Original Article

Posttreatment Occlusal Variability Among Angle Class I Nonextraction Patients

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ABSTRACT

Objective: To test the hypothesis that variability among posttreatment Angle Class I, nonextraction patients is not related to patient and treatment factors.

Materials and Methods: One hundred thirty-eight subjects were randomly selected from the archives of the Department of Orthodontics, St Louis University. Patient factors evaluated included age, sex, mandibular plane angle, and ANB angle; treatment factors included active treatment time and supervising orthodontist. Objective Grading System (OGS) scores for six of the criteria (excluding interproximal contacts and root angulations) and the anterior Bolton ratio were measured on the posttreatment study casts.

Results: The partial mean overall OGS score was 24.9 ± 8.0. Occlusal contact was the most important component contributing to the overall score, followed by alignment. Variation in the OGS scores was explained by sex, pretreatment mandibular plane and ANB angles, the posttreatment anterior Bolton ratio, and treatment duration. The partial overall OGS scores increased by approximately one point for every 4° increase in the mandibular plane angle and nearly one point for every 3 additional months of treatment. Approximately 16% and 15% of the variation in alignment and buccolingual inclination, respectively, was due to the treating orthodontist.

Conclusions: Posttreatment occlusal variability among Class I nonextraction patients can be partially explained by patient- and treatment-related factors.

KEY WORDS: Objective Grading System; Posttreatment; Occlusion; Variability; Class I malocclusion; Nonextraction

INTRODUCTION

The American Board of Orthodontics (ABO) developed the Objective Grading System (OGS) as an occlusal index to evaluate posttreatment dental casts.[1] Studies show considerable variation in OGS scores among posttreatment occlusions (Table 1).[2–12] Variation within samples ranges from 29% to 47%. For example, Cook et al[3] reported an average overall OGS score of 25.1, with individual variation ranging up to almost ±24 for a university sample; Yang-Powers et al[10] showed that the posttreatment total OGS scores could average as high as 45.5 and range higher than ±36. Because orthodontists strive to achieve the best occlusal results possible, it is important to understand how much variability actually exists among treated patients, which components of occlusion are most variable, and what factors determine posttreatment variability.

There are various patient-related factors, such as skeletal discrepancies and anterior Bolton discrepancies, that might be expected to explain posttreatment variability. Moreover, orthodontic treatments of anteroposterior and vertical skeletal discrepancies often require dentoalveolar compensations to correct the occlusion. Anterior teeth are frequently positioned at different angles within the alveolus to compensate for the skeletal disharmonies. Andrews,[13] for example, has demonstrated how third-order angulation of the anterior teeth affect posterior occlusion. Marginal ridges, overjet, occlusal relationships, and occlusal contacts—all components of the OGS—might be affected by such compensations. Differences in the sizes of the

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Accepted: August 2007. Submitted: May 2007.

Table 1. ABO OGS Scores Reflecting Mean Points Lost and Standard Deviations in Previously Reported Samples of Posttreatment Occlusions[2–12] Compared to Current Research Results

