Diagnostic agreement in the assessment of orthodontic treatment need using the Dental Aesthetic Index and the Index of Orthodontic Treatment Need

David Manzanera, José María Montiel-Company, José Manuel Almerich-Silla and José Luis Gandía

Department of Stomatology, University of Valencia, Spain

SUMMARY The aim of this study was to estimate the diagnostic agreement between assessments of orthodontic treatment need of a child population using the Dental Aesthetic Index (DAI) and the Index of Orthodontic Treatment Need (IOTN). A cross-sectional study of a representative random sample of children aged 12 (n = 475) and 15–16 (n = 398) years was carried out in the Valencia region of Spain. A Student's *t*-test was used to compare the DAI means by gender and age and a chi-square test to compare the proportions of the population in need of orthodontic treatment. To calculate the agreement between the two indices, intra-class correlation coefficient and Kappa statistics were employed.

Of the 12-year-olds, 23.5 per cent (n = 121) and of the 15- to 16-year-olds, 26.6 per cent (n = 108) were receiving or had previously received orthodontic treatment. The observed agreement between the two indices on the need for treatment among the 12-year-olds (n = 363) was 83.4 per cent and Kappa for diagnostic agreement was 0.52 [95 per cent confidence interval (CI): 0.42–0.63]. For the 15- to 16-year-olds (n = 292), the figures were 82.5 per cent and 0.38 (95 per cent CI: 0.24–0.52), respectively. For the total sample (n = 655), the observed agreement was 83 per cent and the diagnostic agreement was 0.47 (95 per cent CI: 0.39–0.55).

For this population, there was only moderate agreement between the two indices. This means that, when one of these indices is used to measure or prioritize orthodontic treatment in a determined population, the individuals selected with an obvious treatment need are going to be different in 17 per cent of the cases depending on which index is used, DAI or IOTN. This difference has to be taken in consideration when measuring, recording, or quantifying orthodontic treatment need.

Introduction

A large number of indices to assess malocclusion have been developed with the aim of estimating orthodontic treatment need in particular populations or communities, to select the patients who can be treated in a certain dental care system and to establish priorities when resources are limited. Although no absolute consensus has been reached on the individual characteristics and occlusal features that should be assessed in order to objectively establish treatment need (Richmond et al., 1994), in the recent literature, the orthodontic treatment need indices used in epidemiological studies of malocclusion in different countries have tended to coincide in many ways, to unify criteria, and have been recognized by various international associations. Such indices include the Dental Aesthetic Index (DAI; Cons et al. 1986) and the Index of Orthodontic Treatment Need (IOTN; Brook and Shaw 1989). The DAI links the clinical and Aesthetic Components (ACs) mathematically to arrive at a single mark which combines the physical and aesthetic aspects of the occlusion. It is based on a social acceptability scale of occlusal conditions (Jenny et al., 1980) and has been used in many studies to determine orthodontic

treatment need in different countries (Ansai *et al.*, 1993; Estioko *et al.*, 1994; Otuyemi *et al.*, 1998; Esa *et al.*, 2001; Baca-Garcia *et al.*, 2004; Bernabé and Flores-Mir, 2006). A DAI scale that divided the continuous index score defined by the equation into four malocclusion severity levels was established, making it easier to use and encouraging its application in orthodontic care programmes or malocclusion prevalence studies (Jenny and Cons, 1996b). It was included in the World Health Organization Oral Health Survey Methods (1997).

Unlike the DAI, the IOTN classifies malocclusions according to the presence of particular occlusal features which are considered important for dental health and aesthetics in order to identify individuals who would derive the most benefit from orthodontic treatment. This index includes an AC with 10 severity levels and a Dental Health Component (DHC) with five severity levels. The two components are analysed separately and although they cannot be united into a single score, they can be combined to classify the patient as 'orthodontic treatment need, Yes or No', following the modifications of Burden *et al.* (1999). The IOTN has been used for this purpose in many epidemiological studies (Burden and Holmes, 1994; Hamdan, 2001; Manzanera *et al.*, 2004; Mugonzibwa *et al.*, 2004; Chestnutt *et al.*, 2006; Souames *et al.*, 2006). Other indices, such as the Handicapping Labio-lingual Deviations Index (Beglin *et al.* 2001) used in the United States and, more recently, the Index of Complexity, Outcome, and Need (Daniels and Richmond 2000), have been validated and proposed as useful tools to objectively measure orthodontic treatment need, but the DAI and IOTN are, at present, the most widely used.

