Chapter 4 The Contribution of Periodontics to Orthodontic Therapy

M. Thomas Wilcko, DMD, William M. Wilcko, DMD, MS,
M. Gabriela Marquez, DMD, MSD, and Donald J. Ferguson, DMD, MSD

Periodontally Accelerated Osteogenic Orthodontics (PAOO)

HISTORY

The innovative combination of selective alveolar periodontal decortication surgery and augmentation grafting with orthodontic treatment results in an acceleration of orthodontic treatment, enhanced stability of orthodontic results, and long-term improvement of the periodontium (Wilcko 2003).

The purposes of this section are to describe the Periodontally Accelerated Osteogenic Orthodontics technique and to explain how and why this advanced periodontal surgical technique contributes to orthodontic treatment.

Decortication or corticotomy means simply the intentional cutting or injury of cortical bone. While the bony jaws are composed of both cortical and medullary bone in various combinations depending on site and patient demographics, the periodontal surgery of interest in contemporary selective alveolar decortication involves only surgical injury of alveolar cortical bone.

The application of corticotomy surgery to correct malocclusion was first described in 1892 by L. C. Bryan, but it was Heinrich Köle in 1959 who reintroduced alveolar corticotomy to resolve malocclusion (Köle 1959). He combined interdental alveolar corticotomy surgery with a through-and-through osteotomy apical to the teeth. Generson et al. in 1978 offered a modification of the Köle protocol and eliminated the subapical osteotomy portion of the surgery.

In 2001, Wilcko et al. described selective alveolar decortication with augmentation grafting combined with orthodontic treatment. They patented and trademarked their technique as Periodontally Accelerated Osteogenic Orthodontics (PAOO).

Wilcko et al. observed rapid orthodontics following PAOO and active treatment times of 6 to 8 months were common. They questioned Köle's precept of “bony block” movement and offered an alternative hypothesis that rapid tooth movement resulted from marked but transient decalcification-recalcification of the alveolus. Frost, an orthopedic surgeon, had described a direct correlation between degree and proximity of bone trauma and intensity of physiological healing response, which he coined Regional Acceleratory Phenomena, or RAP (Frost 1983), and the decalcification-recalcification described by Wilcko et al. (2001, 2003) was consistent with RAP.

INDICATIONS

• Increased alveolar volume and enhanced periodontium (i.e., correction of dehiscences and fenestrations)
• Accelerated treatment (i.e., 3 to 4 times more rapid active orthodontic treatment)
• Greater stability of clinical outcomes and less relapse
• Enhanced scope of malocclusion treatment (i.e., avoiding orthognathic surgery and extractions in selected cases)
• Enhancement of patient’s profile when indicated
• Rapid recovery of impacted teeth (i.e., canines)

The initial decortication protocol used by the Wilcko brothers did not include augmentation alveolar grafting. Computed Tomography (CT) scans were taken on the first series of patients to compare pretreatment status with immediate post orthodontics and at least 1-year retention conditions. The CT scans of the alveolus immediately after braces were removed showed a paucity of alveolar bone in the areas where decortication surgery was performed. However, the retention images demonstrated that a minimally adequate amount of bone, and the surgical site was closed using Gore-Tex suture material. A frequently used grafting mixture was equal portions of demineralized freeze-dried bone (DFDBA) and bovine bone (Osteograf/N-300 or Bio-Oss) wetted with clindamycin phosphate (Cleocin) solution.
mineralized alveolar bone would return if the soft tissue periodontal envelope remained intact (Fig. 4.1).

Since 1996, the PAOO technique has included augmentation grafting to increase alveolar volume (Fig. 4.2). Results of research showed no change in alveolar cortical bone thickness at an average of 1.5 years following immediate post orthodontic treatment (Twaddle 2002). A recent study of attached gingival levels in PAOO patients resulted in significantly more attached gingiva evident at least 1 year after active orthodontic treatment. Increases in attached gingiva were consistent in the lower dental arch and inconsistent in the maxillary arch (Kacewicz 2007).

An additional benefit of augmentation bone grafting is the repair of alveolar cortical bone fenestrations and dehiscences.
Fig. 4.2. CT and surgery images of patient treated with selective alveolar decortication and augmentation grafting demonstrating ample cortices post grafting. **A:** CT image at pre-treatment showing root prominences; **A-1:** view of labial cortical bone at the time of selective alveolar decortication surgery; **A-2:** view of surgery area after grafting; **B & C:** CT images at post orthodontic treatment (**B**) and 2.5 years retention (**C**) showing increased volume of labial cortical bone.
The grafting procedure is done without membranes because full-thickness flaps are used followed by primary closure in a healthy periodontium. Under these circumstances, migration of the epithelial attachment is not likely to occur, and the intact periosteum serves as a natural “membrane.”

