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Prevalence of malocclusions in the early mixed dentition and orthodontic treatment need

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SUMMARY Early interceptive treatment for the elimination of factors inhibiting dental arch development and mandibular and maxillary growth is applied varyingly by orthodontists, possibly because there is little scientific evidence that such interventions are of actual benefit. The aim of this study was to determine specific factors for treatment need in the early mixed dentition period in order to obtain basic data to support early intervention. The study was part of a larger survey of 8768 children aged between 6 and 17 years. From this sample, 1975 children aged between 6 and 8 years were used to estimate the prevalence of malocclusions using the Index of Orthodontic Treatment Need (IOTN) during the early mixed dentition period.

The results showed that deep overbite and overjet, both more than 3.5 mm, were the most frequent discrepancies, affecting 46.2 and 37.5 per cent of patients, respectively. An anterior open bite was registered in 17.7 per cent, crossbite in 8.2 per cent, and a reverse overjet in 3.2 per cent. A tooth width to arch length discrepancy was recorded in 12 per cent of teeth in the upper arch and in 14.3 per cent in the lower arch. The proportion of children estimated using the Dental Health Component of the IOTN to have a great or very great treatment need (grades 4 and 5) was 26.2 per cent. The higher values of treatment need during the mixed dentition period may account for temporary changes in the dentition and for the discrepancy in overjet and overbite. These discrepancies will be compensated in part during mandibular growth and development of the dental arch. Nevertheless, the findings indicate the early development of progressive malocclusion symptoms which are evidenced in the IOTN and concur with the acronym 'MOCDO' hierarchy (missing, overjet, crossbite, displacement, overbite). This early formation of progressive symptoms inhibiting or disturbing mandibular or maxillary growth or the development of the normal dental arch, i.e. crossbite, reverse overjet and increased overjet with myofunctional disorders, should be treated at an early stage.

Introduction

Treatment of dental crowding and malocclusions is normally initiated after referral of a child at the age of 10–12 years, i.e. during the second period of the mixed dentition when a canine erupts or an increase in overjet becomes noticeable to the patient and parents. Initiation of treatment at this time may be indicated in subjects with moderate crowding but without bite anomalies. However, patients with discrepancies in occlusion, impairment of voluntary movement, and abnormalities in tooth number require earlier intervention (Miotti, 1991). In these cases, early intervention performs a similar function to interceptive orthodontics by preventing progression to the full form of a given disorder and excluding factors interfering with the regular development of the dental arches.

The disadvantage of an early start is the long treatment period with diminishing compliance and uncertain growth prediction. On the other hand, age-related increases in the severity of crowding and in arch length discrepancies with incisor proclination in Class II malocclusions may justify early treatment (Anders *et al.*, 2000). Ingelsson-Dahlstrom and Hagberg (1994) carried out a longitudinal study in children aged between 7 and 14 years and recorded an increased severity of Class II malocclusions, more pronounced in mild than in severe cases compared with the baseline status. Crossbite is one form of malocclusion requiring early treatment. A posterior crossbite has increased more in industrialized countries than in developing countries and affects between 8 and 13 per cent of nursery school children (Yamasaki *et al.*, 1989; Kerosuo, 1990; Bergström *et al.*, 1998; Ghabrial *et al.*, 1998). Sonnesen *et al.* (2002) reported an asymmetric development of masticatory muscle function in children with unilateral crossbite.

A further reason for early treatment is the prevention of tooth trauma in patients with Class II malocclusions, with an increased overjet and upper incisor inclination (Harzer *et al.*, 1998).

For estimation of the need for early intervention, data on the incidence of malocclusions and their progression is required, together with information on the validity of treatment need (Foster, 1980). There are still insufficient reliable data on the negative functional and psychosocial effects of malocclusion to permit true scientific validation of different indices of orthodontic treatment need (Burden and Holmes, 1994).

