the 1950s to 14% in the 1980s, probably reflecting the increase in the use of pacifiers, but decreased to 8 % in the 1990s (Myllärniemi 1970, Heikinheimo et al. 1987b, Paunio et al. 1993). A prevalence of about 2 % has been reported for anterior crossbite in Finland (Myllärniemi 1970, Heikinheimo et al. 1987b). It seems that the frequency of posterior crossbite has increased more in industrialized countries than in developing countries (Kerosuo 1990).

Kerosuo (1990) studied occlusion in the primary and early mixed dentitions in 580 Tanzanian Children (83% Black African, 10% Asian, 7% Arab) and 575 Caucasian children from Finland. The Tanzanian children had fewer occlusal or space anomalies than the Finnish children (Kerosuo 1990, Kerosuo et al. 1991). Distal bite, lateral crossbite and crowding were significantly less common in the African children than in the Finnish children. A crossbite was found in 13% of the Finnish children. Of the African children, 8% had an anterior crossbite and 10% an anterior open bite.

In Brasilia, Chevitarese et al. (2002) studied the prevalence of malocclusion and its relationship with oral habits in 112 6-year-old children. They found that the presence of malocclusion was high (75.8%), open bite being the most prevalent malocclusion. In an other Brazilian study, occurrence of posterior crossbite was studied in 2016 4-6 year-old-children (da Silva Filho et al. 2007). Normal occlusion was found in 26.7% of the children and malocclusion in 73.3%. Following frequencies for occlusal deviations were reported: unilateral posterior crossbite 11.7%, anterior open bite associated with posterior crossbite 7.0%, and bilateral posterior crossbite 0.2%. The total percentage of transverse problems was 20.8%. 91.9% of children who had a unilateral posterior crossbite had a mandibular functional deviation.

Anderson (2006) studied the terminal plane relationships in the primary dentitions of 189 African American children aged from 2 to 5.2 years (mean 4.1 years), and compared the findings with those obtained from a historical sample of 61 European children (39 boys and 22 girls). A mesial step was observed in 89% of the African American children and in 63% of the European children. The prevalence of distal step and flush terminal plane was lower in the African American children (5% and 6%, respectively) compared to the European children (16% and 21%, respectively). It was concluded that a mesial step rather than a flush terminal plane represents the normal relationship of the second molars in a complete primary dentition in both ethnic groups.

Occlusion and arch dimensions in the primary dentition of 1048 preschool Jordanian children were studied by Abu Alhaija et al. (2003). A bilateral mesial step was found in 48% of children, a bilateral flush terminal molar relationship in 37%, and a bilateral distal step in 4%. An asymmetric molar relationship was found in 12% of the children. In the canines, a Class I relationship was found in 57% of the children, a Class II relationship in 29%, and a Class III relationship in 4%. Overbite was classified as ideal in 44%, reduced in 22%, and increased in 28%. An anterior open bite was observed in 6% and a buccal crossbite in 7% of the children. Spacing of the upper arch occurred in 62% and that of the lower arch in 61% of the children.

Tausche et al. (2004) estimated the prevalence of malocclusion in the early mixed dentition of 1975 children aged between 6 and 8 years using the index of Orthodontic Treatment Need (IOTN). The results showed that the most frequent occlusal discrepancies were excess overbite and overjet (> 3.5 mm) that were found in 46% and 38% of the children, respectively. An anterior open bite was observed in 18%, crossbite in 8%, and reverse overjet in 3% of the children.

Dental crowding in primary dentition and its relationship to arch and crown dimensions was studied by Tsai (2003). Twenty-seven crowded and 34 spaced arches were examined from dental casts. The crowded arches had significantly smaller arch widths than the spaced arches. No differences were found between crowded and spaced arches in arch length, mesiodistal crown width, or crown shape. It was concluded that the width of the arch is the key factor that determines the level of alignment in the primary dentition.

Warren et al. (2005) studied the occurrence of malocclusion in the mixed dentition and the role of non-nutritive sucking habits in the development of malocclusions in 524 children. They found that 55% of the children had malocclusions (anterior open bite, posterior crossbite, bilateral Class II molar relationship, or overjet > 4 mm). A Class II molar relationship was the most common (30%) type of malocclusion. They concluded that anterior open bite and posterior crossbite may be preventable by modifying non-nutritive sucking behaviors.

2.2 The predictive value of deciduous occlusion

Longitudinal studies have shown that a distal step of 1 mm or more in the deciduous dentition invariably leads to a Class II molar relationship in the permanent dentition, and that a mesial step seldom develops into a distal bite (Fröhlich 1961, 1962, Arya et al. 1973, Bishara et al. 1988). In both cases, the relationship of the deciduous molars gives a fairly reliable prediction of the future permanent molar relationship. The occlusal development is more difficult to predict in children with a flush terminal plane because about 40% of them will progress to a Class II occlusion, and 60% to a Class I occlusion (Arya et al. 1973, Bishara et al., 1988). It seems, however, that the canine relationship can be used as a diagnostic aid to predict changes in the molar relationship (Varrela 1997). The combination of a flush terminal plane and a Class II canine relationship seems to indicate a higher risk of developing a distal occlusion. If the upper deciduous incisors are inclined lingually and covered by the lower lip, it is likely that the child will develop a Class II, division 2 relationship in the permanent dentition (Leighton 1969).

Foster and Grudy (1986) studied the persistence of occlusal features of the primary dentition during the development of the permanent dentition. While the results indicated a broad measure of predictability, there was variation that made prediction of occlusal development in an individual patient more unreliable. Incisal overjet and overbite changed only little between the two dentitions, but the changes occurred in both directions. The sagittal relationships of the dental arch were relatively stable; if a change occurred it tended to be in the Class II direction, with the mandibular arch becoming retruded in relation to the maxillary arch. The prediction of crowding in the permanent dentition from a simple count of spaces in the primary dentition, while generally reliable, was not accurate in every individual patient.

Varrela (1998) selected 40 children with a Class II occlusion and 40 children with a normal Class I occlusion from a longitudinal database, and analyzed the occlusal development from the age of three to seven years using the serial records. The results showed that while most of the typical characteristics of a Class II occlusion were present early in the deciduous dentition, only few skeletal differences were found between the groups. The dentition of the normal children showed constant transversal growth, an improvement in the sagittal relationship, and an increase in the anterior spacing from three to seven years of age. Class II children, on the other hand, showed less transversal growth, a gradual change towards a distal step relationship, and no increase in spacing in their anterior segment. The findings indicated that an occlusal Class II pattern is established early in the deciduous dentition, before a skeletal Class II development becomes evident.

The analyses by Leighton (1969, 1971) indicated that crowding in the deciduous dentition always resulted in crowding of the permanent dentition; only with spacing in excess of 6 mm in the anterior segment of the primary dentition did the risk of crowding in the permanent dentition become zero. Lack of adequate space in the deciduous dentition was therefore considered as a reliable indicator of treatment need. Barrow and White (1952) found that the incidence of mandibular incisor crowding increased from 14% at the age of 6 years to 51% at 14 years of age. Bishara et al. (1995, 2006) studied the individual variation in tooth–size/arch-length changes from the primary to permanent dentitions. The mean age of the study group at the beginning was 4.0 years, and at the end 13.3 years. The study group consisted of 32 boys and 27 girls. The findings indicated that of the total sample of 59 children observed on a longitudinal basis, 49% maintained their relative tooth-size/arch-length relationship ranking in the 2 dentitions, while in 51% the relationship became either more favorable or less favorable in the permanent dentition. They also found that there are number of significant correlations between the deciduous and permanent dentitions, but most of these correlations were relatively low (<0.7). Melo et al. (2001), in a study of 9 years old children (12 normal and 11 crowded), concluded that larger primary tooth size is the main indicator in the development of dental crowding. Also the maxillary and mandibular arch lengths and the posterior cranial base length (S-BA) in the primary dentition were considered as indicators for dental crowding in the early mixed dentition.

Sanin and Savara (1973) studied longitudinal growth changes and prediction of development of the dentition. They found that about 80% of children without crowding at 8 years of age did not have crowding at the age of 14 years and approximately 90% of those with crowding at 8 years of age did have crowding also at the age of 14 years. They also found a correlation between mandibular incisor crowding and the size of the first molars, as well as with the angle formed by the long axis of the mandibular incisors and molars.

Overbite and overjet usually increase when the permanent incisors erupt (Moorrees 1959, Leighton 1969, 1975, Bergersen 1988). In the studies of Björk (1953), Moorrees (1959), Leighton (1969, 1971, 1975) and Bergersen (1988) the increase in overjet and overbite during the transition varied between 1 and 2 mm. Thereafter, both tended to become smaller although the decrease was less than 1 mm on average (Björk 1953, Bergersen 1988). On an individual level, however, large changes in both directions have been reported (Björk 1953, Bergersen 1988). It has been suggested that changes in overbite are difficult to predict because they may depend on the growth of the alveolar processes (Bishara and Jakobsen 1998). Stahl and Grabowski (2003) reported that the mean overjet increased significantly from the deciduous to the mixed dentition. It was suggested that the significant increase in the occurrence of traumatic deep bite in the mixed dentition indicated an unfavorable developmental tendency in this anomaly during the eruption of the permanent incisors (Stahl and Grabowski 2003).

2.3 Treatment need in the deciduous dentition

Estimates of treatment need in the deciduous dentition show wide variation, from 6% to 67% (Köhler and Holst 1973, Popovich and Thomson 1975, Järvinen 1981, Heikinheimo et al. 1987b). Järvinen (1981) studied 839 Finnish children aged 6 years and found that nearly 10% of them had received preventive or interceptive orthodontic treatment at age 3-5 years. Orthodontic intervention was needed in 6% of the children due to crossbite of the permanent central incisors, crossbite or scissors bite of the permanent first molars, ectopic eruption of the permanent incisors, numerical variation of the permanent incisors, or functional open bite. A further 3% needed follow-up because of severe crowding, extreme incisal overjet, and early loss of the primary mandibular canines. Köhler and Holst (1973) studied an unselected population of 4-year-old children, and concluded that while 66% of the children had malocclusion, 11% were in need of treatment in the deciduous dentition.

Heikinheimo et al. (1987a) studied the children at the age 7, 9 and 15 years. The reliability of the orthodontic diagnosis made at the age of 7 was tested at 9 and 15 years of age. The results indicated that if a treatment need was obvious at the age of 7, it was highly probable that this need persisted throughout the dental development. In the group they considered to require orthodontic treatment at the age of 7, spontaneous correction was observed in some cases with a posterior crossbite, a Class II, division 1 occlusion, or an open bite caused by thumb-sucking. They also found that there was no spontaneous correction of Class II division 2-type malocclusion. According to this study, considerable changes in the occlusion took place between the ages of 7 and 15. Most misjudgments were made about dental crowding. According to Heikinheimo et al. (1987a) 23.5% of the children needed treatment at the age of seven years and a further 34.5% were considered to need follow-up.

There seems to be a general consensus in the literature that early therapy is indicated in cases of anterior and lateral crossbites, Class III malocclusions, extreme forms of mandibular retrognathism and functional open bites. However, the efficiency of early treatment of these malocclusions has not been studied. Tschill (1997) recommended that early treatment should mainly be focused on lateral crossbites and sagittal malrelationships. Schopf (2003) found that in a group of 2326 schoolchildren aged between 6 and 7 years, 77% had mild to severe dysgnatic symptoms but were not in need of early treatment, 8% needed treatment because of lateral crossbite, and a further 8% because of anterior crossbite. According to his estimate, 20% of the children needed a space maintainer or later orthodontic treatment (space opening or extraction therapy). Tausche et al. (2004) recommended early treatment of symptoms which can inhibit mandibular or maxillary growth or disturb the development of the dental arches, e.g. crossbite, reverse overjet and increased overjet. Karaiskos et al. (2005) studied 395 6- and 9-year-old Canadian children using a modified Index for Preventive and Interceptive Orthodontic Treatment Need (IPION). A large percentage of children had crossbites in the anterior or posterior segment, or both. Openbites were also a common finding. Future orthodontic problems were identified in 28% of these children. No statistically significant differences were found between the sexes or the age groups. They concluded that most of the developing malocclusions would benefit from interceptive orthodontics focusing on space maintenance, crossbite correction and arch expansion.

Treatment requirements and results of preventive and interceptive treatment on a longitudinal basis have been evaluated by Popovich and Thompson (1975) and Thilander et al. (1984). Popovich and Thompson (1975) recommend early treatment only if it is possible to predict facial growth within clinically useful limits, and understand the intraoral and extraoral functional factors that affect occlusal development. They suggested that almost 73% of the children with Class I malocclusion had a balanced skeletal pattern, and that a high percentage of them should respond favorably to interceptive treatment. Thilander et al (1984) studied early treatment of crossbite and recommended that the treatment of posterior crossbite should be started in the early mixed dentition.

Stahl and Grabowski (2003) concluded that the need for preventive orthodontic therapy and for interceptive and early treatment measures is emphasized by the high number of malocclusions found in the deciduous and mixed dentition and by the tendency for some forms of malocclusion to deteriorate as the dentition develops.

