Occlusal status in orthodontically treated and untreated adolescents

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In order to evaluate the outcome of orthodontic care, all available 16-year-old adolescents (n = 138) living within the catchment area of one Finnish health center were invited for a clinical examination. A total of 126 adolescents participated, corresponding to 79% of the whole age cohort. Of these, 47% had been treated orthodontically, 2% were still wearing appliances, and 51% were untreated. In 80% of cases, a non-extraction treatment was carried out. All occlusions were evaluated using a recently developed occlusal morphology and function index (OMFI) based on assessment of 6 morphological and 4 functional traits which are classified applying an acceptable–non-acceptable dichotomy. The occlusal status in untreated individuals was used as a second reference in comparisons between the treated and untreated occlusions. The morphological criteria for an acceptable occlusion were met by 42% of the participants and the functional criteria by 64%. Although the treated occlusions failed to meet the criteria of morphological acceptability more often than the untreated ones (73% vs 40%), the proportions of non-acceptable occlusions were fairly high among untreated occlusions. The main reasons for non-acceptability were the failure of the canine relationship, overbite, and protrusion movement to fulfill the criteria of acceptability. Only 19% of the adolescents had occlusions classified as acceptable, both morphologically and functionally. In the evaluated health center, the allocation of resources resulted in a high coverage of orthodontic care. However, our results indicate that the general occlusal status in the examined age cohort did not reach an optimal level. □ *Orthodontics; outcome and process assessment; reference standards*

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In recent years, increasing interest has been focused on the quality of orthodontic services. Both professional and patient-centered aspects have been emphasized (1–3). Practical guidelines for the achievement of high quality have been given through clinical audit and quality manuals (4–6). In addition, a number of standards against which the quality could be assessed have been developed (7–10). Of these standards, the Peer Assessment Rating Index (PAR, 11) is widely used for a detailed analysis of occlusal morphology. Assessments are made from study casts taken before and after treatment, and the health gain is expressed as a change in PAR scores. Aesthetic aspects have been incorporated into the Index of Orthodontic Treatment Need (IOTN, 12) and the Index of Complexity, Outcome, and Need (ICON, 10), both of which can be used clinically or with study casts. Recently, a new clinical method assessing both the morphological and functional status of occlusion has been developed (13). With this method, 6 morphological and 4 functional characteristics are evaluated, and the occlusions are classified applying an acceptable–non-acceptable dichotomy; the cut-offs define a general standard for a morphologically and functionally acceptable occlusion. This standard is intended for use as a reference in the clinical evaluation of young adults at population level.

For various reasons, not all treatments are completed successfully (14). The outcome is influenced by many factors, including types of appliances (15–17), the provider's orthodontic qualification (18–20) and treatment compliance (21). In health-care systems that cater for whole age cohorts, the treatment goals should be set in terms of the availability of resources, the skills of the clinicians, and the demands of the customers. As suggested by Moyers (1), further development of quality standards should be based on analyses that cover all types of malocclusions treated by orthodontists in their daily practice.

In Finland, the health-care system covers whole age cohorts and free orthodontic care is provided on a population basis up to the age of 18 years. Previously, the Finnish governmental authorities guided the provision of orthodontic treatment through recommendations (22). Prospective patients for subsidized orthodontic care were selected using a 10-grade scale, which is a modification of Grainger's Treatment Priority Index (23). On the 10-grade scale, occlusal deviations are scored according to their severity, with the highest scores being given to gross craniofacial anomalies. Moreover, treatment of functionally disturbing malocclusions is emphasized over those causing mainly aesthetic impairment. Rather than giving unambiguous cut-offs, the 10-grade scale provides a range describing the severity of a given malocclusion. Thus, assessments using this scale inherently include a subjective component. Since a reform in the government subsidy allocation in the early 1990s, the responsibility for organizing care has been borne locally by municipal

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health centers. Because no general guidelines or obligations exist, orthodontic care is organized according to local resources and interests. However, over 50% of the health centers still apply the 10-grade scale, while others use their own criteria (24). The threshold for subsidized care varies from 2 to 8 scores.