The Index of Orthodontic Treatment Need (IOTN), with the Dental Health Component (DHC) and the Standard Component of Aesthetic Need (SCAN), is the most frequently used tool for measuring treatment need (Evans and Shaw, 1987; Brook and Shaw, 1989; Firestone *et al.*, 1993; Kisely *et al.*, 1997; Breistein and Burden, 1998). This index was developed on the basis of all currently available scientific data and concurs with a broad consensus of professional opinion in the UK where it was developed. In most cases the DHC is used to differentiate between 'need' and 'no need'. The SCAN alone is unsuitable for screening treatment need but is a stronger indicator of patient satisfaction (Crowther *et al.*, 1997). Apart from overall treatment need, characteristics of the IOTN comprise the hierarchy of single symptoms. The acronym 'MOCDO' (missing, overjet, crossbite, displacement, overbite) means that missing teeth and overjet, including reverse overjet, have the highest priority in the assessment of treatment need. The hierarchical scale was designed for the purpose of providing a guide for systematic examination, with the examiner recording and focusing the treatment activity to the higher evaluated anomaly in the case of two or more occlusal anomalies (Richmond *et al.*, 1994). In most studies the IOTN has been used in children in the late mixed or full permanent dentition. The measurement of orthodontic treatment need is thus not only a question of the severity of malocclusion traits but also of age, dentition period and growth acceleration. Different morphological and functional factors are involved in the early inhibition of growth and development. This must be taken into account when using the IOTN (Crowther *et al.*, 1997; Breistein and Burden, 1998; Mauck and Tränkmann, 1998; Tarvit and Freer, 1998). The aim of this study was to estimate the prevalence of malocclusions using the IOTN during the early mixed dentition period to provide basic values for the benefit of early orthodontic intervention and to review the hierarchical system against this background.

Materials and methods

The overall investigation was planned as a cross-sectional study with continuation as a longitudinal investigation. In 1996 and 1997 a sample comprising 8768 Dresden schoolchildren was drawn from the 65 000 in the city of Dresden (population: 470 000). From this population, 1975 children (970 boys and 1005 girls) aged between 6 and 8 years 11 months formed the sample for the investigation of treatment need in the early mixed dentition (Table 1).

Fifty features were evaluated together with a profile photograph and a close-up of the mouth.

The findings served to determine orthodontic treatment need with reference to the IOTN. This consists of the DHC and the SCAN (Evans and Shaw, 1987; Brook and Shaw, 1989) and is an internationally acknowledged scoring system for treatment need as perceived by the professional and the patient (Lindauer *et al.*, 1998). Apart from morphological discrepancies, this index also registers functional disorders and gives a systematic order for a hierarchical scale. Considerations as to no treatment need, borderline need, or great need are based on five-grade (DHC) and 10-grade scales (SCAN) (Figures 1 and 2).

Table 1 Distribution of the 1975 subjects related to chronological age between 6 and 8 years.

	6 years	7 years	8 years	Total	Per cent
Female	133	414	458	1005	50.9
Male	128	403	439	970	49.1

As the time factor may be a priority when considering treatment need in terms of safeguarding normal development of the dental arches, an urgent need for intervention was specified for certain anomalies such as reverse overjet or crossbite as early as 6–8 years of age, and the children's parents were informed accordingly. Richmond *et al.* (1994) state that displacement of contact points should not be measured between the primary and permanent teeth. Therefore, crowding was measured as the tooth width to arch length discrepancy and was recorded as anterior and posterior crowding.

Calibrated data recording is important for the application of the IOTN and for its validity and reproducibility. The DHC data were recorded simultaneously at the schools by two authors who had undergone extensive instruction. To test intra-examiner reproducibility, 20 children were re-examined 4 weeks after their initial examination (kappa 0.78). The SCAN was evaluated by one calibrated postgraduate student (ET), with a kappa value of 0.81 being recorded. Kappa values above 0.6 indicate substantial agreement (Landis and Koch, 1977).

Results

Differentiation in the age group from 6 to 8 years was based on the allocation of developmental stages, because the start of treatment was to focus on the dentition rather than on age (Figure 3). In the study group as a whole, the first period of the mixed dentition with eruption of first molars and incisors was dominant, although with a wide inter-individual range.