PAOO has contributed greater stability of orthodontic clinical outcomes and less relapse. Stability of orthodontic clinical outcomes was analyzed by Nazarov in 2003 using the Objective Grading System (OGS) sanctioned by the American Board of Orthodontics (ABO). While no differences were observed in nonextraction therapies at immediate post treatment between PAOO and non-PAOO groups, three of the nine OGS variables (alignment, marginal ridges, and total score) were significantly better in the PAOO group at retention. O’Hara (2005) compared nonextraction orthodontic treatment of moderate malocclusions and found no differences in the OGS alignment variables at post treatment. But at retention, alignment had improved in the PAOO group, whereas in the two non-PAOO groups, fixed and removable appliance retention, alignment had relapsed. In summary, immediate post orthodontic treatment results following nonextraction therapy are statistically the same with or without PAOO. However, during retention, the clinical outcomes of PAOO patients improved and did not demonstrate relapse.

PAOO increases the scope of orthodontic tooth movement and the positions of the teeth after decortication and augmentation grafting are stable long-term. Sarver and Proffit (2005) offered guidelines as to the limits of central incisor tooth movement in the adult patient with orthodontic treatment alone. Ferguson et al. (2006) suggested that these limits can be expanded 2-fold to 3-fold in all dimensions except retraction following PAOO (see Fig. 4.4) and that the stability of these positions is probably due to loss of tissue memory from high turnover of the periodontium as well as increased thickness of the alveolar cortices from the augmentation grafting. Rothe et al. (2006) found that patients with thinner mandibular cortices were at increased risk for having dental relapse—hence the necessity for osseous grafting during the PAOO procedure.

Periodontics, through PAOO therapy, contributes to orthodontic treatment by reducing active orthodontic treatment time. Claims of rapid orthodontic treatment times were first validated in research by Hajji in 2000; average active ortho-

---

Fig. 4.3. Augmentation alveolar grafting repairs bony dehiscences and fenestrations. A: evidence of bony discrepancies after full thickness flap, B: decortication prior to grafting with dehiscences and fenestrations outlined; C-D: absence of dehiscences and fenestrations 7.5 years post PAOO decortication and grafting.
dontic treatment times were 6.1 months for nonextraction PAOO and 18.7 and 26.6 for nonextraction and extraction therapies without PAOO, respectively. In 2001, Fulk compared mandibular arch decrowding in nonextraction orthodontics following PAOO and non-PAOO; active treatment times were 3.1 times more rapid (6.6 versus 20.7 months) following PAOO and post treatment outcomes were statistically the same as judged by cephalometric and study cast variables. Similar results were reported in 2003 by Skountrianos for maxillary arch decrowding, wherein active orthodontic treatment time was 3.0 times more rapid when combined with PAOO than when not combined (7.0 versus 21.2 months).

In summary, the contributions of periodontal therapy to orthodontic treatment vis-à-vis PAOO is to increase alveolar volume and enhance the periodontium, enhance the stability of orthodontic clinical outcomes (less relapse), increase the scope of malocclusion treatable without orthognathic surgery, and reduce active orthodontic treatment time over 3-fold. These benefits are realized for two reasons: (1) tissues lose memory due to high hard and soft tissue turnover induced by the periodontal decortication, and (2) augmentation bone grafting increases alveolar volume and thickness of the alveolar cortices.

**BIOLOGICAL RATIONALE**

The clinical technique involving selective alveolar decortication is a form of periodontal tissue engineering resulting in a transient osteopenia and high turnover adjacent to the injury site. Alveolar decortication initiates a healing response, the degree of which is directly related to the intensity and proximity of the surgical insult. In healthy tissues, bony healing is synonymous with high osseous turnover, calcium depletion from the hydroxyapatite crystal lattice, and diminished bone density but not bone matrix volume (Frost 1983). Bogoch et al. (1993) made a penetrating surgical incision into the head of the tibia in rabbits and studied the healing response adjacent to the surgical wound. They found a 5-fold increase in medullary bone turnover adjacent to the corticotomy site. Buchanan et al. (1988) documented a similar observation in alveolar bone following tooth extraction, as did Yaffe et al. (1994) after alveolar periosteal flap elevation and Verna et al. (2000) after tooth movement.

Sebaoun (2005) studied the effect of decortication without tooth movement on alveolar turnover in the rat in a split mouth design using multiple approaches. Maxillary buccal and lingual full-thickness periosteal flaps were elevated adjacent to the upper left first molar, and decortication was performed with five palatal and five buccal bur marks (0.2 mm) under sterile irrigation. The following was observed adjacent to the decortication site at 3 weeks after surgery: (1) a 2-fold increase in decalcified trabecular bone (histomorphometric analysis using hematoxylin and eosin staining; see Fig. 4.5),

**Fig. 4.4.** PAOO enables a greater amount of tooth movement into stable positions. Limits of adult orthodontic tooth movement (in millimeters) into stable positions using orthodontics only is represented by the inner black-color envelope (after Proffit); limits of tooth movement for orthodontics combined with PAOO is represented by the outer red-color envelope. For example, protraction of the lower incisor into a stable position is 9mm if tooth movement is combined with PAOO compared to a 5mm limit without PAOO. Note that limits are about 2 to 3 times greater for central incisor protraction, extrusion and intrusion but not for incisor retraction. (Reprinted with permission from Bell 2006)

**Fig. 4.5.** Cross section of the dentoalveolus of the rat showing 4 of the 5 upper first molar roots at 3 weeks control (A), 3 weeks decortication (B), and 11 weeks decortication (C). Testing of histomorphometric data resulted in significantly less calcified trabecular bone volume at 3 weeks on the decortication side except for 7 weeks decortication (not shown).
a 1.5-fold increase in new trabecular bone formation (vital staining ad libitum), (3) a 4-fold increase is osteoclast count (osteoclast count after TRAP staining), and (4) a 2-fold increase in lamina dura apposition (vital stain injection series; see Fig. 4.6). These findings collectively indicate high tissue turnover immediately adjacent to the decortication site.