Jenny and Cons (1996a) compared the DAI and IOTN in a descriptive way, providing some historical perspective regarding their development, reliability, and validity as well as similarities and differences. Freer and Freer (1999) analysed the disagreements between the two methods on 100 study models of 11- to 13-year-old students. Beglin *et al.* (2001) compared the indices with a panel of orthodontists and found that they appear to be valid measures of treatment need. The findings of Hlongwa *et al.* (2004) indicate that the two indices could be used consistently to identify orthodontic treatment need in different ethnic groups. In the majority of studies, both indices (DAI and IOTN) have been used together to assess the same broad representative sample and for comparison of the results (Abdullah and Rock, 2001).

The objective of this study was to calculate the diagnostic agreement between DAI and IOTN assessments of orthodontic treatment need in a representative random sample child population where the information was obtained directly in the course of an epidemiological survey.

Subjects and methods

Ethical approval and consent

The study was approved by the ethical committee of the University of Valencia. The examinations were conducted with permission from the education authorities and head teachers, and with informed consent of the pupils' parents.

Study group

Stratified random sampling within clusters was conducted in a population comprising all first and fourth year secondary school children in the Valencia region. Thirty-nine schools were selected and between 20 and 30 pupils were examined in each.

The study was conducted on a representative random sample of 12 (n = 475) and 15 to 16 (n = 398) year old children in the Valencia region of Spain that had been analysed previously (Almerich-Silla and Montiel-Company, 2006; Manzanera *et al.*, 2009). Children who were undergoing or had previously received orthodontic treatment were excluded; this represented 23.5 per cent (n = 112) of the initial sample of 12-year-olds and 26.6

per cent (n = 108) of the 15- to 16-year-olds. The application of this exclusion criterion led to a final sample size of 363 under 12-year-old (175 boys and 188 girls) and 292 under 15- to 16-year-old (131 boys and 161 girls) schoolchildren.

Clinical examination

The epidemiological study was carried out by six dental graduates who were divided into three examination teams, assigning them the function of examiner or recorder depending on their calibration. Prior to the examinations, sessions were conducted to explain the diagnostic criteria and to train the graduates in the use of the DAI and IOTN. The examiners were then calibrated, firstly with 20 plaster models of different malocclusions, and then under real examination conditions with 20 schoolchildren of the ages to be surveyed. To ensure the reliability of the measurements, orthodontic treatment need diagnosis calibration was carried out during the weeks prior to commencement of the study. The three dentists with the highest agreement with one of the authors (DM, a specialist in orthodontics with expertise in the field was considered as the gold standard), assessed using Kappa statistics, were appointed as examiners. Kappa values with the gold-standard examiner were 0.98, 0.88, and 0.86 for the three examiners. To ensure the reproducibility of the measurements, 50 children were re-evaluated (10 per cent of the sample) after 1 month. Kappa values were over 0.80 for the three examiners.

Intraoral examinations were conducted to register all the necessary malocclusion features to obtain the DAI and the IOTN (overjet, overbite, anterior and posterior crossbite, open bite, displacement of the teeth, diastemas, impeded eruption, hypodontia, clefts of the lip and/or palate, and molar relationship), as well as personal details (name, age, and gender).

The DAI results were classified on the four-grade scale proposed by Jenny and Cons (1996b) and individuals placed in levels 3 and 4 were considered to require treatment.

The DHC of the IOTN was determined in a five-grade scale and the IOTN AC on a three-grade scale. In determining the IOTN, the criteria established by Burden and Pine (1999) were employed, considering those who met the requirements specified in the modified IOTN (IOTN DHC \geq 4 and/or IOTN AC \geq 8) to be individuals with a definite need for treatment. The two indices DAI and modified IOTN were dichotomized into 'yes' or 'no' categories of orthodontic treatment need.

Statistical analysis

Statistical analysis was undertaken using the Statistical Package for Social Sciences version 12.0® (SPSS Inc., Chicago, Illinois, USA). The data were entered into a Microsoft Access 2003® database. A Student's *t*-test was used to compare the DAI means by gender and age and a

chi-square test to compare the proportions of the population in need of orthodontic treatment. Differences greater than P < 0.05 were considered statistically significant.