According to Ackerman and Proffit (1980), Gianelly (1995), Bowman (1998), Tulloch (1998), Baccetti et al. (2000), Faltin et al. (2003), and Ackerman (2004), preventive and interceptive treatment modalities of Class II malocclusion can not be cost-effective because they affect only 15-20% of orthodontic problems. Ghafari et al. (1998) concluded that the optimal timing for the first treatment phase appears to be in the late mixed dentition, because then it would eliminate the need for an intermitted retention period before the second phase. However, he emphasized that a number of conditions may indicate an earlier intervention in the individual patient (Ghafari et al. 1998).

The findings that malocclusions can show spontaneous correction during occlusal development (Leighton 1975) have been used as an argument against early orthodontic intervention. However, it is not known how often clinically significant correction does occur. The longitudinal analysis of Heikinheimo et al. (1987a) showed that in many children a positive development in one deviating characteristic was followed by an adverse change in another. Their findings indicated that in a significant portion of the untreated children, the need of treatment that was established in the deciduous or early mixed dentition remained into the permanent dentition.

2.4 Dentofacial features of children in deciduous and early mixed dentition

It has been suggested that a longer anterior cranial base and a more obtuse base angle would be causative factors in the development of Class II malocclusion (Björk 1947, 1950, Elsasser and Wylie 1948, Riolo et al. 1974, Dibbets 1996, Johannsdottir et al. 1999). Klocke et al. (2002) concluded that the relationship between the cranial base flexure and the skeletal pattern of the jaws seems to be established before the age of 5 years and a large cranial base angle demonstrated a skeletal Class II tendency. On the other hand, Baccetti et al. (1997) and Varrela (1998), who studied the morphology of the cranial base in the deciduous dentition, found no difference between Class II children and normal children. Similarly Varjanne and Koski (1982) did not find an association between the shape of the cranial base, sagittal jaw relationship and type of occlusion.

Children with a Class II tendency (distal step) in their decicuous dentition have been found to have a neutrally positioned maxilla but a short, retruded mandible (Baccetti et al. 1997, Varrela 1998). On the other hand, in 6-year-old Icelandic children with a Class II molar relationship, the mandible was retruded but of normal size (Johannsdottir et al. 1999). In older Class II children, in the late mixed and permanent dentition, a neutrally positioned maxilla and short, retruded mandible seem to be consistent characteristics, although findings indicating maxillary retrognathism and normal mandibular size have also been reported (Björk 1947, 1950, Solow 1966, Ingervall and Lennartsson 1972, Mc Namara 1981, Berg 1983, Kerr and Adams 1988, Karlsen 1994, Dibbets 1996). A longitudinal analysis in children from three to seven years indicated that the mandibular position was close to normal at the age of three but became gradually more retruded as the children grew older (Varrela 1998). Karlsen (1994) who compared Class II, division 1 cases with and without deepbite in late mixed and early permanent dentition found several differences between the two groups including a larger mandibular plane angle and a larger anterior face height in the latter.

A deficient transversal width of the maxilla and a narrow upper dental arch seem to be among the first signs of class II malocclusion to appear in early deciduous dentitions (Baccetti et al. 1997, Varrela 1998). Adaptation to narrow maxilla is likely to result in further skeletal changes including mandibular retrognathia, which seems to be one of the most consistent findings in older children with a Class II malocclusion (McNamara 1981, 2001).

A close relationship is assumed to exist between the skeletal growth pattern and the development of malocclusion. However, Moyers and Wainright (1977) who studied occlusal and skeletal development longitudinally in children from 4 to 16 years of age, found little evidence to support the assumption that craniofacial morphology or facial growth would be important determinants of occlusal development, at least in the younger age groups. Similar results were obtained in a longitudinal analysis of the occlusal development from three to seven years of age in children with a Class II tendency (Varrela 1998). The finding that typical occlusal signs of Class II malocclusions appeared well before most skeletal characteristics suggests that the development of the Class II occlusion cannot be attributed to a specific Class II skeletal growth pattern (Varrela 1998). These findings suggest that the association between skeletal growth and occlusal development may more be complicated than is commonly recognized.

2.5 Treatment timing

Leighton (1971) suggested that it might be possible to simplify treatment by careful selection of the age at which treatment is started and emphasized the importance of preventive care in orthodontics. Dugoni (1998) described a comprehensive early treatment protocol and recommended that the treatment should be started in the mixed dentition, between 7 and 9 years of age. Bergersen (1984) suggested that many children with malocclusions could benefit from treatment in the early mixed dentition. In Finland, a treatment modality that could be referred to as a single-phase early orthodontic treatment is becoming increasingly popular because it seems to offer advantages in terms of coverage and economy of treatment (Pietilä 1998, Pietilä et al. 2004, Väkiparta et al. 2005). The appliances used in early treatment include expansion arches, orthopedic headgears, and activator-type appliances, e.g. the eruption guidance appliance (Pietilä et al. 2004).

Several investigations have been carried out to reduce or eliminate malocclusion by early interceptive measures with and without appliance therapy (Popovich and Thompson 1975, Freeman 1977, Ackerman and Proffit 1980, Hiles 1985, Al Nimri and Richardson 2000, Väkiparta et al. 2005). In the study of Popovich and Thomson (1975), preventive or interceptive treatment during the deciduous dentition or early mixed dentition was carried out in 18% of the 1258 children who were followed longitudinally. The treatment included three basic types: 1) space maintenance or regaining, related to early loss of primary teeth: 2) habit control, particularly thumb-sucking: and 3) crossbite correction, anterior and posterior, to relieve occlusal interferences. In a survey made by Ackerman and Proffit (1980), orthodontists considered preventive and interceptive procedures to be successful only in 15–20% of developing malocclusions, while the great majority of children were judged to require comprehensive orthodontic treatment in permanent dentition even if early treatment had been carried out. On the other hand, a significant reduction in treatment need was reported in two studies where early interceptive measures were carried out (Al Nimri and Richardson 2000, Väkiparta et al. 2005).

The benefits of an early treatment phase in Class II treatment have been studied in clinical trials (Gafari et al. 1998, Keeling et al. 1998, Tulloch et al. 1998, O'Brien et al. 2003a). They compared the effectiveness of two alternative treatment modalities in Class II treatment, the first including an early growth modification phase in addition to a later treatment phase, and the other comprising a single treatment phase in the early permanent dentition. The findings of the trials showed that apart from improved self-esteem, only minor benefits were obtained by the inclusion of an early treatment phase (Gafari et al. 1998, Keeling et al. 1998, Tulloch et al. 1998, O'Brien et al. 2003b). However, the results must be interpreted cautiously because only a very limited number of appliances regarding their working principles were tested. For example, treatment effects obtained with a head gear appliance using orthopedic forces were significantly better (Kirjavainen et al. 1997, 2000, 2003, Mäntysaari et al. 2004) than what reported by Gafari et al. (1998) or Tulloch et al. (1998)

Proffit (2002) has suggested that early Class II treatment is indicated only for a selected group of children. Feldman et al. (1999), in their study of 47 untreated children with Class II Division I deep overbite malocclusion, found that there were statistically significant improvements from adolescence to adulthood for all measured occlusal variables except development of mild crowing. However, many studies have indicated that a Class II relationship does not show spontaneous correction with growth (Ingelsson-Dahlström and Hagberg 1994, Baccetti et al. 1997, Bishara et al. 1988, 1997, You Zhi-Hao et al. 2001). Ingelsson-Dahlström and Hagberg concluded that interceptive treatment in the mixed dentition seemed to be favorable in Class II malocclusion cases, even when the malocclusion initially was mild. Baccetti et al. (1997) and Bishara et al. (1997) studied the changes in Class II division through the transition from the deciduous dentition to the mixed dentition, and Bishara et al. (1997) even to the permanent dentition. These studies showed a number of significant differences between Class II, division 1 and normal subjects, including a larger magnitude of maxillary and mandibular lengths in the normal group and greater skeletal and soft tissue convexities in the Class II group. You Zhi-Hao et al. (2001) suggested that disarticulation of the occlusion with an orthodontic appliance could minimize the effects of the adaptive mechanism and allow normal mandibular forward growth. Feldman et al. (1999) studied a sample of 47 untreated children with Class II, division 1 (II/I) deep overbite malocclusion, and found that the occlusions did not deteriorate from adolescence to adulthood except for the development of mild crowding.

2.6 Dentofacial effects of functional appliances

Many studies have indicated that the growth of the mandible can be influenced by functional appliances in the middle or late mixed dentition (Mc Namara et al. 1985, 1990, Pancherz 1985, Mills and Mc Culloch 1998, Toth and Mc Namara 1999, Janson et al. 2000, 2003). In an analysis of treatment effects of the FR-2 appliance of Fränkel, McNamara et al. (1985) found that the growth response was greater in the older patients with a starting age of 11.5 years compared to the younger patients with a starting age of 8.5 years.

Aelbers and Dermaut (1996), in a literature review on the effects of functional appliances, concluded that the role of mandibular growth in the correction of skeletal Class II discrepancies remains controversial despite extensive research. Many authors have obtained findings suggesting that the major contribution in Class II correction derives from dento-alveolar rather than from skeletal changes (Wieslander and Lagerström, 1979, Janson et al. 1997, 2000, Toth and McNamara 1999). Aelbers and Dermaut (1996) further concluded that the Herbst appliance was the only appliance capable of changing the mandibular growth to a clinically significant degree, and suggested that the reason for its effectiveness could be the full-time wear of the appliance. Pancherz and Hansen (1986), who studied the short- and long-term effects of the Herbst appliance on the maxillary complex, found that during the first six months after Herbst therapy most of the treatment changes reverted, while normal growth and development prevailed during the following years.

2.7 Eruption guidance appliance

The prefabricated eruption guidance appliance used in the present investigation was a soft positioner-like appliance. The material was softened PVC-plastic. There were three kind of appliances made for different stages of dental development, nite-guide for deciduous dentition, g-models (hard and soft) of the occlus-o-guide for mixed dentition stage and N-models (hard and soft) of occlus-o-guide for permanent dentition (Figure 1). The eruption-guidance appliance has wide treatment indications but it is usually recommended for mild to moderate malocclusions cases only (Bergersen 1985). However, clinical experience has shown that if the treatment is started in the early mixed dentition, the severity of the malocclusion seldom appears to be a contraindication. At this stage of occlusal development almost all cases can be considered as mild or moderate and are therefore suitable for treatment with the appliance. The eruption guidance appliance is designed to guide the erupting teeth into the correct positions before the fibers of the periodontal ligament mature (Bergersen 1984). By starting active treatment at the onset of the mixed dentition period, as was the case in the present investigation, the action of the appliance can be exerted on all permanent incisors and first molars.

The eruption guidance appliance has been shown to be capable of correcting many aspects of the developing occlusion including overjet and overbite, openbite, spatial deficiencies and the Class II molar relationship (Methenitou et al. 1990, Janson et al. 1997, 2000, 2004). The skeletal changes induced by the eruption guidance appliance were largely restricted to the dentoalveolar region (Janson et al. 1997, 2000). Janson et al. (2000) studied a group of 30 patients, who were treated with the eruption guidance appliance for 26 months, and reported an enhancement in mandibular length. The maxillary growth was not affected. The lower incisors showed bodily protrusion but unchanged inclination, while the upper incisors were tipped lingually and retruded (Janson et al. 2000)

The eruption guidance appliance is designed to solve crowding by expanding the dental arches (Bergersen 1984). Because a transversal deficiency of the upper dental arch is a common finding in Class II patients (Mc Namara 2000), it is possible that this expansion enhanced the transition from a Class II to a Class I relationship. In untreated Class II patients, the effect of mandibular growth that could potentially bring the lower dentition forward, seems to be lost because of intercuspal locking and subsequent adaptive movements of the dentoalveolar complex (You Zhi-Hao et al. 2001).

Figure 1. Appliances for different stages of dental development; nite-guide for deciduous dentition (left), g-model of the occlus-o-guide for mixed dentition stage (right).

3. AIMS OF THE PRESENT STUDY

The aim of this study was to analyze occlusion and facial structures in the deciduous and early mixed dentition and to investigate the effects on dental occlusion induced by an orthodontic appliance. The specific aims were to investigate:

1) the occurrence of malocclusion in the deciduous and early mixed dentition,
2) the dentofacial features of children with distal occlusion, large overjet and deepbite in early mixed dentition,
3) the occlusal effects of the orthodontic intervention, and
4) the craniofacial effects from intervention with orthodontic appliance

4. SUBJECTS AND METHODS

4.1 Material

The study sample is derived from three rural municipalities in western Finland, Jalasjärvi, Kurikka and Seinäjoki, with a combined population of about 50,000 inhabitants. The dental clinics in Jalasjärvi and Kurikka followed an early treatment protocol where all children were screened for malocclusions in the deciduous dentition at the age of four to five years. In most cases, treatment was started either in the deciduous dentition or at the beginning of the mixed dentition period. Because of the established early treatment protocol, it was not possible to assign the children to treatment and control groups in Jalasjärvi and Kurikka. The control group was collected from the neighboring town of Seinäjoki, where no treatment is normally given in the early mixed dentition. Matching of the treatment and control groups was achieved by using large unselected and representative samples from the same age cohorts.

