Original Article

Posttreatment and retention outcomes with and without periodontally accelerated osteogenic orthodontics assessed using ABO objective grading system

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Abstract

Background: The posttreatment and retention outcomes following nonextraction orthodontic therapy, with and without corticotomy, were assessed using the American Board of Orthodontists objective grading system (OGS). **Purpose:** The purpose was to determine if the course of retention was any different following alveolar decortication and augmentation bone grafting, i.e., periodontally accelerated osteogenic orthodontics (PAOO). **Materials and Methods:** Study casts and panoramic radiographs of patients with and without PAOO (28 subjects each) were selected on the basis of the following: (1) comprehensive nonextraction orthodontic treatment using straight wire edgewise appliances for Class I crowding, (2) availability of immediate posttreatment records and retention records at least 1 year post de-bracketing, and (3) use of Hawley removable retainers with similar wearing instructions. **Results:** Independent and paired *t*-test statistical testing revealed the following: (1) Posttreatment orthodontic outcomes were the same, with or without corticotomy. (2) During retention, 5 of 8 ABO grading criteria improved for the sample without corticotomy, and 6 of 8 ABO grading criteria improved for the group with corticotomy. (3) Retention outcome scores were lower (better) for alignment and marginal ridges in the corticotomy-facilitated group. (4) The total score was significantly lower (better) for the corticotomy group at retention and the increment of total score change decreased (improved) significantly more during retention following corticotomy. **Conclusions:** The retention phase was more favorable following corticotomy because the amount of OGS total score change demonstrated a significantly improved retention outcome following PAOO therapy.

Key words: Alveolar corticotomy, orthodontic treatment, retention outcome

INTRODUCTION

A primary goal of orthodontic treatment includes excellent treatment outcomes that are stable life-long. For the clinical orthodontist, one very pragmatic goal is to achieve excellent, long-term results in as short an active treatment time as possible as long as the delivery of services are safe and comfortable to the patient. Excellent, stable results delivered in a shorter period of active treatment time means greater patient flow and clinical income. Orthodontic therapy typically requires about 2–3 years of active care

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with fixed appliances. Since early 2000, accelerated tooth movements techniques have emerged that have seriously challenged the 2+ years active orthodontic treatment time paradigm.

Periodontally accelerated osteogenic orthodontics (PAOO) is an accelerated tooth movement technique that claims active treatment times 3X to 4X more rapid than conventional, non-surgical orthodontics. Moreover, PAOO outcomes have been shown to increase the posttreatment stability of the mandibular anterior segment. Makki[1] compared augmented corticotomy with conventionally treated patients and demonstrated irregularity index change posttreatment to 5 years was + 0.4 versus + 2.8 mm ($P < 0.000$) and posttreatment to 10 years was + 0.9 versus + 2.4 mm ($P < 0.000$). Hence, irregularity index stability was enhanced 2.8 times at 5-year and 2.0 times at 10 years. To date, PAOO is the only active orthodontic therapy shown to increase stability of the mandibular anterior teeth posttreatment outcome; the effectiveness of preventing increases in irregularity index compares favorably with continuous, fixed retainer therapy in the mandibular anterior segment.[2]

It has also been suggested that PAOO posttreatment outcomes enjoy a better retention course compared to conventional orthodontic therapy[3,4] but this contention requires an assessment of orthodontic treatment success using patient posttreatment records and has not, to date, been demonstrated in the scholarly literature. Several assessment indexes have been developed to objectively evaluate orthodontic treatment results.[5-9] However, the most precise and sensitive method to assess orthodontic outcomes was developed by the American Board of Orthodontics. The ABO objective grading system (OGS) uses a specific instrument to measure dental casts and uses final panoramic radiographs to judge root paralleling. Eight criteria are used by the ABO-OGS index to rate final occlusion: Alignment, marginal ridge height, buccolingual inclination, occlusal relationship, occlusal contact, overjet, interproximal contact, and root angulation.[10] A score of "0" is given for best occlusion and alignment and for each parameter that deviates from the ideal, 1 or 2 penalty points are provided. The ABO considers a total score of 20 points or less "successful" and records scored 30 points or greater as "failed."

The ABO-OGS renamed the Cast/Radiograph Evaluation (C-R Eval),[11] is an objective clinical examination tool that has been judged reproducible based on extensive inter- and intra-examiner reliability testing by various investigators.[12] In recent orthodontic literature, the ABO-OGS has been used to compare treatment outcomes of postgraduate residents,[13-16] clinical treatment outcomes of resident versus private practice,[17] mutually exclusive treatment techniques,[18-25,37] retention techniques[26] plaster versus digital study casts,[27-29] and different cultures.[30]

The specificity and sensitivity of the ABO-OGS or C-R Eval used for evaluation of orthodontic treatment outcomes are the highest available for discriminating differences between treatment strategies. Advocates for PAOO claim a more favorable retention course following augmented corticotomy. While degree thesis research has compared immediate and retention outcomes with and without PAOO therapy using the ABO-OGS (C-R Eval) tool,[31] the data details have not been published and made accessible through refereed literature. The null hypothesis tested was no difference in ABO-OGS immediate and retention scores with and without augmented corticotomy.