The agreement between DAI (expressed on a four-grade scale), IOTN DHC (on a five-grade scale), and IOTN AC (on a three-grade scale) was calculated using intraclass correlation coefficients (ICCs)

Observed percentage agreement and unweighted Kappa statistics were used to analyse the agreement between the DAI and modified IOTN dichotomized into yes or no categories of orthodontic treatment need. The agreement was defined using the scale of Landis and Koch (1977).

Results

Orthodontic treatment need according to the DAI

The mean DAI in the 12-year-old group was 26.1 with a standard deviation (SD) of 5.9, and in the 15- to 16-year-olds, it was 25.2 (SD 6.0). The difference between the mean DAI of the two age groups was not statistically significant (P > 0.05). No significant differences by gender were observed in the 12-year-old group; in the 15- to 16-year-olds, the mean DAI was significantly higher in boys than in girls (P < 0.05), although this difference was not significant when DAI scores were classified into category levels. Table 1 shows the percentage of children placed in each of the treatment need

levels after classifying each individual's DAI score. Considering grades 3 and 4 as indicating a clear need for orthodontic treatment, the percentage of the population in need of treatment would be 21.2 per cent [95 per cent confidence interval (CI): 17.1–25.7] at 12 years of age and 16.1 per cent (95 per cent CI: 12.1–20.8) at 15–16 years of age.

Orthodontic treatment need according to the IOTN

Table 2 shows the different IOTN DHC levels. If grades 4 and 5 are considered as representing a definite need for treatment, 21.8 per cent (95 per cent CI: 17.6–26.4) of the 12-year olds and 17.1 per cent (95 per cent CI: 12.9–21.9) of the 15- to 16-year olds required treatment. No significant differences in treatment need proportions by age or gender were found (P > 0.05).

According to the IOTN AC, the treatment need was 4.4 per cent (95 per cent CI: 2.5–7.1) in the 12-year olds and 2.4 per cent (95 per cent CI: 0.9–4.9) in the 15- to 16-year olds (Table 3). No significant differences in the treatment need proportions by age or gender were found (P > 0.05). Considering the modified IOTN (IOTN DHC grades 4–5 and/or IOTN AC grades 8–10), the treatment need was 23.5 per cent (95 per cent CI: 19.2–28.1) at 12 years of age and 18.5 per cent (95 per cent CI: 14.2–23.4) at 15–16 years of age. The differences by age and gender were not significant (P > 0.05).

Table 1 Distribution of Dental Aesthetic Index (DAI) scores and orthodontic treatment need in the examined subjects.

DAI		$\frac{12 \text{-year-olds } (n = 363)}{\% (95\% \text{ CI})}$	15- to 16-year-olds ($n = 292$)	
			% (95% CI)	
≤25 (grade 1) 26–30 (grade 2) 31–35 (grade 3) ≥36 (grade 4)	Normal or minor malocclusion; no treatment or slight need Definite malocclusion; treatment elective Severe malocclusion; treatment highly desirable Very severe (handicapping) malocclusion; treatment mandatory	52.1 (46.7–57.3) 26.7 (22.2–31.5) 13.2 (9.9–17.1) 8 (5.4–11.2)	57.2 (51.2–62.9) 26.7 (21.7–32.0) 9.6 (6.4–13.5) 6.5 (3.9–9.9)	

 Table 2
 Distribution of the Index of Orthodontic Treatment Need (IOTN) Dental Health Component (DHC) levels of orthodontic treatment need in the examined subjects.

IOTN (DHC)	12-year-olds ($n = 363$)		15- to 16-year-olds (<i>n</i> = 292)	
	% (95% CI)		% (95% CI)	
Grade 1. Normal or minor malocclusion. No need. Grade 2. Minor malocclusion. Little need. Grade 3. Moderate malocclusion. Borderline need.	15.4 (11.8–19.6) 31.1 (26.4–36.2) 31.7 (26.9–36.7)	No need; 78.2 (73.6–82.4)	17.1 (12.9–21.9) 46.3 (40.4–52.1) 19.5 (15.1–24.5)	No need; 82.9 (78.1–87.0)
Grade 4. Severe malocclusion. Needs treatment. Grade 5. Very severe malocclusion. Needs treatment.	16.0 (12.4–20.1) 5.8 (3.6–8.7)	Definite need; 21.8 (17.6–26.4)	15.4 (11.4–20.1) 1.7 (1.3–2.2)	Definite need; 17.1 (12.9–21.9)

