European Journal of Orthodontics 34 (2012) 250–256
doi:10.1093/ejo/cjq195
Advance Access Publication 20 January 2011

Inter-examiner variability in orthodontic treatment decisions for Danish children with 'borderline' treatment need

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SUMMARY This study explored the variation between examiners in the orthodontic treatment need assessments of fifth-grade children with a borderline orthodontic treatment need. Each of three groups of children with borderline treatment need (n = 18, 19, and 19, respectively) were examined by one of three groups of orthodontists (33 in each group), whereby each of 56 children had 33 orthodontic treatment need assessments based on a clinical examination. This treatment need determination exercise was subsequently repeated with treatment need determined based on study casts and extraoral photographs. The proportion of positive treatment decisions based on the clinical examination was 49.3, 49.6, and 52.5 per cent, respectively, and 45.7, 46.3, and 50.5 per cent, based on the model assessments. There was a considerable disagreement between examiners in the treatment need assessments, whether assessments were based on a clinical examination or on a model-based case presentation. The average percentage agreement between two orthodontists for the treatment need based on clinical examination was 69, 66, and 61, respectively, corresponding to mean kappa values of 0.38, 0.32, and 0.22. When the model-based assessments were considered, the average percentage agreement between two orthodontists was 62, 58, and 69, respectively, corresponding to mean kappa values of 0.25, 0.16, and 0.37. Linear regression analysis of the orthodontists' treatment propensity as a function of their gender, place of education, years of orthodontic treatment experience, type of workplace, and place of work showed that only the orthodontic experience was influential for the model-based treatment propensity [β = 0.34 per cent/year (95 per cent confidence interval = 0.01–0.66)].

Introduction

In Denmark, the Public Dental Services (PDSs) are administratively as well as organizationally and financially anchored in the Danish municipalities. One of the services offered is the free-of-charge orthodontic treatment to all children aged 0–18 years if their malocclusion traits 'imply a foreseeable or already existing risk of physical damage or psychosocial strain' (Ministeriet for Sundhed og Forebyggelse, 2003). The use of psychosocial strain as an indication for orthodontic treatment is restricted to children with facial features that are considered disabling; thus, orthodontic treatment based solely on cosmetic indications is not supported (Sundhedsstyrelsen, 2006). It follows that the main indications for orthodontic treatment provided by the Danish PDS should hinge on an increased risk of damage to the teeth or the oral tissues or an increased risk of impaired oral function if the malocclusion remains untreated. Owing to these requirements, the tools commonly used for orthodontic treatment need assessments, including the Treatment Priority Index (Grainger, 1967), the Peer Assessment Rating index (Richmond *et al.*, 1992), the Index of Complexity, Outcome, and Need (Daniels and Richmond, 2000), or the Index of Orthodontic Treatment Need (Brook and Shaw, 1989; Shaw *et al.*, 1991) have never gained footing in the Danish PDS system as tools for deciding who should be offered free-of-charge orthodontic treatment and who should not.

Instead, the Danish National Board of Health has issued a set of criteria to be used for the assessment of orthodontic treatment need among Danish children. These criteria aimed to identify children who might benefit from orthodontic treatment. It was estimated that these criteria would result in an average of 25 per cent of all children receiving orthodontic treatment (Sundhedsstyrelsen, 2001). However, the proportion of children who actually undergo publicly financed orthodontic treatment may vary considerably between the Danish municipalities, from a low of 12 to a high of 52 per cent (Dømgaard, 2000). While some variability owing to biological variation and assessment errors is to be expected, the magnitude of the observed variation is too large to be ignored because it indicates considerable differences in the orthodontic service provision across the Danish municipal PDSs. An obvious source of variation to consider is the inter-examiner variability in the application of the orthodontic treatment need assessment criteria. These criteria, as they are described in the 2003 executive order

(Ministeriet for Sundhed og Forebyggelse, 2003), leave much room for interpretation. It is therefore plausible that a substantial variation may exist in the interpretation of the criteria for orthodontic treatment need assessment.