		Alignment		Marginal Ridges		Buccolingual Inclination		Overjet		Occlusal Contacts		Occlusal Relationship		Partial Overall 6 Components	Overall 8 Components		Coefficient of Variation
Study	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	Mean	SD	
Abei et al[2]																	
Orthodontist	126	5.4	4.4	3.9	2.9	4.5	4.0	4.2	4.0	4.1	4.3	3.1	3.4	25.2	26.0[a]	11.4	.438
General practitioner	70	7.8	5.2	4.4	2.9	4.2	3.0	3.8	3.1	4.9	5.2	3.3	3.5	28.4	29.6[a]	12.8	.432
Cook et al[3]																	
University	77	6.1	3.1	2.9	2.2	1.5	1.4	5.7	4.4	2.5	3.4	5.0	4.3	23.7	25.1	11.9	.474
Private practice	62	5.4	2.8	2.2	1.9	1.8	2.0	5.8	4.2	4.7	3.8	3.7	3.5	23.6	26.0	9.7	.373
Cook[4]	115	6.0	2.8	3.7	2.5	2.4	2.4	3.7	3.1	3.5	3.2	3.6	3.0	22.9	28.5	10.0	.351
Costalos et al[5]	24	7.8	3.9	4.0	2.6	6.7	3.1	4.7	2.8	5.3	5.3	2.2	2.6	30.7	31.2	10.5	.337
Deguchi et al[6]																	
Japan	72	5.5	2.3	3.2	2.2	6.9	3.7	6.6	2.5	4.7	3.4	3.1	3.0	30.0	33.6	13.6	.405
United States	54	6.1	3.8	2.9	3.5	5.6	3.3	4.5	3.2	5.8	3.4	3.7	3.8	28.6	32.8	10.3	.314
Djeu et al[7]	48	6.8	3.3	4.4	2.6	2.8	2.6	3.6	2.5	5.7	4.7	5.5	4.7	28.8	32.2	11.7	.363
Nett and Huang[8]	100	5.0	2.8	3.6	2.5	3.0	2.0	4.1	2.8	3.9	3.5	1.8	3.2	21.5	21.5[b]	8.8	.409
Ormiston et al[9]																	
Group 1	41														31.6	12.3	.389
Group 2	45														25.2	9.0	.357
Yang-Powers et al[10]																	
University	92	8.8	5.1	5.4	3.4	9.4	5.0	6.5	5.0	8.2	7.0	4.6	4.1	42.9	45.5	18.3	.402
American Board of Orthodontics	32	7.3	4.3	5.1	3.4	7.9	4.8	2.6	3.0	2.5	3.3	3.2	3.3	28.6	33.9	9.7	.286
Knierim et al[11]	437	3.5	2.0	3.7	2.1	4.1	2.3	2.8	3.0	4.6	3.6	3.3	3.1	22.0	25.2	11.2	.444
Pinskaya et al[12]	521														34.4	10.4	.302
Current study	138	5.2	2.8	4.5	2.3	4.6	2.3	2.6	1.8	6.3	3.7	1.7	1.8	24.9	24.9	8.0	.321

[a] Includes seven of eight component scores.
[b] Includes six of eight component scores.

anterior maxillary and mandibular teeth might also be expected to explain the variation in posttreatment occlusions.

In addition to patient factors, there are treatment factors such as the diagnostic, technical, or motivational skills of the doctor that could contribute to variation in posttreatment occlusions. Treatment outcomes might also be affected by treatment duration because the duration depends on patient compliance, missed appointments, debonds, and so forth. Since treatment factors are controllable, their contribution to variability must be understood so that orthodontists can provide the best treatment possible for each patient.

The purpose of the current study was to evaluate patient- and treatment-related variability among patients with Angle Class I malocclusions who underwent nonextraction treatment at the postgraduate orthodontic clinic at St Louis University. These relationships have not been previously explored. Class I malocclusions were chosen because they comprise most of the cases treated in the typical orthodontic practice.

MATERIALS AND METHODS

The sample includes 81 females and 57 males randomly selected from the archives at the Department of Orthodontics, St Louis University. To be included in the study, patients had to have Class I molar relationships at the beginning of treatment (T1), nonextraction treatment as determined from casts taken immediately following treatment (T2), second molars in occlusion, only one supervising instructor, and no more than two treating residents. The treatment techniques used by the clinical instructors varied from nontorqued and nonangulated brackets, through straight wire, to Tip-edge appliances. A variety of wires, including M-NiTi, A-NiTi, and TMA, among others, and self-ligating brackets were also used. Exclusion criteria included patients with missing teeth, patients with craniofacial anomalies or syndromes, patients who were treated in two phases or with surgery, and retreated subjects. The patients were chosen without regard to age, race, or sex.

The data collected from the patients' charts included

Table 2. Age, Treatment Duration, and Morphological Characteristics of the Sample (N = 138)

	Age at T1, y	Treatment Time, mo	ANB, °	Sn-GoGn, °	Anterior Bolton, %
Mean	13[a]	20.6	2.6	31.6	77.3
SD	—	6.0	2.4	5.5	2.3
Range	10–48	8–44	−3 to 11	17–48	70.7–83.3

[a] Median age.

age, sex, time in fixed appliances, the ANB angle at T1, the T1 mandibular plane angle as defined by SN-GoGn (FMA plus 7° was used in the 7% of cases for whom this value was unavailable), and the supervising instructor. The anterior Bolton ratio was measured at T2 by the primary investigator using a Boley gauge. The ABO Objective Grading System, as defined by Casko et al,[1] was used to evaluate the casts of all subjects at T2. The primary investigator measured all of the casts after having been calibrated for the OGS. To control for bias, the examiner was blinded as to the patients' and instructors' identity when scoring the casts.

