Selection of criteria for assessment of occlusal acceptability

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Svedström-Oristo A-L, Pietilä T, Pietilä I, Helenius H, Alanen P, Varrela J. Selection of criteria for assessment of occlusal acceptability. Acta Odontol Scand 2002;60:160–166. Oslo. ISSN 0001-6357.

There is no general agreement on criteria that could be applied to distinguish between orthodontically acceptable and non-acceptable occlusions after the completion of dental development. The aim of the present study was to analyse morphological and functional features that could be used as an index to define an acceptable occlusion in young adults. Three expert panels representing specialists in orthodontics and stomatognathic physiology participated in a modified Delphi method. Each panel responded to a questionnaire concerning the usefulness of various occlusal features, and a set of characteristics was selected on the basis of the responses; thereafter, applicability of the chosen characteristics and their cut-offs for an acceptable–non-acceptable dichotomy was tested clinically. To obtain a consensus level of 100%, the last panel session was completed with a group discussion. Assessments made using the morphological criteria were compared with those made with the dental health component of the Index of Orthodontic Treatment Need. The selected morphological characteristics consisted of overjet, overbite, canine relationship, crossbite, scissors bite and midline deviation. The functional evaluation comprised assessments of discrepancy between the centric relation and the intercuspal position, working- and non-working-side contacts and protrusion contacts. The dental health component and our morphological criteria showed different sensitivity to contact point displacements, interdigitation in buccal segments and increased overbite. This study provides a set of morphological and functional indicators reflecting the current consensus opinion of Finnish professionals. Further studies are needed to analyse the reproducibility of assessment of the characteristics included. ☐ *Delphi technique; orthodontics; outcome and process assessment; reference standards*

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In evaluating the outcome of orthodontic treatment, researchers have frequently applied their own criteria or the indices designed for the assessment of orthodontic treatment need (1–5). Only 2 indices have been developed specifically for this purpose: the Peer Assessment Rating (PAR) (6) and the combined Index of Complexity, Outcome and Need (ICON) (7). Although the PAR and ICON comprise slightly dissimilar sets of criteria and use different weightings for the assessed characteristics, they share the common feature that both indices evaluate occlusion from a morphological point of view without considering functional aspects. This is at odds with the idea that function is an essential characteristic of occlusion, and with the recent suggestions that functional factors may affect occlusal morphology and should therefore be included when evaluating the acceptability of occlusion (8–10).

Although good occlusion can be described as a harmonious combination of morphological, functional and aesthetic features, there is no general agreement on the criteria that would define the acceptability or non-acceptability of occlusion in young adults. This study is part of the process aimed at developing a clinical method for assessing acceptability of occlusion that could be applied, e.g., in studies evaluating the effectiveness of orthodontic treatment at population level. Our aim is to include morphological, functional and aesthetic aspects in the new index, and to complement it with the patient's view on dental appearance and function. The purpose of the present study was to analyse the various morphological and functional features that could be used in the index to define an acceptable adult occlusion. The ultimate goal was to find a set of occlusal characteristics that would enable a comprehensive evaluation of the occlusion and, at the same time, be limited in number and feasible without extra equipment.

Methods

The Delphi process

A modified Delphi technique (11) with three expert panels was used to obtain consensus in selection of the included morphological and functional characteristics and their cut-offs for an acceptable–non-acceptable dichotomy. Each of the panels had 3 to 5 members representing orthodontists and specialists in stomatognathic physiology. All were experienced clinicians and, with one exception, also researchers.

A framework for the criteria was collected through reviewing the literature and using the results of our previous studies outlining Finnish professional opinion on the characteristics of an acceptable occlusion (9, 10). The