Pham-Nguyen (2006) studied the three-dimensional volume of periodontal tissues surrounding the upper first molar in the rat model following buccal and lingual selective decortication. Using micro-CT technology, a significant decrease in alveolar mineralization was evident by 7 days post decortication (Fig. 4.7).

Conceptually, increased tissue turnover (osteopenia) is a condition that favors rapid tooth movement. This tenet was demonstrated by Verna et al. (2000) using a rat model by moving teeth after pharmacologically inducing high and low bone turnover. They showed significantly greater tooth movement in the high turnover group compared with normal and low bone turnover groups. In our laboratory rat studies (Pham-Nguyen 2006, Sebaoun 2005), surgical injury to the alveolus induced a dramatic increase in tissue turnover that was expressed both spatially and temporally. The effect of alveolar decortication was localized to the area immediately adjacent to the injury. It is obvious that considerable medullary bone demineralization occurs immediately adjacent to the decortication site. Although induced osteopenia is a transient condition in the functionally normal alveolus, it was surmised that tooth movement perpetuates the decalcified condition of the trabecular bone (Fig. 4.8).

PERIODONTALLY ACCELERATED OSTEGENIC ORTHODONTICS IN THE TREATMENT OF CROWDING

Using the PAOO technique, cases of moderate dental arch crowding are routinely completed in 4 to 6 months instead of 18 to 24 months of active orthodontic treatment, and the results have been shown to be remarkably stable (Figs. 4.9 and 4.10).

RAPID RECOVERY OF IMPACTED TEETH

Recovery of impacted teeth typically prolongs active orthodontic treatment time. Impacted tooth recovery combined with selective alveolar periodontal decortication surgery accelerates the recovery and reduces orthodontic treatment time. The purpose of this section is to describe an advanced periodontal surgical technique of recovering impacted cusps that features the following: (1) complete exposure of the clinical crown, (2) clearing a path for recovery by way of alveolar ostectomy, and (3) selective alveolar decortication or intramarrow penetrations surrounding the impacted tooth root.

With the exception of the third molars, the maxillary canines are the most frequently encountered impaction, with an incidence of approximately 2% according to Ericson and Kurol (1987). The incidence of maxillary canine impaction is 3 times greater in females than in males and is often associated with missing or peg-shaped laterals (Bec et al. 1981, Peck et al. 1994). Maxillary permanent canines are impacted palatally...
much more frequently than labially (85% palatal compared
with 15% labial; Bass 1967, Hitchin 1956, Jacoby 1979). Rayne (1969) has pointed out that labially impacted canines are often associated with inadequate arch space. Interceptive treatment of impacted maxillary canines can often be successful in 10- to 13-year-olds depending on the degree of the impaction (Jacobs 1992). The more severely impacted maxillary canines typically require combined surgical/orthodontic treatment (Bishara 1992).

Previous authors have indicated that details of the recovery technique depend on the type of impaction. When the crown is not covered by bone and there is a broad band of keratinized gingival tissue present, Kokich and Mathews (1993), Shiloh and Kopczyk (1978), and Jarjoura et al. (2002) have suggested a surgical window (gingivectomy) to expose the shallow impaction. In situations where there is only a narrow zone of gingival attachment and a relatively shallow labial or mid-alveolar bony impaction, an open technique consisting of an apically repositioned flap is more suitable according to Wong-Lee and Wong (1985) and Vanarsdall and Corr (1977). When the bony impaction is deep in the vestibule, mid-alveolar, or impacted palatally, Vennette et al. (1985), McDonald and Yap (1986), and Smukler et al. (1987) have suggested erupting the canine through the gingiva following primary surgical flap closure.

**RECOVERY OF LABIALLY IMPACTED CANINES**

Recovery of labially impacted maxillary canines is illustrated in the treatment of a girl aged 14 years 4 months using selec-
Fig. 4.9. Adult female patient with moderate upper and lower dental arch malocclusion (A,B) treated by PAOO (A-1, A-2, B-1, B-2) showing immediate post treatment outcome after 7 months of active orthodontic therapy (C,D).
Fig. 4.10. Retention outcome at 2 years (A,B) and 9 years (C,D) after the completion of PAOO treatment. Improvement during retention and long term stability are likely due to high tissue turnover induced by decortication and increase in cortical bone thickness.
tive de cortication technique (Figs. 4.11, 4.12, and 4.13). A full-thickness labial flap, using a sulcular incision with vertical releasing incisions mesial to the first premolars, was reflected to reveal upper cuspid crowns labial to the upper permanent lateral incisors. No lingual flap was reflected. The upper primary canines were extracted, and the soft tissue follicle and thin layer of bone surrounding cuspid crowns were removed. A path (trough) was cleared for the forced eruptions by removing the facial cortical plate between the cuspid crowns and extraction sockets including the facial plates over the sockets. In addition, numerous intrararrow penetrations were made to stimulate alveolar bone turnover and to induce

Fig. 4.11. Labially impacted maxillary canines showing pre-surgery (A), partial exposure of canine crowns after full-thickness flap (B), and bone removal to expose canine crowns completely, intrararrow penetrations, and creation of a path by removing facial cortical plates of extraction socket (C).

