Original Article

Relationship between pretreatment case complexity and orthodontic clinical outcomes determined by the American Board of Orthodontics criteria

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ABSTRACT

Objective: To evaluate the relationship between pretreatment case complexity and orthodontic treatment outcomes.

Materials and Methods: The total sample contained 1693 cases (853 females and 840 males, mean age = 16.3 years) from the archives of postgraduate orthodontic clinics. The complexity of each case was evaluated using the American Board of Orthodontics (ABO) Discrepancy Index (DI), and orthodontic clinical outcomes were evaluated using the ABO Objective Grading System (OGS). Only one investigator evaluated all cases. Multivariate analysis of variance, correlation analysis, and multiple variable regression analysis were used for statistical evaluation ($P < .05$ as significant).

Results: The mean total DI score was 16.2, and the mean total OGS score was 18. No significant correlation was found between the total DI and the total OGS scores. However, pretreatment overbite, lateral open bite, crowding, buccal posterior crossbite, and other components affected the total OGS score significantly. The highest percentage of passing OGS values was found for cases of medium-level complexity.

Conclusion: This retrospective study of university clinical records showed that the posttreatment clinical outcomes were significantly affected from pretreatment case complexity. Posttreatment alignment was affected significantly from pretreatment buccal posterior crossbite and cephalometric values. Similarly, posttreatment buccolingual inclination was affected from pretreatment anterior open bite, occlusion, and other factors. Occlusal contacts were affected significantly from pretreatment lingual posterior crossbite and other factors. In addition, we determined that posttreatment root angulations were affected significantly from pretreatment crowding values. (*Angle Orthod.* 0000;00:000–000.)

KEY WORDS: Orthodontics; Case complexity; Clinical outcomes; ABO

INTRODUCTION

The goal of the American Board of Orthodontics (ABO) since its beginning is to raise the standards of the practice of orthodontia.[1] The ABO has used the Discrepancy Index (DI) to assess pretreatment case complexity since 1998. There are presently 10 categories that are evaluated in the DI: overjet, overbite, anterior open bite, lateral open bite, crowding, occlusion, lingual posterior crossbite, buccal posterior crossbite, cephalometric values (ANB angle, IMPA, SN-GoGn), and an "other" category.[1,2]

Occlusal indices are helpful to clinicians in diagnosis, research design, decision making, and evaluation of orthodontic treatment need and clinical outcomes. The Peer Assessment Rating (PAR) index was developed to record measurements of a malocclusion and has been widely used for the evaluation of the severity of malocclusions and the effects of treatment in resolving them.[3,4] Even though it has been useful for quantifying the amount of change during malocclusion correction, the PAR index cannot be used to quantify tooth positions exactly. A commission of ABO directors was formed in 1994 to develop a system that could be used to quantify tooth positions more exactly. After 4 years of clinical trials at each yearly ABO clinical examination, in 1997, the ABO completed its Objective

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Grading System (OGS) for scoring posttreatment case records. This system comprises eight criteria that are evaluated using a numeric measure: alignment, marginal ridge height, buccolingual inclination, occlusal relationship, occlusal contact, overjet, interproximal contact, and root angulation.[5,6] This system mainly has a specific gauge to standardize the measurements by the examiners. Using an ABO measuring gauge, this system was implicated in the evaluation of the final casts and panoramic radiographs of each case.

Many studies have been carried out to evaluate the reliability of the ABO-DI. Most of these studies were all in agreement that the DI could be a reliable instrument to evaluate the pretreatment case complexity.[7–10] The validity and reliability of the ABO-OGS was confirmed, and the measure was subsequently used in the evaluation of orthodontic records. The ABO-OGS provides a method for an objective assessment of the outcome and achievement of orthodontic treatment.[6]

There are few studies in the literature performed to investigate the relationship between the DI of the pretreatment dental records and the OGS of the posttreatment dental records. The current study differs from previous studies correlating the DI with the OGS because only cooperative patients who completed treatment are considered in this study, while previous studies considered all patients. In addition, the current study has a larger sample size than the previous studies.