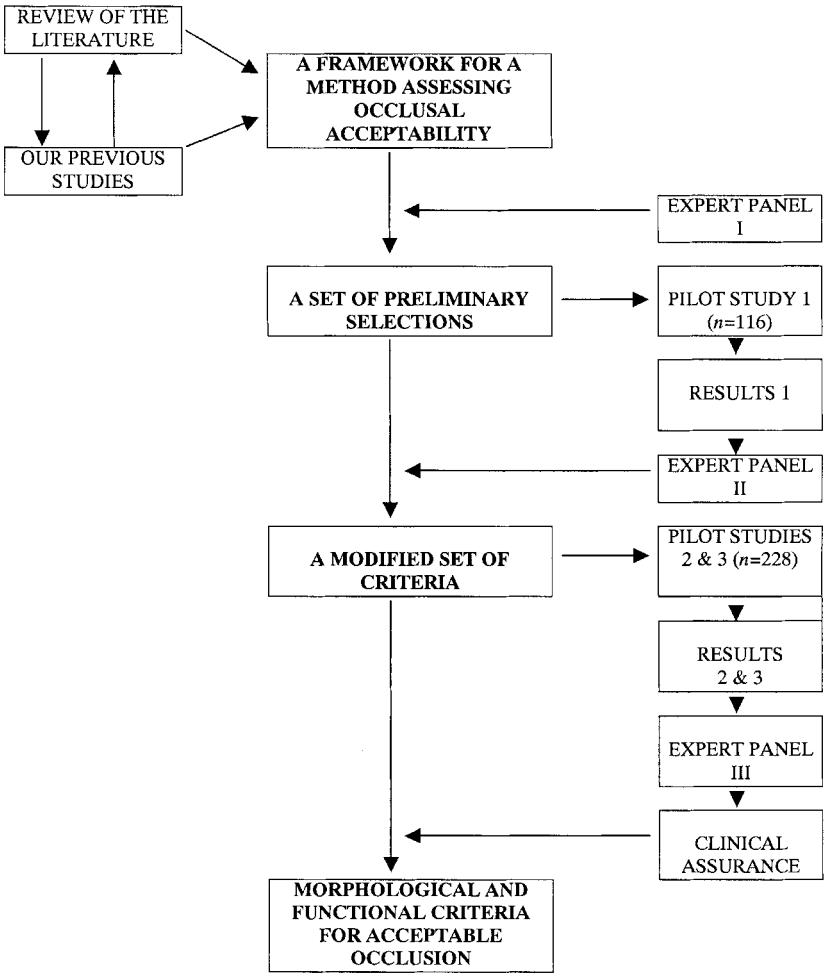

Fig. 1. The Delphi method in the selection of the morphological and functional criteria for an acceptable occlusion.

original framework was modified in accordance with the advice of the first expert panel and the selected criteria were tested in pilot study 1. In the Delphi process, a summary of the opinions of the former panel is fed to the next panel. In the present study, these results were complemented with clinical data and experiences from the respective pilot study. After considering the feedback, i.e. the selections of the first expert panel and the results of pilot study 1, the second expert panel modified the criteria. The new set was tested in pilot studies 2 and 3, and this modified set, together with the clinical results, was evaluated by the third expert panel. The number of iterations was not limited in advance and an agreement of 100% was determined as the goal for consensus. A detailed flow chart of the Delphi process is presented in Fig. 1.

Application of criteria

The evaluation of occlusal acceptability was based only on a clinical examination. No radiographs or dental casts were used. The assessments and their reference positions are given in Tables 1 and 2. In measurements of recurrent deviation, mouth opening was repeated at least 3 times. A toothpick between the lower central incisors was used as a recorder, and the amplitude of deviation was read from a transparent scale paper. Other numerical measurements were taken to the nearest millimetre with a ruler. In assessments of lip posture, the E-plane (12) was visualized by a second ruler. Contacts between upper and lower incisors were marked with articulating paper; if upper and lower incisors were not in contact, the vertical position of the contact point was estimated.

Comparison of the criteria

The assessments based on the morphological criteria were compared with the ratings acquired from the dental health component (DHC) of the Index of Orthodontic Treatment Need (IOTN) (13). All occlusions were assessed by one of two orthodontists, both of whom were calibrated in the use of IOTN.