All 137 children born in 1992 in Kurikka (population 11,000), all 253 children born in 1992 and 1993 in Jalasjärvi (population 9000) and a randomized sample of 205 children born in 1992 or 1993 in Seinäjoki (population 30,000), altogether 595 children, were originally called in for a clinical examination. Twenty-six children in Kurikka, 21 in Jalasjärvi and 3 in Seinäjoki were excluded at this point because of difficulties in co-operation. In addition, expansion treatment had already been started in 11 children with a posterior crossbite (9 in Jalasjärvi and 2 in Kurikka). All available pre-treatment information from these 11 children was utilized but they were not included in the treatment sample of this study. Consequently, 534 children, 268 girls and 266 boys, were clinically examined between their fourth and fifth birthday. The ethnic background of all children was Finnish. Because there were no other ethnic groups than Finnish in Jalasjärvi and Kurikka in 1992 and 1993 age cohorts, only children with the same ethnic background were selected into the control group in Seinäjoki. All were healthy and none had had earlier orthodontic treatment.

In order to control the variation caused by individual differences in the rate of development, the timing of examinations and interventions was based on the stage of dental development rather than on chronological age. The treatment in the treatment group and the follow-up of occlusal development in the control group was started at the beginning of the mixed dentition period (T1), defined as the time immediately following the exfoliation of the first deciduous tooth. The evaluation of the occlusal and dentofacial changes in the treatment and control groups was carried out at the interphase of the early and middle mixed dentition (T2), defined as the time when all permanent incisors and first molars were fully erupted.

All 534 children were recalled at the beginning of the mixed dentition period when the radiographic records and occlusal impressions were taken. At the same time, the treatment was started in the children who belonged to the treatment group. The mean age of the children at the second examination was 5.1 years (SD 2.6, range 4.0–7.8 years). Dental casts were collected from 486 children, 244 girls and 242 boys. The bite was registered in the centric relation and the casts were trimmed accordingly. Forty-eight (9.0%) of the 534 children either refused to co-operate or did not want to participate in the study. Of the children, only the information collected at the first examination was used in the present analysis. The data on overjet and overbite of these 48 children indicated that their occlusal characteristics were no different from those of the 486 who participated in the second examination.

The first examination, performed by two experienced orthodontists, included measuring of the overbite, overjet, gummy smile, recording of crossbite and scissors bite, measuring of the maximal opening, and recording of joint sounds during repeated opening and closing movements. The two examiners were calibrated to carry out the measurements in a similar manner. Overbite and overjet were measured between the first upper and lower deciduous incisors on the right side, as suggested by Moorrees (1959), using a metal ruler, with an accuracy of 0.1 mm. The values obtained for overbite were not corrected for incisal wear. At T1, a dentition without spacing in the incisor region and with rotated or labiolingually misplaced deciduous incisor(s) was denoted as crowded. At T2, a dentition was considered to be crowded if there was one or more labially or lingually broken contact. The gummy smile was measured from the gingival margin of the right upper central to the lower border of the upper lip while the child was smiling, using a metal ruler, with an accuracy of 1 mm. The smile was not standardized. Maximal opening was measured as the vertical distance between the incisal edges of the upper and lower right central with an accuracy of 1 mm. In those cases where the right central incisor was missing, the left central incisors were used for all measurements.

The children in the treatment and control groups were selected on the basis of the occlusal findings at the beginning of the mixed dentition stage. The inclusion criteria were: 1) distal step of ≥ 1 mm, 2) Class II canine relationship of ≥ 1 mm, 3) crowding, 4) overjet of ≥ 3 mm, and lack of tooth contact between the incisors 5) overbite of ≥ 3 mm, and lack of tooth contact between the incisors, 6) anterior crossbite, and/or 7) buccal crossbite (scissors bite). Children with a skeletal Class III relationship or a posterior crossbite were excluded from the present study. Of the children in Jalasjärvi and Kurikka, 315 fulfilled the above criteria. Of them, 33 were treated with other appliances, mainly a quad-helix appliance, because of a narrow maxillary arch. They were excluded from the study sample. In 27 cases, the child or the family refused orthodontic treatment. Consequently, a total of 255 children from Jalasjärvi and Kurikka were included in the treatment group. During the treatment, 12 children were excluded from the study because they moved to another municipality and could not complete the treatment. Of the remaining 243 children, 167 completed the treatment successfully. Seventy-six children (31%) had to be excluded from the study because they did not wear the appliance. In most cases, the reason for the premature termination of the treatment was the child's or the parents' own decision not to wear the appliance any longer. In three cases, a severe illness of the child prevented the completion of the orthodontic treatment. From the random sample collected from Seinäjoki, 104 children fulfilled the above criteria and were included in the control group. (Figure 2)

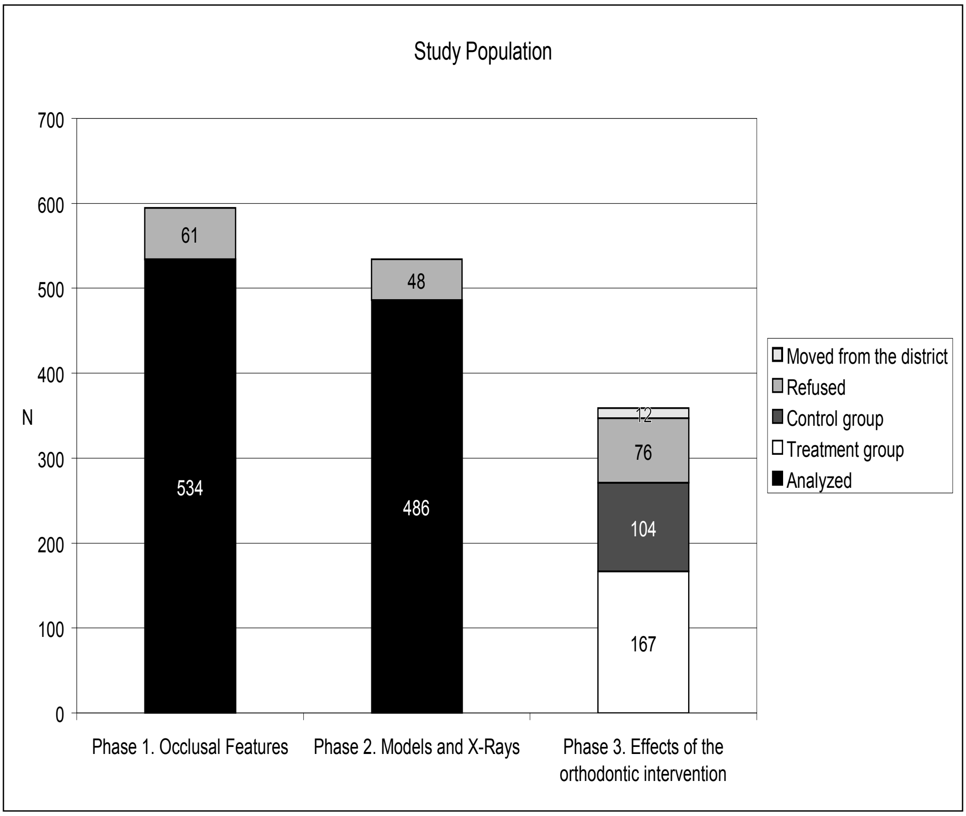

Figure 2. The number of the children in the different phases of the study.

The treatment with the eruption guidance appliance was initiated immediately after the clinical examination at the beginning of the mixed dentition period (T1). Two to three prefabricated appliances (Nite-Guide® or Occlus-o-Guide®, Ortho-Tain Inc.) were used in each patient. The appropriate size of the appliance was determined as recommended by the manufacturer. The appliances were worn during the night only. If difficulties were encountered, daytime wear of one hour was recommended until the problems with night-wear disappeared. The average duration of the active treatment period from T1 to T2 was 3.3 years. At point T2, all treated children entered the retention period, during which the last of the two or three appliances was used as a retainer, two nights per week. Following the early treatment protocol, the retention was to be continued till all permanent canines, premolars and second molars had fully erupted (T3). The retention is extended to T3, because it was estimated that only part of the total cumulative growth of the maxilla and mandible is completed at T2. Appointments were every 12 weeks during the active period, and once every six months during the retention period.

The occlusal and dentofacial features of the treatment and control children were analyzed at T1 and T2. In the treatment group, the occlusal analysis is based on the records of all 167 children (85 boys and 82 girls) who completed the treatment. The dentofacial analysis included the records of 115 consecutively treated children (62 boys and 53 girls) who were the first to complete the treatment. The control group comprised 104 children (52 boys and 52 girls). In both groups, the mean age at T1 was 5.1 years (SD 0.5), and at T2, 8.4 years (SD 0.5).

4.2 Occlusal investigations

From the dental casts, the presence of crowding or spacing in the anterior segment was assessed qualitatively by registering the presence of overlapping teeth or interdental spaces. The terminal plane relationship was measured between perpendicular projections, on the occlusal plane, from the distal surfaces of the upper and lower second deciduous molars as suggested by Bishara et al. (1988). A child was considered to have a flush terminal plane if the distance was less than 1 mm in either direction. If the difference was ≥ 1 mm the child was classified as having a distal step or a mesial step, depending on the direction of the deviation. The sagittal relationship of the canines was measured between perpendicular projections, on the occlusal plane, from the tip of the upper deciduous canine and the contact point of the lower deciduous canine and the first molar. In case of wear of the tip of the canine, the midpoint of the facet was used as the reference point. Similarly, the mid-point between the lower canine and the first molar was used if an interproximal space was present. Analogously to the Angle classification of molar relationship, the canine relationship in this study was defined as Class I if the tip of the upper canine deviated less than 1 mm from the ideal position in either direction. A deviation of 1 mm or more to the mesial or the distal was classified as Class II or Class III, respectively. All assessments and measurements from the dental casts were performed by the author (K. Keski-Nisula). All intermaxillary measurements were obtained from the casts trimmed in the centric relation. The measurements were taken with a digital caliper to the nearest 0.01 mm. The method error for the measurements, assessed by means of the standard error of a single determination (Dahlberg 1948) on repeated measurements of 30 randomly selected cases, was 0.14 mm.

4.3 Cephalometric methods

Lateral cephalograms were taken with standard cephalostats. The distance from the focus to the object plane and the object plane-film distance were standardized. The head was positioned in the cephalostat and oriented to the Frankfort horizontal plane with the teeth in maximum intercuspidation. The mid-sagittal enlargement was 1.1-fold for which the measured values were not corrected. At T1, radiographic records of 486 children were available, 244 girls and 242 boys. At T2, the treatment sample comprised 115 children, 53 girls and 62 boys, and the control group 104 children, 52 girls and 52 boys.

Computer-assisted analysis of the cephalograms was carried out by the author (K. Keski-Nisula) with the RMO Jiffy Orthodontic Evaluation 32 software program. The cephalometric measurements used in the analysis were adopted from McNamara (1981, 1996), Ricketts (1981) and Ricketts et al. (1982). The Wits appraisal was introduced by Jenkins (1955) who used the functional occlusal plane to assess anteroposterior maxillary and mandibular relationships by perpendicular intersect from point A and B. The functional occlusal plane is drawn along molars and premolars (Jenkins 1955, Thayer 1990). The landmarks and measurements are listed in Table 1a and b. Classification of the faces

Table 1a. Landmarks and measurements, points (Study IV)

Points	
Nasion (Na)	Anterior limit of the nasofrontal suture
Orbitale (Or)	Lowest point on external border of orbital cavity
Porion (Por)	Most superior point of external auditory meatus
Basion (Ba)	Most inferior posterior point of occipital bone at anterior margin of occipital foramen
Sella (Se)	Midpoint of sella turcica
Anterior Nasal Spine (ANS)	Tip of anterior nasal spine
Posterior Nasal spine (PNS)	Tip of posterior nasal spine
Pt point (Pt)	Intersection of inferior border of foramen rotundum with posterior wall of pterygomaxillary fissure
Gonion (Go)	Intersection of line connecting most distal aspect of condyle to distal border of ramus and line at base of mandible
Condylion (Co)	Most posterior–superior point on head of mandibular condyle
Pogonion (Pog)	Most anterior point on mandibular symphysis
Menton (Me)	Most caudal point in outline of symphysis, formed at intersection of mandibular plane
Gnathion (Gn)	Cephalometric landmark formed by intersection of (1) tangent of most inferior point of symphysis and most inferior point of gonial region and (2) line connecting NA and Pog
Point CC (center of cranium)	Cephalometric landmark formed by intersection of Ba-Na and Pt-Gn lines
Point A	Deepest point of curve of maxilla between ANS and dental alveolus
Point B	Deepest point of curve of mandible between Pog and dental alveolus
PM (protuberance menti or supra pogonion)	Point selected where curvature of anterior border of symphysis changes from concave to convex
XI point	Point at geographic center of ramus
AI incisor	Incisal tip of maxillary incisor
BI incisor	Incisal tip of mandibular incisor

into brachyfacial, mesofacial and dolichofacial types was performed as suggested by Ricketts et al. (1982). The measurement error was evaluated by digitizing and measuring 30 randomly selected cephalograms twice, at an interval of 6 months. The agreement between measurements was tested by analysis of variance (ANOVA, Bland and Altman 1996). The intra-class correlation coefficient (one-way random effects) varied between 0.92–0.99 in all measurements, indicating good accuracy.