The ABO OGS uses eight components: alignment, marginal ridges, buccolingual inclination, overjet, occlusal contacts, occlusal relationships, interproximal contacts, and root angulation. Six of the eight criteria were measured in the current study, as described by Nett and Huang.[8] Interproximal contacts and root angulation, the other two criteria, were not included in this nonextraction study because they pertain primarily when extraction spaces must be closed.

Replicate analyses of 20 randomly chosen models showed no significant systematic errors. Method errors for the six components ranged from 0.45 to 0.77, with buccolingual and occlusal contacts showing the greatest technical errors. Method error for the partial overall score was 1.20. Stepwise multiple regression was used to evaluate each component's contribution to the variation of the overall OGS score. Multilevel modelling[14] was used to determine the effects of patient and treatment factors.

RESULTS

Females and males comprised 58.7% and 41.3% of the sample, respectively. The median pretreatment age was 13 years, with a range from 10 to 48 years (Table 2). The average treatment duration was 20.6 months and ranged from 8 to 44 months. The pretreatment ANB and mandibular plane angles were 2.6° ± 2.4° and 31.6° ± 5.5°, respectively. The mean anterior Bolton ratio was 77.3%, with a range from 70.7% to 83.3%.

The total of the six graded OGS components was 24.94 ± 7.99 (Table 3), with a coefficient of variation of .321. The distribution of the partial overall scores ranged from 5 to 48 and was approximately normal (Figure 1). The highest average component score (most points lost) was occlusal contacts at 6.25 ± 3.75. The lowest average component score (fewest points lost) was occlusal relationships at 1.74 ± 1.83. Independently, occlusal contacts accounted for approximately 26% of the total deductions, followed by alignment (21%), buccolingual inclinations (18%), marginal ridges (18%), overjet (10%), and occlusal relationships (7%). Stepwise multiple regression (Table 4) showed that most (56.2%) of the variation in the partial overall score was explained by the occlusal contacts, followed by alignment (17.7%), marginal ridges (10.3%), overjet (6.1%), buccolingual inclination (5.4%), and occlusal relationships (4.2%).

Multilevel estimates showed that treatment duration (.297) and the mandibular plane angle (.256) had significant effects on the partial overall OGS scores (Table 5). Variation in marginal ridges and occlusal relationships was explained by sex, variations in alignment and buccolingual inclinations were explained by treatment duration, the mandibular plane angle explained variation in buccolingual inclinations and occlusal contacts, the ANB angle explained variation in buccolingual inclinations, and the anterior Bolton explained the variation in overjet. Sixteen percent of the variation in alignment and 15% of the variation in buccolingual inclinations could be attributed to the orthodontists (Table 6). Only a small portion of the variation (2.3%) in the partial overall OGS score was explained by doctor variation. There was no significant variation among the treating orthodontists' outcomes for marginal ridges, overjet, occlusal contacts, or occlusal relationships.

DISCUSSION

The OGS scores indicated less posttreatment occlusal variability and lower average overall scores than

Table 3. Objective Grading System Component and Total Scores Based on Six Components (N = 138)[a]

	Alignment	Marginal Ridges	Buccolingual Inclination	Overjet	Occlusal Contact	Occlusal Relations	Total
Mean	5.20	4.50	4.64	2.62	6.25	1.74	24.94
SD	2.76	2.32	2.31	1.85	3.75	1.83	7.99
Minimum	0	0	0	0	0	0	5
Maximum	14	11	13	8	18	11	48

[a] Interproximal contacts and root angulations were not evaluated.