The present study analyzed the morphological and functional status of occlusion in one age cohort of adolescents in a rural Finnish health center. The provision of care had been ample; all subjects with professionally assessed treatment needs as well as those expressing a subjective need had received treatment. The individuals for orthodontic care had been selected by general dental practitioners during routine oral examinations; a severity score exceeding 5 entitling the subject to free orthodontic care. All treatments had been carried out during the period 1990–2001 by one experienced general practitioner under the supervision of one consulting orthodontist. Twice a year, the orthodontist had examined all prospective patients (except some 'routine cases', e.g. crossbites) and had drawn up the treatment plans. The aim was to evaluate the outcome of the orthodontic care delivered by a rural health center.

Subjects and methods

According to the population register, in the catchment area of the evaluated health center there were 159 16-year-old adolescents (i.e. all those born in 1985). Because of student exchange, high-school studies, or a severe illness, 21 of them were temporarily elsewhere and could not be reached. All the remaining 138 individuals were invited for a clinical examination. A total of 126 adolescents participated, representing 79% of the whole age cohort. After obtaining informed consent from all participants, they were examined by the first author (A-L S-O). The examiner did not know which adolescents had been orthodontically treated.

All occlusions were assessed applying a recently developed clinical method, the occlusal morphology and function index (OMFI). The morphological and functional criteria used, as well as their demarcation lines for acceptability, were selected using a modified Delphi method, and they reflect the current opinion of Finnish orthodontists on the minimum requirements for acceptable mature occlusion (13). The morphological assessments consisted of overjet, overbite, canine relationship, crossbite, scissors bite and difference between the facial midline and the midline of the upper dental arch. Functional assessments comprised evaluations of discrepancy between the centric relation (CR) and the intercuspal position (ICP), working- and non-working side contacts, and protrusion contacts. All numerical measurements were taken to the nearest millimeter. The assessments and the cut-offs for acceptability—non-acceptability are given in Table 1.

After the examination, the orthodontic treatment history of the participants was gathered from their documents. In the following analyses, the occlusal status

Table 1. Morphological and functional criteria used in the analysis of acceptability of occlusion in a cohort of 16-year-olds

Morphological criteria	Cut-off for acceptability	Conventions
Coincidence of the facial midline and the midline of the upper dental arch	Max 3 mm deviation accepted	
Overjet	0–5 mm accepted	Measured from the most labial central incisor
Overbite	Occlusal contact incisal to the gingival third of the palatal surface of upper incisors accepted. Open bite only accepted in laterals	
Canine relationship right/left	Normal ±2 mm accepted. Postnormal relationship accepted in the case of missing upper incisors	
Crossbite, anterior	Not accepted	
Crossbite, posterior	Not accepted in canines. Accepted in one tooth pair/side without interference or slide between CR*-ICP†	
Scissors bite	Not accepted	
Functional criteria		
Discrepancy between CR* and ICP†	Max 2 mm accepted sagittally and vertically. No slide accepted laterally	Measured from pencil markings in one pair of premolars and incisors
Guided lateral excursions	Accepted: canine protection/group contact including canine/contacts in incisors, premolars and molars	Guided lateral gliding until upper and lower canines at same transversal level
Non-working side contacts	Accepted without disclusion of working side contacts	
Protrusion contacts	Anterior guidance accepted	

* Centric relation; † intercuspal position.

in untreated adolescents was used as a second reference representing the general occlusal health level in the target population.

Statistical analyses

All subjects were classified according to their previous orthodontic history. Differences between the treated and untreated occlusions, as well as associations between patient compliance and type of appliances were evaluated using the chi-square test. The adolescents still wearing appliances and those who had failed to complete the treatment were excluded from first-mentioned analysis.

Results

Five subjects were excluded from the analyses because their documents were incomplete. Of the final 121 participants, 47% had received orthodontic treatment, 2% were still wearing appliances, and 51% were untreated. Orthodontic treatment had been started at between 5 and 14 years of age with a mean of 9.7 years. The mean duration of the active treatment was 23.9 months (range 3–56 months), and in 80% of the subjects, a non-extraction treatment had been carried out. Cervical headgear had been used in 42%, an upper or lower fixed appliance in 41%, a quad helix in 27%, a passive transpalatal or lingual arch without other appliances in 19%, a removable appliance in 8%, and cross-elastics in 8% of the treatments. In 7% of cases, fixed appliances had been used in both jaws. Eleven percent of all treatments had been discontinued because of lack of cooperation; in addition, less serious cooperational problems had been documented in 18% of cases. No statistically significant association was found between any particular type of appliance and prematurely discontinued treatment or poor cooperation.