Fig. 4.12. Treatment for labially impacted maxillary canines showing views of different cases at the time of surgery (A, D, G, B, E, H) and at 10 weeks post surgery (C, F, I). An orthodontic bracket was placed in an optimal position on the exposed right canine (A) but on the lingual surface of the crown on the left canine (G). At the time of soft tissue closure, a vertical incision was made in the flap allowing exposure of the right canine bracket (B) but not the left canine (H) before suturing the flap to the original position (E). The canines were beginning to move rapidly by 10 weeks after the canine recovery surgery (C, F, I).
RAP or osteopenia. At least 1.5 mm of bone was left undisturbed mesial to the first premolars and distal to lateral incisors. An orthodontic bracket was placed in an optimal position of the upper right permanent canine, but the upper left permanent canine was rotated, which necessitated placing the bracket on the lingual surface. On the right side, the bracket was exposed with a vertical incision in line with the bracket, and then suturing the flap back into the original position. The upper left canine was covered by the flap, a backup ligature wire was also used. In this case, a resorbable Vicryl suture was used.
Fig. 4.13. Results of treatment for labially impacted maxillary canines showing pre-treatment malocclusion (A-C) and clinical outcome 4 months after removal of orthodontic appliances (D-F). Active treatment time to recover the canines was 5 months and 2 weeks.
Selective decortication is especially helpful in the recovery of maxillary permanent canines that are deeply impacted on the palatal side and require a considerable amount of movement through alveolar medullary bone as illustrated with the treatment of a boy aged 14 years 6 months (Figs. 4.14 and 4.15). Decortication injury stimulates an osteopenic response that reduces the mineral content of spongiosa, thereby reducing the resistance to impacted canine movement.

**RECOVERY OF DEEP PALATALLY IMPACTED CANINES**

Selective decortication is especially helpful in the recovery of maxillary permanent canines that are deeply impacted on the palatal side and require a considerable amount of movement through alveolar medullary bone as illustrated with the treatment of a boy aged 14 years 6 months (Figs. 4.14 and 4.15). Decortication injury stimulates an osteopenic response that reduces the mineral content of spongiosa, thereby reducing the resistance to impacted canine movement.
Fig. 4.15. Treatment for deep palatally impacted maxillary canine showing pretreatment malocclusion (A) and radiograph (H), flap with vertical releasing incision showing labial cortical plate (B), ostectomy removal of labial cortical and medullary bone to clear a movement path and expose canine crown, and labial intramarrow penetrations (C), bracket placement and application of elastic traction (D), immediate postsurgical flap suturing (E) and radiograph (F) with radiograph (I), and 9 days after orthodontic appliance removal (G) with radiograph (K). Active treatment time to recover the canine was 6 months 0 weeks.
Fig. 4.15. (continued)
Both facial and lingual full-thickness flaps are used with distal vertical releasing incisions for access to deep palatally impacted canines. Preference is given to placement of orthodontic brackets into an optimal positioned on the labial surface of the canine crown for control and efficiency. When direct access to the labial surface and optimal bracket placement is not possible, the surface of choice for bracket placement is the distolabial surface of impacted canines. An ostectomy is required between the first premolar and the lateral incisor to gain access to the appropriate impacted canine surface. The ostectomy not only permits optimal bracket placement but also creates a space for the elastic chain from the bracket on the impacted canine to the brackets on the adjacent teeth already well positioned in the dental arch. Moreover, bone needs to be removed when crowns are exposed because the follicle surrounding the enamel is eliminated and bone resorption secondary to follicular activity is lost. The ostectomy should eliminate all bone in the movement path of the crown during impacted canine recovery, but it is important to leave about 1.5 mm of bone on the proximal surfaces of the adjacent teeth. Intramarrow penetrations are also performed, especially in the bone that lies between the impacted tooth and its eventual position in the dental arch. Intramarrow penetrations over the root prominence of the impacted tooth facing in the direction of movement stimulate medullary osteopenia and reduce tooth movement resistance. After the bracket has been placed, a ligature wire is secured to the bracket of the impacted tooth as backup in the event the elastic chain was to break. A bracket with a post or power arm pointing apically is preferred to reduce the likelihood of the chain elastic slipping off the bracket. The full-thickness flaps are returned to their original positioning and sutured. In the case demonstrating recovery of deep palatally impacted canines (Figs. 4.14 and 4.15), nonresorbable 5-0 green braided polyester suture material was used, but the type of suture material used is usually not relevant. Suture removal, when necessary, is recommended anytime after 1 week of postoperative healing.

