Scope of treatment with periodontally accelerated osteogenic orthodontics therapy

Donald J. Ferguson, M. Thomas Wilcko, Willam M. Wilcko, and Laith Makki

Guidelines for tooth movement limits are meant to help clinicians in treatment-planning decisions, especially for “severe” or “borderline” adult malocclusions. The purpose of this article was to review well-accepted scope of care beliefs and compare with suggested scope of treatment offered by periodontally accelerated osteogenic orthodontics (PAOO). PAOO is a surgical technique that accelerates tooth movement and expands the scope of conventional orthodontic treatment in the adult 2–3 fold in most spatial dimensions. (Semin Orthod 2015; 1:i–i.) © 2015 Elsevier Inc. All rights reserved.

Introduction

Severity of malocclusion is a dominant factor in orthodontic treatment planning. The goals of orthodontic treatment must include good facial esthetics, adequate function as well as stability in the ultimate positions of the dentition and jaws. It is the responsibility of the clinician to offer a treatment plan that will accomplish desirable esthetic, functional and stable results. In the orthodontic treatment of non-growing patients, malocclusions viewed as “borderline” or “severe” are filtered or sorted on the basis of two broad possibilities for correction: (1) camouflage (orthodontic positioning of the teeth to compensate for the jaw discrepancy), and (2) orthognathic surgery in conjunction with orthodontics to reposition the jaws and/or dentoalveolar segments.1

The ability to resolve severe malocclusion without surgical intervention is of great interest to the orthodontist clinician.2 The strong majority of clinicians who comprise the clinical discipline of orthodontics are conservative in nature, and for them, avoiding surgery is the prevailing canon. But conservative judgment runs a-foul when compromise or camouflage impacts too strongly upon esthetics, function and/or stability.

Alveolar decortication with augmentation bone grafting technique combined with orthodontics is called periodontally accelerated osteogenic orthodontics or PAOO and was first described by Wilcko et al.3 This surgical technique has been sufficiently described and the main features include full thickness periosteal flap reflection followed by intentionally scoring the alveolar cortical bone, both labial and lingual, in the area of desired tooth movement. Bone grafting is placed at the corticotomy sites and is typically comprised of a mixture of demineralized freeze-dried bone allograft (DFDBA) and bovine bone. The surgical flap is sutured, and the patient is seen every 2 weeks after the surgery for orthodontic adjustments. It is recommended that the surgical procedure be performed within 1 week of fixed orthodontic appliance placement and that the appliance be activated at the time of surgery.4

PAOO accelerates orthodontic tooth movement and malocclusions are resolved 3–4 times faster; treatment times for complex cases average 6 months compared to 18–27 months.3 But PAOO has been described as intrepid by some and dismissed by others as unnecessary or overreaching.5 This reaction or resistance in the orthodontic community is understandable.
considering that the value of corticotomy plus grafting technique and the scope of implications are not widely recognized. The purpose of this article is to compare scope of PAOO treatment with well-accepted and prevailing scope of care tenets with a focus on malocclusion severity.

Orthodontic tooth movement limits

Severity of the malocclusion is a dominant factor in treatment-planning decisions but not the only factor. Tullock et al. astutely pointed out that relying solely on the presenting anatomic arrangement of teeth and jaws clearly ignores many of the factors that determine the treatment response and thereby influence treatment plan choice. Factors over and beyond simple presenting morphological characteristics, such as age, psychological profile, patient treatment-planning preferences, esthetics, estimated compliance, and anticipated tissue response to biomechanical forces, etc. must be considered in treatment-planning decisions.

Maxillary and mandibular incisors

Proffit’s “envelope of discrepancy,” describing limits of orthodontic treatment in the context of

![Figure 1. Limits of orthodontic tooth movement suggested by Proffit’s “envelope of discrepancy” represented by the black inner circle and PAOO limits represented by the red circle. The two visual circles are documented also by millimeter amounts for retraction, protraction, intrusion, and extrusion for central incisor tooth movements in the maxilla and mandible. (Proffit’s “envelope of discrepancy” is redrawn with permission.)](image-url)
producing normal, stable occlusion, has been cited by most authors exploring orthodontic treatment limits and is represented in Fig. 1. These limits when applied to the non-growing individual vary by the tooth movement that would be needed if other restraints, such as soft tissue limits, do not apply. According to Profit's opinion, teeth can be moved further in some directions than others; the range described is 7 mm (maxillary incisor retraction) in the anteroposterior spatial plane to 2 mm (maxillary incisor protraction and some incisor vertical dimension changes).

