Original Article

The Association of Malocclusion Complexity and Orthodontic Treatment Outcomes

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ABSTRACT

Objective: To determine the relationship of the ABO Discrepancy Index (DI) to outcomes for routine malocclusions, and to ascertain whether significant trends in DI scores could be noted among annual samples of patients taken from 1998 to 2004.

Materials and Methods: A total of 716 consecutive patients with permanent dentition from a large urban graduate orthodontics program were sampled over the 7-year span. A group of six researchers with a dental background were trained and calibrated in the various components of the DI method to ensure reproducible criteria and accurate recording of clinical and radiographic data across researchers. Data management and analyses were undertaken by two other investigators who were not involved in data coding.

Results: Only a weak positive association was seen between the DI and Objective Grading System (OGS) and Comprehensive Clinical Assessment (CCA) scores. The DI was not significantly related to a general time trend.

Conclusion: The DI was found to be a reliable and relatively stable index for measuring malocclusion complexity in annual samples of patients. Although the DI is significantly related to outcomes for the most severe malocclusions, it was not a good predictor of outcome for more routine malocclusions. If the minimal acceptable outcome is defined as 30 OGS points, the mean DI (15.7) and the average OGS score (28.2) indicate that many of the malocclusions in patients in the present sample were of potential board quality. (*Angle Orthod.* 2009;79:468–472.)

KEY WORDS: Discrepancy Index; Orthodontic outcomes; Malocclusion complexity; Annual trends

INTRODUCTION

The complexity of a patient's malocclusion can be used to predict the complexity of orthodontic treatment. Over the years, several indices have been developed in an effort to quantify and/or categorize the complexity of malocclusion.[1–5] These indices have their limitations.[6–8] The Peer Assessment Rating (PAR) index estimates the deviation of a malocclusion from normal alignment and occlusion; pretreatment and posttreatment scores are used to calculate the degree of improvement.[9] The PAR index has good reliability and validity, but it does not evaluate many of the aspects of a malocclusion that must be corrected for American Board of Orthodontics (ABO) case reports.[10] The Index of Orthodontic Treatment Need (IOTN), the Dental Health Component (DHC), and the Standard Component of Aesthetic Need (SCAN) are commonly used methods for determining level of orthodontic need.[11] The latter method contains a subjective component (esthetics), which is difficult to quantify in a reliable manner. In general, treatment need indices are not well suited to outcomes assessment.

As guidelines for achieving board certification, the ABO developed objective measures of malocclusion complexity and treatment outcome. The Discrepancy

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Index (DI) measures pretreatment overjet, overbite, anterior open bite, lateral open bite, crowding, molar occlusion, lingual posterior crossbite, buccal posterior crossbite, ANB angle, IMPA, and SN-GoGn angle[12] The higher the DI score, the more severe is the malocclusion.

In 1999, after 5 years of testing, the ABO initiated the Objective Grading System (OGS) in the phase 3 clinical examination. The purpose was to provide both examiners and candidates with a reliable and objective method for evaluating orthodontic treatment outcome with the use of dental casts and panoramic radiographs.[10] To supplement the ABO OGS, a Comprehensive Clinical Assessment (CCA) was developed by the Indiana University Graduate Orthodontics Program to assess other outcomes such as facial form, dental esthetics, vertical dimension, arch form, periodontium preservation, root resorption, and treatment efficiency. The sum of the CCA and the ABO OGS scores is the comprehensive clinical outcome.[13]

Pinskaya et al[13] found a positive correlation between OGS and CCA scores for a large consecutive sample of patients. Hsieh et al[14] divided the same sample into patients started in mixed or permanent dentition. The early-treatment group had longer treatment times and worse CCA scores compared with late-treatment patients. However, no significant difference in OGS scores was noted between the early- and late-treatment groups, indicating that the CCA method was more sensitive in detecting compromised outcomes for patients with long treatment times. Deguchi et al[5] reported that the DI, OGS, and CCA were effective for comparing orthodontic treatment outcomes between two universities, but the PAR method was less reliable.