The purpose of this retrospective study was to evaluate the relationship between the complexity of cases using the ABO-DI and clinical outcomes using the ABO-OGS. The null hypothesis tested states that there is no significant relationship between the components of the ABO-DI and the posttreatment ABO-OGS scores.

MATERIALS AND METHODS

Ethical approval for this study was obtained from the Ethical Committee of the University of Erciyes, Faculty of Dentistry. The sample chosen for this retrospective study was selected randomly from the archives of nine postgraduate university orthodontic clinics in a variety of cities in Turkey. There is an important issue that the duration and quality of treatment is parallel to the practitioner's level of orthodontic experience; thus, in current research, we used cases that were treated only by experienced residents in orthodontics. The orthodontic competence of the residents was generally similar (third or fourth years of the postgraduate education in orthodontics). All cases were treated with traditional Roth prescription 0.018-inch brackets in all investigated orthodontic clinics.

The following inclusion and exclusion criteria were applied during the selection of cases. Inclusion criteria were the following:

- Patients with regular appointments
- Fixed appliances must contain wires and brackets
- Patients who started and completed treatment in the same clinic
- Those whose treatment was started and finished by the same orthodontist
- Cases that included pretreatment panoramic radiographs and lateral cephalograms and also posttreatment dental casts and panoramic radiographs

Cases were excluded if:

- They began treatment before the year 2005
- They were treated by orthodontic teaching staff
- Treatment was finished for personal reasons (poor oral hygiene, moving to another city, leaving treatment, etc)
- Cases had only digital dental casts
- Dental plaster casts were broken
- Records were incomplete/missing
- Negative chart entries due to lack of cooperation or poor oral hygiene

The total sample contained 1693 cases (853 female and 840 male) with an average age of 16.3 years at the start of treatment. Every case had pretreatment and posttreatment orthodontic records, including panoramic radiographs and lateral cephalograms, as well as dental casts. Treatment plans and progress notes were also examined.

The principal author was initially trained in the ABO-OGS using the ABO Calibration Kit from March 2011 as well as a tutorial using the ABO gauge (Figure 1). Only one investigator evaluated all the cases. Pretreatment dental casts, panoramic radiographs, and lateral cephalograms were used to calculate the total DI score. The DI scores were determined by the formula introduced by Cangiolosi et al.[1] and announced in the ABO November 2006 guidelines. The dental models were evaluated with a digital caliper and ruler according to directions by Cangialosi et al.[1] Posttreatment panoramic radiographs and dental models were used to collect the OGS score. The dental models were evaluated with the ABO gauge according to directions by Casko et al.[6]

The total sample was separated into three groups according to pretreatment case complexity according to ABO-DI scores as low, medium, and high complex patients. The low DI group contained cases that scored <7, the medium DI group contained cases that scored 8–16, and the high DI group consisted of cases that scored ≥ 17. These groupings were

Figure 1. ABO measuring gauge.

identified based on the ABO's classification of case discrepancy.[5,7,11]

Furthermore, all cases were divided into subgroups according to the measure of three grades of treatment quality (passing, undetermined, and failing) based on their OGS scores of the posttreatment records. These groupings were based on the ABO's experience that cases with scores of less than 20 commonly pass (passing) and cases with scores of more than 30 are generally unsuccessful (failing). The 20–30 scores show undetermined scores (undetermined).[5,6]

Statistical Analysis

A power analysis performed prior to the data collection indicated that a sample size of 1450 achieves 90% power to detect an R^2 of .01 attributed to 10 independent variables using an *F* test with a significance level (alpha) of .05000.

To assess the intraexaminer repeatability, a subsample of 20 patients was randomly selected from the main sample. The measurements were repeated at 8 weeks after the first measurements. A paired-sample *t*-test was applied to the first and second measurements, and the differences between measurements were evaluated. The paired-sample *t*-test results for the intraexaminer repeatability indicated that the first and second measurements and the differences between measurements were insignificant.

A multivariate regression analysis was conducted to test the main effects of the ABO-DI components such as overjet, overbite, anterior open bite, crowding, occlusion, lingual posterior crossbite, buccal posterior crossbite, cephalometric values, and other on the eight ABO-OGS components: alignment, marginal ridge height, buccolingual inclination, overjet, occlusal contact, occlusal relationship, interproximal contact, and root angulation.