PERIODONTAL SURGICAL PROCEDURES FOR ORTHODONTIC ACCESS, AESTHETICS, AND STABILITY

Excessive gingival attachment serves no useful purpose before, during, or after orthodontic treatment. There are several reasons for excessive gingival attachment. Gingival excess can result from systemic medications that produce undesirable side effects of gingival hyperplasia such as dilantin, nifedipine, and amlodipine or gingival swelling such as cyclosporine; thick, fibrotic gingival overgrowth can produce tooth movement and/or malocclusion. Excessive gingival attachment can result from familial hereditary gingival hyperplasia or, more commonly, by delayed passive eruption of teeth (Fig. 4.16).

Surgical removal of gingiva is called gingivectomy, and gingivoplasty refers to recontouring the gingival architecture and/or changing the gingival shape. These simple periodontal surgical procedures can contribute meaningfully to orthodontic access, aesthetics, and treatment outcome stability. The fundamental reasons for gingivoplasty procedures are to provide more optimal clinical crown appearances or access and to change gingival shape. According to Sarver (2004), exposure of the clinical crowns that contribute most to the aesthetic smile, the maxillary central incisors, should be approximately 80% width compared with height. Moreover, the gingival architecture for the anterior teeth should have certain characteristics. The gingival shape of the mandibular incisors and the maxillary laterals should exhibit a symmetrical half-oval or half-circular shape, and the maxillary centrals and canines should exhibit a gingival shape that is more elliptical. Thus, the gingival zenith (the most apical point of the gingival tissue) should be located distal to the longitudinal axis of the maxillary centrals and canines, and the gingival zenith of the maxillary laterals and mandibular incisors should coincide with their longitudinal axis (Fig. 4.17).

Excessive gingival attachment often makes optimal orthodontic bracket placement difficult. When the patient is ready for orthodontic treatment with fixed appliances but access to the clinical crown precludes optimal bracket position placement, a gingivoplasty procedure can be used to establish a more favorable crown-to-crestal height relationship by removal of excess gingiva. This is a frequent finding in young patients ready for orthodontic treatment in the late mixed or early permanent dentition (Fig. 4.18).

Removal of excessive gingival tissues is useful during the course of orthodontic treatment to facilitate good oral hygiene and to help in the consolidation of the dental arch.

Fig. 4.16. Delayed passive eruption of teeth can lead to excessive gingival attachment: normal attachment (left), moderate excess attachment (center), and severe excess attachment (right). Note that the tip of the periodontal probe rests at the gingival crest demonstrating that clinical crown length decreases as gingiva excess increases.
Fig. 4.17. Optimal maxillary incisor exposure for esthetics is 1.0 to 0.8 crown height-to-width ratio and ideally, gingival zenith or most apical point of the gingival tissue is distal to longitudinal crown axis. (After: Sarver MS, AJODO, 126:749-753, 2004.)

Fig. 4.18. Increasing access to upper incisor clinical crowns for bracketing on an 11 year old orthodontic patient: pre-treatment (A), 15 days post gingivoplasty (B), and post incisor bracketing (C).
spacing and orthodontic detailing and finishing. Moreover, gingivoplasty at least 2 weeks before removal of fixed orthodontic appliances allows sufficient gingival healing to enable the fabrication of an overlay, Essix type of orthodontic retainer that is well adapted to the gingival contours (Fig. 4.19).

Post orthodontic gingivoplasty can contribute to both smile aesthetics and stability of treatment outcomes (Fig. 4.20). The supracrestal gingival fibers have been identified as contributing to orthodontic relapse, especially rotation relapse, and consequently the procedure called supracrestal fibrofomy has been recommended (Edwards 1988). Others have suggested that orthodontic treatment outcome stability is more likely due to an increase in the elasticity of the whole compressed gingival tissue (Redlich et al. 1996). In either case, gingivoplasty influences the turnover and adaptation of both supracrestal and compressed gingival tissues, thereby reducing orthodontic treatment outcome instability.

Fig. 4.19. Removal of excessive upper anterior gingiva was accomplished during the course of active orthodontic treatment in a 15 year old patient: pre-gingivoplasty (A,B), gingivoplasty and frenectomy (C), and 7 days after the gingivoplasty (D) and post orthodontic treatment (E).
REFERENCES


Fig. 4.20. Effect of recontouring gingival architecture to improve the aesthetics and stability of orthodontic treatment outcome in a 18 year old male patient; immediate post orthodontics (A,B), immediate post gingivectomy (C) and 4 months post gingivectomy (D,E).


Miniscrew Implants for Orthodontic Anchorage

HISTORY

Implants for use as orthodontic anchorage devices have recently become very popular because most are easy to place and remove and inexpensive and can be directly or indirectly loaded with biomechanical forces immediately after placement. Unlike the osseointegrated implants used for prosthetic restorations, implants for orthodontic anchorage rely on mechanical retention and depend on the thickness of cortical bone for stability (Huja 2005). This screw-in type of implant is known by many names such as temporary anchor device (TAD), mini-implant, microscrew, or miniscrew.

