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REVIEW ARTICLE

PERIODONTALLY ACCELERATED OSTEOGENIC ORTHODONTICS A RACE AGAINST TIME WITH BONE GRAFTS AND CORTICOTOMY

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ABSTRACT

One of the current techniques in the orthodontic realm, periodontally accelerated osteogenic orthodontics (PAOO) expedites the treatment time. This procedure which combines the periodontally engineered regenerative surgery and traditional orthodontic movement is performed shortly before the application of orthodontic forces and has been suggested to enhance tooth movement and, hence, orthodontic treatment as a whole. The arrival of techniques such as corticision, piezocision and micro-osteoperforations has allowed accelerated tooth movement with minimal surgical intervention. This article gives a clear review of the historical aspect and principles of this therapeutic approach with the description of the technique and its advantages and disadvantages.

INTRODUCTION

There is nothing more rewarding in the practice of dentistry than working with a team of like-minded dental professionals to solve complex functional/esthetic problems. This interdisciplinary collaboration will help to deliver the best treatment to the patient by providing a well functioning dentition in a healthy periodontal environment.

One of the major barriers with patients seeking orthodontic treatment is the long duration of the treatment.[1] Adults have more specific concerns related to facial and dental aesthetics, the type of orthodontic appliance and the extent of treatment time. Growth is an almost insignificant factor in adults compared to children and there is a higher chance of hyalinization occurrence during treatment. In addition, cell mobilization and conversion of collagen fibers is much slower in adults than in children. Finally, adult patients are more prone to periodontal complications since their teeth are confined to non-flexible alveolar bone.[2]

All these factors make adult orthodontic treatment a challenging therapeutic modality in dentistry, which necessitates the need for improvised concepts and procedures for the purpose of creating an esthetic functional dentition in a healthy periodontal environment. A number of techniques and theories are available to accelerate the procedure where an ideal force would allow for physiological tooth movement with the quickest treatment modality. One such theory is Periodontically Accelerated Osteogenic Orthodontics, patented by Wilckodontic.[3] It is said to harness the regional acceleratory phenomenon (RAP).[4,5] The tooth movement synchronized with tissue engineering principles of periodontal regenerative surgery aids in rapid orthodontic therapy and overcome its side effects.[6]

Historical review

1800-Experiments with surgically assisted orthodontic tooth movement started.

1893-Cunningham presented luxation or the immediate method in the treatment of irregular teeth

1959-Kole theorized that by disrupting the continuity of the resistant cortical layer of bone, he created moving blocks of bone in which teeth were embedded (bony block movement).[7]

1975-Duker *et al* found that the health of the periodontium is maintained if the marginal bone is preserved during corticotomy.[8]

1990-Gantes and his co-workers suggested corticotomy facilitated orthodontics. Corticotomy cuts were given labially and lingually to circumscribe the roots of the teeth.

2001-Wilcko reported that the rapid tooth movement was not the result of bony block movement, but it was due to a transient localized remineralization-demineralization phenomenon in the bony alveolar housing consistent with the wound healing pattern of the regional acceleratory phenomenon (RAP). [3]

2008-PAOO was introduced by Wilcko which is the combination of selective decortication-facilitated orthodontic technique and alveolar augmentation.[9]

Biology underlying PAOO

The regional acceleratory phenomenon (RAP) is the reaction of tissue to an injurious stimulus which increases the healing capacity of the affected tissues. It is characterized by acceleration of the normal cellular activities, as an 'SOS' phenomenon of the body that has to respond to the new perturbation. In the alveolar bone, the RAP is characterized, at a cellular level, by increased activation of the basic multicellular units (BMUs), thereby increasing the remodeling space. At the tissue level, the RAP is characterized by the production of woven bone, with the typical unorganized pattern, that will be reorganized into lamellar bone at a later stage. In the alveolar bone, the RAP occurs typically in the healing process of the alveolar sockets after tooth extraction, in periodontal disease, after surgery and trauma and during orthodontic tooth movement.[10-13] This phenomenon causes bone healing to occur 10-50 times faster than normal bone turnover.[14] RAP begins within a few days, usually peaks at 1-2 months, and may take from 6 to 24 months to subside completely.[11]

During tooth movement, the compression of the periodontal membrane between the tooth root and the socket wall on the pressure side results in damage and hyalinization of the periodontal ligament.[15-17] Bone resorption is inhibited as long as the hyaline is still present. Hyaline is gradually removed by macrophages that differentiate from mesenchymal cells that travel to the area and takes up to 4 weeks for the hyaline to be removed. During this initial period, no tooth movement occurs.[15]

When an alveolar corticotomy is performed near the tooth to be moved, Mathews and Kokich suggested that by histological results, the RAP occurs and it accelerates the appearance of the macrophages that remove the hyaline as early as 1 week after the initiation of orthodontic force.[15,18] Earlier removal of the hyaline allows earlier bone resorption, resulting in more rapid tooth movement compared with the noncorticotomy side.[18]