Table 1. Selection of the morphological criteria. In the left-hand column, the preliminary set of criteria used in pilot study 1. The modified set of criteria (pilot studies 2 and 3) in the middle, and the final criteria in the right-hand column

Preliminary set of criteria	Modified set of criteria	Final criteria for acceptability
Profile		
Lower lip to E-plane (−3 mm – +1 mm accepted)		
Upper lip to E-plane (−5 mm – +1 mm accepted)		
Frontal plane	Frontal plane	Frontal plane
Discrepancy between facial and upper dental midlines (max. 3 mm accepted)	Discrepancy between facial and upper dental midlines (max. 3 mm accepted)	Discrepancy between facial and upper dental midlines (max. 3 mm accepted)
Centric relation	Centric relation	Intercuspal position
Overjet (0–6 mm accepted)	Overjet (0–6 mm accepted)	Overjet (0–5 mm accepted)
Overbite (in mm; accepted with incisal or middle third of lower anterior teeth overlapped by upper incisors; negative overbite, i.e. open bite only accepted in laterals)	Overbite (accepted if occlusal contact incisal to the gingival third of the palatal surface of upper incisors; open bite only accepted in laterals)	Overbite (accepted if occlusal contact incisal to the gingival third of the palatal surface of the upper incisors; open bite only accepted in laterals)
Canine relationship (Angle Class I accepted; Class II only if missing incisors)	Canine relationship right/left (Angle Class I accepted; Class II only if missing incisors)	Canine relationship right/left (Angle Class I ±2 mm accepted; Class II only if missing incisors)
Scissors bite (not accepted)	Scissors bite (not accepted)	Scissors bite (not accepted)
Crossbite (accepted in one tooth pair/side without interference or slide CR* – ICP§)	Crossbite (accepted in one tooth pair/side without interference or slide CR* – ICP§)	Crossbite (not accepted in incisors or canines; in premolars and molars accepted in one tooth pair/side without interference or slide CR* – ICP§)
Contact point displacements (accepted without a premature contact or interference).		

* Centric relation.
§ Intercuspal position.

Pilot studies

Three pilot studies carried out in 4 different municipalities in Finland had 3 main aims. First, they were intended to provide practical information on the selected criteria, e.g. how time-consuming the set was or whether there were any difficulties in the clinical management. Second, for each criterion, the usefulness of the chosen demarcation line for an acceptable–non-acceptable dichotomy was tested in these samples. Third, the pilot

Table 2. Selection of the functional criteria. In the left-hand column, the preliminary set of criteria used in pilot study 1. The modified criteria (pilot studies 2 and 3) in the middle, and the final criteria in the right-hand column

Preliminary set of criteria	Modified set of criteria	Final criteria for acceptability
Frontal plane	Frontal plane	Frontal plane
Lateral excursions (range of lateral movements ≥6 mm, their difference ≤4 mm)		
Maximal opening (≥40 mm accepted)		
Recurrent deviation in maximal opening (max. 4 mm accepted)	Recurrent deviation in maximal opening (max. 4 mm accepted)	
		Protrusion contacts (anterior guidance accepted)
Centric relation	Centric relation	Centric relation
Working-side contacts (canine protection/ group contact accepted)	Working-side contacts (canine protection/ group contact accepted)	Working-side contacts (accepted: canine protection/group contact including canine/contacts in incisors, premolars and molars)
		Non-working-side contacts (accepted without disclusion of working-side contacts)
Discrepancy between CR* and ICP§ (max. 2 mm accepted sagittally and vertically; no slide accepted laterally)	Discrepancy between CR* and ICP§ (max. 2 mm accepted sagittally and vertically; no slide accepted laterally	Discrepancy between CR* and ICP§) (max. 2 mm accepted sagittally and vertically; no slide accepted laterally)

* Centric relation.
§ Intercuspal position.

Table 3. Inter-examiner agreement between observers 1 and 2 in pilot study 1. The intraclass correlation was calculated for numerical variables and the weighted kappa values for categorical variables

	Good (>0.75)	Moderate (0.40–0.75)	Poor (<0.40)
Intraclass correlation	Maximal opening	Lateral excursions	Recurrent deviation
	Overjet	Slide CR*-ICP§ sagittally	Midline deviation
	Overbite		Difference right-left ltr¶
	Upper lip to E-plane		Slide CR*-ICP§, vertically
	Lower lip to E-plane		Slide CR*-ICP§, laterally
Weighted kappa	Scissors bite	Canine relationship	Open bite
	Overbite	Crossbite	Contact point displacement
		Lateral excursions	

* Centric relation.
§ Intercuspal position.
¶ Laterotrusion.

studies were used to analyse agreement between the selected morphological criteria and the ratings using the DHC.