After a significant test statistic was obtained for multivariate analysis of variance using the same dependent and independent variables, the multivariate regression analysis was performed preceding univariate follow-up tests on each predictor.

Follow-up hypothesis testing for each predictor was conducted to determine whether each of the predictors had a statistically significant effect across all regression equations simultaneously, holding the impact of the other predictors constant. Those tests were based on the *F* statistic with degrees of freedom of (p-1, n-k), where p is the number of criterion variables and k is the number of parameters.

When the *P* value was less than .05, the statistical test was determined as significant.

RESULTS

Descriptive statistics and the results of the correlation between DI and OGS scores are given in Table 1. The mean total ABO-DI score was 16.2, and the mean total ABO-OGS score was 18. There was no significant correlation between total DI and total OGS scores ($F =$ 1.87; $P = .172$).

Descriptive statistics and comparison of the overall average scores of the DI groups based on "passing," "undetermined," and "failing" OGS values are given in Table 2. When comparing the overall average scores of the DI groups based on passing, undetermined, and failing OGS values, an insignificant difference was observed ($P > .05$). But the highest percentage of passing OGS values was found for medium-level complex cases.

The multivariate regression test between DI and OGS components is given in Table 3. Overbite ($P = .017$*), lateral open bite ($P = .049$*), crowding ($P = .012$*), buccal posterior crossbite ($P = .003$**), and other components ($P = .015$*) were significant predictors of eight regression equations simultaneously.

Posttreatment alignment was affected significantly from pretreatment buccal posterior crossbite and

Table 1. Descriptive Values and Multiple Comparisons of the Two Groups

	Mean	SD	n	*F*	Significance
OGS score	18.01	8.850	1693	1.87	.172
DI score	16.21	8.403	1693		

Table 2. Comparison of the Overall Average Scores of the DI Group Based on "Passing," "Undetermined," and "Failing" Values[a]

Groups			Clinical Outcomes (OGS Scores) Passing	Undetermined	Failing	Total
Pretreatment case complexity	Low complex cases	Count	129_a	52_a	22_a	203
		% Within DI group	63.5	26.5	10.0	100.0
		% Within quality	12.4	10.6	9.3	11.6
		% Of total	7.7	3.1	0.8	11.6
	Medium complex cases	Count	474_a	246_a	62_a	782
		% Within DI group	60.6	31.5	7.9	100.0
		% Within Quality	45.5	50.0	41.1	46.4
		% Of total	28.1	14.6	3.7	46.4
	High complex cases	Count	439_a	194_a	75_a	708
		% Within DI group	62.0	27.4	10.6	100.0
		% Within quality	42.1	39.4	49.7	42.0
		% Of total	26.1	11.5	4.5	42.0

[a] Each subscript letter denotes a subset of OGS categories whose column proportions do not differ significantly from each other at the .05 level.

cephalometric values ($P < .05$). Posttreatment buccolingual inclination was affected significantly from pretreatment anterior open bite, occlusion, and other factors ($P < .05$). Posttreatment occlusal contacts were affected significantly from pretreatment lingual posterior crossbite and other factors ($P < .05$). Posttreatment root angulation was affected significantly from pretreatment crowding ($P < .01$).

According to these different findings, the null hypothesis of the present study was rejected.

Figure 2 is a scatter plot of total DI and total OGS showing the regression equation (R^2 linear = .001).

DISCUSSION

The current study differs from previous studies correlating DI with OGS because only cooperative patients who completed treatment are considered in this study, while previous studies considered all patients and the current study has a larger sample size than the previous studies. Thus, the aim of this retrospective study was to evaluate the relationship between the complexity of cases at the pretreatment stage and the posttreatment clinical outcomes.

Okunami et al.[12] assessed the differences between digital and plaster dental casts to score the ABO-OGS. They reported that the recent digital programs were not adequate for scoring all parameters as required by the ABO-OGS. So only dental plaster casts were used, and digital models were excluded in the current study.