The prevalence of the malocclusions are listed in Tables 2–5. An open bite with ranges from 1 to 12 mm was recorded in 17.7 per cent of the children. Deep bite with and without gingival contact was registered in 46.2 per cent (Table 2). Crossbite was found more frequently on the right than the left side, but occurred on both sides in 7.7 per cent. Scissors bite was rare, being recorded

GRADE 1 (None)
1. Extremely minor malocclusions including contact point displacements less than 1 mm.

GRADE 2 (Little)
2.a Increased overjet greater than 3.5 mm but less than or equal to 6 mm with competent lips.
2.b Reverse overjet greater than 0 mm but less than or equal to 1 mm.
2.c Anterior or posterior crossbite with less than or equal to 1 mm discrepancy between retruded contact position and intercuspal position.
2.d Contact point displacements greater than 1 mm but less than or equal to 2 mm.
2.e Anterior or posterior open bite greater than 1 mm but less than or equal to 2 mm.
2.f Increased overbite greater than or equal to 3.5 mm without gingival contact,
2.g Pre-normal or post-normal occlusions with no other anomalies (includes up to half a unit discrepancy).

GRADE 3 (Borderline need)
3.a Increased overjet greater than 3.5 mm but less than or equal to 6 mm with incompetent lips.
3.b Reverse overjet greater than 1 mm but less than or equal to 3.5 mm.
3.c Anterior or posterior crossbites with greater than 1 mm but less than or equal to 2 mm discrepancy between retruded contact position and intercuspal position.
3.d Contact point displacements greater than 2 mm but less than or equal to 4 mm.
3.e Lateral or anterior open bite greater than 2 mm but less than or equal to 4 mm.
3.f Deep overbite complete on gingival or palatal tissues but no trauma.

GRADE 4 (Need treatment)
4.h Less extensive hypodontia requiring pre-restorative orthodontics or orthodontic space closure to obviate the need for a prosthesis.
4.a Increased overjet greater than 6 mm but less than or equal to 9 mm.
4.b Reverse overjet greater than 3.5 mm with no masticatory or speech difficulties.
4.m Reverse overjet greater than 1 mm but less than 3.5 mm with recorded masticatory and speech difficulties.
4.c Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact position and intercuspal position.
4.1 Posterior lingual crossbite with no functional occlusal contact in one or both buccal segments.
4.d Severe contact point displacements greater than 4 mm.
4.e Extreme lateral or anterior open bites greater than 4 mm.
4.f Increased and complete overbite with gingival or palatal trauma.
4.t Partially erupted teeth, tipped and impacted against adjacent teeth.
4.x Presence of supernumerary teeth.

GRADE 5 (Need treatment)
5 i Impeded eruption of teeth (except for third molars) due to crowding, displacement, the presence of supernumerary teeth, retained primary teeth and any pathological cause.
5.h Extensive hypodontia with restorative implications (more than 1 tooth missing in any quadrant) requiring pre-restorative orthodontics.
5.a Increased overjet greater than 9 mm.
5.m Reverse overjet greater than 3.5 mm with reported masticatory and speech difficulties.
5.p Defects of cleft lip and palate and other craniofacial anomalies,
5.s Submerged deciduous teeth.

Figure 1 Index of Orthodontic Treatment Need: morphological and functional symptoms in the five grades (1 and 2 = no need; 3 = borderline need; 4 and 5 = great/very great need) of the Dental Health Component.

in only 0.5 per cent of the children (Table 3). A Class III malocclusion (skeletal) with reverse overjet was found in 3.2 per cent (Table 4). Overjets ranging from 0.5 to 14.0 mm were recorded, with an overjet greater than 3.5 mm (Class II division 1) being registered in 31.4 per cent of cases (Table 4). Anterior crowding greater than 3 mm was recorded in the mandible in 14.3 per cent of subjects and in the maxilla in 12 per cent (Table 5, Figure 4).