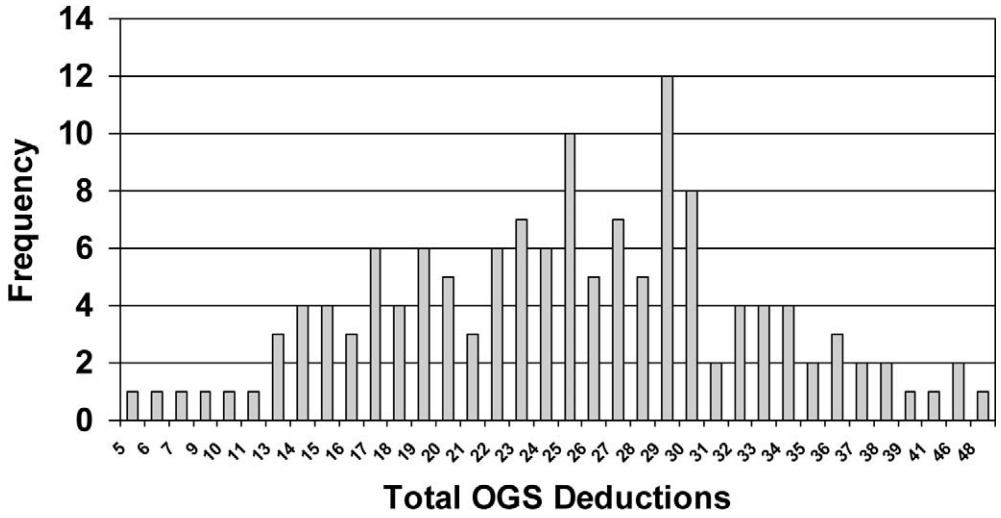

Figure 1. Frequency distribution of total Objective Grading System score deductions.

Table 4. Stepwise Multiple Regression Describing the Contributions of the Components (Independent Variables) to the Total Score (Dependent Variable)

Step	Variable	*R*	R^2	R^2 Change	Standardized Coefficient
1	Occlusal contacts	.750	.562	.562	.469
2	Alignment	.860	.739	.177	.345
3	Marginal ridges	.918	.842	.103	.291
4	Overjet	.951	.904	.061	.232
5	Buccolingual inclination	.979	.958	.054	.289
6	Occlusal relationships	1.000	1.000	.042	.228

Table 5. Multilevel Estimates and Standard Errors for the Effects of Age at the Start of Treatment, Sex of the Patient, Treatment Duration, Initial Mandibular Plane Angle (MPA), Initial ANB Angle, and Initial Anterior Bolton Ratio on the Objects Grading System Scores[a]

	Constant		Sex		Duration		MPA		ANB		Bolton	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Alignment	3.469	0.847			.084	.038	—	—	—	—	—	—
Marginal ridges	4.838	0.255	−.803	.394	—	—	—	—	—	—	—	—
Buccolingual inclination	0.986	1.187	—	—	.076	.030	.087	.032	−.252	.073		
Overjet	2.623	0.157	—	—	—	—					−.131	.067
Occlusal contacts	2.366	1.836	—	—	—	—	.123	.057				
Occlusal relations	1.362	0.197	.896	.304	—	—	—	—	—	—	—	—
Total scores	10.760	4.260	—	—	.297	.109	.256	.119	—	—	—	—

[a] Dashes indicate not statistically significant; for example, alignments = 3.469 = (.084 × duration).

previously reported. The coefficient of variation (CV) showed 2% to 15% less overall variability than previous studies. Reduced variability could be attributed to sample selection. Whereas this study focused on Class I malocclusions treated without extractions, previous studies included various malocclusion types. Reduced variability was probably not due to the limited number of OGS components used. Nett and Huang,[8] who used the same six criteria and a comparably sized university sample (n = 100), reported slightly lower partial overall OGS scores (mean = 21.5) but more variation (CV = .409).