A total of 116 adolescents (46 M and 70 F, age range 16–25 years) from 3 secondary schools and a vocational school participated in the first pilot study. All the adolescents were examined clinically by 2 orthodontists using the preliminary set of morphological and functional criteria (Tables 1 and 2). Before the study, they had together examined the occlusions of 5 adolescents, and, after each examination, all ambiguities were discussed. A third orthodontist assessed the occlusions using the DHC. Because of recording deficiencies, 5 subjects were excluded from the comparisons with the DHC.

In the second pilot study, the sample comprised 36 adolescents (15 M and 21 F, aged 17–18 years) who participated in a follow-up visit. At the age of 9 to 10 years, they had been treated with a quad-helix because of a posterior crossbite. At the age of 17–18 years, their occlusions were assessed by 2 orthodontists, one using the modified set of criteria (Tables 1 and 2) the other using the DHC.

For the third pilot study, we invited all adolescents born in 1981 (18-year-olds) and every second of those born in 1983 (16-year-olds) and living in one municipality. A total of 192 adolescents responded. Of these, 17 were excluded either because of an ongoing orthodontic treatment or because of insufficient data. Of the remaining 175 (62 M and 113 F), 82 had been treated orthodontically, while 93 were untreated. The sample was examined by 1 of the 2 calibrated orthodontists using the modified set of criteria and the DHC. The calibration included an independent examination of 20 dental casts. The sources of disagreement were discussed and the interpretations of overbite, open bite and canine classification were clarified. Clinically, the first 5 adolescents were assessed together. To ensure a high level of agreement throughout the study, 10% of the sample was examined by both orthodontists.

Statistical analysis

In pilot study 1, the inter-examiner agreement on categorical variables was calculated using the kappa statistic (14, 15) and the intraclass correlation was calculated for numerical measurements. To reduce the number of final assessments, the results of a cluster analysis for variables were used as an advisory tool (16, 17).

Results

Assessment of the preliminary selections (pilot study 1)

Clinical assessment of the characteristics of the preliminary set took about 10–12 min. The measurements of soft tissues proved difficult and time-consuming and interpretation of contact point displacements turned out to be ambiguous. Wide variation was found in the assessments of lip posture, maximal opening and the amplitude of lateral excursions. The intraclass correlations and weighted kappa values between the observers ranged from good to poor (Table 3).

Only in vertical slide between the centric relation (CR) and the intercuspal position (ICP), did the observers agree that all subjects met the criterion of acceptability. In all other characteristics, there was disagreement on the classification. In further analysis, however, a characteristic was considered acceptable if 1 of the 2 observers had classified it as acceptable. As a result, all subjects were classified as having an acceptable occlusion when midline deviation, crossbite, sagittal slide between the CR and the ICP, right laterotrusion (in millimetres) or difference between the amplitude of right and left laterotrusion was used as the criterion. According to other criteria, the subjects were classified into both groups, acceptable and non-acceptable. The similarity between the ratings with these criteria was analysed with the cluster analysis for variables. Classification by canine relationship differed from those by other criteria.

After excluding three morphological criteria (upper and lower lip posture and contact point displacements), 62 of the 111 adolescents were rated as having a morphologically acceptable occlusion. Assessed with the DHC of the IOTN, 31 of the 62 were in need of orthodontic

treatment, either because of contact point displacements (30 adolescents) or an increased overjet (one adolescent). Of the 49 adolescents categorized into the non-acceptable group with the preliminary set of criteria, 20 had no need of treatment according to the DHC. The reasons for their non-acceptability were a non-Class I canine relationship (20 cases), overbite (8 cases) and scissors bite (3 cases).