Implants for orthodontic anchorage were first described in the literature in 1945 by Gainsforth and Higley and were used to retract the canine tooth in the dog model. In 1983, Creekmore and Eklund reported placement of a screw device in the anterior nasal spine area for use in the intrusion of upper permanent incisors in the treatment of adult deep bite malocclusion. Kanomi in 1997 provided detailed description of loading microimplants less than 1.0 mm in diameter following 3 months of osseous integration. Since 2000, the dental literature has been inundated with articles describing new designs and the use of immediate-load implants as anchorage devices for the treatment of malocclusion. In general, they have proved successful for intrusion and extrusion, protraction, and retraction of individual teeth as well as groups of teeth.

Miniscrew implants are the smallest among all fixed implants; they are the most versatile and adaptable for clinical use and are categorized as either non-bracket-head or bracket-head. The most commonly used implant for orthodontic anchorage is self-drilling with a nonbracket head. These self-drilling and self-tapping (a different cutting point for self-drilling) miniscrews have emerged during the past 6 years as the most popular and frequently used type of orthodontic anchorage implant, and this type of miniscrew will be the focus of this chapter.

Desirable features of a miniscrew include the screw threads, soft tissue sleeve or transmucosal collar, platform, and head (Fig. 4.21). The screw thread portion interfaces with cortical bone; the transmucosal collar interfaces with the soft tissues of the periosteum, either keratinized or nonkeratinized; the platform or soft tissue stop protects the soft tissue from the attachments that connect the miniscrew to the orthodontic appliance and also decreases the likelihood of tissue overgrowth around the screw head; and the head provides the means (often a round hole) for connecting the miniscrew to the orthodontic appliance as well as the screwdriver slots for applying self-drilling and self-tapping pressure.

INDICATIONS

- When “absolute” orthodontic anchorage is needed
- Adequate cortical bone thickness and quality
- Healthy soft and hard tissues of the periodontium

Miniscrews are now considered a reliable anchorage device for orthodontic treatment. Since Food and Drug Administration approval in 1999, these devices have broadened the scope of treatment possibilities not only in orthodontics but in periodontics and prosthodontics as well. Without the use of

References:


implants, forces are generated using other structures as anchorage such as teeth in order to produce desired orthodontic tooth movement. Teeth used as anchorage will inevitably respond with some movement because the anchor teeth are surrounded by a periodontal ligament (PDL), and the PDL is sensitive and responsive to changes in the environment. Miniscrews implanted into cortical bone are stable and do not respond like teeth because the screw threads interface directly with cortical bone as there is no mechanism like the PDL that enables movement of the implant.

Miniscrew implants are most appropriate when there is a need for “absolute” anchorage. They should be inserted into keratinized gingiva if possible and loaded immediately.

Fig. 4.22. Use of miniscrews as orthodontic anchorage to correct Class II malocclusion by retracting upper incisors and canines and to intrude upper left first molar: pre-treatment (A-C), during treatment (D-F) and completed treatment (G-I). Note placement of miniscrew at junction of attached gingiva and mucosa during treatment and use of palatal implant to assist with molar intrusion. Also note the interocclusal space created by intrusion of the upper left premolar and molar.
or within the first 2 weeks of healing (Liou et al. 2004). These devices are effective as anchorage for moving teeth in three spatial planes such as retracting the upper incisors and canines in the treatment of Class II malocclusion following first premolar extraction or intrusion of molars (Fig. 4.22) or protracting posterior teeth to close space (Fig. 4.23).

Miniscrew stability depends on cortical bone thickness because spongy bone contributes virtually nothing to implant stability (Melsen 2005). Alveolar bone is composed of compact (cortical) and spongy (trabecular or medullary) bone. Medullary bone is a highly adaptable tissue, and it responds quickly to changes in the environment with modeling or surface change, whereas cortical bone responds...
slowly to stimuli with remodeling or internal change. Bone modeling is an uncoupled activity of activation (A) followed by formation (F) or resorption (R). Because an activation can lead to either resorption (A-R) or formation (A-F), spongy bone very quickly adapts to any stimuli or change in environment. In contrast, compact bone undergoes bone remodeling which is a coupled sequence of activation (A) followed by resorption (R) followed by formation (F) or A-R-F sequence. The A-R-F sequence is otherwise known as the process of secondary osteon formation: physiological activation (a stimulus) followed by bone resorption (cutting cone) followed by bone formation (filling cone). Remodeling (A-R-F) is a slow process that assures structural integrity of the host skeleton (Roberts et al. 2004). The principal reason for miniscrew implant stability is attributed to the slow bony turnover response of cortical bone (Fig. 4.24).

Miniscrew thread lengths vary from 4 mm to 12 mm with longer thread lengths recommended for bicortical retention (Freudenthaler et al. 2001). In most circumstances, miniscrew thread length need not exceed the width of monocortical thickness. A miniscrew thread length of 6 mm should be adequate and a 4-mm thread length is optimal under most circumstances because monocortical alveolar bone thickness ranges between 2 and 3.5 mm on the facial or lingual mandible in the areas of the first and second molars (Masumoto et al. 2001) and 2 and 7 mm in the palate (Bernhart et al. 2000, King et al. 2006). The soft tissue sleeve width should be at least 2.5 mm, as this is approximately the average thickness of keratinized soft tissue of the periodontium (Costa et al. 2005). Some manufacturers provide short and long transmucosal collars to accommodate variations of soft tissue thickness.