The purpose of the present study was to explore inter-examiner variability among Danish orthodontists in the interpretation of the Danish criteria for orthodontic treatment need assessment when used among 11-year-old children (fifth graders) with 'borderline' malocclusions. Additional aims were to identify examiner-related factors impacting on the outcome of treatment need assessments and to assess the extent to which assessments made on the basis of study models and photographs would be different from assessments based on a clinical examination.

Subjects and methods

The orthodontists participating in this study were recruited from those attending the 2005 annual meeting of the Danish Association of Orthodontic Specialists, which has all Danish orthodontic specialists as members. This association has approximately 135 members, and 101 of these attended the 2005 meeting. These 101 orthodontists were allocated to one of three equal-sized groups: A, B, or C. The participating orthodontists were asked to provide information on age, gender, experience in orthodontics (years since completion of specialization), type of workplace (private/public/both), place of education (Copenhagen/Aarhus/Other), and place of work. Table 1 shows selected demographic characteristics of the participating orthodontists.

In each of three municipalities Fredericia, Horsens, and Kolding (henceforth F, H, and K, respectively), 100 school children from the fifth grade were screened by the orthodontist affiliated with the municipality. Children, who had completed or were currently undergoing orthodontic treatment (n = 42) were excluded from the study (Table 2). All children (n = 142) for whom the screening orthodontist judged that the occlusion was close to perfect were also excluded. The remaining children (n = 116) comprised those children with a possible orthodontic treatment need and were therefore considered eligible at step 1 (Table 2). These 116 children had casts made and extraoral photographs taken, and based on these case presentations, each of six orthodontists independently assessed their treatment need. Children, for whom the treatment need assessments were the same by all six orthodontists (n = 51), were excluded, leaving 65 children eligible at step 2. These borderline children were invited to participate in the study, and 57 children agreed to participate based on informed consent (Table 2). However, one child failed to attend the actual examination.

The examinations were carried out in the central municipal clinics. In the morning, each of the 18 children from municipality F were clinically examined by all 33 orthodontists in group A, one at a time. Similarly, in municipality H, each of the 19 children were examined by each of 33 orthodontists in group B and in municipality K, each of the 19 children were examined by the 33 orthodontists in group C (Table 3). Both the children and the examiners were instructed not to reveal the results of the assessments. In the afternoon, assessments of orthodontic treatment need were based on the case presentations consisting of study models and clinical photographs. In order to eliminate recollection bias, the orthodontists made their assessments based on case presentations from a municipality other than the one they had assessed in the morning (Table 3).

For each child present, and for each case presentation, the orthodontists were asked to determine if they would recommend orthodontic treatment based on the criteria issued by the Danish National Board of Health. The orthodontists had to make a decision (yes/no) but were allowed to provide comments if they felt the need.

In order to provide an overview of the data, graphs were created, which show the assessments made by each orthodontist for each child in each of the three municipalities (F, H, and K) using each of the two examination types (clinical or model-based). In these graphs, the orthodontists were arranged according to their overall 'treatment

Table 1 Selected characteristics of the participating orthodontists.

	Male (n = 46)	Female (n = 55)
Years of orthodontic experience, mean (SD)	21.2 (11.1)	16.2 (10.5)
Place of orthodontic education (%)		
Copenhagen	69.6	54.6
Aarhus	17.4	36.4
Other	13.0	9.1
Type of workplace (%)		
Public	78.3	87.3
Private	17.4	10.9
Both	4.4	1.8
Workplace in Northern Sealand (%)	17.4	14.6
Workplace (Copenhagen, Aarhus, Odense, or Aalborg; %)	19.6	23.6

Table 2 The child identification process in each of the municipalities Frederica, Horsens, and Kolding (F, H and K).

	F	H	K	Total
Number screened	100	100	100	300
Orthodontic treatment completed	4	9	7	20
Undergoing orthodontic treatment	6	10	6	22
No orthodontic treatment need	54	38	50	142
Eligible at step 1	36	43	37	116
No orthodontic treatment need	10	9	12	31
Unequivocal orthodontic treatment need	4	11	5	20
Eligible at step 2—invited to participate	22	23	20	65
Agreed to participate	18	20*	19	57

*One child did not attend for the examination.

Table 3 The distribution of orthodontist groups according to municipality and the basis for the orthodontic treatment need assessment.