MATERIALS AND METHODS

Sample

The sample was comprised of 56 orthodontically treated patients with ($n = 28$) and without ($n = 28$) a history of PAOO therapy. The group facilitated with augmented alveolar corticotomy (Cort+) was selected from the stratified private patient file archives of Dr. William Wilcko, orthodontist, Erie, Pennsylvania; average age of the Cort+ sample was mid-twenties and mean retention period was 19.6 months. The conventionally treated group without surgery (Conv) was randomly selected from the stratified institutional patient file archives of the Orthodontic Department, Saint Louis University; average Conv sample age was mid-teens and the mean retention period was 16.4 months.[31]

Orthodontic patient records were selected based on the following criteria:

1. Nonextraction orthodontic edgewise, straight wire therapy for Class I malocclusion in the permanent dentition
2. Patient instructed to wear removable Hawley type retainers full time for 6 months, then nighttime thereafter
3. Availability of diagnostic quality study casts taken at posttreatment and retention demonstrating second molars
4. Availability of diagnostic quality panoramic radiographs taken at posttreatment and retention
5. Retention records taken at least 1 year following debanding
6. Orthodontic records without evidence of congenitally missing teeth, supernumerary teeth, and/or prosthetic bridges.

For the Cort+ sample, every record of each nonextraction, corticotomy-facilitated orthodontic patient was reviewed and excluded from the study based only on the sample selection criteria; two corticotomy patient files were excluded because active treatment was terminated prematurely in one patient, and there was a lack of compliance in the retention protocol in another patient. For the Conv sample, patient records were continuously reviewed, beginning with the patient records most recently archived, until 28 subjects were located that fulfilled the subject selection criteria. Data were collected from the routine postorthodontic treatment records taken on the day of fixed appliance removal and the at least 1 year following removal of the active, fixed orthodontic appliance.

Procedures

Each set of study casts was measured with the specialized ABO-OGS instrument, and the ABO protocol was followed for scoring alignment, marginal ridge height, buccolingual inclination, occlusal relationship, occlusal contact, overjet, interproximal contact, and root angulation.

Experimental error

Method error assessment was performed by randomly selecting and re-measuring 5 sets of study casts from each sample. The error method was calculated with Dahlberg formula: $\frac{\sqrt{\Sigma D^2}}{2N}$, where D was the difference between the repeated measurements and N was the number of double measurements made. Maximum error was 0.5 score points as determined by repeated measures on two separate occasions as well as separate measures in one setting.

Statistical analysis

Statistical analysis of the data was performed using Statistical Package for Social Services (SPSS) software, version 15.0.1, IBM, Armonk, NY, USA. Paired *t*-test was used to determine intra-group differences due to therapy (posttreatment to retention comparisons). Independent *t*-tests were used to identify intergroup differences with significance probability set at $P \leq 0.05$.

RESULTS

Sample means and standard deviations were computed for the eight criteria of the ABO-OGS plus total score. No differences were found at posttreatment, but Cort+ scores were significantly lower at retention than Conv for alignment (1.71 vs. 3.7, $P = 0.003$) marginal ridges (3.25 vs. 4.86, $P = 0.014$) and total score (21.79 vs. 27.21, $P = 0.011$) [Table 1].

Posttreatment and retention scores were compared per group using paired *t*-test. For Conv, five scores significantly improved during retention: Occlusal contact (3.25 vs. 1.96, $P = 0.004$), marginal ridges (5.86 vs. 4.86, $P = 0.034$), interproximal contact (1.07 vs. 0.46, $P = 0.010$), root angulation (4.68 vs. 3.50, $P = 0.000$), and total score (30.43 vs. 27.11, $P = 0.005$). For Cort+, six scores significantly improved during retention: Alignment (2.43 vs. 1.71, $P = 0.045$), occlusal contact (3.57 vs. 1.71, $P = 0.000$), marginal ridges (5.00 vs. 3.25, $P = 0.000$), interproximal contact (0.57 vs. 0.11, $P = 0.010$), root angulation (5.54 vs. 3.96, $P = 0.000$), and total score (29.82 vs. 21.79, $P = 0.000$) [Table 2].

The increment of change per group for each OGS criteria was calculated and compared. The amount of Cort+ change was insignificantly greater for 7 or the 8 criteria but not interproximal contact. Total score change was significantly greater for Cort+ than Conv, i.e. 8.04 versus 3.32, $P = 0.003$ [Table 3].