The application of orthodontic force can act as a sole stimulant sufficient to trigger mild RAP activity. RAP activity is increased when tooth movement is coupled with selective decortications.[14,19] Wilcko *et al* speculated that the dynamics of physiologic tooth movement in patients who underwent selective decortication might be due to a demineralization-remineralization process rather than bony block movement.[5] An additional report by Wilcko, *et al.* suggested that the tooth movement can be surgically best facilitated by providing for a thin layer of activated bone over the root surfaces especially in the direction of the intended tooth movement. The demineralization of this thin layer of bone will leave the soft tissue matrix of the bone and islands of osteoid that can be carried with the root surfaces of the teeth where it will remineralize in the desired position. This remineralization process is almost complete in the adolescent, but only partially complete in the adult, resulting in a reduction in bone volume including residual labial and lingual bony dehiscences.[9] The addition of the grafts to augment the alveolar bone will provide for increase in its volume and sandwiches the roots of the teeth between intact lingual and facial layers of bone. It corrects the preexisting fenestrations and dehiscences. It also compensates for any corticotomy-related reduction in bone volume, thereby ensuring adequate periodontal support.[9,19]

Facilitated tooth movements will occur only close to the corticotomized teeth as result of limited demineralised area. The relative anchorage between teeth alters as a result of increased differential rate of movement between corticotomized and non-corticotomized teeth. The anchorage teeth become more effective anchors if not corticotomized; on the other hand, corticotomized teeth move with greater ease. The greater ability of teeth to move quickly depends on the intensity and proximity of corticotomy rather than its pattern.[20]

Surgical Technique

Flap Design

Proper access to the surgical area, preservation of gingival form and proper coverage of the graft material are important for the success of a procedure. The basic flap design is a combination of a full thickness flap in the most coronal aspect of the flap with a split-thickness dissection performed in the apical portions. In order to avoid vertical releasing incision, the flap should be extended beyond the corticotomy sites mesially and distally. The periosteal layer is carefully elevated from the alveolar bone, providing access to the alveolar bone surface and facilitating identification of critical neurovascular structures.[22]

Decortication

The removal of the cortical portion of the alveolar bone initiates RAP response. Corticotomy perforations are done by using 0.5mm diameter stainless steel no. 1 or no.2 round bur with high speed hand piece on the labial and lingual aspects alveolar bone in between the roots of teeth with depth of 1.5 to 2mm. Vertical groove is placed in the interradicular space, midway between the root prominences in the alveolar bone. This groove extends from a point 2 to 3 mm below the crest of the bone to a point 2 mm beyond the apices of the roots. These vertical corticotomies are then connected with a circular-shaped corticotomy. Care is taken not to extend the cuts near any neurovascular structures. If the alveolar bone is of sufficient thickness, solitary perforations may be placed in the alveolar bone over the radicular surface.[22]

Particulate Grafting and Closure Techniques

Autografts, allografts and synthetic grafts or a combination thereof can be used for grafting after decortication. The volume of the graft material used is dictated by the pretreatment thickness of the alveolar bone, direction and amount of tooth movement predicted, and the need for labial support by the alveolar bone. 0.25 to 0.5 ml of graft material per tooth can be used.[22] Recently, platelet rich plasma is also used to increase the stability of the graft material. If there is any recession in an area, it can be treated at the same time with connective tissue graft or acellular dermal matrix allograft.[22,23] Closure Techniques The therapeutic endpoints of suturing are primary closure of the gingival flaps without excessive tension and graft containment. This can be achieved by using

nonresorbable interrupted sutures and left in place for 1 to 2 weeks. No packing is required.[22]

Timing of Orthodontic Treatment

Orthodontic treatment can be resumed 2 weeks postsurgery. The interval between subsequent orthodontic appointments should be ranging from 1 to 3 weeks. A delay is avoided to take advantage of the time period that the RAP is occurring. The orthodontist has a period of 4-6 months to accomplish accelerated tooth movement, after which finishing movements occur with a normal speed. [22]

Indications [22,24,25]

1. For decrowding of the dental arches.[22]
2. For reducing treatment time with sufficient stability.[3]
3. For uprighting of tipped molars and intrusion of supraerupted molars.[24,25]
4. For single or segmental intrusion and treating open bite.[26]
5. For expansion of arches in buccal region.[26]
6. For early space closure in extraction case.[20,27]
7. To facilitate eruption of impacted tooth.[9]

Contraindications[18]

1. Patients with systemic diseases
2. Patient with poor oral hygiene and active periodontal disease
3. Patients on long term medications which will slow down bone metabolism, such as bisphosphanate and NSAIDs. NSAIDs lead to prostaglandin inhibition resulting in reduced osteoclastic activity thus disturbing bone remodeling.
4. Patients on long term steroid therapy due to the presence of devitalized areas of bone
5. Patients with compromised width of the attached gingiva.