In this early mixed dentition group (first period), the IOTN revealed an urgent treatment need in 26.2 per cent using the DHC (greater than or equal to grade 4) and in 21.5 per cent with the SCAN (greater than or equal to grade 8) (Figures 5 and 6). When the borderline cases were taken into consideration, the treatment need increased to 51.7 per cent with the DHC and to 66 per cent with the SCAN. Between the ages of 9 and 11 years, the treatment need according to the IOTN–DHC and

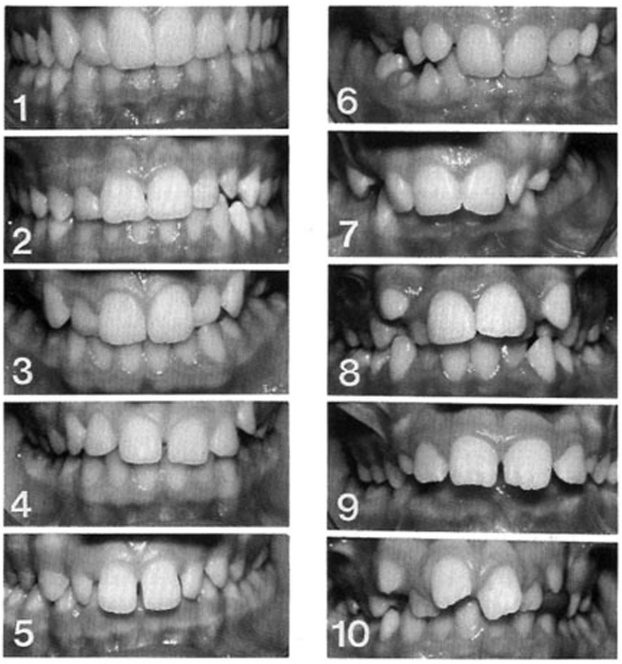

Figure 2 Index of Orthodontic Treatment Need: Standard Component of Aesthetic Need with 10 grades (1–4 = no need; 5–7 = borderline need; 8–10 = great need).

including grade 3 (moderate or borderline cases) was 45 per cent. When grade 3 was disregarded, the treatment need was reduced by approximately 20 per cent (Figure 7).

Discussion

The development of the dentition in children aged between 6 and 8 years is characterized by a wide range of variations. Figure 3 shows that this variability concerned both the eruption of teeth and their alignment. Obviously this was paralleled by an age-related variation in the development of disorders. The establishment of a relationship between the registered onset of orthodontic treatment and disorders inhibiting growth of the alveolar bone and development of the dentition reflects, on the one hand, the lack of validity of the indices used to estimate treatment need but, on the other hand, shows that most orthodontists fail to take account of the potential progression of malocclusions at this early stage (Figure 4). The lag effect is also reflected in the proportion of children affected by crossbite, mandibular prognathism and the presence of asymmetries with a functional shift up to the age of 9 years.

At this point the hierarchical system of the IOTN needs to be taken into consideration. The 'missing teeth' priority should be focused on early diagnosis for guidance of the dentition in cases of orthodontic space closure. However, hypodontia cannot be investigated without radiography. The high prevalence of overjet, including reverse overjet, in this age group suggests that trauma prevention in severe cases should be started at an early stage. Kluemperer *et al.* (2000) showed that an early treatment start may be effective and desirable in specific situations, but should be decided on a case-by-case basis, bearing in mind that an open bite and increased overjet are known to diminish with the elimination of thumb sucking and other habits. This reduction through the elimination of habits, permanent mouth breathing and other environmental factors is not uniform. On the other hand, the same applies to increased severity of the malocclusion. Crowther *et al.* (1997) found that progression was less pronounced in younger children with large overjets than in those with moderate overjets. Early treatment should depend on the severity of the malocclusion and its impact on the neuromuscular system, i.e. disturbed lip function and permanent mouth breathing. In the present study, 6.3 per cent of the children had an overjet greater than 6.1 mm, resulting in these dysfunctions. In cases of