The relationships between occlusion and skeletal characteristics were analyzed in four groups of children with different signs of malocclusion. The groups were formed on the basis of the occlusal characteristics using the following cut-off points: overjet ≥ 4mm, overbite ≥ 4mm, bilateral distal step ≥ 1mm (Table 2). Three of the groups were selected by one criterion only, while the fourth included the children who met all the criteria. A control group was formed of children who had 0-3mm overjet, 0-3mm overbite, ≥ 1mm of mesial step bilaterally, a Class I canine relationship, and no occlusal anomalies. The

Table 1b. Landmarks and measurements, plane and angles (Study IV)

Planes and angles	
Maxilla to cranium	Distance from Point A to NA-perpendicular (constructed by dropping line vertically inferior to Na and perpendicular to Frankfort horizontal), describes sagittal position of anterior border of maxilla to cranium
Mandible to cranium	Distance from Pog to NA-perpendicular, describes sagittal position of chin in relation to cranium
Anterior cranial length	Measured from Point CC to Na along the Ba-Na plane, describes length of anterior cranial base
Convexity	Point A to plane from Na to Pog, describes sagittal relation of maxilla to mandible
Lower facial height	Angle formed by XI-ANS plane and XI-Pog plane
Condylion to point A	Describes effective midfacial length
Condylion-Gnathion	Describes effective mandibular length
Maxillo-mandibular differential	Difference between distance from Co to Point A and distance from Co to Gn, evaluates sagittal skeletal imbalance
Menton-ANS	Describes lower anterior face height
Facial axis angle	Angle formed by Point CC-Gn plane and Ba-Na plane, describes growth direction of mandible
Mandibular Plane to Frankfort Horizontal	Angle formed by mandibular plane and Frankfort horizontal
PNS-ANS	Measure of maxillary length
PNS-A	Measure of maxillary length
Interincisal Angle	Angle formed by long axes of maxillary and mandibular incisors
B1 to A-Pogonion plane	Measured from tip of mandibular incisor to plane from Point A to Pog, describes protrusion of mandibular incisors
A1 to A-Pogonion plane	Measured from tip of maxillary incisor to plane from Point A to Pog, describes protrusion of maxillary incisors
IMPA	Angle formed by long axis of mandibular incisor and mandibular plane, describes inclination of mandibular incisors
A1 to S-Na	Angle formed by long axis of maxillary incisor and Sella-Na plane, describes inclination of maxillary incisors
Wits appraisal (mm)	Distance between perpendicular projection from Point A to occlusal plane and perpendicular projection from Point B to occlusal plane (measured along the occlusal plane), evaluates horizontal skeletal relationship

analysis was repeated using slightly different cut-off values (2 mm in distal step, 6 mm in overjet and overbite). Because the analyses gave practically identical results, only those obtained in the first analysis are reported and discussed.

Table 2. Selection criteria and number of children in the study groups. Note that the malocclusion groups are not mutually exclusive (Study II)

	Overjet	Overbite	Mesial step	Distal step	Number of children
Control group	0-3 mm	0-3 mm	≥ 1mm		44
Group 1	≥ 4mm	≥ 4mm		≥ 1mm	29
Group 2	≥ 4mm				128
Group 3		≥ 4mm			160
Group 4				≥ 1mm	108

4.4 Statistical analysis

Descriptive parameters were evaluated for the entire data set and expressed as Mean, Median, Minimum, Maximum and Standard Deviation. Differences between continuous variables were tested with the Student t-test, and between categorical variables with the Chi-square test. The relationships between continuous variables were tested with correlation analysis and simple linear regression analysis. A P-value less than .05 was considered to be statistically significant. In addition, the 95% confidence interval was used to express the results of statistical tests.

5. RESULTS

5.1 Occlusal findings in the deciduous dentition

5.1.1 Molar and canine relationship

Dental casts were collected from 486 children but because10 children had one or more second deciduous molars missing, the analysis is based on 476 casts. Combining the right and left sides, the frequencies of distal step, flush terminal plane and mesial step were 33%, 48% and 19%, respectively (Table 3). While in the majority of the children (70%) the terminal relationship was symmetrical, a considerable portion (31%) showed asymmetry. This asymmetry was, however, non-directional, the right and left sides showing almost equal numbers of mesial, flush and distal terminal planes. In 137 out of the 145 asymmetrical cases, a flush terminal plane was combined either with a distal step (61 %) or a mesial step (32%). Only eight children were found to have a combination of a mesial step on one side and a distal step on the other. Altogether 43% of the children had a distal step on one or both sides. No statistical difference was found between boys and girls in the frequency of distal step.

Table 3. Terminal plane relationship; analysis is based on 476 casts where both sides were observable. Differences between the right and left side are statistically non-significant (Study I)

	Right side (N=476)	Left side (N=476)	Right and left side combined (N=952)	Symmetrical (N=331)	Asymmetrical (N=145)
Distal step (≥ 1 mm)	156 (33%)	159 (33%)	315 (33%)	109 (33%)	97 (33%)
Flush terminal plane (±1 mm)	235 (49%)	220 (46%)	455 (48%)	159 (48%)	137 (47%)
Mesial step (≥ 1 mm)	85 (18%)	97 (20%)	182 (19%)	63 (19%)	56 (19%)
Total	476(100%)	476 (100%)	952 (100%)	331 (100%)	290 (100%)

The frequencies of Class I, Class II and Class III canine relationship were 46%, 52% and 2%, respectively, when pooling the right and left sides (Table 4). The number of children with an asymmetrical canine relationship (33%) was similar to that with an asymmetrical terminal plane (31%) but with a greater amount of directional asymmetry. The majority, 78%, showed a Class II relationship on the right side and only 22% on the left. The difference between the right and left side was statistically significant. A Class I / Class II canine relationship was found in 93% of the children with asymmetry, while a Class I / Class III combination was found in 5% and a Class II / Class III in 2%. The number of children with a Class II canine relationship on one or both sides was 68%. More boys than girls showed a unilateral or bilateral Class II canine relationship (173 vs. 158) but the difference was only of marginal significance ($p = .05$).

Table 4. Relationship of the deciduous canines. The analysis is based on 486 casts where both sides were observable (Study I)

	Right side (N=486)	Left side (N=486)	Right and left side combined (N=972)	Symmetrical (N=325)	Asymmetrical (N=161)
Class II (≥ 1mm)	298 (61%) ***	211 (43%)	509 (52%)	178 (55%)	153 (48%)
Class I (±1 mm)	182 (37%) ***	266 (55%)	448 (46%)	145 (45%)	158 (49%)
Class III (≥ 1mm)	6 (1%)	9 (2%)	15 (2%)	2 (1%)	11 (3%)
Total	486 (100%)	486 (100%)	972 (100%)	325 (100%)	322 (100%)

***Difference between right and left sides: $p < .001$

The interrelation of terminal plane and canine relationship was analyzed on the right and left sides separately (Table 5). A distal step was predominantly accompanied by a Class II (89%) and a mesial step with a Class I canine relationship (86%). A flush terminal plane was associated almost equally with a Class I (55%) or Class II (45%) canine relationship. With a very few exceptions, a Class II canine relationship was associated either with a distal step (56%) or with a flush terminal plane (57%) or a mesial step (35%). In most cases, a Class III canine relationship was associated with a mesial step.

Table 5. Interrelationship between terminal plane and canine relationship; right and left sides were analyzed separately and the combined frequencies are given (number of children 476; number of sides 952) (Study I)

Terminal plane	Canine relationship			Total
	Class II (≥ 1 mm)	Class I (± 1 mm)	Class III (≥ 1 mm)	
Distal step (≥ 1mm)	280	36	0	316
Flush terminal plane (±1 mm)	205	252	1	458
Mesial step (≥ 1mm)	13	158	13	184
Total	498	446	14	958

5.1.2 Incisor relationship

Relationship of the incisors was recorded in the 521 children who took part in the first clinical examination. When the jaws were in centric relation, the upper and lower incisors were in contact in 28% of the children. Contact of the lower incisors with the palatal gingiva was observed in 33% of the children. In 39% of the children, the bite was open and no contact was present either between the upper and lower incisors or between the lower incisors and the palatal gingiva.

Overjet (Figure 3) ranged from – 2 to 10 mm with a mean of 2.9 mm (SD 1.6). In 27% of the children overjet was 4 mm or larger, and in 6%, 6 mm or larger; a negative overjet (anterior crossbite) was found in 1% of the children. Overbite (Figure 4) ranged from – 5 (openbite) to 8 mm with a mean of 2.8 mm (SD 1.9). In 34% of the children, the overbite was 4 mm or larger, and in 5%, 6 mm or larger; and openbite was found in 5%.

The number of children with both overbite and overjet of 4 mm or larger was 11%. No statistically significant difference was found between boys and girls in the frequency of excessive (≥ 4 mm) overbite or overjet. Altogether 126 children (24%) had a gummy smile of 5 mm or more. There was no significant sex-related difference.

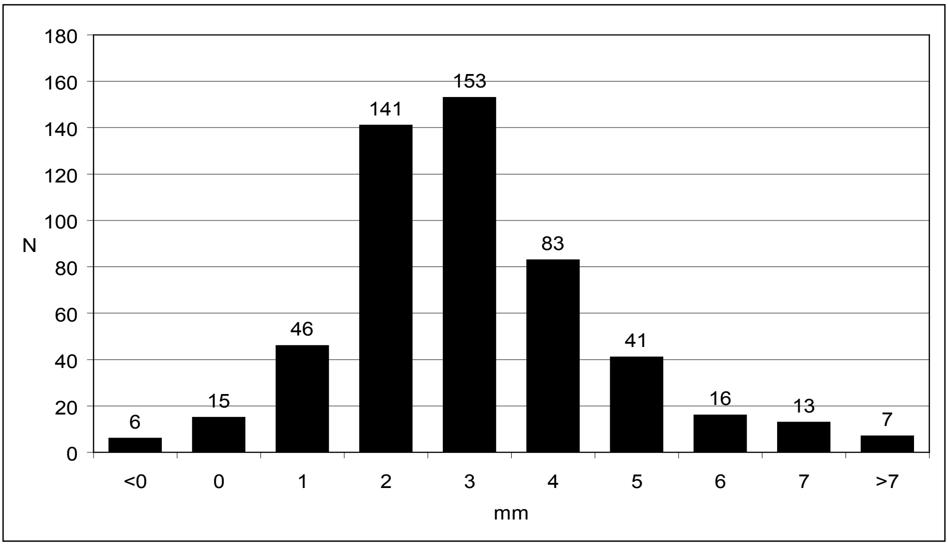

Figure 3. Distribution of overjet (N=521) (Study I)

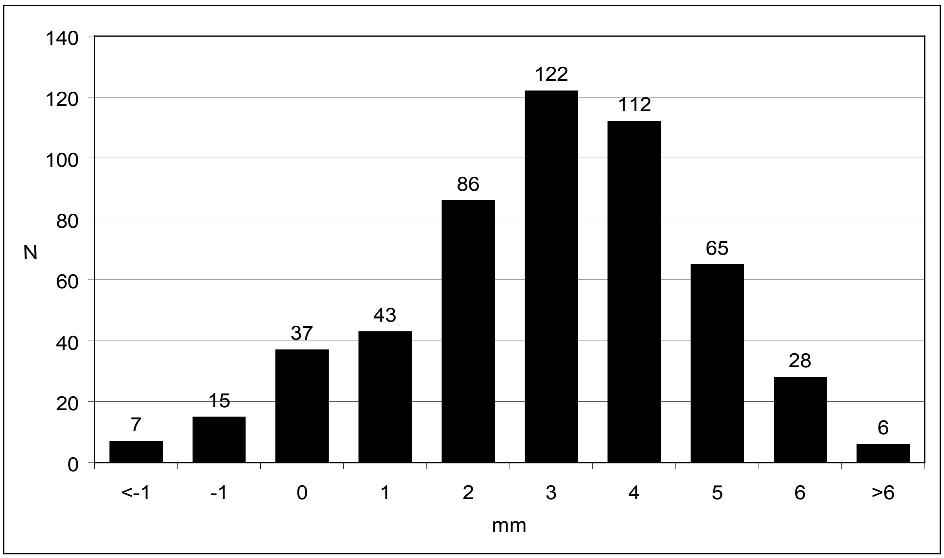

Figure 4. Distribution of overbite (N = 521) (Study I)

5.1.3 Crowding / spacing

At baseline, 12% of the children had crowding in the upper anterior arch and 39% in the lower anterior arch. Forty-one percent of the children had closed anterior contacts (no spacing) in the upper anterior arch, and 33% in the lower. Spacing in the anterior segments of upper and lower arches was observed in 47% and 29% of the children, respectively. No sex difference was found in the maxillary arch, but mandibular crowding was significantly more common in girls. Crowding was observed simultaneously in the upper and lower arches in 8% of the children.