Municipality	Treatment need based on	Orthodontist group		
		A	B	C
F	Clinical examination $n = 18$	33		
	Model-based examination $n = 18$			32
H	Clinical examination $n = 19$		33	
	Model-based examination $n = 20$	34		
K	Clinical examination $n = 19$			33
	Model-based examination $n = 19$		32	

The orthodontist groups are arbitrarily labelled A, B, or C, while the municipalities F, H, and K correspond to Fredericia, Horsens, and Kolding.

propensity', measured as the percentage children for whom they recommend treatment. Similarly, the children were arranged according to the 'signal strength' of their treatment need, assessed by means of the percentage orthodontists who recommended that they receive orthodontic treatment.

Pairwise comparisons were made for all possible combinations of examiners, and the agreement between examiners was estimated as the percentage agreement (per cent assessments in which the two examiners agree) and in the form of Cohen's Kappa (Cohen, 1960), which estimates the proportion of the observed agreement that exceeds that expected by chance. A linear regression analysis was performed of the relationship between the children's likelihood of orthodontic treatment based on the clinical examination and that based on study model assessment. These likelihood estimates were derived as the proportion of orthodontists who would recommend orthodontic treatment for the child.

Finally, linear regression analyses were undertaken of the orthodontist's treatment propensity for a borderline child. The determinants considered were gender, place of education, years of experience in orthodontics, type of workplace, and place of work. The latter was operationalized into two variables, one whether or not the workplace was located in Northern Sealand and the other whether or not their workplace was located in one of the four large Danish municipalities (Copenhagen, Aarhus, Odense, and Aalborg). The rationale underpinning the first of these was the impression that orthodontic treatment propensity might be higher in Northern Sealand owing to the wealthier population placing more demands for orthodontic treatment, whereas the second variable was motivated by the working environments in the four large Danish municipalities allowing for better calibration among orthodontists.

Results

Overall, the proportion of positive treatment decisions made based on the clinical examination was 49.3, 49.6, and 52.5 per cent for children from municipalities F, H, and K, respectively. The corresponding figures from the study model assessments were 45.7, 46.3, and 50.5 per cent, respectively, for the children from the three municipalities. Figure 1 provides an overview of treatment need based on clinical examination of the children in each of the municipalities. For all three municipalities, considerable disagreement was noted. Complete agreement between examiners was noted for only one child in municipality F, who was judged as having no treatment need by all 33 orthodontists in group A. This child was also classified as not having a treatment need when assessed on study models and clinical photographs by the orthodontist in group C (Figure 1). Figure 1 shows that there was a considerable variation between orthodontists in their assessments of the children's treatment need, whether assessments were based on a clinical examination or on a case presentation.

Table 4 provides a summary of the agreement in treatment assessments among pairs of orthodontists. The average percentage agreement between two orthodontists based on clinical examination was 69, 66, and 61 per cent, respectively, in municipalities F, H, and K, respectively. When agreement by chance was adjusted for, the mean kappa values were 0.38, 0.32, and 0.22, respectively, based on clinical examination (Table 4). When the model-based assessments were considered, the average percentage agreement between two orthodontist were 62, 58, and 69 per cent, respectively, corresponding to mean kappa values of 0.25, 0.16, and 0.37 (Table 4).

Linear regression analysis of the relationship between the children's likelihood of orthodontic treatment based on clinical examination or study models showed a clear and statistically significant positive relationship (Figure 2), indicating that model-based treatment likelihood may be described as a linear function of clinical treatment likelihood. The model-based likelihood at zero clinical treatment likelihood was 8 per cent and increased with a value of 0.78 for every unit increment of clinical treatment likelihood. R^2 for the linear model was 0.69. Even so, for some children, there was a notable discrepancy between clinical and model-based assessments. In some cases, model-based assessments were considerably more likely to results in a treatment recommendation, whereas in other cases, the reverse was observed. For the case shown in Figure 3, 15 per cent of the orthodontists recommended treatment at the clinical examination whereas 71 per cent recommended treatment based on the models.