While limits of tooth movement are a matter of clinical experience and opinion and are not based in scientific fact, in general, PAOO treatment limits for incisors exceed the envelope of discrepancy described by Proffit for adult, non-growing patients by 2–3 times in all dimension except retraction. Corticotomy surgery is recommended within 1 week of fixed orthodontic appliance placement; alignment of incisors is rapid after surgery, but the time it takes to align incisors encroaches upon post corticotomy healing. Retraction movement is usually constrained because RAP has dissipated and healing has advanced ahead of space closure precluding accelerated retraction. The combination of corticotomy and dental distraction is recommended to facilitate retraction tooth movement.

Corticotomy surgery increases the soft and hard tissue turnover, augmentation bone grafting expands the bony alveolus and both processes expand hard and soft tissue limits and enable teeth to be moved a greater distance. Unlike instantaneous jaw segment movements from orthognathic surgery constrained by soft tissues and muscles, the augmentation bone grafting of PAOO increases the alveolus size and expands the soft tissue envelope gradually with much less constraint from the craniofacial muscles. The accelerated tooth movement process involves a demineralization of alveolar bone adjacent to the corticotomy, bone matrix transport to a new position secondary to orthodontic biomechanical forces, and remineralization of the alveolus after active tooth movement has been completed. It is surmised that the remarkable stability of PAOO treatment outcomes is the consequence of increased tissue turnover and increased thickness of cortical bone in conjunction with low constraint from pre-existing soft tissues and muscles.

Large changes in the alveolus housing the dentition are very amenable to PAOO technique. Hence, PAOO is applicable to the most moderate to severe malocclusion conditions because soft tissue constraints are reduced and the limits of the alveolar housing are increased. Moderate to severe malocclusions amenable to PAOO therapy are problems requiring alveolar extrusion or intrusion, transverse alveolar expansion (orthodontists rarely constrict), and alveolar protraction. PAOO cannot extend the limits of alveolar retraction because this tooth movement in severe malocclusion is typically defined by the skeletal position of the jaw in the anteroposterior dimension. For conditions of micrognathia or macrognathia accompanied by excess or deficient overjet, only orthognathic surgery is applicable because PAOO does not have the capacity to move jaws in the anteroposterior spatial plane.

**Mandibular arch width**

Arch expansion requires primarily the dentoalveolar tooth movements of tipping, uprighting and rotation. Considering the therapeutic constraints offered by the mandibular dental arch, Proffit has suggested mandibular arch expansion limits as follows: 2 mm anterior movement of the mandibular incisors, 0–1 mm intercanine width, 2 mm inter-first premolar expansion, 2–3 mm inter-second premolar width, and 3 mm transverse expansion of inter-molar width.

Anteroposterior expansion greater than 2 mm and transverse expansion by more than 4 or 5 mm will likely be unstable according to Proffit. Conventional wisdom suggests that orthodontic treatment should reflect the amount of incisor change that would occur relative to stability because the pretreatment position likely reflects the soft tissue influences. Moreover, gingival recession and dehiscence of the alveolar bone may occur with orthodontic expansion when the attached gingiva is thin, especially when accompanied by plaque accumulation and inflammation.

There is a paucity of stability studies related to PAOO technique, but it has been recently demonstrated that mandibular intercanine expansion averaging 2.1 mm was stable 5 years after active PAOO treatment. In contrast to expected intercanine width decrease, there was a...
0.7 mm non-significant increase in intercanine width during the 5 years after active treatment; the removable retainer wear compliance was judged “average” in a sample comprised of 33 patients with a mean age of 35.3 years.19

**PAOO technique for treatment of severe malocclusion**

Several cases representing severe malocclusion are presented all treated using PAOO technique. The purpose of this article is to compare scope of treatment with PAOO with Proffit’s “envelope of discrepancy” to illustrate the capacity of PAOO therapy to resolve severe malocclusion. The goal of demonstrating limits of tooth movement using alveolar decortication and augmentation bone grafting (PAOO) is achieved at the expense of a limited amount of patient records provided.