Patients with good oral hygiene may be more likely to cooperate with other features of treatment.[3,13] Nevertheless, it is also likely that orthodontic tooth movement may be more successful when there is a little amount of gingival inflammation. Thus, patients who had negative chart entries due to absence of cooperation or poor oral hygiene were excluded from the present study.

Detterline et al.[14] evaluated clinical outcomes of cases treated in a university graduate orthodontic clinic with 0.018-inch and 0.022-inch brackets using ABO-OGS. They found lower ABO-OGS scores in four categories (alignment, marginal ridges, overjet, and

Table 3. Multivariate Regression Test Between DI and OGS Components

DI Components	OGS Components Alignment*	Marginal Ridge Height	Buccolingual Inclination***	Overjet	Occlusal Contact**	Occlusal Relationship	Interproximal Contact	Root Angulation**	Multivariate Significance
Overjet	.011	.022	.034	.068	.088	.013	.019	.002	.265
Overbite	.029	.099	.044	.172	.100	.110	.015	.011	**.017***
Anterior open bite	.029	.030	.073*	.026	.014	.014	.023	.013	.086
Lateral open bite	.041	.153	.113	.027	.231	.140	.062	.002	**.049***
Crowding	.029	.016	.025	.078	.052	.015	.000	.013**	**.012***
Occlusion	.016	.031	.042*	.006	.009	.016	.008	.002	.199
Lingual posterior crossbite	.012	.067	.043	.028	.158*	.055	.007	.008	.317
Buccal posterior crossbite	.014*	.043	.080	.106	.094	.016	.005	.069	**.003****
Cephalometric values	.019*	.004	.004	.014	.029	.011	.002	.003	.149
Other	.035	.002	.06*	.080	.139*	.052	.014	.007	**.015***

* $P < .05$; ** $P < .01$; *** $P < .001$. The mean difference is significant at the .05 level.

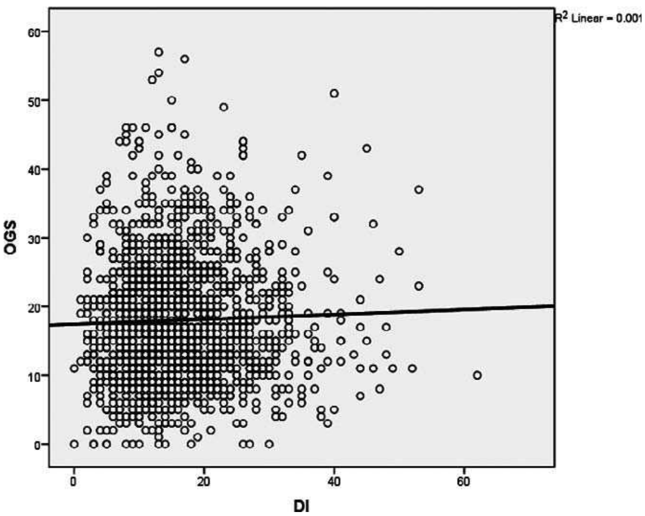

Figure 2. A scatter plot of total OGS and total DI showing the regression equation.

root angulations) as well as lower total ABO-OGS scores with the 0.018-inch brackets. In the present study for the bracket design variable, we standardized it and used only cases treated with the 0.018-inch brackets.

Understanding the presence of the relationship between DI and different OGS categories might be valuable for every orthodontist. If a positive relationship were determined and the residual amount of predictability were known, the orthodontist could guess the quality of treatment outcomes as evaluated by the OGS.[8]

Various recent studies have examined the possibility of a correlation between case complexity and orthodontic clinical outcomes. Some of these studies have been carried out at the same clinic with opposing results. Campbell et al.[9] investigated 382 cases and determined a positive correlation between case complexity and clinical outcome (correlation coefficient = .2), precisely in more complex cases. Although this is a weak correlation, the research concluded that complex malocclusions were interesting to treat well. These findings were supported by another study by Pulfer et al.[11] Pulfer et al.[11] evaluated the relationship between the ABO-DI and outcomes for routine malocclusions. They found a mean DI of 15.7, a mean OGS score of 28.2, and only a weak correlation between the DI and OGS components (correlation coefficient = .17). For most patients, the outcome was more dependent on treatment duration and on patient cooperation than on the complexity of the malocclusion. The DI is a reliable and stable index for evaluating malocclusion complexity.[11] The DI and ABO malocclusion classifications are essential indicators for guessing the difficulty expected in achieving an ideal result.[8]