Linear regression analyses of the orthodontists' treatment propensity as a function of their gender, place of education, years of orthodontic treatment experience, type of workplace, and place of work showed that only one of these variables was influential. Hence, for each additional year of orthodontic experience, the model-based treatment propensity decreased by 0.34 per cent (95 per cent confidence interval = 0.01–0.66). No influential factors

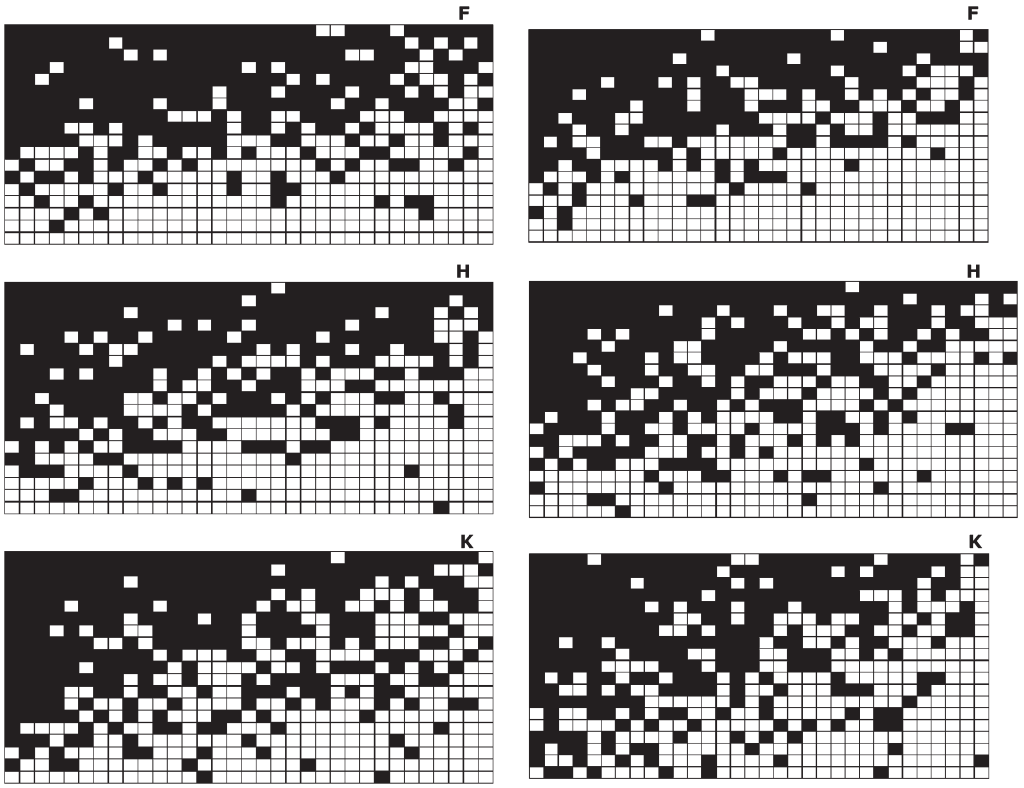

Figure 1 Graphs showing for children in each municipality Fredericia, Horsens, and Kolding the treatment need assessment made by each examiner (columns) for each child (rows) based on clinical examination (left panel) and (right panel) on a case presentation consisting of models and clinical photographs. A black square in the intersection between a given child (row) and a given orthodontist (column) indicates that the examiner recommended treatment for the child. Conversely, white squares indicate no treatment need.

Table 4 Mean values, standard errors (SEs), and ranges of the inter-examiner estimates of percentage agreement and kappa values for the orthodontic treatment need decisions.

Municipality	Treatment need assessment based on	Inter-examiner reliability		
		Estimate	Mean (SE)	Range
F	Clinical examination *n* = 18 children (33 group A orthodontists)	% Agreement	69 (0.6)	39–94
		Kappa	0.38 (0.01)	−0.22 to 0.89
	Model-based examination *n* = 18 children (32 group C orthodontists)	% Agreement	62 (0.6)	40–90
		Kappa	0.25 (0.01)	−0.17 to 0.79
H	Clinical examination *n* = 19 children (33 group B orthodontists)	% Agreement	66 (0.5)	37–89
		Kappa	0.32 (0.01)	−0.25 to 0.79
	Model-based examination *n* = 20 children (34 group A orthodontists)	% Agreement	58 (0.8)	16–89
		Kappa	0.16 (0.01)	−0.46 to 0.78
K	Clinical examination *n* = 19 children (33 group C orthodontists)	% Agreement	61 (0.6)	21–89
		Kappa	0.22 (0.01)	−0.46 to 0.79
	Model-based examination *n* = 19 children (32 group B orthodontists)	% Agreement	69 (0.6)	39–94
		Kappa	0.37 (0.01)	−0.08 to 0.89

The orthodontist groups are arbitrarily labelled A, B, or C, while the municipalities F, H, and K correspond to Fredericia, Horsens, and Kolding.

were identified for the treatment propensity when based on clinical examination.