Although the DI is used widely to assess malocclusion complexity, its reliability, relative to secular trends in malocclusion complexity and treatment outcomes, is unknown. The objectives for the present study were to (1) analyze a large consecutive sample of treated patients to determine the relationship of the initial DI to clinical outcome, and (2) ascertain whether any significant trends in DI scores occurred over a 7-year period.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board (IRB). Clinical and radiographic information was extracted from existing patient records and was coded to prevent identification of patients in the sample. Data were entered onto a spreadsheet according to the coded case number.

Six dental student investigators were trained by the principal investigator to assess DI scores. They were calibrated with 20 randomly selected cases to replicate scores to a tolerance of ±5%. Cohen's kappa coefficients ranged from 0.68 to 0.94, depending on the index component under scrutiny. They then independently determined the DI scores from patient records of 1720 consecutive completed cases that were started and finished by orthodontic residents from 1998 to 2004. An equal number of cases from each year were randomly assigned to each of the investigators.

Table 1. Comparison of DI, OGS, and CCA Scores[a]

	N	Mean	SD	Min	Max
DI	716	15.7	10.6	1.0	78.0
ABO OGS score	708	28.2	13.0	5.0	90.0
CCA score	708	4.2	2.8	0.0	17.0

[a] CCA indicates Comprehensive Clinical Assessment; DI, Discrepancy Index; and OGS, Objective Grading System.

For each patient, an ABO DI score was calculated following the formula outlined by Cangialosi et al.[12] Patients with any deciduous teeth, missing records, or broken casts were not included in this study. Fewer than 20 patients were excluded because of inadequate records. Applying the exclusion criteria resulted in a total sample of 716 patients started in the permanent dentition. A search of previous databases for the Hsieh et al[14] and Knierim et al[15] studies recovered the previously published ABO OGS and CCA scores for 708 of the 716 patients.

One outlier was identified in the DI scores (score of 152 compared with the next highest score of 78). Because none of the student investigators recalled scoring a DI >100, the outlier was removed from all analyses. Pearson correlation coefficients were calculated to evaluate the associations of continuous variables with DI score. Two-sample *t*-tests or analysis of variance (ANOVA) was used to evaluate the associations of categorical variables with DI score. Time trends were examined with the use of correlation coefficients, with the treating year serving as a continuous variable. ANOVA (parametric) and Kruskal-Wallis tests (nonparametric) were used when the treating year was a categorical variable.

RESULTS

Mean ± standard deviation (SD) values for the DI, ABO OGS, and CCA scores were 15.7 ± 10.6, 28.2 ± 13.0, and 4.2 ± 2.8, respectively (Table 1). ABO OGS scores showed a weak positive association with DI scores (correlation = 0.17; Figure 1). CCA scores also showed a weak positive association with DI scores (correlation = 0.24; Figure 2). However, because of these low correlations, neither of the scores explains even 10% of the variance in DI scores.

The highest scoring DI components, as shown in Table 2, were cephalometric values (4.7), followed by

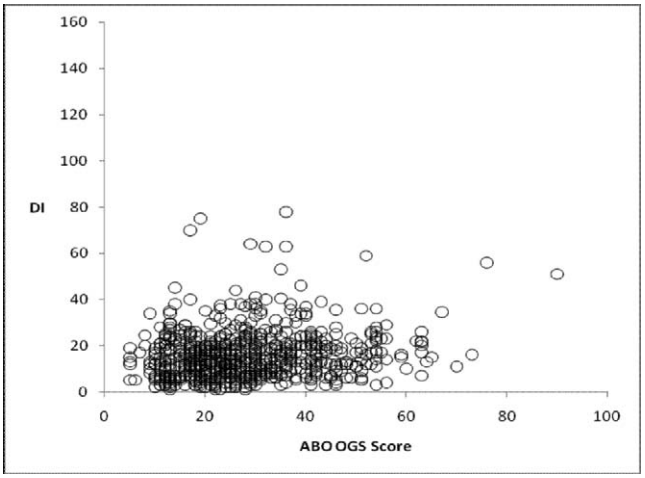

Figure 1. Discrepancy Index (DI) versus ABO Objective Grading System (OGS) score. Correlation = 0.17.

occlusion (2.5), crowding (2.2), and overjet (1.9). The smallest contributors were buccal posterior crossbite (0.2), lingual posterior crossbite (0.5), lateral open bite (0.5), anterior open bite (0.7), and other (0.8). The DI versus year data show a narrow range of mean DI scores (13.9 to 16.8) over 7 years for patients started in the permanent dentition (Table 3). The malocclusion complexity distribution over time (DI vs year) was not statistically significant (Figure 3).