Assessment of the modified set of criteria (pilot studies 2 and 3)

The modified set of criteria proved quick (6–7 min) and easy to assess. In pilot study 2, all the chosen morphological criteria were met by 58% of the sample, and all the functional criteria by 64%. From the morphological point of view, the main reasons for non-acceptability were a non-Class I canine relationship uni- or bilaterally (28%) and deep bite (17%). Functionally, the recurrent deviation in maximal opening exceeded 4 mm in 22% of the adolescents. In 19% of the sample, the occlusions were found not to be acceptable because of a discrepancy between the CR and the ICP.

In pilot study 3, according to the morphological criteria, 43% of the treated and 41% of the untreated occlusions were rated as acceptable. The percentages for functionally acceptable occlusions were 71% and 76%, respectively. As in pilot study 2, the main morphological reason for non-acceptability was a non-Class I canine relationship (48% of the treated, 50% of the untreated) followed by deep bite (27% and 18%, respectively). From the functional point of view, unacceptable working-side contacts were present in 17% of the treated and in 13% of the untreated adolescents.

According to the DHC, 55 of the 94 acceptable occlusions in pilot studies 2 and 3 were in moderate ($n = 48$) or definite ($n = 7$) need of treatment because of contact point displacements. Moreover, no treatment need was found in 47 of the 117 unacceptable occlusions. As in pilot study 1, the main reasons for their non-acceptability were a non-Class I canine relationship (39 adolescents) and excess overbite (15 adolescents), followed by crossbite (4 adolescents) and midline deviation (1 adolescent).

Morphological criteria for an acceptable occlusion

In pilot studies 1–3, the occlusal morphology was evaluated in the CR. However, after considering the results from pilot studies 2 and 3, the majority of the third expert panel preferred the use of the ICP as the reference in morphological assessments. After testing the final criteria clinically, the experts recommended that, in the case of a dual bite, i.e. if there was 2 mm or more of sagittal slide, evaluation should be carried out in both the CR and the ICP. Six morphological assessments were included in the final set of criteria: overjet, overbite, canine relationship, crossbite, scissors bite and midline deviation (Table 1).

Functional criteria for an acceptable occlusion

In the evaluation of functional aspects, the experts agreed on using the CR as the reference. Four functional assessments remained in the final set of criteria: discrepancy between the CR and the ICP, working- and non-working-side contacts and protrusion contacts (Table 2). Assessments related to occlusal features (e.g. to the curves of Spee and Wilson) were included in the set, while criteria assessing the adaptive capacity of the temporomandibular joints and muscles were excluded.

Assessment of the final set of morphological and functional criteria took about 3–4 min.

Discussion

The Delphi technique has been developed as a consensus method in order to obtain agreement in controversial questions (18). As emphasized by Jones & Hunter (19), this method can be applied to solve questions where scientific evidence is contradictory or non-existent. In dentistry, the Delphi technique has been used to assess for example diagnostic methods and healthcare services (20–23). In the present study, the method was used because no general agreement has so far been reached over the criteria defining an acceptable occlusion. Our previous results indicated that orthodontic professionals in Finland stress the importance of good function as a part of acceptable occlusion (9, 10). Therefore both orthodontists and stomatognathic physiologists were included in the panel.

During the rounds, a preliminary set of 16 characteristics, selected to describe a morphologically and functionally acceptable occlusion, was reduced to 10, consisting of overjet, overbite, canine relationship, crossbite, scissors bite, midline deviation, discrepancy between the CR and the ICP, working- and non-working-side contacts and protrusion contacts. The cluster analysis was used to minimize unnecessary overlap, i.e. to identify characteristics that measure the occlusion in a similar manner. Because our goal was to develop an index that could be used clinically, it was considered important that the selected characteristics were quick and easy to assess. Most of the 6 morphological characteristics selected for the final set are the same as used in the previous indices assessing either the need or outcome of treatment (1–7, 24). The functional characteristics, on the other hand, have not been used in orthodontic indices.

Traditionally, orthodontic evaluation of occlusal morphology has been performed with the jaws in the ICP (1–7, 24, 25). However, use of the CR has been advocated in the recent literature (26–29). This question was evaluated by the expert panels but no agreement over a single reference position could be reached, with the orthodontists preferring the ICP and the stomatognathic physiologists the CR. Because of the division of opinion, it was decided that the morphological characteristics would be evaluated with the jaws in the ICP, while assessment of the functional

characteristics would be carried out using the CR as the reference position.