Discussion

The results of the present study showed considerable inter-examiner variation in the assessment of orthodontic treatment need among borderline children, whether their assessment was based on a clinical examination of the children or on a case presentation. Clearly, the children included in the present study were *a priori* selected as those for whom there might be doubts as to their treatment need and the results obtained should therefore not uncritically be extrapolated to the entire population of children.

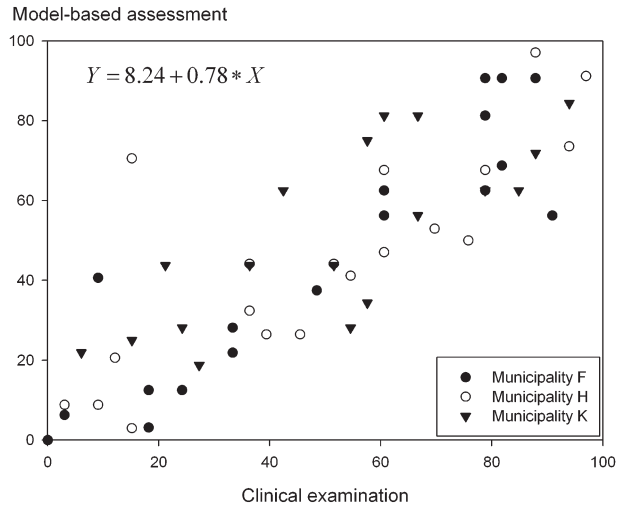

Figure 2 Relationship between a child's likelihood of orthodontic treatment need based on clinical or on model-based assessment. A child's likelihood of treatment is estimated as the percentage of orthodontists who recommend treatment for the child.

It may be argued that the request to the orthodontists to make a decision has contributed to the inter-examiner variation since it is at variance with the clinical situation where the decision may sometimes be postponed and the child placed on an observation list until a final decision is made. While this might be the case, leaving it to the examiners to make a treatment need decision or not would have more seriously biased the results. Hence, the orthodontists knew that they were being studied with respect to their decisions, and this knowledge might well induce more decisions to 'place on observation list' that would have been the case in a real world clinical setting.

Although the extent of variation when the entire child population is considered remains speculative, it cannot be taken for granted that there would be no variation between orthodontists in the treatment decisions for those children found ineligible for inclusion in the present study. It is worth noting that of the 300 children considered for the study, 142 were screened and found ineligible because a single orthodontist judged them to have a close to perfect occlusion. However, for some of these children, it is possible that this decision might have been different had another orthodontist undertaken the initial screening. Screening in step 2 (Table 2) was carried out by six orthodontists, all of whom had to agree in their treatment decision in order to exclude the child from inclusion in the study. However, as amply illustrated in Figure 1, it is possible for each and every borderline child to find a subset of six orthodontists who agree that the child definitely has no orthodontic treatment need or that the opposite is the case. It is thus worth noting that for one child who was included as a borderline child (i.e. at least one of the six screening orthodontists found a treatment need), all clinical assessments by each of the 34 orthodontists and all model-based assessments by each of 32 orthodontists resulted in the decision of no orthodontic treatment need.

The variation observed is further supported by the observations of considerable and sustained variation across the Danish municipalities in the frequency of orthodontic treatment among children (Dømgaard, 2000; Sundhedsstyrelsen, 2004), with a treatment frequency varying between 12 and 52 per cent. Although the more extreme estimates originated in the smaller of the municipalities and may reflect the implementation of local policies accepting treatment frequencies that deviate markedly from the anticipated level of 25 per cent, the variation may also indicate a lack of calibration among the orthodontists. As the possibilities for calibration are greater in the four major Danish municipalities, a variable reflecting workplace in these municipalities was included, but analysis showed that this variable was not influential as a determinant of the orthodontists' treatment assessments for borderline children. The only influential factor identified pertained to the model-based assessments and concerned orthodontic experience.