DISCUSSION

The large sample size of 716 patients, spanning 7 years, provided adequate power to assess the overall relationship between malocclusion complexity and outcomes relative to treatment time. Patients treated during the first 3 years were part of the baseline study of clinical outcomes that demonstrated an inverse relationship between treatment duration and outcome.[13]

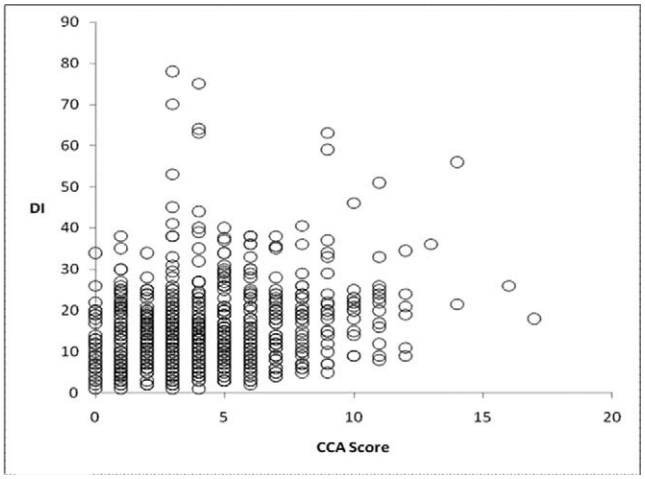

Figure 2. Discrepancy Index (DI) versus Comprehensive Clinical Assessment (CCA) score. Correlation = 0.24.

Table 2. Discrepancy Index (DI) Components

	N	Mean	SD	Min	Max
Overjet	716	1.9	2.2	0	25
Overbite	716	1.7	1.6	0	6
Ant Open Bite	716	0.7	3.4	0	44
Lateral Open Bite	716	0.5	1.8	0	26
Crowding	716	2.2	2.0	0	7
Occlusion	716	2.5	3.0	0	16
Lingual Posterior Crossbite	716	0.5	1.2	0	9
Buccal Posterior Crossbite	716	0.2	0.8	0	8
Ceph	716	4.7	6.6	0	55
Other	716	0.8	1.5	0	10

Assessing the same sample, Hsieh et al[14] found that most of the long treatment time, uncooperative patients were those started in the early mixed dentition (≤10.5 years). Problems identified in the baseline studies[13,14] were addressed with changes in the clinical protocol to limit early (mixed dentition) treatment, focus on finishing long treatment time patients as soon as possible and prematurely terminating uncooperative patients. A follow-up study by Knierim et al[15] of the subsequent 3 years in the series showed a dramatic improvement in both outcomes and treatment times. However, cast scores (ABO OGS) were more amenable to improvement than were more comprehensive outcomes (CCA).

The present study, which spanned 6 years of the previous studies plus 1 additional year, demonstrated that malocclusion complexity (DI) was only a modest factor in determining treatment outcomes for most patients. Thus, the timing of the treatment plan and patient cooperation are the most important factors in determining the quality of the result in most clinical circumstances.

Although statistically significant for this large sample, ABO OGS scores for the present study explained only a small proportion of the variability in DI scores. This weak relationship between treatment outcome (ABO OGS) and malocclusion complexity (DI) is not clinically significant for most patients. However, in a recent study, Campbell et al[16] extracted 382 cases from the same sample that met the requirements for the eight categories of the most difficult malocclusions,

Table 3. Discrepancy Index (DI) versus Year*

Year	N	Mean	SD	SE	Min	Max
1998	123	15.7	11.5	1.0	1.0	75.0
1999	116	15.8	10.8	1.0	1.0	64.0
2000	89	17.4	9.7	1.0	3.0	63.0
2001	80	16.8	10.0	1.1	3.0	56.0
2002	84	14.4	9.5	1.0	1.0	45.0
2003	117	15.8	12.3	1.1	1.0	78.0
2004	107	13.9	8.7	0.8	2.0	59.0

* ANOVA, $P = .25$; correlation = −0.06.