Agreement between DAI-IOTN DHC and DAI-IOTN AC

The agreement between the DAI (four-grade scale) and IOTN DHC (five-grade scale) using ICC was 0.49 (95 per cent CI: 0.02–0.73) in the 12-year-olds, 0.44 (95 per cent CI: 0.10–0.64) in the 15- to 16-year-olds, and 0.47 (95 per cent CI: 0.05–0.65) for the total sample, indicating moderate agreement. The agreement between DAI (four-grade scale) and IOTN AC (three-grade scale) using ICC was 0.16 (95 per cent CI: 0.02–0.29) in the 12-year-olds, 0.13 (95 per cent CI: 0.001–0.25) in the 15- to 16-year-olds, and 0.15 (95 per cent CI: 0.02–0.26) for the total sample, indicating low agreement.

Agreement between the DAI and the modified IOTN

The results of the treatment need assessment of the two age groups with the two indices are shown in Table 4. The percentage agreement between the two indices on the need for treatment among the 12-year-olds (n = 363) was 83.4 per cent and the Kappa statistics for diagnostic agreement was 0.52 (95 per cent CI: 0.42–0.63). For the 15- to 16-year-olds (n = 292), the figures were 82.5 per cent and 0.38 (95 per cent CI: 0.24–0.52), respectively. For the total sample (n = 655), the observed percentage agreement was 83 per cent and the Kappa statistics for diagnostic agreement was 0.47 (95 per cent CI: 0.39–0.55), indicating moderate agreement.

Table 3Distribution of the Index of Orthodontic TreatmentNeed (IOTN) Aesthetic Component (AC) levels in the examinedsubjects.

IOTN (AC)	12-year-olds $(n = 363)$	15- to 16-year-olds (<i>n</i> = 292)
	% (95% CI)	% (95% CI)
AC grades 1–4. No need. AC grades 5–7. Moderate need. AC grades 8–10. Definite need.	85.4 (81.3–88.9) 10.2 (7.2–13.8) 4.4 (2.5–7.1)	93.5 (90.0–96.0) 4.1 (2.1–7.1) 2.4 (0.9–4.9)

Table 4Cross table showing the determination of orthodontictreatment need using the Dental Aesthetic Index (DAI) and theIndex of Orthodontic Treatment Need (IOTN) modified in 12-year-olds, 15- to 16-year-olds, and both age groups together.

			DAI	
			No need	Need
IOTN modified	12-year-olds	No need	252	26
	(n = 363)	Need	34	51
	15- to 16-year-olds	No need	217	23
	(n = 292)	Need	28	24
	Both groups	No need	469	49
	(n = 655)	Need	62	75

The DAI and modified IOTN gave very similar quantifications of orthodontic treatment need proportions at both ages. The IOTN DHC also detected a similar treatment need but the IOTC AC showed a significant lower need (P < 0.01).

In 62 of the subjects (9.5 per cent of the total sample), the IOTN identified certain individuals while the DAI did not. The reasons for this discrepancy are shown in Table 5. In 49 children (7.5 per cent of the total sample), the DAI classified certain individuals as having a definite treatment need while this was not the case for IOTN.

Discussion

The percentage of children in need of orthodontic treatment was in this study comparable with that encountered in most investigations that employed the DAI (Jenny *et al.*, 1991; Estioko *et al.*, 1994; Esa *et al.*, 2001; Souames *et al.*, 2006) or IOTN (Brook and Shaw, 1989; Burden and Holmes, 1994; Nimri and Richardson, 2000; Manzanera *et al.*, 2004; Chestnutt *et al.*, 2006; Manzanera *et al.*, 2009). It was higher than that found in an African population (Otuyemi *et al.*, 1998; Mugonzibwa *et al.*, 2004) but lower than in Turkish (Ucuncu and Ertugay, 2001) and Japanese (Ansai *et al.*, 1993; Katoh *et al.*, 1998) populations.