5.1.4 Crossbite

Data on crossbite were available from 545 children. A posterior crossbite was found in 7.5% of the children, unilaterally in 6.4%, and bilaterally in 1.1%. A unilateral crossbite was observed on the right side in 20, and on the left side in 15 children. A scissorsbite was detected in three children (1%), bilaterally in one child and unilaterally in two. Of the unilateral cases, one was on the right side and one on the left. An anterior crossbite was registered in 2% of the children, while in 2% the deciduous incisors were in an edge-to-edge relation. One child had a crossbite both in the anterior and in the left lateral segment. There was no statistically significant difference in the frequency of crossbite or scissorsbite between the sexes.

5.1.5 Interrelationship of occlusal deviations

Simultaneous occurrence of the deviating occlusal characteristics was analyzed by cross-tabulation of their frequencies (Table 6). Children with distal step also showed a significantly higher frequency of deep bite and increased overjet. Similarly, those with a Class II canine relationship more often had a distal step and an increased overjet. Deep

Table 6. Interrelations of distal step, Class II canine relationship, overbite, overjet, upper and lower crowding and posterior crossbite. The table only gives frequencies that are significantly higher or lower than could be expected on the basis of the frequencies in the whole sample (Study I)

Overall frequency	Distal step ≥ 1 mm, 33%	Class II canine ≥ 1 mm, 52%	Overbite ≥4 mm, 34%	Overjet ≥ 4 mm, 27%	Crowding upper, 12%	Crowding lower, 39%	Posterior crossbite, 8%
Distal step (≥ 1 mm; N = 206)		92%***	43%**	41%***			1%**
Class II canine (≥ 1 mm; N = 331)	58%**			35%**			3%*
Overjet (≥ 4 mm; N = 139)	62%***	84%***					1%**
Overbite (≥ 4 mm; N = 176)	52%***	69%***					0%***
Upper crowding (N = 56)		77%***				69%***	
Lower crowding (N = 189)		69%***			21%**		
Posterior crossbite (N = 32)	9%**		0%***	3%**		19%*	

*p < .05, **p < .01, ***p < .001

bite and increased overbite both showed a strong association with a Class II relationship (molar and canine) but occurred independently of each other. Upper and lower crowding was seen in 8% of the same individuals, nearly twice the frequency expected by chance alone. No association was found between crowding and other signs of malocclusion. In children with posterior crossbite, the frequencies of other deviating characteristics were significantly lower than in the whole sample. The number of children with unilateral or bilateral distal step (≥ 1 mm) and Class II canine relationship (≥ 1 mm), deep bite (≥ 4 mm), increased overjet (≥ 4 mm), upper and/or lower crowding, posterior crossbite, anterior crossbite and/or Class III relationship was 93 %. If only bilateral cases of distal step and Class II canine relationship were included, the percentage of children with signs of malocclusion dropped to 79%. Using a threshold value of ≥ 6 mm for deep bite and increased overjet, the percentage further decreased to 68%.

5.2 Occlusal changes from T1 to T2

5.2.1 Overjet and overbite

In the treatment group (167 children) and in the control group (104 children), overjet varied from -2 to 10 mm at T1; no statistically significant difference was found between the groups (Figure 5). From T1 to T2, overjet decreased from 3.1 mm (SD 1.4) to 1.9 mm (SD 0.7) in the treatment group, and increased from 2.9 mm (SD 1.8) to 4.1 mm (SD 1.9) in the control group. The difference between the groups at T2 was highly significant. The

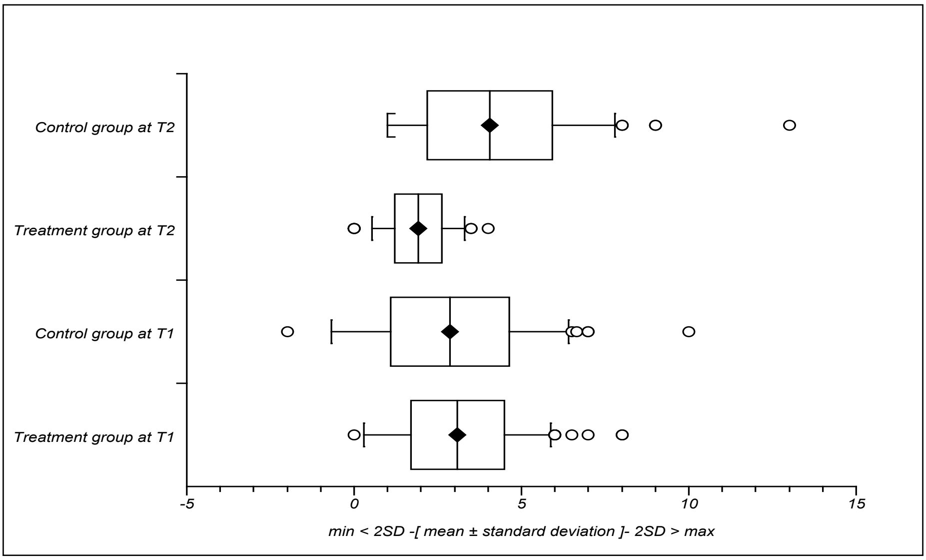

Figure 5. Box plot (mean, ± 1 SD, ± 2 SD, outliers) of overjet. At T1, the mean in the treatment group was 3.1 mm (SD 1.4) and in the control group 2.9 mm (SD 1.8). The difference was not significant (P = .26; 95% CI -0.2 to 0.6). At T2, the mean in the treatment group was 1.9 mm (SD 0.7) and in the control group 4.1 mm (SD 1.9). The difference was highly significant (P < .001; 95% CI -2.5 to -1.8).

mean change from T1 to T2 was -1.2 mm (SD 1.6) in the treatment group, and 1.2 mm (SD 1.5) in the control group. The difference in the T1-T2 change was highly significant (P < .001; 95% CI -2.74 to -1.99).

Overbite varied from -3 to 7 mm at T1 with a mean of 3.2 mm (SD 1.7) in the treatment group, and 3.3 mm (SD 1.9) in the control group. The difference between the groups was not statistically significant (Figure 6). At T2, overbite had decreased to 2.1 mm (SD 0.9) in the treatment group, and increased to 4.1 mm (SD 1.9) in the control group. The difference was highly significant. The mean change from T1 to T2 was -1.1 mm (SD 1.9) in the treatment group, and 0.9 mm (SD 1.3) in the control group. The difference in the T1-T2 change between the groups was highly significant (P < .001; 95% CI -2.3 to -1.6).

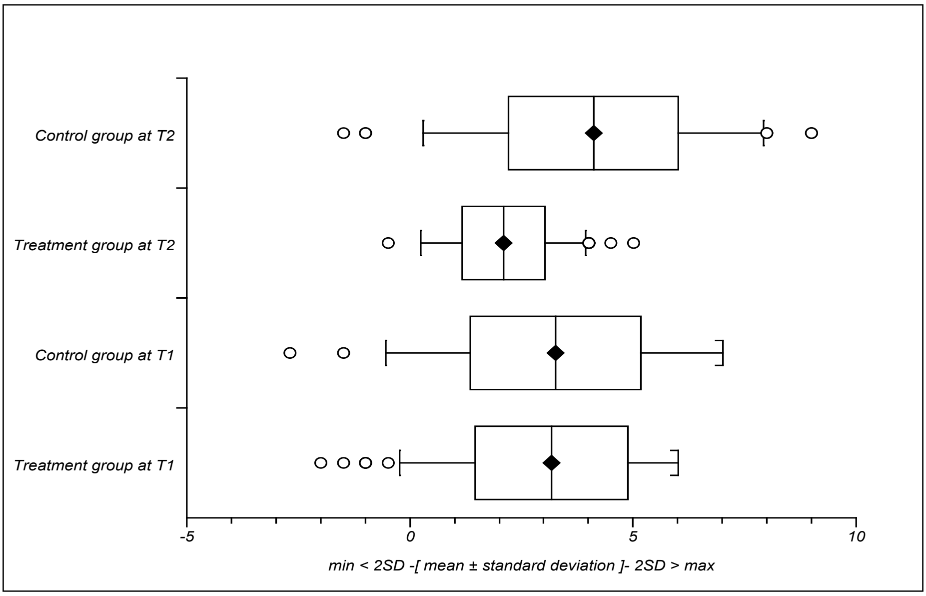

Figure 6. Box plot (mean, ± 1 SD, ± 2 SD, outliers) of overbite. At T1, the mean in the treatment group was 3.2 mm (SD 1.7) and in the control group 3.3 mm (SD 1.9). The difference was not significant (P = .67; 95% CI -0.5 to 0.4). At T2, the mean in the treatment group was 2.1 mm (SD 0.9) and in the control group 4.1 mm (SD 1.9). The difference was highly significant (P < .001; 95% CI -2.4 to -1.6).

At T1, a contact to upper gingival/palatal mucosa or an open bite was seen in 81% of the children in the treatment group and in 78% in the control group (Table 7). Only 18% of the children in the treatment group and 22% of the control children had a tooth-to-tooth contact at T1 (P = .43). In the control group, the situation did not change significantly from T1 to T2. In the treatment group, 99% of the children showed a tooth-to-tooth contact between the upper and lower incisors at T2; the remaining two children had a slight open bite. The difference between the groups at T2 was statistically significant.

Table 7. Contact of the lower incisor, registered at centric relation, at T1 and T2. The differences between the treatment and control group are non-significant at T1 and significant at T2 (P < .001)

	Treatment group (N=167)				Control group (N=104)			
	T1		T2		T1		T2	
	N	%	N	%	N	%	N	%
Tooth-to-tooth contact	30	18	165	99	23	22	25	24
Gingival contact	50	30	0	0	50	48	42	40
Open bite	86	51	2	1	31	30	37	36

5.2.2 Crowding

At T1, the upper incisor segment was crowded in 11% of the children in the treatment group and in 9% of the control children (Table 8). The frequencies in the lower incisor segment were 48% and 44%, respectively. In the control group, upper crowding increased to 32% and lower crowding to 47% from T1 to T2. In the treatment group, all but four children had a well-aligned incisor segment at T2; slight crowding was still present in the lower jaw of one child, in the upper jaw of two children, and in both jaws of one child. The difference between the groups was statistically non-significant at T1 (P = .99) but significant at T2.

Table 8. Incisor crowding at T1 and T2. The differences between the treatment and control group are non-significant at T1 and significant at T2 (P < .001) (Study III)

	Treatment group (N=167)				Control group (N=104)			
	T1		T2		T1		T2	
	N	%	N	%	N	%	N	%
Upper arch	19	11	3	2	9	9	33	32
Lower arch	80	48	2	1	46	44	49	47

5.2.3 Sagittal relationships

The mean sagittal relationship of the canines at T1 showed a Class II tendency in both groups: 1.6 mm (SD 1.5) in the treatment group and 1.4 mm (SD 1.7) in the control group (Figure 7). The difference was statistically non-significant. No change was observed in the control group from T1 to T2 with the canine relationship remaining at 1.4 mm (SD 1.6). In the treatment group, an improvement in the canine relationship was observed from T1 to T2 and the canines were only 0.2 mm (SD 0.7) away from a full Class I relationship at T2. The difference at T2 was statistically significant.

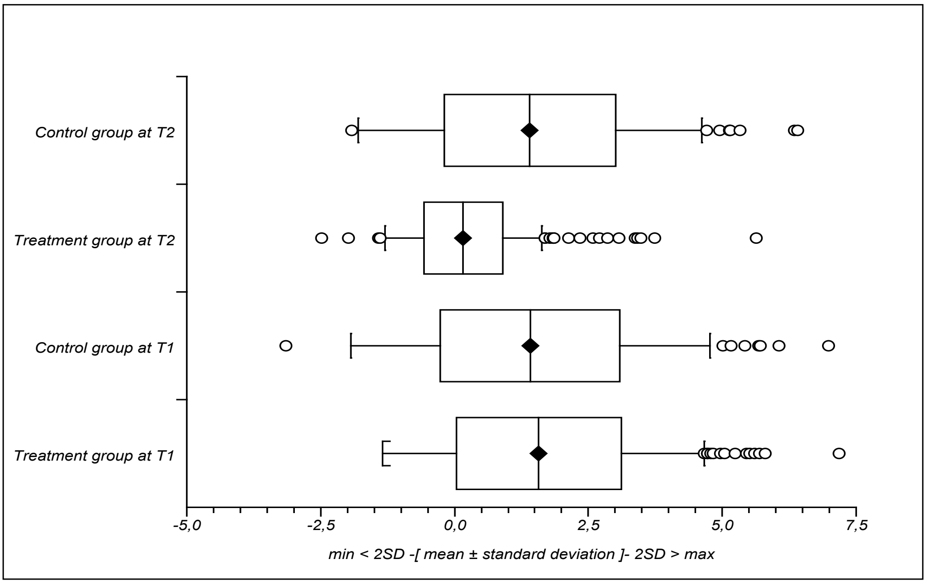

Figure 7. Box plot (mean, ± 1 SD, ± 2 SD, outliers) of sagittal relationship of the deciduous canines. Zero indicates that the tip of the upper canine coincides with the contact point of the lower canine and first molar; positive values indicate a shift towards Class II relationship. At T1, the mean in the treatment group was 1.6 mm (SD 1.5) and in the control group 1.4 mm (SD 1.7). The difference was not significant (P = .25; 95% CI -0.1 to 0.4). At T2, the mean in the treatment group was 0.2 mm (SD 0.7) and in the control group 1.4 mm (SD 1.6). The difference was highly significant (P < .001; 95% CI -1.5 to -1.0).