**Extrusion for open bite**

Open bite treated with PAOO by extrusion of maxillary incisors 10 mm is illustrated in Fig. 2.

Maxillary central incisor incisal edges were vertically short of lower broader of upper lip by 8 mm. Corticotomy was performed on maxillary anterior segment between maxillary first premolars on labial and lingual followed by bone grafting. Active treatment time was 8 months.

**Intrusion for deep bite**

Deep bite treated with PAOO by intruding mandibular incisors 7 mm is demonstrated in Fig. 3. Mandibular incisors and right canine represented a 7 mm deviation in the curve of Spee. Alveolar decortication was performed labial and lingual to all mandibular incisors and the mandibular right canine followed by bone augmentation grafting. Intrusion was achieved by intruding incisors and right canine. Active treatment time was 8 months.

**Protraction for crowding**

Maxillary incisors protracted 5 mm by PAOO treatment and advancing maxillary incisors to

---

**Figure 2.** Maxillary incisor extrusion of 10 mm following PAOO labial and lingual to maxillary incisors and canines for correction of open bite.
accommodate a blocked out maxillary left canine is shown in Fig. 4. For the maxillary incisor advancement, alveolar decortication was performed labial and lingual to all maxillary incisors and the maxillary left canine followed by bone augmentation grafting. Maxillary dental arch malocclusion was resolve in 5 months following PAOO in preparation for mandibular advanced orthognathic surgery; overall treatment time including the orthognathic surgery was 9 months. Photos with orthodontic brackets show position of incisors prior to and after PAOO treatment effects. Finished photos represent 4 years following active orthodontic treatment.

**Protraction of mandibular incisor**

Mandibular incisors were protracted 9 mm by PAOO treatment in order to correct a post trauma injury of the mandible as demonstrated in Fig. 5. Trauma resulted in loss of the mandibular left first premolar and ankylosis of the canine which required extraction. Alveolar decortication was performed labial and lingual to all teeth anterior to the mandibular first molars accompanied by ample augmentation grafting of the alveolar bone. Temporary anchorage devices (mini-screws) were place between maxillary laterals and canines in order to protract the mandibular incisors and correct the lower midline deviation. Photos represent 4 months of active treatment following the PAOO surgery. The anatomy of the alveolar bone and soft tissues in the area after PAOO therapy suggests that the limit of mandibular incisor protraction is substantially greater than without the procedure.

**Expansion for posterior crossbite**

Maxillary constriction was treated by expansion of about 7 mm at intercanine width following PAOO on both arches as illustrated in Fig. 6. The maxillary expansion was achieved by archwire expansion only after labial and lingual corticotomy and augmentation bone grafting from maxillary first molar to first molar. Active treatment time was 6.5 months. Prior to PAOO, free gingival grafts were placed labial to maxillary canines and labial to mandibular second premolar to second premolar. This case was treated early in PAOO development; today the free gingival grafts would not be performed.

**Decrowding in the mandible**

Mandibular crowding of 12 mm was resolved by PAOO therapy as shown in Fig. 7. Maxillary lateral incisors were missing and pretreatment first molar occlusion was Class II. Alveolar decortication in both arches and ample bone...
grafting was performed labial and lingual to all teeth anterior to second molars. In the mandibular arch, fixed orthodontic appliances were used to first tip the incisor crowns labially followed by uprighting incisor roots into the labial augmentation graft to achieve incisor positions that were more upright than at pre-treatment. Active treatment time was 8 months.

Discussion
The benefits of PAOO therapy include the following: (1) increase limits of tooth movement created by augmentation bone grafting as demonstrated in the present article, (2) enhanced stability of orthodontic treatment outcomes,19,20 (3) rapid orthodontics for severe malocclusion averaging 6–8 months of active treatment time,21 and (4) increased robustness of the periodontium.