Modifications and Various Techniques

Piezocision[28,29]

Since full thickness flaps may cause reduction of bone height and dehiscences, Dibart introduced "piezocision" a new, minimally invasive flapless alveolar decortication procedure, combining microincisions with selective tunneling that allows for hard or soft-tissue grafting and piezoelectric incisions made through the buccal cortical layer only. This procedure has the advantages of minimal discomfort with greater patient acceptance and shorter orthodontic treatment time.

Corticision[29, 30]

One more technique to hasten the tooth movement is by corticision where reinforced scalpel is used to separate the interproximal cortices transmucosally without reflecting a flap.

Alveocentesis [30,31]

Teixeira *et al*., placed microosteoperforations (MOPs) on alveolar bone during orthodontic tooth movement. By stimulating the expression of inflammatory markers, there is an increase in osteoclast activity and the rate of tooth movement. PROPEL System works on this principle and decreases orthodontic treatment time by 50-60%.

Lasers[32]

The cortical bone layer is reduced to facilitate tooth movement by Erbium, Chromium doped Yttrium Scandium Gallium Garnet laser.(Er,Cr:YSGG)

Monocortical Tooth Dislocation and Ligament Distraction Technique. (MTDLD)[33]

This technique was introduced by Vercellotti and Podesta. Tooth dislocation, on the buccal side are done by giving vertical and horizontal microsurgical corticotomies around each root surface of the tooth. Applied forces given on the lingual side produces rapid distraction of ligament fibers leading to faster tooth movement.

DISCUSSION

Corticotomy-facilitated orthodontics imparts a means for rapid movement of teeth purportedly with less harmful effects on the periodontium and with greatly reduced treatment time.[3] Hajii's studies showed that the treatment time by PAOO was reduced to one-third to one-fourth when compared to that of traditional orthodontics.[34] According to Sebaoun,[35] the selective alveolar decortication injury gave rise to a vast stimulus for both the catabolic resorption response (osteoclastic count) and the anabolic formation response (apposition width and rate) which peaked at 3 weeks. This response was 3 fold times higher.

Wilcko described that alveolar augmentation with allografts (DFDBA)/ xenograft(bovine bone) or alloplastic graft (bioactive glass) combined with corticotomy assisted orthodontic tooth movements covers the fenestrations and dehiscences and increases the bony support for teeth.[9] These graft material has the advantage of availability and no secondary surgical site when compared to autografts.

Studies showed that there was no effect on the vitality of the pulps of the teeth in the area of corticotomy.[36] In an animal study, Liou *et al*. showed a normal pulp vitality when tooth was moved at a rate of 1.2 mm per week.[37] However, pulp vitality deserves additional investigation.

Some amount of root resorption is expected with any orthodontic tooth movement. Increased duration of the applied force has been associated with root resorption.[38-40] The reduced treatment duration of PAOO may reduce the risk of root resorption. In an animal study, Ren *et al*. reported rapid corticotomy induced tooth movement without any associated root resorption or irreversible pulp injury.[41] Fergusson[42] found that rapid orthodontic treatment and reduced apical root resorption are probably due to the transient osteopenia induced by the cortical surgery and inspired by regional acceleratory phenomenon. Further studies on long-term effect of PAOO are required.

Advantages of PAOO[34]

1. Decreased overall treatment time to one-third to that of conventional orthodontics.
2. Increased bone support due to the addition of bone graft.
3. Reduced root resorption due to decreased resistance by cortical bone.
4. Low relapse reported.

Disadvantages of PAOO[34]

1. Mildly invasive surgical procedure.
2. Post-surgical crestal bone loss and recession may occur.

3. Extra-surgical cost.
4. Some pain and swelling is expected, and the possibility of infection.
5. Not applicable to all cases, proper case selection is necessary to attain good results.

The efficacy, effectiveness, and efficiency of corticotomy facilitated orthodontics for accelerating tooth movement in adult patients were evaluated by Mathews and Kokich.[18] They concluded that efficiency of this procedure was questionable due to:

a. Limited duration of RAP
b. Additional surgical procedure and significant expense associated to PAOO
c. Lack of evidence that there are no randomized controlled trials to substantiate reduction in orthodontic treatment time reported till date.

A systemic review conducted by Hoogeveen[43] reported that this procedure is safe for the oral tissues and is characterized by a temporary phase of accelerated tooth movement. No prospective studies have compared overall treatment time and treatment outcome with those of a control group. Well-conducted, prospective research is still needed to draw valid conclusions.

CONCLUSION

The spirit of multidisciplinary approach in dentistry has raised synthesized periodontal engineered regenerative surgery and traditional orthodontic tooth movement protocols, toward a method of rapid tooth movement. This accelerated tooth movement along with reduced treatment time, is a great advantage to the periodontal health because it reduces patient "burnout" and significantly lessens the time available for relatively benign commensal bacterial biofilms to assume qualitative changes, thereby converting to a destructive cytotoxic potential which is often seen when fixed appliances have remained on the teeth for more than 2 to 3 years.

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