Table 6. Absolute and Relative Between-Doctor (B/D) and Between-Patient (B/P) Variation in Objective Grading System Scores (N = 138)

	B/D	B/P
Alignment	1.17 (16.1%)	6.101 (83.9%)
Marginal ridges	0.001 (0.0%)	5.284 (100.0%)
Buccolingual inclination	0.78 (15.1%)	4.373 (84.9%)
Overjet	0.002 (0.1%)	3.372 (99.9%)
Occlusal contacts	0.08 (0.6%)	13.787 (99.4%)
Occlusal relation	0.001 (0.0%)	3.303 (100.0%)
Total scores	1.399 (2.3%)	59.835 (97.7%)

Occlusal contacts was the most important component contributing to and explaining the variability in the partial overall OGS scores of Class I nonextraction patients. Occlusal contacts have been previously shown to be important determinants of the overall OGS scores.[2,6,7,10,11] This suggests that less attention was given to this aspect of finishing. However, occlusal contacts, particularly those of the maxillary palatal cusps, are the most difficult of the occlusal components to inspect clinically prior to appliance removal. Furthermore, occlusal contacts typically improve as the occlusion settles after appliance removal,[8] suggesting that this component is likely to be less problematic over time.

Alignment was the next most important component of occlusion contributing to the variation in the overall OGS scores. Alignment has been previously shown to be the most important component.[2–8] Since alignment is a primary objective of orthodontic treatment, it is weighted heavily in the OGS. There are 56 possible point deductions for this component (excluding third molars), and deviations as small as 0.5 mm warrant a deduction.[1] Most other components have half or fewer possible point deductions and a larger threshold of deviation before points are deducted. This could explain the large contribution of alignment to the overall OGS score in this and other studies. It suggests that this component of the OGS may have to be rescaled to ensure more equal contributions.

Patients with higher pretreatment mandibular plane angles had significantly higher total OGS scores (more total deductions) than patients with lower mandibular plane angles. The multilevel estimates showed that the partial overall OGS score increased by one point for every 4° increase in the mandibular plane angle. This indicates that the pretreatment mandibular plane angle, when used as a diagnostic patient factor, can have an effect on the final occlusion. It validates the use of SN-GoGn in the ABO Discrepancy Index[15] to estimate pretreatment case complexity. The mandibular plane also accounted for variation in occlusal contacts and buccolingual inclinations. Transverse skeletal discrepancies that often accompany a high mandibular plane often require dentoalveolar compensations that could explain its effect on these two occlusal components and the overall score.

Patients with longer treatment times also had significantly higher partial overall OGS scores (more total deductions). The large range of treatment times observed (8 to 44 months) could have been due to differences in the initial malocclusion, patient cooperation, various treatment approaches used, timing of eruption, and the teaching environment. Overall OGS scores increased nearly one point for every 3 additional months of treatment. Longer treatment time has been previously related to higher OGS scores.[11] This suggests that prolonged treatment does not routinely result in a better posttreatment occlusion. Specifically, alignment and buccolingual inclinations had more deductions with increased treatment time. This was likely due to appliance breakage or other compliance issues. Orthodontists should critically evaluate cases that have exceeded estimated treatment times to determine if termination of therapy is warranted in light of poor compliance or other factors.

The orthodontists accounted for significant variation in alignment and buccolingual inclinations. The differences observed might be associated with second molars. Orthodontists have differing preferences or philosophies regarding second molars during treatment. Some routinely band or bond second molars initially, while others fail to control these teeth during treatment. Although second molars were not examined separately in this study, they represent a common deficiency in alignment and buccolingual inclinations,[1] and differences in orthodontic techniques pertaining to second molars might be expected to explain some of the variation observed between doctors.

Only a small amount of variation in the partial overall OGS score (2.3%) was explained by the orthodontists. This could be due to sample selection because nonextraction treatment might be expected to exhibit less variation than extraction treatment. By studying only Class I nonextraction treatment, much of the variation introduced by the orthodontist was therefore removed. Also, the variation between supervising orthodontists might have been mitigated by the variation among the residents delivering patient care.

This is the first study specifically designed to evaluate variation in the OGS scores. It focused on Class I malocclusions treated without extractions, patients theoretically least likely to exhibit variability. More studies of this kind could lead to a better understanding of the OGS and, it is hoped, produce better and more consistent orthodontic results.

CONCLUSION

- Class I nonextraction patients show moderate posttreatment occlusal discrepancies, with variability that was partially explained by
  - —patient factors, including sex, pretreatment mandibular plane and ANB angles, and the posttreatment anterior Bolton ratio, and
  - —treatment related factors, treatment duration, and the attending orthodontist.

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