DISCUSSION

No differences were found in posttreatment orthodontic treatment outcome when Cort+ and Conv were compared. Removable retention strategies were the same for both groups; however, when ABO-OGS scores were compared approximately 1.5 years later, two OGS criteria scores and total score differed significantly: Scores were significantly lower for Cort+ than Conv for alignment (1.71 vs. 3.79, $P = 0.003$) and marginal ridges (3.25 vs. 4.86, $P = 0.014$).

The most dramatic finding in this study was demonstrated in comparing total scores between the groups. Both groups showed significant total score improvement during retention although the amount of improvement was substantially greater in Cort+ (8.04 vs. 3.32, $P = 0.000$). No differences between the two groups in the total score were found at posttreatment (30.93 vs. 29.82, $P > 0.05$), but at retention, the total Cort+ score had dropped to be significantly lower (better) than Conv (21.79 vs. 27.21, $P = 0.011$).

It is logical to consider that total score is a reasonable barometer of overall outcome. While only 2 of the 8 OGS criteria was significantly lower for Cort+ than Conv at 1.5 years posttreatment, all OGS scores were numerically lower (better) than Conv except one (root angulation). All of the ABO-OGS scores decreased (improved) in the Cort+ sample whereas alignment, anteroposterior relationships, and overjet mean scores increased nonsignificantly in the Conv sample. Collectively, these differences during retention resulted in a dramatic decrease (improvement) in Cort+ total score. The precipitous drop in total score of 8.04 points for Cort+ during the 1.5 years of retention indicates a more favorable retention phase for PAOO

Table 1: Posttreatment and retention score means and standard deviations were computed for each study group and statistically compared using *t*-test

OGS criteria	Posttreatment					Retention				
	Conventional		Corticotomy		*P* significant	Conventional		Corticotomy		*P* significant
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Alignment	3.32	2.07	2.43	1.62	NS	3.79	3.05	1.71	1.79	0.003
Occlusal contact	3.25	2.05	3.57	2.13	NS	1.96	2.40	1.71	1.80	NS
Marginal ridges	5.86	2.16	5.00	2.06	NS	4.86	2.68	3.25	2.03	0.014
AP relationship	2.75	2.17	2.93	2.80	NS	2.93	3.22	2.21	2.15	NS
Buccolingual inclinations	6.61	2.94	6.64	2.26	NS	6.25	2.95	6.14	1.96	NS
Overjet	2.89	2.33	3.14	2.54	NS	3.36	3.05	2.68	2.25	NS
Interproximal contact	1.07	1.49	0.57	0.92	NS	0.46	1.20	0.11	0.42	NS
Root angulation	4.68	2.64	5.54	3.13	NS	3.50	2.03	3.96	2.58	NS
Total score	30.93	7.33	29.82	7.37	NS	27.21	8.50	21.79	4.95	0.011

Note that no differences were found at posttreatment but retention scores were lower for corticotomy for objective grading system criteria alignment, marginal ridges and total score. OGS – Objective grading system; SD – Standard deviation; AP – Anteroposterior; NS – not significant (*P*>0.05)

Table 2: Intra-group posttreatment and retention score means were compared for each study group using paired *t*-test

OGS criteria	Conventional			Corticotomy		
	Posttreatment (mean)	Retention (mean)	*P* significant	Posttreatment (mean)	Retention (mean)	*P* significant
Alignment	3.32	3.79	NS	2.43	1.71	0.045
Occlusal contact	3.25	1.96	0.004	3.57	1.71	0.000
Marginal ridges	5.86	4.86	0.034	5.00	3.25	0.000
AP relationship	2.75	2.93	NS	2.93	2.21	NS
Buccolingual inclinations	6.61	6.25	NS	6.64	6.14	NS
Overjet	2.89	3.36	NS	3.14	2.68	NS
Interproximal contact	1.07	0.46	0.010	0.57	0.11	0.010
Root angulation	4.68	3.50	0.000	5.54	3.96	0.000
Total score	30.43	27.11	0.005	29.82	21.79	0.000

Note that scores significantly improved for 5 conventional group criteria and 6 corticotomy group criteria. OGS – Objective grading system; AP – Anteroposterior; NS – not significant (*P*>0.05)

Table 3: Increment of posttreatment to retention score change for the two groups was compared using *t*-test

OGS criteria	Change increment			
	Conventional (mean)	Corticotomy (mean)	X different	*P* significant
Alignment	−0.46	0.71	1.18	NS
Occlusal contact	1.29	1.86	0.57	NS
Marginal ridges	1.00	1.75	0.75	NS
AP relationship	−0.18	0.71	0.89	NS
Buccolingual inclinations	0.36	0.50	0.14	NS
Overjet	−0.46	0.46	0.93	NS
Interproximal contact	0.61	0.46	-0.14	NS
Root angulation	1.18	1.57	0.39	NS
Total score	3.32	8.04	4.71	0.003

Note that the amount of total score improvement was significantly greater in the corticotomy group. OGS – Objective grading system; AP – Anteroposterior; NS – not significant (*P*>0.05)

patients. This evidence strongly suggests that something happened following augmented alveolar corticotomy that leads to an improved orthodontic outcome at retention.