It should be pointed out that, irrespective of the index employed in assessing treatment need (DAI or IOTN), the results obtained were very similar and there were no statistically significant differences in the proportion considered in need of treatment: 23.5 per cent with the IOTN and 21.2 per cent with the DAI in 12-year-olds and 18.5 and 16.1 per cent, respectively, in 15- to 16-yearolds. Nonetheless, on calculating the Kappa statistics, only moderate agreement was found. Johnson *et al.* (2000) also found that both indices assessed the same number of children with malocclusions requiring orthodontic treatment, but not all were ranked similarly by each index.

Previous studies (Freer and Freer, 1999; Johnson *et al.*, 2000) found significant correlations between the two,

 Table 5
 Reasons for discrepancy in cases determined as 'need treatment' with the Index of Orthodontic Treatment Need (IOTN) modified and 'no need' with the Dental Aesthetic Index (DAI).

	n	%
Posterior crossbite with functional deviation	19	30.6
Deep overbite with gingival or palatal trauma	16	25.8
IOTN AC score ≥ 8	10	16.1
Maximum irregularity >4	8	12.9
Anterior crossbite with functional deviation	4	6.5
Hypodontia of one tooth	4	6.5
Overjet >6	1	1.6
Total	62	100

although they did not use kappa statistics as the agreement measure. It would appear logical to presume that the two indices will differ in certain cases, as there are evident differences in how they work and how they score certain occlusal features (Beglin et al., 2001). This fact needs to be analysed, as it cannot be concluded that the same percentage of the population in need of treatment would be detected whichever index is used, which is of epidemiological importance, since if it were known that the results were not going to vary, the most appropriate index for future studies could be chosen on the basis of different considerations; no less important, however, is the fact that if these indices are used for administrative purposes and the aim is to prioritize the available resources in an orthodontic service or institution, the index used (DAI or IOTN) entails evident differences as regards which patients are selected by one or the other. In 17 per cent of cases, bearing in mind that the percentage disagreement between the two indices in the present study, the selection would not be identical; this means that the same individual may or may not be selected for treatment depending on which index is used, circumstance that may be problematic and undesirable.

The findings of this study coincide with those of Jenny and Cons (1996a). DAI and IOTN are different in nature, designed and drawn up using methods that are not comparable, so although they try to measure the same condition (orthodontic treatment need), they do not do it in the same way and, obviously, there are cases in which they differ.

The IOTN is divided into two components which are designed to assess different malocclusion parameters and are never unified. In the IOTN DHC, the basis for the treatment need grades, founded on an extensive review of the literature on this subject, is that certain occlusal features are potentially detrimental to the dental health of the individual. For this reason, it takes into account certain conditions and aspects of the dentition which, while often not aesthetically detrimental, could be dentally or functionally negative (anterior or posterior crossbite with functional deviation, impacted teeth, increased overbite, etc.). The difference is clear on examining the main reasons why the IOTN selected certain individuals and the DAI did not: in most cases, it was because of the existence of a posterior or anterior crossbite with functional malocclusion, deep overbite with signs of indentation or trauma in the vestibular or palatal mucosa, an IOTN AC score greater than 7, or maximum irregularity greater than 4 mm.

The DAI is based on dental aesthetics, and its constituent features do not include functional considerations or potential risks to the dentition. It was developed by asking approximately 2000 adolescents and adults to rate the aesthetics of 200 photographs of occlusal configurations, representing the entire spectrum of possible malocclusions, then selecting those which were considered the least acceptable by the study population. For this reason, unlike the IOTN, the DAI does not take into account possible occlusal findings that could be functionally detrimental to the individual but are not aesthetically significant. Additionally, the scoring system of the IOTN AC is based on the response of the individual concerned, i.e. on how the malocclusion is selfperceived, through comparison with one of the IOTN AC photographs, which are arranged from the most to the least attractive. These reasons may go a long way towards explaining why the IOTN selects certain individuals that the DAI did not.