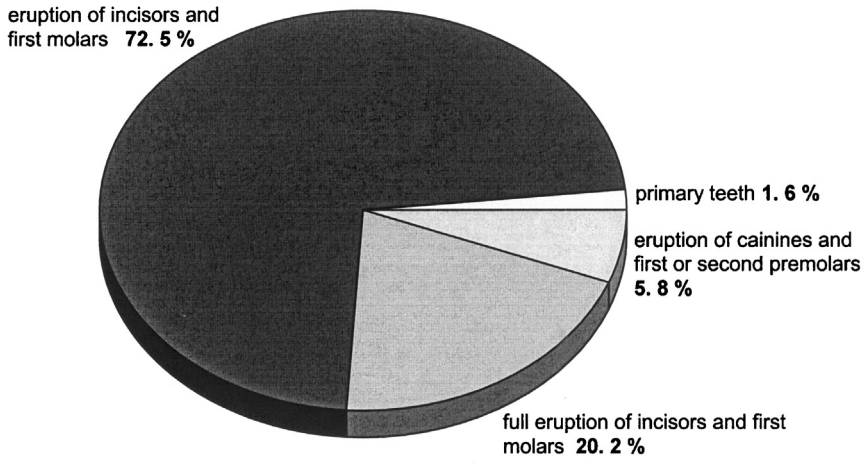

Figure 3 Distribution of developmental stages in 1975 schoolchildren aged between 6 and 8 years.

Table 2 Prevalence of anterior open bite and deep overbite in 1975 children aged between 6 and 8 years.

	Frequency (*n*)	Per cent
Anterior open bite		
None	1626	82.3
1–3 mm	294	14.9
4–6 mm	47	2.4
Greater than 6 mm	8	0.4
Total	1975	100
Overbite		
Less than 3.5 mm	1061	53.8
Increased overbite greater than or equal to 3.5 mm without gingival contact	313	15.8
Deep overbite complete on gingival or palatal tissues but not trauma	315	15.9
Increased and complete overbite with gingival or palatal trauma	286	14.5
Total	1975	100

Table 3 Prevalence of crossbite and scissors bite in 1975 schoolchildren aged between 6 and 8 years.

	Frequency (*n*)	Per cent
No findings		
Right	1877	95.0
Left	1912	96.8
Crossbite		
Right	92	4.7
Left	60	3.0
Scissors bite		
Right	6	0.3
Left	3	0.2

Table 4 Prevalence of positive and negative overjet in 1975 schoolchildren aged between 6 and 8 years.

	Frequency	Per cent
Reverse overjet (Class III)		
Less than –1 mm	10	0.5
Less than 0 mm but greater than or equal to –1 mm	17	0.9
0 mm	36	1.8
Positive overjet (Class II)		
Greater than 0 mm but less than or equal to 3.5 mm	1189	60.2
Greater than 3.5 mm but less than or equal to 6 mm	500	25.3
Greater than 6 mm but less than or equal to 9 mm	99	5.0
Greater than 9 mm	21	1.1
Missing*	103	5.2

*No measurement because incisors unerupted.

reverse overjet there is no doubt that early treatment prevents asymmetric alveolar bone growth and disturbances in the maxillary dentition (Kluemperer *et al.*, 2000). The early treatment of Class III malocclusions

Table 5 Distribution of maxillary and mandibular crowding in 1975 schoolchildren aged between 6 and 8 years.

	Upper anterior crowding	Lower anterior crowding
No crowding	1354 (68.6%)	1045 (52.9%)
Mild (0–2 mm)	384 (19.4%)	648 (32.8%)
Moderate (3–4 mm)	201 (10.2%)	251 (12.7%)
Severe (greater than 4 mm)	36 (1.8%)	31 (1.6%)

produces more favourable changes in older children, and palatal expansion in cases of crossbite appears to be most effective and stable if initiated before the start of ossification of the midpalatal suture (Enlow, 1966). The timing of expansion should therefore focus on the patient's specific needs. Nevertheless, the functional shift resulting from crossbite should be corrected at an early stage in the interests of reducing or even preventing asymmetric growth of the mandible and the maxilla (Thilander *et al.*, 2001). Sonnesen *et al.* (2002) pointed out that crossbite occlusion supports the development of an asymmetric bite force.