There was no statistically significant difference in the distribution of the terminal plane relationships between the treatment and control group at T1 (P = .14) (Table 9). During the period from T1 to T2, the frequency of Class I occlusions decreased among the control children from 53% to 48%, while that of Class II occlusions increased from 30% to 35%. The frequency of Class I / Class II cases remained at 18%. In the treatment group, the frequency of Class I occlusion increased from 41% to 90%, while that of Class I / Class II occlusion decreased from 20% to 7%, and that of Class II occlusion from 40% to 3%. The difference between the groups at T2 was statistically significant.

Table 9. Relationship of the upper and lower posterior segments at T1 and T2. The differences between the treatment and control group are non-significant at T1 and significant at T2 (P < .001) (Study III)

Posterior relationships	Treatment group (N=167)				Control group (N=104)			
	T1		T2		T1		T2	
	N	%	N	%	N	%	N	%
Class I	68	41	151	90	55	53	50	48
Class I/II	33	20	11	7	18	17	18	17
Class II	66	40	5	3	31	30	36	35
Total	167	100	167	100	104	100	104	100

The mean terminal plane relationship at T1 showed a slight distal tendency in both groups, 0.7 mm (SD 1.7) in the treatment group and 0.5 mm (SD 1.5) in the control group (Figure 8). The difference was statistically non-significant. In the treatment group, the terminal plane relationship decreased from T1 to T2 by 2.0 mm, being -1.3 mm (SD 1.2) at T2. In the control group, a change of 0.1 mm was observed with a mean of 0.4 mm (SD 1.9) at T2. The difference at T2 was highly significant.

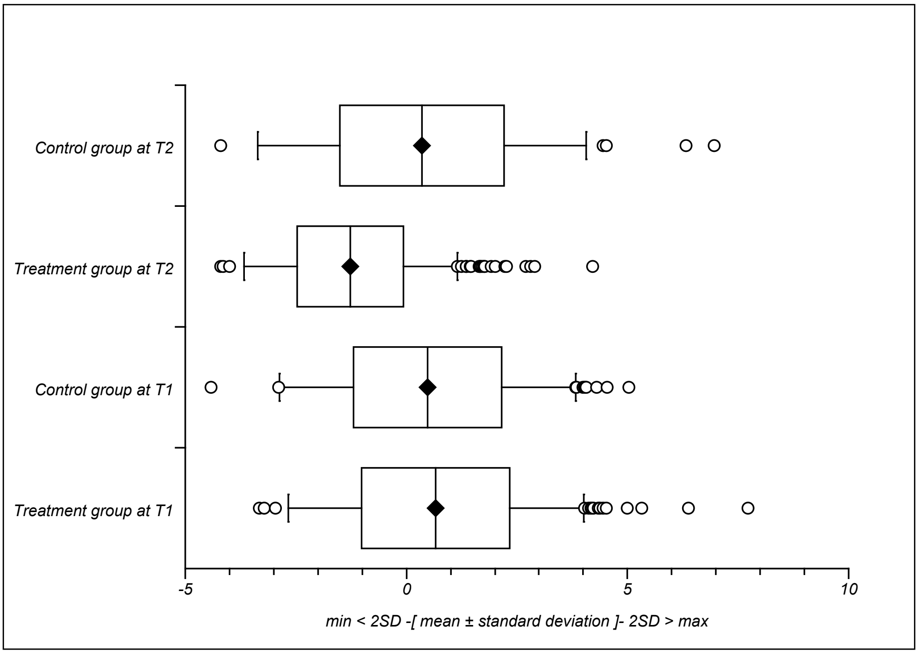

Figure 8. Box plot (mean, ±1 SD, ±2 SD, outliers) of terminal plane relationship between the second deciduous molars. Zero indicates a flush terminal plane and positive values a shift towards distal step. At T1, the mean in the treatment group was 0.7 mm (SD 1.7) and in the control group 0.5 mm (SD 1.7). The difference was not significant (P = .2; 95% CI -0.1 to 0.5). At T2, the mean in the treatment group was -1.3 mm (SD 1.2) and in the control group 0.4 mm (SD 1.9). The difference was highly significant (P < .001; 95% CI -1.9 to -1.3).

5.3 Dentofacial features at the interphase of the deciduous and mixed dentitions

At baseline, the faces of 224 children were classified as brachyfacial, 200 as mesofacial, and 62 as dolichofacial. The mean values and standard deviations of linear measurements and angles of the children at baseline are shown in Table 10, and a comparison of the malocclusions groups in Table 11. In the malocclusion groups, the anterior cranial base was of normal length, and the position of the anterior border of the maxilla was neutral in relation to the cranial base but protruded in relation to the mandible. Midfacial and maxillary lengths were greater in all groups, although in children with distal step, the difference in maxillary length did not reach statistical significance. In the children with distal step, analysis of distances from Point-A to Condylion, Point-A to Posterior Nasal Spine and Anterior Nasal Spine to Posterior Nasal Spine, suggested that the maxilla was of normal length but the position of the Condylion was more distal making, the midface longer than normal.

Table 10. Descriptive statistics for cephalometric measurements at base line (distances in mm and angles in degrees) (Study II)

	Mean	SD	Min	Max
Overjet	2.9	1.6	-2.0	10.0
Overbite	2.9	1.9	-5.0	8.0
Molar relationship (right side)	0.5	1.7	-4.4	6.4
Molar relationship (left side)	0.4	1.7	-4.0	7.7
Maxillary skeletal position				
A/Na-perpendicular	-0.8	2.7	-9.0	10.6
Condylion-A	80.4	4.1	70.0	92.0
SNP-SNA	47.2	2.8	35.2	54.5
SNP-A	43.9	2.6	32.4	51.2
Anterior cranial length	55.0	3.1	46.0	64.0
Mandibular skeletal position				
Pogonion/NA-perpendicular	-9.2	5.2	-24.5	8.1
Condylion-Gnathion	97.6	5.2	82.0	112.0
Facial axis angle	91.9	3.4	81.0	101.0
Mandibular plane/ Frankfort horizontal	24.7	4.6	11.0	37.0
Maxilla to mandible				
Maxillo-mandibular differential	17.1	3.5	6.0	30.0
Convexity	4.4	2.2	-3.9	11.0
Lower facial height				
Menton-ANS	56.9	4.0	43.0	72.0
Lower facial height (Ricketts)	45.5	3.9	33.0	58.0
Dental relationship				
A1/A-Pogonion	3.9	1.9	-3.0	9.0
B1/A-Pogonion	-0.2	2.3	-7.0	8.0
Interincisal angle	146.8	13.9	100.0	178.0

Compared to controls, the mandible was retrusive in relation to the anterior cranial base in the malocclusion groups. The mandible was also shorter but the difference was not statistically significant in children with excess overjet. The angle between the mandibular plane and the Frankfort horizontal was smaller in the malocclusion groups, but the difference was statistically significant only in children with excess overbite. The facial axis angle was normal in the malocclusion groups, but the maxillo-mandibular differential was significantly smaller. The malocclusion groups showed slightly smaller lower facial heights than the controls, but the difference was statistically significant only in children with excess overbite. The distance from Menton to ANS did not differ statistically from the controls in any of the malocclusion groups. Upper incisors were more labially positioned in children with excess overjet. The lower incisors were retrusive and the interincisal angle was greater in the malocclusion groups compared to controls.

Table 11. Comparison of the malocclusion groups with the ideal occlusion group (control group) (Study II)

	Control group (N=44)		Group 1 (N=29)			Group 2 (N=128)			Group 3 (N=160)			Group 4 (N=108)		
	Mean	SD	Mean	SD	P	Mean	SD	P	Mean	SD	P	Mean	SD	P
Maxillary skeletal position														
A/ Na-perpendicular	-0.7	2.5	0.0	3.1	.226	-0.5	3.1	.683	-0.6	2.7	.709	-0.6	2.9	.732
Condylion-A	79.4	3.1	81.2	4.0	.021	81.7	4.2	.001	81.3	3.8	.003	81.0	4.1	.020
SNP-SNA	46.5	2.6	48.3	2.2	.002	48.2	2.8	.001	47.5	2.5	.016	47.3	2.6	.077
SNP-A	43.5	2.3	44.9	1.9	.005	44.8	2.7	.004	44.3	2.3	.038	44.1	2.3	.130
Anterior cranial length	54.8	3.5	55.6	3.0	.193	55.5	3.2	.227	55.3	3.0	.357	55.4	3.3	.367
Mandibular skeletal position														
Pogonion/ NA-perpendicular	-7.6	4.1	-10.1	5.2	.024	-10.3	5.8	.005	-9.4	4.7	.019	-9.7	5.2	.015
Condylion-Gnathion	99.0	4.8	95.2	5.5	.006	97.5	5.5	.098	97.2	5.2	.043	96.9	5.5	.025
Facial axis angle	92.1	3.7	92.7	3.2	.540	91.8	3.4	.611	92.3	3.2	.771	91.9	3.3	.814
Mandibular plane/ Frankfort horizontal	25.4	4.8	22.9	5.5	.045	24.8	4.7	.497	23.6	4.6	.027	23.9	4.7	.082
Maxilla to mandible														
Maxillo-mandibular differential	19.6	4.0	14.0	2.8	<.001	15.8	3.4	<.001	16.0	3.2	<.001	15.9	3.7	<.001
Convexity	3.5	2.3	5.6	3.8	<.001	5.2	2.0	<.001	4.8	2.0	.001	4.8	2.2	.002
Lower facial height														
Menton-ANS	57.2	3.6	56.7	3.5	.694	58.0	4.3	.288	56.3	3.7	.130	56.9	3.9	.657
Lower facial height (Ricketts)	45.8	3.7	44.0	4.0	.074	45.3	5.5	.567	44.5	3.7	.046	45.2	3.8	.365
Dental relationship														
A1/ A-Pogonion	3.7	1.4	4.6	2.1	.043	5.0	1.9	<.001	3.5	2.0	.594	4.2	1.9	.127
B1/ A-Pogonion	1.2	1.9	-1.4	2.3	<.001	-0.5	2.4	<.001	-1.4	2.2	<.001	-0.9	2.3	<.001
Interincisal angle	139.5	10.9	146.7	14.3	.013	143.9	14.3	.059	154.0	13.2	<.001	147.3	15.3	.002

Group 1 bilateral distal step, overjet and overbite ≥ 4 mm; Group 2 overjet ≥ 4 mm; Group 3 overbite ≥ 4 mm; Group 4 bilateral distal step

In general, the correlations between the occlusal and cephalometric variables were weak and the predictive value of the correlation coefficients low (Table 12). There seemed to be very few interrelationships that would be of any clinical relevance. The incisal relationships (overjet and overbite) showed the strongest associations with the skeletal variables in all groups. Regarding the associations with the r^2-value exceeding 0.1, a significant positive correlation was found between facial convexity and protrusion of the upper incisors, as well as between overbite and interincisal angle, and a significant negative correlation between overbite and protrusion of the lower incisors. Considering all statistically significant correlations, the results can be interpreted to indicate some weak associations between the occlusal and skeletal parameters. Increase in overjet seemed to be associated with a longer and more protruded maxilla, a retruded mandible, a smaller maxillo-mandibular difference, a longer lower facial height, protruded upper incisors and retruded lower incisors. Increase in overbite was associated with a tendency towards a longer midface, a posteriorly rotating mandible, a convex face, a smaller maxillo-mandibular differential, a shorter lower facial height, retruding upper and lower incisors, and a larger interincisal angle. An increase in distal step was associated with a smaller maxillo-mandibular differential, a convex face and retruded lower incisors.