In addition to the above reasons, a further consideration should be taken into account when analysing the differences between the IOTN and the DAI: the latter is a cumulative index, the former is not. This has consequences for the final results, as the IOTN will not select an individual with various occlusal anomalies that do not reach grade 4 or 5 of the IOTN DHC since none of these conditions is of a severity that classifies that individual as definitely needing treatment. From this point of view, the IOTN is an 'all or nothing' index. The DAI, on the other hand, takes 10 occlusal situations into account, weights them according to their relative contribution to the aesthetic impairment caused by the malocclusion, then sums them to arrive at a final score. As each of the situations can contribute to a small degree to the final score, it is not possible to determine exactly which specific occlusal finding causes the discrepancy between the IOTN and the DAI because it is always due to a sum of different factors. For this reason, in those cases (when the DAI selected patients that the IOTN did not), no ordered classification of the causes of the diverging criteria was made. To attempt to explain them, an assessment was made of the occlusal parameters that are taken into account and score higher in the DAI but not in the IOTN, such as midline diastema and maxillary and mandibular spacing. Of these subjects, 71.1 per cent scored 3 in the IOTN DHC, making them borderline treatment need cases; 35.6 per cent presented a midline diastema, which adds points in the DAI but is not taken into account in the IOTN; additionally, in 57.8 per cent of these cases, the same individual presented maxillary and mandibular irregularity (but not exceeding 4 mm) and an overjet greater than 3 mm (but below 7 mm), so their DAI scores increased but they did not reach IOTN DHC grade 4 and were therefore not selected by the IOTN.

The differences found in the determination of orthodontic treatment need depending on which particular index (DAI or IOTN) is used to reinforce the point stated by some authors (Tsakos *et al.*, 2006, Klages *et al.*, 2006) that normative measures should be used in combination with quality-of-life questionnaires to cover the malocclusion dimension of oral health.

Conclusions

There is only moderate agreement between the DAI and the IOTN. This means that, although the proportion of individuals in need of treatment detected by both indices is very similar, there are differences in the assessment of need for the same individuals depending on which index is used. This difference has to be taken in consideration when measuring, recording, or quantifying orthodontic treatment need.

Address for correspondence

Dr José Manuel Almerich-Silla Departament d'Estomatologia Clínica Odontològica Universitat de València C/Gascó Oliag No. 1 46010-Valencia Spain E-mail: jose.m.almerich@uv.es

References

- Abdullah M S, Rock W P 2001 Assessment of orthodontic treatment need in 5112 Malaysian children using the IOTN and the DAI. Community Dental Health 18: 242–248
- Almerich-Silla J M, Montiel-Company J M 2006 Oral health survey of the child population in the Valencia region of Spain. Medicina Oral Patología Oral Cirugía Bucal 11: 369–381
- Ansai T *et al.* 1993 Prevalence of malocclusion in high school students in Japan according to the Dental Aesthetic Index. Community Dentistry and Oral Epidemiology 21: 303–305
- Baca-Garcia A, Bravo M, Baca P, Baca A, Junco P 2004 Malocclusions and orthodontic treatment needs in a group of Spanish adolescents using the Dental Aesthetic Index. International Dental Journal 54: 138–142
- Beglin F M, Firestone A R, Vig K W, Beck F M, Kuthy R A, Wade D 2001 A comparison of the reliability and validity of 3 occlusal indices of orthodontic treatment need. American Journal of Orthodontics and Dentofacial Orthopedics 120: 240–246
- Bernabé D, Flores-Mir C 2006 Orthodontic treatment need in Peruvian young adults evaluated through Dental Aesthetic Index. The Angle Orthodontist 76: 417–421
- Brook P H, Shaw W C 1989 The development of an index of orthodontic treatment priority. European Journal of Orthodontics 11: 309–320
- Burden D J, Holmes A 1994 The need for orthodontic treatment in the child population of the United Kingdom. European Journal of Orthodontics 16: 395–399
- Burden D J, Pine C M, Burnside G 1999 Modified IOTN: an orthodontic treatment need index for use in oral health surveys. Community Dentistry and Oral Epidemiology 27: 413–418
- Chestnutt I G, Burden D J, Steele J G, Pitts N B, Nuttall N M, Morris A J 2006 The orthodontic condition of children in the United Kingdom. British Dental Journal 200: 609–612
- Cons N C, Jenny J, Kohout F J 1986 DAI: the Dental Aesthetic Index. College of Dentistry. University of Iowa, Iowa City
- Daniels C, Richmond S 2000 The development of the index of complexity, outcome and need (ICON). Journal of Orthodontics 27: 149–162
- Esa R, Razak L A, Allister J H 2001 Epidemiology of malocclusion and orthodontic treatment need of 12-13-year-old Malaysian schoolchildren. Community Dental Health 18: 31–36