The morphological criteria for an acceptable occlusion were met by 42% of the participants. The main reasons for the occlusions to be classified as non-acceptable were a postnormal canine relationship and excessive overbite. The treated occlusions failed to meet the criteria of morphological acceptability more often than the untreated occlusions (73% vs 40%). For example, 6 cases of non-acceptable crossbite were found among the treated occlusions. In the untreated group, 2 cases of crossbite were recorded, but in each case only a single tooth per side was involved, and no interferences due to the crossbite were detected.

A functionally acceptable occlusion was found in 64% of the sample. The most common functional reason for an occlusion to be categorized as non-acceptable was the lack of anterior guidance during protrusion. The criteria of functional acceptability were fulfilled equally by the treated and untreated occlusions, 63% and 61%, respectively. When the morphological and functional criteria were considered simultaneously, only 19% of the sample had an acceptable occlusion. The results of the clinical examination, performed using the OMFI, are given in Table 2.

Discussion

As in other samples studied by our group (13), the main reasons for occlusions being classified as morphologically non-acceptable were failure to meet the criteria set for canine relationship or overbite. The prevalence of increased overjet, open bite, crossbite, scissors bite, and

Table 2. Distribution of occlusal traits rated as non-acceptable with the OMFI* in the age cohort of 16-year-olds

	Distribution (%)			
	All participants	Treated	Untreated	
Morphology	(n = 121)	(n = 51)	(n = 62)	
A non-Class I	34	39	26	
Unilateral	23	27	18	
Bilateral	11	12	8	
Excess overbite	32	37	24	
Open bite	7	8	5	
Excess overjet	6	6	5	
Crossbite	5	12	0	(P = 0.009)
Scissors bite	3	4	3	
Midline deviation	0	0	0	
Function				
Protrusion interference†	32	31	37	
Failure in laterotrusion	12	14	10	
Mediotrusion interference†	4	4	3	
Discrepancy between CR‡ – ICP§	2	4	2	

* Occlusal morphology and function index.
† As defined by Heikinheimo et al., 1990.
‡ Centric relation.
§ Intercuspal position.

mediotrusion interferences was in accordance with earlier findings in Scandinavia and Great Britain (25–31). However, the frequency of lateral discrepancy between the CR and the ICP turned out to be considerably lower than reported previously (26, 28–29, 32–33). On the other hand, the prevalence of protrusion interferences, i.e. contacts of posterior teeth during protrusion, was higher than in most earlier studies (30, 33–35). Only Sadowsky & Polson (36) have reported a higher frequency among patients examined 10 years after the completion of orthodontic treatment.

The orthodontic treatment rate in the present health center was 49%, which exceeds the average level in Finland (29, 37–39). Despite the high percentage of children who received treatment, only 19% of all the participants fulfilled the morphological and functional criteria for an acceptable occlusion. Although morphological deficiencies appeared more often among the treated adolescents, the percentages of morphologically and functionally non-acceptable occlusions were also high among the untreated adolescents. This is in contrast to the results of Espeland & Stenvik (40), who found that increasing orthodontic treatment rates were followed by a decrease in the normative treatment need, i.e. in the number of deviating occlusal traits, among untreated individuals. On the other hand, the expected outcome should be in line with the agreed treatment objectives prescribed in the selection criteria. According to the 10-grade scale, for example, the severity of a distal occlusion without other anomalies varies from 3 to 5, not entitling the subject to free orthodontic treatment. It is thus possible that the results of the present study reflect a disparity between the mainly morphological selection criteria and the requirements inbuilt in the OMFI.