Previous studies on orthodontic treatment outcome assess the occlusions on an individual level (1, 2, 5, 30, 31). The samples comprise individuals classified according to their orthodontic treatment need, and the results compare occlusal traits before and after treatment. The health gain is measured by the change in orthodontic treatment need category. During the course of any orthodontic treatment, the clinician has to evaluate the occlusion to decide whether the stated treatment goals have been achieved, or whether further treatment is indicated. From the organizational point of view, based on population strategy it would be important to assess whole age cohorts, both treated and untreated individuals, when planning, targeting and developing orthodontic services, or evaluating the cost-effectiveness of the care. In such studies, the standard, i.e. 'an acceptable occlusion', against which assessments are made, should be comprehensive and meaningful both to the professionals and to the target population.

Professional opinions on orthodontic treatment outcome and occlusal acceptability have been shown to be influenced by factors such as country, practice domain, experience and payment method (32). The present occlusal characteristics and their cut-offs for an acceptable–non-acceptable dichotomy have been selected to meet the requirements of both the healthcare system and orthodontic professionals in Finland (9, 10). Of these characteristics, overjet, transverse discrepancy and buccal segment sagittal occlusion have earlier been found to be important predictors of acceptability (32).

To study further how the 6 selected morphological characteristics describe the acceptability of occlusion, we examined 322 adolescents and compared the results with those obtained using the DHC of the IOTN. The results showed that the DHC indicated a moderate to definite treatment need in more than 50% of the cases that were rated acceptable by our criteria. There could be several explanations for the apparent controversy between our 'acceptable occlusion' and 'orthodontic treatment need' of the DHC. The DHC has been designed to be used in mixed dentition on an individual level. It classifies various morphological traits of occlusion into 5 categories determining the level of orthodontic treatment need (13). Our criteria are intended to define a general standard for morphologically acceptable occlusion. This standard, complemented by the functional and aesthetic criteria, will be used in evaluations of young adults at population level. Because of the different purposes, recorded occlusal traits and particularly their demarcation lines differ in many respects (9, 32). It is also possible that the use of different reference positions, the CR for our criteria and the ICP for the DHC, had a conflicting effect on classifications.

A comparison of the 2 methods reveals that they show different sensitivity to contact point displacements, interdigitation in buccal segments, and increased overbite. The DHC shows high sensitivity to contact point displacements (33) and indicates a need for treatment if the displacement exceeds 1 mm; according to our criteria, occlusion is defined as non-acceptable only if the displacements cause functional disturbances. In evaluation of the sagittal jaw relationship, the DHC indicates a low need of treatment in cases with pre- or post-normal occlusion if no other deviations are present. On the basis of opinion of Finnish professionals, occlusal acceptability requires a Class I canine relationship and only minor deviations are tolerated. Similarly, the DHC shows low sensitivity to increased overbite unless a soft tissue contact is found, while in our study the consensus of opinion only accepts contact of the lower incisors to the incisal or middle third of the upper incisors.

The results show that different definitions of acceptability can lead to significantly different outcomes in occlusal examinations. A method reflecting the special needs of the organization of orthodontic care provides an important tool with which to assess the occlusal outcome, enabling, for example, comparisons between different treatment modalities and their cost-effectiveness.

Conclusions

This study provides a set of morphological and functional indicators for use in evaluations of occlusal acceptability in young adults. The indicators reflect the current consensus opinion of Finnish professionals; their applicability will be tested in future investigations. Further studies are also needed to ascertain the reproducibility of assessment of the included characteristics.

Acknowledgements.—We thank the chief dental officers and their staff in Jyväskylä, Savonlinna, Tampere and Varkaus for permission to conduct the study. The cooperation of the adolescents and our colleagues is gratefully acknowledged. This investigation was supported by grants from the Emil Aaltonen Foundation, the Finnish Dental Society and the University Central Hospital of Turku.

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Received for publication 1 November 2001
Accepted 7 February 2002