There is a general consensus that treatment of crowding should start in the permanent dentition. Gianelly (2002) suggests intervention while the second primary molars are still in function, in the interests of preventing arch length discrepancies. For application of the IOTN to the mixed dentition, the results of the present study indicate that contact point deviation between teeth of the primary and permanent dentition should not be measured, i.e. this calculation should be deleted in the application of the IOTN to the early mixed dentition. The prevalence of deep overbite in the investigated group was very high (46.2 per cent greater than 3.5 mm). However, there was a difference in the combinations of malocclusions. In the age range between 6 and 8 years, deep overbite, increased overjet and open bite were predominant, whereas crowding was the main factor in malocclusions in the permanent dentition. The main reason for this change was the more pronounced mandibular growth with reduced overjet and overbite. In a number of subjects, however, the severity of Class II division 1 and Class II division 2 malocclusions increased. A combination of an overjet greater than 9 mm and deep overbite with gingival trauma should be treated early in order to prevent tooth fracture and to normalize lip function. Myofunctional training to improve lip function and permanent nose breathing are the treatment goals of an open bite in this age group.

The present investigation showed a great and very great treatment need (DHC 4 and 5) in 26.2 per cent of children during the mixed dentition period, similar to that found in investigations in older age groups (Bishara *et al.*, 1998; Proffit *et al.*, 1998; Tarvit and Freer, 1998; Chi *et al.*, 2000).

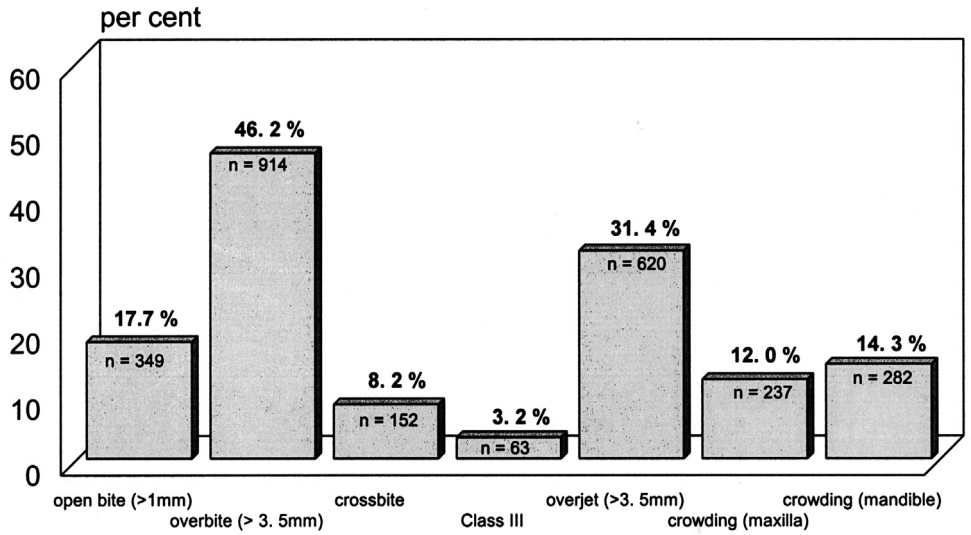

Figure 4 Distribution of malocclusion and occlusal anomalies in 1975 schoolchildren aged between 6 and 8 years.

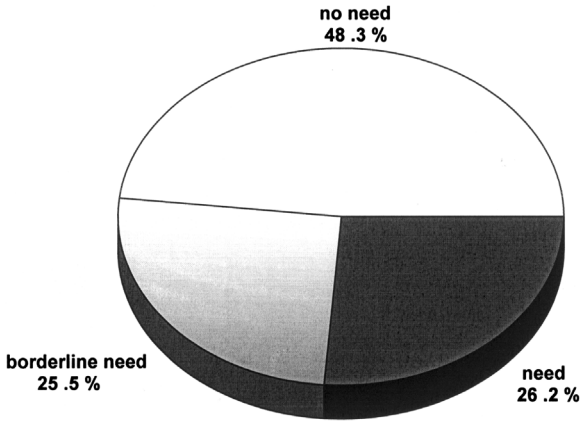

Figure 5 Orthodontic treatment need in 1975 schoolchildren, evaluated with the Dental Health Component of the Index of Orthodontic Treatment Need.