The literature on inter-examiner variation in orthodontic assessments broadly falls in one of three groups. Some studies focus on inter-examiner reliability of specific malocclusion traits (Keeling *et al.*, 1996; Pair *et al.*, 2001; Svedström-Oristo *et al.*, 2002; Ovsenik *et al.*, 2004, 2007; Gesch *et al.*, 2006b), some focus on the reliability of overall malocclusion scores (Ovsenik *et al.*, 2004, 2007; Louwerse *et al.*, 2006), or on the reliability of treatment need decisions (Richmond *et al.*, 1994; Lee *et al.*, 1999; Berk *et al.*, 2002; Johansson and Follin, 2005; Gesch *et al.*, 2006a; Sherlock *et al.*, 2008). The present results are in agreement with studies that found examiners to vary greatly in their treatment need assessments. Reliability has been observed to range from poor (Lee *et al.*, 1999) to almost perfect (Berk *et al.*, 2002). The causes of the observed variability have been described as a lack of evidence for the effectiveness of competing treatments (Lee *et al.*, 1999), use of examiners with less orthodontic experience (Gesch *et al.*, 2006a), absence of strict criteria (Sherlock *et al.*, 2008), unclear definitions of what constitutes treatment need (Richmond *et al.*, 1994), and the means of assessment in the form of clinical examination or use of study casts (Gesch *et al.*, 2006a).

However, many of the abovementioned studies base their conclusions on the calculation of kappa values (Lee *et al.*, 1999; Berk *et al.*, 2002; Gesch *et al.*, 2006a; Sherlock *et al.*, 2008), which may lead to distorted conclusions (Cicchetti and Feinstein, 1990; Feinstein and Cicchetti, 1990; Byrt *et al.*, 1993), particularly when weighted kappa values are used (Maclure and Willett, 1987). It is thus difficult to give a valid interpretation to weighted kappa values owing to the arbitrary nature of the selection of weights. Similarly, it seems inappropriate to give interpretation to the kappa values