Some situations contraindicate use of miniscrews, according to Park et al. (2003). Miniscrews are contraindicated in the presence of active infection such as untreated periodontal disease and when there is inadequate bone quantity such as in severe alveolar bone loss. When bone quality is compromised, as in untreated osteoporosis or a history of systemic drug use to counteract calcium depletion, miniscrews may be contraindicated. Miniscrews should not be used when there is a limitation in blood supply, when patients are incapable of following home care instructions, and during the mixed dentition if there is risk of permanently damaging tooth buds. The small size of the miniscrews for the most part precludes any permanent tissue damage (Kanomi 1997); root perforation is unlikely and any minor root damage will heal uneventfully (Mah and Bergstrand 2005). No litigation concerning miniscrew use has yet been reported; however, case selection should be carefully considered. An informed consent should be presented to the patient, fully explaining the benefits and risks (including pain, bleeding, inflammation, implant fracture and implant mobility, and/or failure) of using miniscrews.
ARMAMENTARIUM

- Self-drilling or self-tapping miniscrews
- Profound topical anesthetic or an injectable anesthetic
- Manual screwdriver or slow-speed handpiece with appropriate screwdriver attachment

**Technique**

The overall soft and hard tissue periodontal condition of the patient should be thoroughly evaluated and healthy before miniscrew placement and application of biomechanical forces. Self-drilling miniscrews are easy to place and can be implanted under local soft tissue anesthesia or with the use of a topical anesthetic alone (Graham 2006). A profound topical anesthetic is preferred because anesthetizing the teeth alters the patient’s perception of increased resistance to screwdriver pressure (suggesting contact with a root) and a change in sensitivity from pressure to sharp pain. If resistance is encountered during placement, the miniscrew should be backed away and redirected or removed completely and placed elsewhere. Melsen (2005) suggests at least 1 month of healing if there is a desire to place a miniscrew at the identical location of a previous miniscrew. When a miniscrew needs to be relocated immediately, she suggests at least a 5-mm distance from the initial implant site. Vital structures such as major blood vessels, nerves, maxillary sinus, and tooth roots need to be avoided during implant placement. The use of a guide or “jig” and a vertical bitewing as a reference point to determine the location of insertion can be useful in miniscrew placement (Figs. 4.25 and 4.26).

**Fig. 4.25.** Example of an implant guide or “jig” fabricated to assist in the placement of a miniscrew implant: Vacuum-type retainer fabricated on study cast incorporating wire adapted approximating the long axis of 1st molar and 2nd premolar (top left); transfer of guide to patient’s mouth (top right); radiographic image of patient with guide seated (bottom left); and transfer of guide back to study cast to mark position of miniscrew placement after measuring distance between wires on the radiograph (bottom right).
Optimal placement of the miniscrew is into attached or keratinized gingiva or at the junction of attached gingiva and mucosa (Fig. 4.27). Keratinized gingiva is abundant on the hard palate but usually limited on the buccal or labial alveolus. An apically directed insertion is suggested when the band of attached gingiva is thin or the attached gingiva level is coronal to the mid-root.

Depending on design, some miniscrews require drilling a pilot hole using a dental handpiece before insertion. Self-drilling and self-tapping miniscrews are placed without the assistance of a preliminary tap-hole and require only a screwdriver to turn the screw. Miniscrews can be inserted using a slow-speed handpiece attachment, but the use of a hand-manipulated screwdriver is more common. Whenever a manual screwdriver is used, irrigation is not necessary; however, a slow insertion speed should be used to minimize the heat generated in the bone. The type of equipment needed to insert the implant device depends on the screw diameter, screw design (cylindrical versus conical), location (palate versus buccal-labial), and recipient’s bone density.

