Periodontally Accelerated Osteogenic Orthodontics (PAOO) - An Updated Literature Review and Recent Advances

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Abstracts: Malpositioned teeth are responsible for aesthetic and occlusal aberrations in many adults. Orthodontic movement is considered a "periodontal phenomenon" because all the periodontal tissues are involved in tooth movement. Lengthy orthodontic treatment time has been linked to an increased risk of root resorption, gingival inflammation, decalcification, and dental caries**.** [2] Therefore, reducing the treatment time is an appropriate goal, which requires increasing the rate of tooth movement. To meet the constant demand to shorten the treatment time and to maintain the integrity of periodontal structures an alternative clinical procedure has been popularized, known as Accelerated Osteogenic Orthodontics (AOO) and, more recently, the Periodontally Accelerated Osteogenic orthodontics. This article over review of literature of this technique and describes recent advances in this procedure. [Pavankumar A NJIRM 2016; 7(4): 140-146]

Key words: AOO, PAOO, Corticotomy

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Introduction: A corticotomy is a procedure whereby only the cortical bone is cut, perforated, or mechanically altered in a controlled surgical manner. At the same time penetrate into the bone marrow only minimally. This is in contrast to an osteotomy, which is defined as a surgical cut through both the cortical and medullary bone. This term is frequently used when describing the creation of bone segments.

The PAOO procedure was introduced by Dr. William Wilcko and Dr. Thomas Wilcko [1].It is patented as Wilckodontics.

The conventional view of orthodontic tooth movement is that of a cell-mediated process orchestrated predominantly within the periodontal ligament (PDL). Sustained force on a tooth translates into a PDL cell population shift where in pleomorphic fibroblasts are converted to osteoblasts. Osteoclasts are derived from the influx of blood borne monocytic precursors. With time, the lamina dura undergoes osteoclasis in the area of PDL "pressure," and bone apposition occurs in the areas of PDL "tension". [2] The massive cell death and hyalinization zone are common features of conventional orthodontic treatment, takes 3 to 5 weeks for this zone of sterile necrotic tissue to be eliminated and repaired, during which time tooth movement by frontal resorption is virtually at a standstill. [2] Moreover there is an association between orthodontic root resorption and the presence and removal of necrotic hyalinized PDL tissue. [2]

But the rapid tooth movement in corticotomy facilitated tooth movement is because of increased bone turnover in response to surgical trauma. This change results in a localized decrease in trabecular bone density, which in turn would offer less resistance to tooth movement. [2]

After any trauma to bone tissues, remodelling, which is commonly found in the bone tissue structures is greatly increased to accelerate the repair process and consequently functional recovery. This takes place by a phenomena called as RAP. [3]

The metabolism in the healing response is thus accelerated in both the hard and soft tissues of the periodontium and when synthesized with the periodontal tissue engineering principles of enhanced clot stabilization around particulate bone grafting materials provided for orthodontic tooth movement (OTM) 3 to 4 times faster, increases in the envelope of motion (degree of movement) two to three-fold, and increased alveolar density for more stable clinical outcomes and subtle facial morphing. [4]

The surgical component of the PAOO technique is an in-office procedure. The post-operative recovery should be no more uncomfortable than that of other orthodontic-related surgeries such as third molar removal and gingival grafting, and it is certainly less of an issue than the recovery following orthognathic surgery.[5]

The Periodontally Accelerated Osteogenic Orthodontics (PAOO) procedure is a powerful technique that can make the treatment of very complicated scenarios more routine, make the treatment of routine cases extremely fast and predictable and providing a more intact periodontium with increased alveolar bone thickness. [1]

Literature over view: Bryan et al. [6] first reported surgical approaches to correct poorly positioned teeth in patients with malocclusion.

Cunningham [7] used mesial and distal interseptal osteotomies with a circular saw to reposition palatally inclined maxillary teeth and stabilized them in correct occlusion with wire ligatures or metal splints for 35 days. The most important feature was the fact that this combined active surgical-orthodontic treatment reduced the treatment time to one-third to that of conventional treatment time and allowed more predictable treatment in older patients.