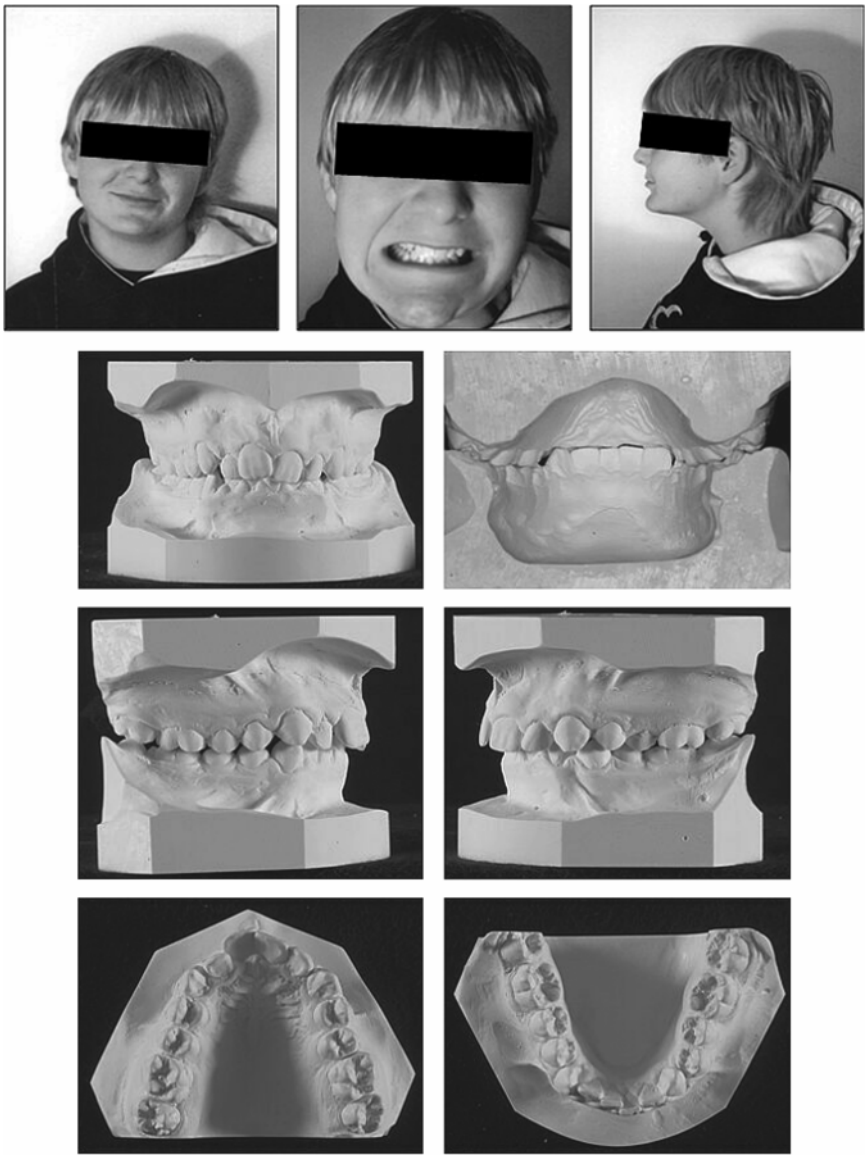

Figure 3 Photographs of a subject with a great discrepancy between clinical treatment need and model-based assessment.

using the various scales proposed (Landis and Koch, 1977; Fleiss 1981; Byrt, 1996) that seek to translate observed kappa values using value-laden adjectives such as 'excellent' or 'good' agreement. What constitutes excellent must necessarily depend on the context, and it is difficult to understand that a kappa value of 0.75 should mean the same in cancer diagnosis as in orthodontic diagnosis. The kappa coefficient measures how much of the maximum obtainable agreement beyond chance has actually been achieved. The results presented in Table 4 thus indicate that there is agreement beyond chance and that overall 22–38 per cent of the maximum obtainable agreement beyond chance was achieved based on the clinical examinations, while the corresponding figures for the model-based assessments were 16–37 per cent. These estimates should be interpreted in the light of the present cases, which represent borderline orthodontic treatment need. This definition of the cases implies that their treatment likelihood should be around 50 per cent, which was indeed observed, as 49.3, 49.6, and 52.2 per cent of the children in the three municipalities were recommended orthodontic treatment based on clinical assessment.

The borderline children studied here represent a range of manifestations of (mal) occlusion that may signal treatment need in the range from the barely perceptible to the virtually obvious treatment need. If indeed the orthodontists perceived the treatment need of these borderline children as such a range, then this would have been expected to manifest through a ranking of the children in order of increasing

treatment likelihood. This would manifest as a relatively distinct diagonal line from lower left to upper right corner (Figure 1) separating positive and negative treatment recommendations. However, no such distinct diagonal line is seen, and this highlights that the real problem is not one of using the same threshold for deciding treatment need. The problem is more fundamental disagreement regarding the types of (mal) occlusion that warrant treatment. Hence, the problem is that children for whom even the most treatment prepared orthodontist recommended no treatment, could be recommended treatment by the much less treatment prepared orthodontists and vice versa. This indicates that the orthodontists may weigh different aspects of malocclusions rather differently. By virtue of the possibilities inherent in the 2003 executive order (Ministeriet for Sundhed og Forebyggelse, 2003) for interpretation of the criteria for orthodontic treatment need assessment, this might be expected. However, it remains to be elucidated which are the malocclusion aspects that may be weighted differently, just as it remains to be seen if clarification and operationalization of the criteria for treatment need assessment may reduce the variability in orthodontic treatment need decisions.

Conclusions

The present study demonstrated a considerable variation between examiners in the assessment of orthodontic treatment need among borderline fifth graders. This variation is apparent whether treatment need assessments were based on clinical examination or on study casts and extraoral photographs. The major determinants of this variation among a set of socio-demographic variables could not be identified, suggesting that the source of the variation may lie in orthodontists weighing various aspects of malocclusions differently.

Funding

This study was funded by the Danish Society of Orthodontic Specialists Quality Committee.

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