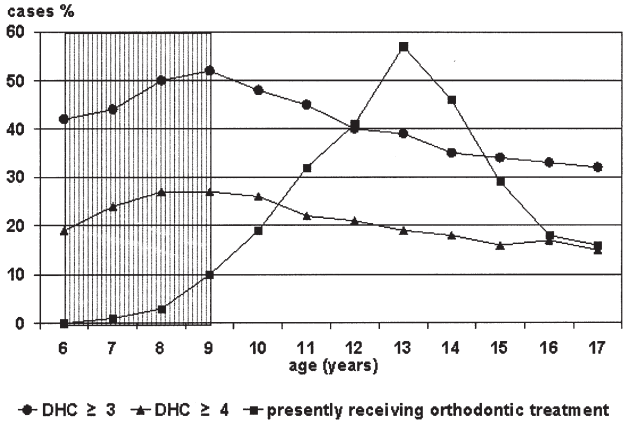

Figure 7 Orthodontic treatment need and ongoing orthodontic treatment in 8768 schoolchildren aged between 6 and 17 years (hatched area = 1975 schoolchildren aged between 6 and 8 years).

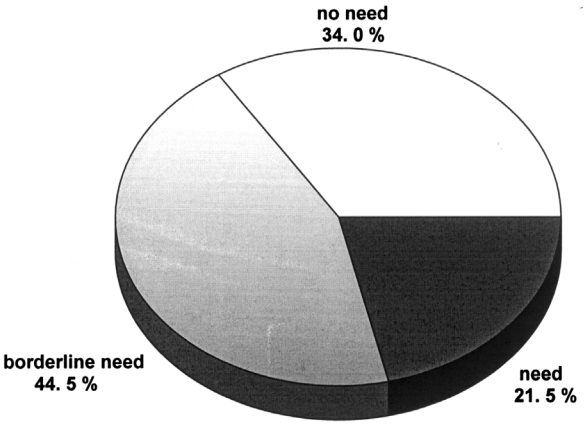

Figure 6 Orthodontic treatment need in 1975 schoolchildren, evaluated with the Standard Component of Aesthetic Need of the Index of Orthodontic Treatment Need.

Although the IOTN measures the incidence of treatment need and does not specify the stage at which treatment should be carried out, the prevention of progression is a justifiable reason for early treatment in these cases (White, 1998; Pangrazio-Kulbersh *et al.*, 1999). Kluemperer *et al.* (2000) concluded that early orthodontic treatment of these malocclusions may prevent asymmetric alveolar bone growth and disturbances in the permanent dentition. A second advantage is the inhibition of progression and severity of the malocclusion (Bishara *et al.*, 1998). Crossbite and reverse overjet do not diminish with age. The prevalence in the permanent dentition reflects progression in severity and dysfunction, so that early intervention aimed at preventing deterioration and at stimulating well-balanced growth and occlusal development is indicated. In the overall sample of 8768 schoolchildren aged between 6 and 17 years, the

frequency of orthodontic treatment coincided with the estimated treatment need as determined by the IOTN, but orthodontic intervention in the cases described above was initiated too late. Bäßler-Zeltmann *et al.* (1998) found an urgent treatment need in 32 per cent of 9-year-old children.

With reference to the validity of the IOTN in different dentition periods, Johnson *et al.* (2000) suggested that symptoms in the mixed dentition might be slightly overestimated between the ages of 10 and 13 years. Nevertheless, this minor discrepancy is no reason to delay the start of treatment. If symptoms such as overjet, overbite and crowding are excluded, the estimated treatment need in children aged between 6 and 8 years is about 25 per cent.

A previous study demonstrated that, for the estimation of treatment need, the DHC gave more stable age-related results than the SCAN (Tarvit and Freer, 1998).

Conclusions

1. Between the ages of 6 and 8 years the prevalence of malocclusions is similar to that in adults, but the distribution of specific symptoms is different.
2. Deep overbite and increased overjet show the highest frequency, but there is a decline in line with growth and development.
3. The IOTN data give support for early treatment need. Reverse overjet, crossbite and severe cases of overbite and overjet should be treated at an early stage. These priorities conform with the hierarchical system of the IOTN.

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