Table 12. Correlations between occlusal and cephalometric characteristics (Study II)

	Overjet			Overbite			Distal step –right side			Distal step –left side		
	r	r^2	p	r	r^2	p	r	r^2	p	r	r^2	p
Maxillary skeletal position												
A/ Na-perpendicular	0.13	0.02	.006	0.01	0.00	.811	0.03	0.00	.453	0.05	0.00	.244
Condylion-A	0.19	0.04	<.001	0.12	0.01	.009	0.08	0.01	.075	0.12	0.01	.011
SNP-SNA	0.23	0.06	<.001	0.07	0.00	.151	0.05	0.00	.267	0.09	0.01	.052
SNP-A	0.25	0.06	<.001	0.10	0.01	.040	0.06	0.00	.192	0.08	0.01	.102
Anterior cranial length	0.10	0.01	.040	0.01	0.00	.850	0.03	0.00	.571	0.06	0.00	.183
Mandibular skeletal position												
Pogonion/ NA-perpendicular	-0.15	0.02	.001	-0.06	0.00	.221	-0.14	0.02	.003	-0.07	0.01	.119
Condylion-Gnathion	-0.06	0.00	.215	-0.08	0.01	.077	-0.14	0.02	.002	-0.09	0.01	.062
Facial axis angle	-0.09	0.01	.052	0.01	0.00	.764	-0.04	0.00	.349	-0.02	0.00	.705
Mandibular plane/ Frankfort horizontal	0.01	0.00	.854	-0.17	0.03	<.001	-0.09	0.01	.045	-0.12	0.01	.009
Maxilla to mandible												
Maxillo-mandibular differential	-0.31	0.10	<.001	-0.27	0.07	<.001	-0.31	0.10	<.001	-0.27	0.07	<.001
Convexity	0.33	0.11	<.001	0.13	0.02	.005	0.23	0.05	<.001	0.15	0.02	.009
Lower facial height												
Menton-ANS	0.21	0.04	<.001	-0.15	0.02	.001	0.02	0.00	.705	0.01	0.00	.888
Lower facial height (Ricketts)	0.05	0.00	.237	-0.22	0.05	<.001	-0.02	0.00	.682	-0.06	0.00	.219
Dental relationship												
A1/A-Pogonion	0.43	0.19	<.001	-0.14	0.02	.003	0.11	0.01	.092	0.06	0.00	.225
B1/ A-Pogonion	-0.18	0.03	<.001	-0.46	0.21	<.001	-0.20	0.04	<.001	-0.27	0.07	<.001
Interincisal angle	-0.11	0.01	.018	0.44	0.19	<.001	0.11	0.01	.019	0.12	0.01	.009

5.4 Dentofacial changes from T1 to T2

No statistically significant differences were detected between the treatment group (115 children) and the control group (104 children) in the cephalometric variables at the beginning of the study (Table 13). An equal amount of growth took place in most skeletal variables in the treatment and control children during the observation period (Table 13). In addition, the growth direction of the mandible, measured by the facial axis angle, was similar in both groups. In midfacial length, mandibular length and maxillo-mandibular

Table 13. Occlusal and cephalometric variables in the treatment and control groups at T1 and T2. The differences between the groups at T1 were non-significant (Study IV)

	Treatment group at T1		Control group at T1		Treatment group at T2		Control group at T2		Difference between treatment and control group at T2	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P	95 % confidence interval
Overjet	3.0	1.4	2.9	1.8	1.9	0.6	4.1	1.9	<.001	2.69 to 3.50
Overbite	3.2	1.6	3.3	1.9	2.0	1.0	4.1	1.9	<.001	1.79 to 2.58
Molar relationship	0.6	1.7	0.5	1.7	-1.3	1.0	0.4	1.9	<.001	-1.98 to -1.41
Cuspid relationship	1.6	1.6	1.4	1.7	0.1	0.7	1.4	1.6	<.001	-1.50 to -1.02
Maxillary skeletal position										
A/ Na-perpendicular	-0.7	2.6	-0.4	2.5	-1.4	3.0	-1.2	2.8	.562	-1.01 to 0.55
Condylion-A	80.6	3.9	80.8	4.7	86.3	4.3	84.7	4.5	.010	0.38 to 2.73
SNP-SNA	46.8	2.5	47.6	2.5	49.8	2.9	49.7	2.5	.931	-0.69 to 0.75
SNP-A	43.8	2.4	44.5	2.2	46.1	2.9	45.9	2.4	.565	-0.5 to 0.93
Anterior cranial length	54.9	3.0	55.3	3.1	54.9	3.0	55.4	3.2	.277	-1.29 to 0.37
Mandibular skeletal position										
Pogonion/ NA-perpendicular	-9.4	4.9	-8.5	4.2	-9.0	6.5	-8.0	5.8	.260	-2.58 to 0.7
Condylion-Gnathion	96.9	5.1	98.2	5.9	108.0	5.4	105.4	5.8	<.001	1.18 to 4.1
Facial axis angle	92.5	3.4	92.3	3.2	91.0	3.8	91.6	3.4	.235	-1.56 to 0.39
Mandibular plane/ Frankfort horizontal	24.6	4.9	24.2	4.9	25.9	4.8	24.4	5.2	.03	0.15 to 2.82
Maxilla to mandible										
Maxillo-mandibular differential	16.3	3.2	17.3	3.6	21.8	3.2	20.7	4.0	.031	0.1 to 2.06
Convexity	4.6	1.9	4.3	2.1	3.2	2.3	2.9	2.3	.449	-0.38 to 0.86
Lower facial height										
Menton-ANS	56.0	3.8	57.0	3.9	61.2	4.6	60.4	4.3	.183	-0.39 to 1.99
Lower facial height (Ricketts)	44.8	3.9	44.3	5.8	44.4	4.2	43.6	3.8	.166	-0.32 to 1.83
Dental relations										
A1/ A-Pogonion	3.7	1.7	4.0	1.9	6.7	7.6	6.5	2.3	.838	-1.37 to 1.69
B1/ A-Pogonion	-0.2	2.3	-0.1	2.3	3.8	1.8	1.0	2.5	<.001	2.29 to 3.45
Interincisal angle	148.6	13.9	145.0	13.9	126.2	6.8	130.7	10.8	<.001	-6.88 to -2.02
Wits	0.5	2.8	0.1	3.2	-1.9	2.4	-0.6	3.0	<.001	-2 to -0.53
IMPA	87.8	7.5	89.7	7.3	97.0	6.0	94.0	8.1	.002	1.08 to 4.91
AI to S-Na	91.7	10.5	92.7	14.2	104.1	5.6	103.7	7.9	.680	-1.46 to 2.23

differential, the treatment children showed a significantly greater increase compared to the controls. In mandibular length, the growth increment was 11.1 mm in the treatment group and 7.2 mm in the control group. It seems that the greater mandibular growth in the treatment group also largely explains the difference in midfacial length and maxillo-mandibular differential. The mandibular plane/Frankfort horizontal angle was greater in the treatment group at T2 and the difference was statistically significant. The Wits

Appraisal was significantly smaller in the treatment group at T2, indicating a better intermaxillary relationship in comparison to the control group. The treatment did not seem to have any effects on the protrusion or angulation of the upper incisors. The lower incisors, on the other hand, became more protruded and more labially inclined in the treatment group. At the same time, the interincisal angle decreased.

Correlations between the occlusal characteristics at T1 and skeletal variables at T2 were analyzed in the control group where no intervention was carried out. In general, the correlations were low and of little clinical relevance. However, a moderate and statistically significant positive correlation ($r = 0.4$, $P < .001$) was found between the width of the upper dental arch at T1 and the length of the mandible at T2. This suggests that a narrow upper deciduous dental arch was associated with less growth of the mandible.

6. DISCUSSION

6.1 Occlusal and skeletal features in the deciduous and early permanent dentition

Both the methods of assessment and the definitions of malocclusions vary in different studies, and their findings should therefore be compared with caution. Allowing for the methodological differences, the present results do not significantly differ from those reported earlier. In the British sample studied by Foster and Hamilton (1969), for example, when both unilateral and bilateral cases are taken into account, the frequency of distal step was 38.8%, and that of a Class II type canine relationship 59%. The respective values in the present sample were 43% and 68%. Thirty-one percent of the children showed asymmetrical relationship in molars and 33% in canines. Directional asymmetry was more common in the canine relationship with 78% of the children showing a class II relationship on the right side and only 22% on the left. The difference between the right and left side was statistically significant. This is in contrast with the findings of Lundström (1961) who reported a Class II relationship more frequently of the left side. Foster and Hamilton (1969) reported that 37% of the children were lacking a contact between the upper and lower incisors, while in 20% the lower incisors were biting into the palatal gingiva. In the current sample, the frequencies were 39% and 32%, respectively. The percentages of children with overjet exceeding 2 mm were also similar (72% and 60%, respectively).

The number of children in the present sample who showed one or more deviating occlusal characteristics varied between 68% and 93%, depending on what threshold values were used to define malocclusion. Even the most conservative estimate (68%) appears high but similar figures have been reported for Swedish and Canadian children; 67% and 66%, respectively (Köhler and Holst 1973, Popovich and Thompson 1975). In an earlier Finnish study (Heikinheimo and Salmi 1987b) that analyzed the occlusion of five-year-old children, a prevalence of 61% was found. All these studies were based on unselected samples from the general population. Estimates of treatment need, on the other hand, show much wider variation, from 11% to 67% (Köhler and Holst 1973, Popovich and Thompson 1975, Heikinheimo and Salmi 1987b). It seems obvious that the assessment of treatment need in the deciduous dentition reflects not only the presence of occlusal deviations but also the opinions of the authors concerning the clinical management of malocclusions in the early stages of occlusal development.

The present 5-year-old children with distal bite, large overjet and deepbite all showed a rather similar skeletal pattern in the deciduous dentition. In addition to a neutrally positioned maxilla and a short and retruded mandible, these malocclusions were characterized by a neutral facial growth direction, retruded lower incisors and a large interincisal angle. Distal molar relationship and excess overjet are both classical signs of Class II malocclusion, and it is not unexpected that the groups should show similar dentofacial features. Dissimilarities included a long maxilla and protrusive upper incisors found in children with excess overjet, but not in those with distal step. Karlsen (1994), who compared Class II, division 1 cases with and without deepbite in late mixed and early permanent dentition, found several differences between the two groups, including a larger mandibular plane angle and a larger anterior face height in the latter group. These findings are in agreement with the results of this study. Similar findings were also reported in earlier studies of Class II children in the deciduous dentition (Bachetti et al. 1997, Varrela 1998). On the other hand, in a group of 7-year-old Icelandic children with a Class II molar relationship, the mandible was found to be retruded but of normal size (Johannsdottir et al. 1999).

6.2 Prediction of occlusal development and early orthodontic treatment

Occlusal and skeletal signs of malocclusion tend to be rather subtle in the deciduous dentition, making the diagnosis less straightforward. However, longitudinal investigations have shown that occlusal development in the mixed and permanent dentition depends on the deciduous occlusion, and that traits of the deciduous dentition such as distal step, large overjet and overbite, lack of spacing or crossbite reliably predict the presence of similar malocclusions in the permanent dentition (Föhlich 1961, 1962, Leighton 1969, 1971, Arya et al. 1973, Thilander et al 1984, Bishara et al. 1988, Baccetti et al. 2000). Less severe occlusal and skeletal discrepancies in the deciduous dentition can be seen to favor early intervention because the achievement of a good occlusion at this stage of the development will require less effort and time. However, many clinicians express their concern that unfavorable skeletal growth will inevitably override the treatment result if the treatment is given "too early". The present results, as well as earlier findings (Moyers and Wainright 1977, Varrela 1988), suggest that the occlusal development in the deciduous and early mixed dentition might not be as strongly associated with a particular skeletal growth pattern as is often assumed.

Although the occlusal development in general seems to result in a worsening of the malocclusion, the likelihood of self-correction should be considered. It has been shown that both positive and negative changes are possible in the occlusion during growth (Moorrees 1959, Heikinheimo et al. 1987a). The analysis of the present control group revealed that the chance of the malocclusions spontaneously disappearing is low. The longitudinal study of Heikinheimo et al. (1987a) indicated that in many children a positive development in one deviating characteristic was often followed by an adverse change in another. Consequently, most of the children who were originally classified as having a definite need of treatment remained in that category, although the reason for the classification might have been different.

Posterior crossbite of the deciduous dentition has been reported to occasionally self-correct during the eruption of the permanent teeth, albeit in only a small number of cases (Leighton 1966, Heikinheimo et al. 1982, Thilander et al. 1984). Early intervention has been recommended because several studies have indicated that posterior crossbite is a risk factor that may cause mandibular dysfunction and facial asymmetries (Thilander 1985, Pirttiniemi 1992, Kecik et al. 2007). Kurol and Berglund (1992) concluded that while the early treatment of crossbites is beneficial for functional reasons, grinding was not a cost- effective type of treatment.

In addition to questions related to early diagnosis and spontaneous correction, other important factors that affect the decisions on treatment timing include organization of the orthodontic care, cooperation of the children, risks in postponing the treatment, risks of relapse, and direct and indirect costs. The rationale of early treatment is based on the assumption that occlusal development can effectively be corrected by an intervention in the early stages of occlusal development. Therefore, the most crucial question for early treatment is whether or not efficient methods that can be applied in the early mixed dentition are available.