Alternatively, the seemingly low treatment standard might be accounted for by the chosen demarcation lines for acceptability. However, an overjet of 3.5 to 6 mm with incompetent lips indicates a moderate treatment need according to the IOTN (12), while in the study by Beyer & Lindauer (41), a midline deviation exceeding 2 mm was found to be unacceptable. Although the Delphi method used in the development of the OMFI was complemented by clinical data (13), it is likely that some of the chosen cut-offs may in future need further adjustment. The preliminary results from this first population-based study may not allow generalizations; instead, they call for additional data from various health centers to obtain a wider perspective on the feasibility of the selected values.

However, the low number of acceptable occlusions raises questions about the use of the available resources. In Finland, a full-time orthodontist is employed only in every 5th health center, mainly in urban areas in the southern part of the country (24). Other health centers acquire orthodontic expertise through consultation contracts, with most orthodontic treatments being provided by general practitioners under the supervision of a consulting orthodontist. Because of the uneven distribution of specialists and lack of general guidelines for organizing care, there is wide regional variation in the provision of orthodontic treatment. For example, the use of consultant services varies from once a week to once a year, leading to differences in clinical practice. The optimal ratio of 1 orthodontist/4000 seven to 16-year-olds (42) is only achieved in 1 of the 11 Finnish provinces. Over the period 2002–2010, an increase of 10 specialization posts would be needed to keep the number of practicing orthodontists at the present level of 140 orthodontists (43). According to the estimates of the health service system, achieving an optimal orthodontist to patient ratio would require an additional 80 orthodontists.

In Norway, where orthodontic treatment is provided mainly by orthodontists, the treatment standard has been reported to be high (44). When the specialist manpower is limited, treatment in Scandinavia is usually carried out by non-specialists under the supervision of orthodontists. The standard of supervised treatment, however, has been found to be lower than that achieved by specialists (45–46). The resources used in the supervision seem to be decisive: with sufficient supervision, the treatment standard achieved by non-specialists in the treatment of less-demanding cases was high, while insufficient guidance resulted in a less favorable treatment outcome (18).

In the evaluated health center, the 2 consultation visits per year were found to be sufficient. The orthodontist examined most patients only once, at the start of treatment, and did not participate in the treatment procedures. Some 'routine cases' had been treated by the general practitioner alone without consulting the orthodontist. A more optimal use of the available manpower might have been achieved if the orthodontist could have carried out the treatment of complex cases. A more systematic evaluation of the less demanding cases could have led to changes in the treatment plans or to discontinuation of treatments with poor cooperation. Further, it might have been appropriate to restrict the number of patients, because the caseload has an adverse effect on treatment outcome (5). Bergström & Halling (46) found that the outcome in the treatment of cases with little need was questionable, and they suggested that low treatment priority should be given to minor malocclusions. Because even a minor deviation may have wide psychosocial implications (47), the final decisions should always be made individually, with the emphasis on both subjective and objective indications for treatment (40, 48).

There are findings suggesting that the results obtained with two-arch fixed appliances are better than those with other appliances (15–17). As only 7% of the treated individuals wore dual arch fixed appliances, the partial results achieved in this study may, to some extent, be accounted for by the predominance of headgears, active palatal bars (quad helixes), and other similar appliances. On the other hand, the choice of appliance reflects the agreed treatment goals. In a recent article, Bergström et al. (49) suggested that, as a result of different values, individuals in rural areas put less emphasis on dental appearance than their urban counterparts. It is therefore

possible that in some cases the treatment goal has been partial, for example, elimination of crossbite only. However, the use of simple appliances may also reflect the caseload or the preferences of the clinician.

Although the discontinuation rate in the evaluated age cohort was lower than reported recently (19, 21, 50–54), cooperational problems were common among the adolescents who completed the treatment. Several studies have indicated that cooperation often starts to decrease once the patient becomes satisfied with the occlusion (50, 52, 55). According to Bergström et al. (49), small deviations are more likely to be accepted in rural areas, where discontinuation of treatment also occurs more frequently.

Conclusions

In the evaluated health center, a high proportion of the 16-year-old cohort had received orthodontic treatment. However, morphological and functional deficiencies were common among both treated and untreated individuals. Although the results from one health center may not allow generalization, we suggest that a further specification of the treatment objectives at population level, as well as an evaluation of the treatment outcome, should be considered when planning and organizing the provision of future care.

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