To further investigate this notion, the two groups were compared for maxillary alignment and mandibular alignment separately; there was no difference found at posttreatment, but alignment of both arches differed significantly at 1.5 years posttreatment. Alignment scores at retention were lower (better) for Cort+ than Conv for the maxilla (0.71 vs. 1.96, $P = 0.002$) and the mandible (1.00 vs. 1.82, $P = 0.027$). The same was found at posttreatment

for marginal ridges as neither maxillary nor mandibular marginal ridges scores differed ($P > 0.05$) on the basis of corticotomy. However, at 1.5 years posttreatment, maxillary marginal ridges score was significantly lower (better) for Cort+ than Conv (1.32 vs. 2.39, $P = 0.008$) but not mandibular marginal ridges score, i.e., 1.93 versus 2.46, $P > 0.05$ (data not shown).

Diminished alveolar bone density (mineralization) at posttreatment for Cort+ is a plausible explanation facilitating a more favorable retention "settling" phase. Alveolar bone turnover with alveolar corticotomy has been judged to be 2–3 times greater than without corticotomy,[32] and active orthodontic treatment times average about 6–8 months.[33] It is anticipated that the alveolar housing 6–8 months following corticotomy is not mineralized to the same extent and that this lack of mineralization allows greater functional adaptation of the dentition during retention. Moreover, the fact that tissues comprising the periodontium have undergone regional acceleratory phenomena or high turnover after corticotomy[34] suggests that periodontal tissue memory may have been reduced or lost.

Makki[1] reported greater stability of mandibular irregularity index posttreatment with PAOO citing the benefits of augmentation bone grafting as a possible contributing factor; other investigators have identified thin alveolar cortices as a risk factor for increased postorthodontic mandibular incisor re-crowding.[35,36] While the anterior maxillary and mandibular segments are taken into account with OGS grading, the primary aim of the ABO postorthodontic treatment evaluation system is to assess the quality of static orthodontic outcome. Subtle posttreatment tooth movements that lead to improved orthodontic outcomes are quite different from lack of tooth movement resulting in less recrowding. Again, it is entirely conceivable that the relative state of remineralization in Cort+ was less than Conv at posttreatment and that the dentition moved subtly in the direction of improved orthodontic outcome.

There were confounding factors associated with the study that may have influenced results. Although both samples were treated with nonextraction orthodontics for Class I malocclusion crowding, various aspects of the initial malocclusion were not matched nor were pretreatment record scores using the ABO Discrepancy Index. Moreover, samples were not matched for age as Cort+ patients averaged mid-twenties and Conv patients averaged mid-teens; it may be argued that younger patients have the tendency to "relapse" more than older patients, but the 10-year mean age difference likely did not play a significant role in this particular investigation.

CONCLUSIONS

The purpose of this study was to compare, using the ABO OGS, immediate posttreatment and retention outcomes in subjects treated with and without corticotomy facilitated orthodontic nonextraction therapy. Two samples of Class I crowded malocclusion of 28 each was selected satisfying given inclusion and exclusion criteria. The OGS criteria advocated by the American Board of Orthodontics were used to evaluate study casts and panoramic radiographs at posttreatment and 1.5 years posttreatment. Measurements were made with a special instrument designed specifically by ABO directors for self-assessment in preparation for the Phase III ABO clinical examination. Study casts and panoramic radiographs had been collected on the day of appliance removal and at least 1 year following de-bracketing. All subjects had been instructed to wear Hawley type removable retainers in a similar manner. Study variables were analyzed statistically to identify significant differences within and between the two study groups.

Parametric statistical testing revealed the following:

1. Posttreatment orthodontic outcomes were the same, with or without corticotomy
2. During retention, 5 of 8 ABO grading criteria improved for the sample without corticotomy, and 6 of 8 ABO grading criteria improved for the group with corticotomy
3. Retention outcome scores were significantly lower (better) for alignment and marginal ridges in the corticotomy-facilitated group
4. The total score was significantly lower (better) in the corticotomy group at retention. Moreover, the increment of total score change during retention (effect size) was significantly greater (more improved) following corticotomy resulting in significant clinical outcome improvement.

Based on the conditions of this investigation, orthodontic patients facilitated with the alveolar corticotomy and augmentation grafting technique (PAOO) had a more favorable retention course because OGS total score improved about 2.4 times more with PAOO than without during the 1.5 years retention phase.

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Conflicts of interest

There are no conflicts of interest.

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