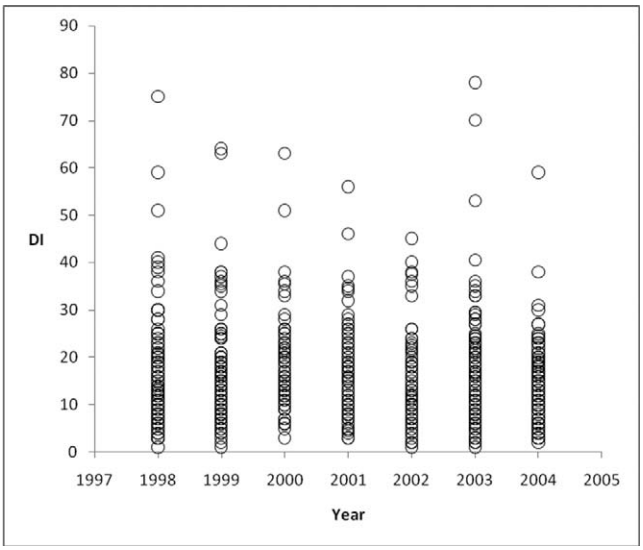

Figure 3. Discrepancy Index (DI) versus year.

as defined by the ABO.[17] The OGS and CCA scores were positively correlated with the DI score, meaning that complex malocclusions are challenging to finish well. Thus, the DI may be a useful index for estimating a fee for difficult malocclusions that is fair to both the patient and the clinician.

As shown in Table 1, the average DI score for malocclusions in the permanent dentition was 15.7. When the size of the sample (n = 716) is considered, these data indicate that the patients reviewed are representative of the range of DI scores required for ABO certification.[12] Most of the patients required for phase 3 exam must have a DI ≥16, which is approximately the average for the present study. Thus, the present patient base is adequate for achieving board certification requirements.

For all finished cases in the current sample, the average ABO OGS score was 28.2 ± 13.0. Figure 1 demonstrates that the DI did not correlate strongly with the ABO OGS score. The experience of the ABO is that OGS scores ≥30 probably will fail, and a score of ≤20 probably will pass.[10] However, OGS scores are only a general guide; many aspects of case evaluation are important. From an outcomes perspective, an OGS score >30 points is defined as an inadequate finish for most patients. Overall, the mean DI (15.7) and the average OGS score (28.2) suggest that many of the patients in the present sample were of potential board quality.

Figure 2 shows the distribution of DI scores to the CCA. No strong correlation was found between the two. The average CCA score for the present sample was 4.2 ± 2.8, which compares favorably with the means of 4.67 and 4.38 reported by Pinskaya et al[13] and Knierim et al,[15] respectively. The improved CCA for the present sample reflects the exclusion of patients started in the mixed dentition.

Figure 3 demonstrates that the distribution of DI scores is relatively uniform from year to year with no significant secular trend. These data indicate that the DI is a reliable index for assessing malocclusion complexity in a graduate orthodontics program. Although the most severe malocclusions tended to have compromised outcomes,[16] the present analysis of all patients started in the permanent dentition shows that overall clinical standards for correcting malocclusions were relatively independent of the complexity of the problem. These data are encouraging, relative to management of routine malocclusions. However, it is important to use DI scores and ABO malocclusion classification to identify the most severe problems. The latter require special attention and monitoring to achieve an optimal result. From a private practice perspective, the additional effort required to treat severe malocclusions should be reflected in the fee for treatment. Averaging costs over all patients is not fair to the clinician or to those individuals with more moderate malocclusion.

CONCLUSIONS

- DI and outcomes (OGS and CCA scores) are significantly related for the most severe malocclusions (ABO classification), but only a weak positive association is seen for all patients treated in the permanent dentition.
- For most patients, the outcome is more dependent on treatment timing and on patient cooperation than on the complexity of the malocclusion (DI).
- The DI is a reliable and relatively stable index for assessing malocclusion complexity.
- DI and ABO malocclusion classifications are important indicators for estimating the difficulty expected in achieving an optimal result.

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