Where the miniscrew is to be inserted should be determined based on the biomechanical requirements and type of mechanics as well as the root proximity. The location of miniscrew placement between the permanent second premolar and first molar at the level between mid-root to apex is frequently used in orthodontics because this location typically provides adequate cortical bone thickness (Masumoto 2001) and is both convenient and strategic as a biomechanical anchorage site. In general, the hard palate provides ample cortical bone thickness, and all soft tissue is keratinized. Alveolar cortical bone is typically thinner in the maxilla than in the mandible and thinner in females than in males, and the canine fossa regions can be particularly thin and problematic for miniscrew retention (Costa et al. 2005).
Clinical success of the miniscrew is determined by implant stability as long as it is being used as an anchorage device. No randomized clinical trials have yet been published but many case reports describe miniscrew failure rates (screw loss or mobility) ranging from 3% to 50% (Cheng et al. 2003, Deguchi et al. 2003, Melsen 2005B, Miyawaki et al. 2003). The stability depends on mechanical retention at the interfaces of the cortical bone and the screw threads; physical factors that influence stability are screw diameter, thickness of cortical bone, and placement orientation (Miyawaki et al. 2003). There is a direct relationship between miniscrew diameter and stability but an inverse relationship between miniscrew diameter and ease of placement with screw thread diameters over 2.5 mm. Self-drilling miniscrews with diameters greater than 2.5 mm become difficult to place and screws less than 1.0 mm in diameter are at risk for implant fracture, increased instability and/or complete failure (loss). The optimal range of self-drilling miniscrew diameter is between 1.5 and 2.0 mm. Placement of a miniscrew perpendicular to cortical bone surface is acceptable when cortices are at least 2 mm thick, but when cortical bone is thinner, changing the orientation of the screw and inserting in a more apical direction allows greater screw thread to cortical bone contact and greater stability. Optimally, the miniscrew should be placed into keratinized attached gingival or at least at the boundary between attached gingival and unbound mucosal tissue. While some implant systems advocate placement in mucosa to favor distance and/or vector of force between the miniscrew and the target teeth, inflammation and soft tissue overgrowth are often problems. In those cases where miniscrew placement in mucosa cannot be avoided, a soft tissue punch prior to insertion is highly recommended to prevent the loose tissue from engaging the threads of the screw. A postinsertion radiograph should be taken to confirm appropriate location of the miniscrew, and a 1-week follow-up visit whenever possible is recommended to check for pain, peri-implantation soft tissue inflammation, and stability. After treatment has been completed, removal of the miniscrew does not require anesthesia.

COMPlications

- Miniscrew mobility
- Peri-implantation inflammation
- Soft tissue injury
- Root damage
- Root resorption/bone loss
- Sinus perforation
- Implant fracture

Complications are less likely to occur with self-drilling or self-tapping miniscrews than with immediate load orthodontic anchorage systems that require soft tissue incisions or surgical flaps during placement. Complications that may arise during self-drilling and/or self-tapping miniscrew placement and use include the following.

Miniscrew Mobility

Instability occurs when the interface between cortical bone and miniscrew is not sufficient to provide adequate support for the implant. The most common scenarios are when cortical bone is too thin or when there is sufficient thickness of the alveolar cortex, but soft tissue thickness is excessive, the miniscrew is too short, and screw threads do not sufficiently implant into bone. Failing to load the miniscrew within 2 weeks of placement promotes epithelial proliferation in the interface of the bone and miniscrew and is another reason for excessive implant mobility. Miniscrews often become loose in patients with compromised bone quality resulting from some systemic bone conditions or the therapeutic effects of osteoporosis/osteopenia treatment. The miniscrew should be adequate if it is stable enough to withstand the loading forces; however, if mobility is excessive, then the miniscrew should be removed.

Peri-implantation Inflammation

Placing miniscrews into alveolar mucosa introduces the risk of soft tissue inflammation and overgrowth with the miniscrew head buried and out of reach. The risk of soft tissue inflammation can be reduced by prescribing and using chlorhexidine rinses for 7 days starting the day of the miniscrew insertion into alveolar mucosa. When miniscrews are used, home care instruction should be carefully explained to the patient and monitored throughout the treatment, especially when miniscrews are placed into nonkeratinized periodontal soft tissues.

Soft Tissue Injury

Soft tissue injury may result during placement of a miniscrew into alveolar mucosa if a soft tissue punch is not used before insertion because the loose mucosa easily engages the threads of the screw. Attachments from the fixed orthodontic appliance to the head of the screw can injure soft tissue; this problem can be minimized by using screws designed with soft tissue stops or platforms.

Root Damage

Minor root damage usually heals with no consequence (Mah and Bergstrand 2005), especially if the damaged PDL area does not exceed 2 mm (Andreasen and Kristerson 1981). If the damage is greater than 2 mm, ankylosis and/or external/internal root resorption may result. In these situations develop, close radiographic monitoring is recommended.

Root Resorption/Bone Loss

Root resorption can be the result of excessive force, especially during intrusion. Park et al. (2003) used between 200g
and 300g force to intrude posterior teeth without noticeable root resorption or vitality problems. Melsen et al. (1988) reported that following tooth intrusion, periodontal tissue was recovered by new attachment only when good hygiene was enforced. Intrusion under unhealthy conditions can precipitate bone loss; therefore, a 3-month recall regimen is recommended for all patients undergoing intrusion movement.

**Sinus Perforation**

Sinus perforation can be easily avoided by close inspection of the patient’s radiographs. Pneumatization of the sinus can increase the likelihood of perforation. If the communication does not exceed 2 mm, no further action needs to be taken.

**Implant Fracture**

The greater the miniscrew diameter, the less likely it is that the implant will fracture or break. Miniscrews with diameters exceeding 1.5 mm are easy to place, and the likelihood of screw breakage is minimal. A broken miniscrew should be removed unless the retrieval effort will result in an excessive amount of tissue removal.

Complications in the placement and use of self-drilling and self-tapping miniscrews are infrequent. As with other forms of therapy, complications are minimized when miniscrews are placed, used, and monitored with careful and continuous attention to the patient’s physical anatomy, health, and well-being.

**REFERENCES**