The upper tooth movement limits considered achievable following PAOO was represented in a series of cases presented with limited patient records. These cases represented maxillary incisor extrusion of 10 mm, mandibular incisor intrusion of 7 mm, maxillary incisor protrusion of 5 mm, mandibular incisor protrusion of 9 mm, maxillary intercanine expansion of 7 mm, and mandibular de-crowding of 12 mm. In all of these PAOO cases, only archwires were used to achieve the ultimate positions of the dentition.

Ackerman et al. astutely pointed out that stability after orthodontic treatment is determined by the ability of the soft tissues to adapt to

Figure 4. Maxillary incisor protraction of 5 mm by PAOO treatment surrounding maxillary incisors and left canine to accommodate a blocked out maxillary left canine. After 4 months of PAOO therapy, the patient underwent mandibular advancement orthognathic surgery.
changes in hard tissue morphology. These authors and others argue that since pretreatment position of the teeth already reflects soft tissue influences, it is better to think in terms of the amount of change in tooth position that treatment would produce and the relationship of the amount of change to stability. Evaluating soft tissue contours clinically is a critical step in

Figure 5. Mandibular incisor protraction of 9 mm by PAOO therapy labial and lingual to all teeth mesial to the first molars in an post traumatic injury patient. PAOO treatment was chosen to avoid the high risk alternate of a multi-piece mandibular orthognathic surgery.
gathering an adequate diagnostic data base before making treatment-planning decisions.\textsuperscript{18,22}

PAOO therapy influences the entire periodontium, i.e., both hard and soft tissues surrounding the dentition, and augmentation bone grafting ultimately increases the size of the bony alveolus. The influence of soft tissue on orthodontic outcome stability is moderated by the healing processes described collectively by Frost as regional acceleratory phenomena or RAP wherein all tissues turnover at a high rate and likely lose the type of “memory” that result in undesirable relapse-type changes.\textsuperscript{23} Moreover, an increase in the thickness of the alveolar cortical bone most likely contributes to enhance orthodontic treatment outcome stability.\textsuperscript{24,25}

Orthodontic problems must be solved without causing irreversible damage to the periodontium, and the greater the tooth movement, the greater the chance of endangering the periodontium.\textsuperscript{18} A patient with thin biotype and little attached gingiva on the labial of mandibular incisors may be at risk for gingival recession if the tooth is moved facially out of its alveolar bone

\textbf{Figure 6.} Maxillary intercanine expansion of 7 mm by PAOO therapy and archwires only for correction of maxillary arch constriction.
Figure 7. Crowding of 12 mm in the mandibular dental arch was resolved by PAOO therapy labial and lingual to all teeth in the arch.
PAOO treatment has been demonstrated to repair cortical alveolar dehiscence and fenestration problems discovered at the pretreatment stage and that increases in cortical thickness from the grafting appears to be permanent. During adulthood, the width of keratinized or attached gingiva does not increase. It has been revealed recently that the width of keratinized gingiva increases as a consequence of PAOO procedure as shown in Fig. 8. Stretching the full thickness flap over the bulk of grafting materials appears to extend the keratinized gingiva from the gingival margin. Keratinized gingiva increased 0.78mm in PAOO versus a decrease of 0.38mm in non-PAOO group.

Augmentation bone grafting increasing the size of the alveolus and healing dynamics subsequent to corticotomy changes the physiologic limits of the soft tissues and in doing so extends the limits of tooth movement and orthodontic treatment. Without PAOO, the anatomic limits of tooth movement far exceed the ability of soft tissues to adapt to the changes in the position of the teeth. When it appears that it is not possible to achieve ideal occlusion, excellent stability, normal function and optimal facial balance with conventional orthodontic therapy, PAOO may offer a viable alternative. When orthognathic surgery is judged too expensive or risky, PAOO should be considered for solving imbalances secondary to alveolar deficiencies in the vertical and transverse dimensions.

**Summary**

The purpose of this article was to compare PAOO scope of treatment with well-accepted and prevailing scope of care tenets with a focus on malocclusion severity. In the authors opinion, PAOO treatment expands the scope of conventional orthodontic treatment in the adult 2-fold to 3-fold in most spatial dimensions.

**References**

7. Tullock JFC, Lenz BE, Phillips C. Surgical versus orthodontic correction for Class II patients: age and