6.3 Occlusal and skeletal treatment effects in the early mixed dentition

The findings of the present investigation indicate that a significant improvement in the occlusion was achieved through the early intervention. After reaching the middle mixed dentition stage, most treated children showed a favorable intermaxillary relationship in the incisor, canine and molar segments. Overbite and overjet were both close to 2 mm, the incisors were in a tooth-to-tooth contact and good alignment, a mesial step was established in the molar region, and the canines showed almost a full Class I relationship (Figure 9).

A B

Figure 9. A) A patient showing gummy smile, distal bite and deep bite in the deciduous dentition. Note that the lower incisors are in contact with palatal gingiva. B) The same patient in the middle mixed dentition after treatment with eruption guidance appliance. Note the correction of the occlusion. Only a slight midline discrepancy remains.

As shown in Table 14, need of further treatment had markedly decreased because of the intervention. Only 22 (13%) of the 167 children in the treatment group showed persisting mild deviations in their occlusion. None of these children was considered to need further treatment at this point. In the control group, on the other hand, 92 (88%) of the 104 children had one or several deviating occlusal characteristics.

Table 14. Frequencies of deviating occlusal characteristics in the middle mixed dentition at T2 (Study III)

	Treatment group (N=167)		Control group (N=104)	
	N	%	N	%
Overjet ≥ 5 mm	0	0	31	30
Overbite ≥ 5mm	1	1	40	38
Open bite	2	1	37	36
Gingival contact of the lower incisors	0	0	42	40
Upper crowding	3	2	33	32
Lower crowding	2	1	49	47
Unilateral Class II	11	7	18	17
Bilateral Class II	5	3	36	35

The skeletal changes induced by the treatment were largely restricted to the dentoalveolar region. The earlier studies that investigated the effects of the eruption guidance appliance reported similar findings (Janson et al. 1997, 2000). However, the eruption guidance appliance seems to exert a clinically significant effect on the mandibular growth. In the present study, the mandibular length, measured from Condylion to Gnathion, increased 3.9 mm more in the treatment sample compared to the controls, equaling an extra growth of 1.2 mm per year. Janson et al. (2000) studied a group of 30 patients who were treated with the eruption guidance appliance for 26 months, and reported a similar annual enhancement in mandibular length. Both the present results and the earlier findings indicate that the maxillary growth is not affected. Similarly, the direction of the facial growth seems to remain unaffected. It seems likely that the greater mandibular growth in the treatment group explains the difference in the midfacial length, as well as in the maxillo-mandibular differential.

Many studies have indicated that the growth of the mandible can be influenced by functional appliances in the middle or late mixed dentition (Pancherz 1985, McNamara et al. 1985, 1990, Mills and McCulloch 1998, Toth and McNamara 1999, Janson et al. 2000, 2003). The present results indicate that the effect of the eruption guidance appliance is similar to that of other functional appliances. The present findings further show that an orthopedic effect on mandibular growth can be achieved during the early mixed dentition.

In an analysis of treatment effects of the FR-2 appliance of Fränkel, McNamara et al. (1985) found that the growth response was greater in older patients with a starting age of 11.5 years compared to the younger patients with a starting age of 8.5 years. The annual growth increment was 1.8 mm in the older group, and 1.2 mm in the younger (McNamara et al. 1985). The growth rate in the present treatment sample was 1.2 mm per year. These figures are in line with suggestions that the best response to functional therapy in terms of the mandibular growth rate is achieved at or near the peak of the pubertal growth spurt (Baccetti et al. 2000, Faltin et al. 2003). However, the present study shows that a clinically significant orthopedic effect can also be obtained in the early mixed dentition between 5 and 8 years of age.

A recent analysis of untreated Class II subjects indicated that the effect of mandibular growth that could potentially bring the lower dentition forward, seems to be lost because of intercuspal locking and subsequent adaptive movements of the dentoalveolar complex (You Zhi-Hao et al. 2001). Earlier, Johnston (1999) suggested that the key effect of a functional appliance is to displace the mandible forward and let the condyle grow into the fossae without producing maxillary dentoalveolar compensations. In the present study, the changes in occlusion and Wits appraisal toward a Class I relationship were significantly greater in the treatment group compared to controls. On the other hand, no differences were found in measurements that describe the position of the anterior border of the maxilla and mandible in relation to the cranium. It thus seems that a major effect of the eruption guidance appliance was indeed to induce a change in the dentoalveolar component without significantly affecting the position of the basal skeletal components. Johnston (1999) further suggested that the forward displacement of the mandible, typical of functional appliances, would cause a relative retrusive effect on maxillary dentition. However, no such effect was evident in the present study, as the maxillary dentition seemed to move forward equally in both groups. The present findings are thus in agreement with the previous results indicating that the eruption guidance appliance does not cause a significant restriction of anterior growth of the maxilla (Janson et al. 2000).

The eruption guidance appliance is designed to resolve crowding by expanding the dental arches (Bergersen 1984). Because a transversal deficiency of the upper dental arch is a common finding in Class II patients (McNamara 2000), it is possible that this expansion, in addition to the mandibular growth, enhanced the transition from a Class II to a Class I relationship. In the control group, a moderate but significant correlation was found between the width of the upper dental arch at T1 and mandibular length at T2. This suggests that a narrow upper arch tends to restrict anterior mandibular growth in early mixed dentition.

A significantly smaller overjet, overbite and interincisal angle were observed in the treatment group compared to the controls at the end of the study. The more pronounced labial inclination and the more anterior position of the lower incisors in the treatment group seem to be the main factors that affected the incisors relationships. There seemed to be no treatment effect on inclination or protrusion of the maxillary incisors. These findings are at odds with those of a previous study that showed bodily protrusion but unchanged inclination of the lower incisors, as well as palatal inclination of the upper incisors after treatment with the eruption guidance appliance (Janson et al. 2000). Linear retrusion and lingual tipping of the maxillary incisors also seem to be frequent findings with other functional appliances (Wieslander and Lagerstöm 1979, McNamara et al. 1985, Pancherz and Hansen 1986, Bishara and Ziaja 1989, Janson et al. 2003). The response of the incisors observed in the present study may relate to the fact that the present patients were younger and that the treatment took place during the period when the permanent incisors were erupting.

6.4 Early orthodontic treatment with the eruption guidance appliance

The guidelines set for the orthodontic treatment at the Dental Clinics of Jalasjärvi and Kurikka have been designed as a comprehensive early treatment protocol. Potential malocclusion cases are screened for and diagnosed in the deciduous dentition, and the treatment is started either in the deciduous dentition or at the beginning of the mixed dentition period. A similar approach to early treatment was described by Dugoni (1998) although the suggested time to start the treatment was later in the mixed dentition, between 7 and 9 years of age. The early treatment at Jalasjärvi and Kurikka is intended to be a one-phase treatment, i.e. the treatment plan does not normally include a second phase of treatment. Conditions that cannot be detected early, such as congenitally missing premolars, ectopically erupting molars and impacted canines, are diagnosed and treated later.

In the present treatment protocol, active treatment with the eruption guidance appliance was carried out during the entire period when the permanent incisors and first molars were erupting to ensure that these teeth were guided into the correct positions and intermaxillary relationships. As a consequence, the duration of the treatment period was 3.3 years. On the other hand, the total chair-side time that was required for the completion of the treatment remained relatively short because routine check-ups, carried out every 12 weeks, normally took no more than 5-10 minutes each. One of the advantages of the eruption guidance appliance is that it not only guides the eruption of the teeth but simultaneously acts on the transversal, sagittal and vertical relationships of the maxillary and mandibular dental arches. Figure 9 shows an example of the treatment effects that can be achieved with the eruption guidance appliance. This child, who in the deciduous dentition had a gummy smile, distal bite, deep bite and the lower incisors in contact with the palatal soft tissues, has an excellent occlusion after the treatment.

The earlier attempts to reduce or eliminate malocclusion by early interceptive measures with and without appliance therapy all reported beneficial effects, but the results were variable, probably reflecting the diversity of the interceptive protocols and the wide age range of the children participating in these studies (Popovich and Thompson 1975, Freeman 1977, Ackerman and Proffit 1980, Hiles 1985, Al Nimri and Richardson 2000, Väkiparta et al 2005). Two of the studies were carried out in countries where orthodontic treatment is publicly subsidized (Al Nimri and Richardson 2000, Väkiparta et al. 2005). Their findings indicated that early interceptive measures, when applied in the community, can result in a significant reduction in treatment needs. A similar, but even more extensive, improvement of the occlusion was observed in the present study.

On the basis of the existing literature, Proffit (2002) suggested that early Class II treatment is indicated only for a selected group of children. However, many studies have shown that a Class II relationship does not show spontaneous correction with growth (Baccetti et al. 1997, Bishara et al. 1997, 1998, Feldman et al. 1999, You Zhi-Hao et al. 2001). Instead, the skeletal and occlusal features of Class II tend to become exaggerated with age. It would therefore be logical to seek a treatment modality that would offer a method to intercept and correct Class II development at an early stage of occlusal development. The eruption guidance appliance seems to be a promising appliance for such a purpose. Not only the Class II relationship, but also many other signs of disturbed occlusal development such as crowding, excess overjet, deepbite, and openbite are treated simultaneously with this appliance in the early mixed dentition.

Although the effectiveness of the eruption guidance appliance is not limited to the period of active eruption (Janson et al. 2000), clinical experience indicates that the treatment tends to become more complicated if it is started later. After maturation of the periodontal ligament, day-time wear is regularly needed to achieve the desired effect because the tooth movement requires higher forces and longer treatment time. In many cases a combined treatment with other appliances such as head gear, rapid maxillary expansion, or fixed appliances may become necessary (Kangaspeska et al. 2001). On the other hand, if the treatment is carried out during the active eruption of the teeth, the appliance seems to be effective in the majority of patients.

Parental guidance and support are always essential when treating young children with removable appliances, particularly at the beginning of the treatment. Of the children in the present study who completed the treatment successfully, four had problems with the appliance at the beginning of treatment but all quickly overcame the difficulties. On the other hand, treatment of 76 children (31%) had to be discontinued due to persistent problems with compliance, either because the child was not willing to wear the appliance, or the parents were not motivated enough to support the child. Our rate of non-compliance was somewhat higher than that reported for the Twin-block appliance (O`Brien et al. 2003b), and about the same as for the Fränkel appliance (Gafari et al. 1998). It has been suggested that the young age of the patients would be a major limiting factor in applying early treatment in the community (White 1998). The present findings indicate that the family background seems to be the single most important factor affecting compliance, not the age of the patient per se. On the other hand, treatment was carried out in public health centers by general dentists and it also seemed important for the patient-dentist relationship that the child has his or her own doctor throughout the treatment.

It should be emphasized that in spite of problems with cooperation, 43% of the children of the entire 1992 and 1993 age cohorts in Jalasjärvi and Kurikka were successfully treated with the eruption guidance appliance.

Intervention in the early mixed dentition with the eruption guidance appliance appears to offer an effective method to reduce the need of orthodontic treatment. Clinical experience indicates that with proper retention, treatment results remain good with little or no relapse. However, the long-term effectiveness of the present treatment modality can only be assessed once the retention period and subsequent out-of-retention follow-up are completed.

7. CONCLUSIONS

Malocclusions are common at the onset of the mixed dentition period. In many cases the occlusal deviation is severe enough to reliably indicate need of treatment *at some point* of the occlusal development, while in others the changes are less definitive and prediction of the development may be either impossible or beyond the knowledge presently available.

The skeletal signs of distal bite, excess overjet and deepbite are similar in the early mixed dentition. Typical characteristics include a short and retruded mandible and a small maxillo-mandibular difference, retruded lower incisors and a large interincisal angle. Maxillary length and position, vertical dimensions and the facial growth direction are comparable in children with normal occlusions and those with malocclusions. Correlations between occlusal and skeletal variables are weak. No malocclusion-specific skeletal growth pattern can be detected in the deciduous and early mixed dentition. On the contrary, the occlusal development and skeletal growth seem to be relatively independent of each other.

The occlusal development of children with a Class II relationship or with a Class II tendency, excess overjet, deep bite, openbite, crowding, anterior crossbite and/or buccal crossbite can be effectively corrected in the early mixed dentition with the eruption guidance appliance. The eruption-guidance-appliance can also be used together with other orthodontic appliances such as headgear and Quad-helix. As a result, a significant reduction is achieved in the further need of orthodontic treatment.

During the treatment, the erupting permanent incisors and first molars are guided into their correct positions in the dental arches. At the same time, intermaxillary relationships in the incisor, canine and molar segments are corrected. Occlusal correction brought about by the eruption guidance appliance is achieved mainly through changes in the dentoalveolar region of the mandible. Mandibular growth is enhanced, resulting in a clinically significant increase in mandibular length. The eruption guidance appliance does not seem to affect the maxillary position, maxillary size, inclination or protrusion of the maxillary incisors.

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