A third study from the same clinic as the earlier two studies showed contrasting results. Samples of 455 patients finished between years 2004 and 2006 were evaluated mainly to determine factors of treatment time as well as the association between treatment time and the quality of treatment outcomes. Their outcomes showed that the pretreatment DI scores were not significantly correlated with the posttreatment OGS score. Although patients with a DI $>$20 required a longer duration to treat, a similar OGS outcome was achieved compared with less severe cases (DI $<$ 20).[7,8]

In the present study, there was no statistically significant difference in the posttreatment OGS scores among the three groups of different complexity. Overall, 61.8% of the total cases were in the passing group, 29.2% were in the undetermined group, and 9% were in the failing group. Deguchi et al.[10] stated that a serially finished sample from a university clinic had 14% in the passing group, 33% in the undetermined group, and 53% in the failing group. But although Deguchi et al.[10] used only 126 cases in total, we used 1693 cases. The total sample achieves 100% power in the present study.

An analysis of variance was achieved among the three groups to analyze whether there was a difference in the passing, undetermined, and failing groups among the low, medium, and high patient complexity groups. The results are shown in Table 2. When comparing the overall average scores of the DI groups based on passing, undetermined, and failing values, an insignificant difference was observed. But the highest percentage of passing cases was found for the medium-complexity patient group.

One of the aims of this study was to define whether there are any associations among any of the factors included that may contribute some estimator value for the orthodontist. For example, research done by Campbell et al.[9] found that for each increase in the DI score, the OGS score increased by 0.23 $\pm$ 0.06. Unlike Campbell et al., Cameron[8] found no significant correlation between the total DI score and total OGS score. But buccolingual inclination, occlusal contacts, and the occlusal relationship, which are the posttreatment OGS components, were the highest contributors to this difference in posttreatment scores. In the present study, there was no significant correlation between the total DI score and total OGS score (F = 1.87; P = .172). But according to regression results, the components overbite, lateral open bite, crowding, buccal posterior crossbite, and "other" were significant predictors of eight regression equations, simultaneously. Thus, overbite, lateral open bite, crowding, buccal posterior crossbite, and "other" DI components affected the total OGS score significantly.

Even though there was no significant correlation between the total DI and total OGS scores, posttreatment alignment, buccolingual inclination, occlusal contacts, and root angulation components were affected significantly from some of the pretreatment DI components. Pretreatment buccal posterior crossbite, anterior open bite, occlusion, lingual posterior crossbite, cephalometric values, and other factors affected the posttreatment clinical outcomes. Posttreatment alignment was affected significantly from pretreatment buccal posterior crossbite and cephalometric values. Similarly, posttreatment buccolingual inclination was affected from pretreatment anterior open bite, occlusion, and other factors. Occlusal contacts were affected significantly from pretreatment lingual posterior crossbite and other factors. In addition, we determined that posttreatment root angulations were affected significantly from pretreatment crowding values.

Knierim et al.[15] assessed treatment outcomes for a graduate orthodontics clinic using ABO-OGS for 2001–2003. They found a mean OGS score of 25.19. The OGS scores have improved over time. Thus, treatment outcomes have become better over the years. It was thought that if OGS scores were evaluated regularly in orthodontic clinics, treatment outcomes would be improved. In the future, multiyear analysis of OGS scores might be useful and valuable.

CONCLUSIONS

- The mean total DI and OGS scores were found to be 16.2 and 18, respectively. There was no significant correlation between the total DI and total OGS scores.
- Pretreatment overbite, lateral open bite, crowding, buccal posterior crossbite, and other components affect the total OGS score.
- Posttreatment alignment was affected from pretreatment buccal posterior crossbite and cephalometric values.
- Posttreatment buccolingual inclination was affected from pretreatment anterior open bite, occlusion, and other factors.
- Posttreatment occlusal contacts were affected from pretreatment lingual posterior crossbite and other factors.
- Posttreatment root angulation was affected from pretreatment crowding.

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