- Estioko L J, Wright F A C, Morgan M V 1994 Orthodontic treatment need of secondary schoolchildren in Heidelberg, Victoria: an epidemiologic study using the Dental Aesthetic Index. Community Dental Health 11: 147–151
- Freer E, Freer T J 1999 Variations in treatment need using four screening methods. Australian Orthodontic Journal 15: 214–218
- Hamdan A M 2001 Orthodontic treatment need in Jordanian school children. Community Dental Health 18: 177–180
- Hlongwa P, Beane R A, Seedat A K, Owen C P 2004 Orthodontic treatment needs: comparison of two indices. Journal of the South African Dental Association 59: 421–424
- Jenny J, Cons N C 1996a Comparing and contrasting two orthodontic indices: the Index of Orthodontic Treatment Need and the Dental Aesthetic Index. American Journal of Orthodontics and Dentofacial Orthopedics 110: 410–416
- Jenny J, Cons N C 1996b Establishing malocclusion severity levels on the Dental Aesthetic Index (DAI) scale. Australian Dental Journal 41: 43–46
- Jenny J, Cons N C, Kohout F J, Frazier P J 1980 Test of a method to determine socially acceptable occlusal conditions. Community Dentistry and Oral Epidemiology 8: 424–433
- Jenny J, Cons N C, Kohout F J, Jakobsen J 1991 Differences in need for orthodontic treatment between native Americans and the general population based on DAI scores. Journal of Public Health 51: 234–238
- Johnson M, Harkness M, Crowther P, Herbison P 2000 A comparison of two methods of assessing orthodontic treatment need in the mixed dentition: DAI and IOTN. Australian Orthodontic Journal 16: 82–87
- Katoh Y, Ansai T, Takehar T 1998 A comparison of DAI scores and characteristics of occlusal traits in three ethnic groups of Asian origin. International Dental Journal 48: 405–411
- Klages U, Claus N, Wehrbein H, Zentner A 2006 Development of a questionnaire for assessment of the psychosocial impact of dental aesthetics in young adults. European Journal of Orthodontics 28: 103–111
- Landis J R, Koch G G 1977 The measurement of observer agreement for categorical data. Biometrics 33: 159–174
- Manzanera D, Montiel-Company J M, Almerich-Silla J M, Gandía J L 2009 Orthodontic treatment need in Spanish schoolchildren: an epidemiological study using the Index of Orthodontic Treatment Need. European Journal of Orthodontics 31: 180–183
- Manzanera D, Ortiz L A, Gandía J L, Cibrián R, Adobes-Martin M 2004 Índice de Necesidad de tratamiento Ortodóncico (IOTN) en escolares de 10 a 12 años. Revista Española de Ortodoncia 34: 209–217
- Mugonzibwa E A, Kuijpers-Jagtman A M, Van't Hof M A, Kikwilu E N 2004 Need for orthodontic treatment among Tanzanian children. East African Medical Journal 81: 10–15
- Nimri K, Richardson A 2000 Interceptive orthodontics in the real world of community dentistry. International Journal of Paediatric Dentistry 10: 99–108
- Otuyemi O D *et al.* 1998 Perceptions of dental aesthetics in the United States and Nigeria. Community Dentistry and Oral Epidemiology 26: 418–420
- Richmond S, O'Brien K D, Roberts C, Andrews M 1994 Dentists' variation in the determination of orthodontic treatment need. British Journal of Orthodontics 21: 65–68
- Souames M, Bassigny F, Zenati N, Roirdan P J, Boy-Lefevre M L 2006 Orthodontic treatment need in French schoolchildren: an epidemiological study using the Index of Orthodontic Treatment Need. European Journal of Orthodontics 28: 605–609
- Tsakos G, Gherunpong S, Sheiham A 2006 Can oral health-related quality of life measures substitute for normative needs assessment in 11 to 12-year-old children? Journal of Public Health Dentistry 66: 263–268
- Ucuncu N, Ertugay E 2001 The use of the Index of Orthodontic Treatment Need (IOTN) in a school population and referred population. Journal of Orthodontics 28: 45–52
- World Health Organization 1997 Oral health surveys: basic methods. WHO, Geneva

Copyright of European Journal of Orthodontics is the property of Oxford University Press / UK and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.