Bichlmayr [8] reported the expansion provided by corticotomy applied to the buccal region of premolar and molar teeth in patients with bilateral narrow maxilla, with substantial influence in the dental society, leading to the acceptance of corticotomy in German-speaking European countries as the 'Bichlmayr method'

Kole's [9] procedures involve the reflection of full thickness flaps, followed by Interdental cuts through the cortical bone, barely penetrating the medullary bone. The sub apical horizontal cuts (approximately 1 mm beyond the apices of the roots) connecting the interdental cuts were osteotomy style, penetrating the full thickness of the alveolus. He suggested that the blocks of bone was being moved rather than the individual teeth, the root resorption would not occur and retention time will be minimized. But the invasive nature of Kole's technique made it unacceptable.

Duker [10] used Kole's basic technique to investigate how rapid tooth movement with corticotomy affects the vitality of the teeth and the marginal periodontium. The health of the periodontium was preserved by avoiding the marginal crest bone during corticotomy cuts and concluded that neither the pulp nor the periodontium was damaged following orthodontic tooth movement after corticotomy surgery.

Suya et al. [11] reported an improved surgical procedure which differed from Kole's technique with the substitution of a supra apical horizontal corticotomy cut in place of the horizontal osteotomy cut beyond the apices of the teeth. Suya contrasted his technique with conventional orthodontics as being less painful, producing less root resorption, and exhibiting less relapse.

Wilcko WM et al.[12] reported a study that was conducted on two patients who presented with class I molar relation with crowding of maxillary teeth along with some amount of constriction in the maxilla. Braces were placed on both patients, and the arch wires were engaged during the week preceding the surgery. Surgery was performed and the surgical site was covered by bone graft. The study showed that corticotomy facilitated orthodontic tooth movement, decreased the treatment time in both the cases and the overall treatment was completed in 6 months and 2 weeks.

Wilcko WM et al. [13] treated a patient with upper and lower arch crowding. The bone activation was performed labially and lingually. The activated bone was then covered with a particulate bone grafting mixture. The ability to increase the alveolar volume is readily apparent in a comparison of the pre-treatment and post-treatment surface computed tomographic scans of the lower arch. This increased thickness of cortex will help provide for increased stability after treatment.

Skountrianos et al. [14] compared the efficacy of maxillary de-crowding and stability in non-extraction orthodontic treatment with and without alveolar corticotomy. Patients were treated by non-extraction orthodontics with alveolar corticotomy surgery plus augmentation grafting and without surgery. It was concluded that corticotomy-facilitated, non-extraction orthodontic treatment resulted in nearly the same post treatment outcome in 1/3rd the treatment time, and the outcome was more stable during retention.

Germec et al. [15] conducted a study on a patient with severe anterior crowding, anterior cross bite, class III dental relationship. Treatment consisted of extraction of 4 premolars and corticotomy was performed on the labial side with orthodontic therapy for retraction of lower anterior teeth. The result showed reduced

treatment time without any adverse effect on the periodontium and tooth vitality.

Shoichiro et al. [16] retracted the maxillary and mandibular anterior teeth using corticotomy. Orthodontic treatment was combined with corticotomy and the placement of titanium miniplates. The maxillary first premolars and mandibular second premolars were extracted. At the same time, a corticotomy was performed on lingual and buccal sides in the maxillary and mandibular regions. Cephalometric superimpositions showed no anchorage loss, and panoramic radiographs showed neither significant reduction in the crest bone height nor marked apical root resorption in corticotomy group.

Fischer et al. [17] performed a study to check the orthodontic treatment acceleration with corticotomy-assisted exposure of palatally impacted canines. One canine was surgically exposed using a conventional surgical technique while the contra lateral canine was exposed using a corticotomy assisted technique. After the tooth movement was completed, statistical comparisons of the two methods revealed a reduction of treatment time of 28- 33 % for the corticotomy assisted canines.

Moon et al. [18]did the intrusion of over erupted molars by Corticotomy and Orthodontic Skeletal Anchorage. The authors performed a corticotomy and used orthodontic skeletal anchorage with miniplates. They achieved a sufficient amount of molar intrusion without discomfort, root resorption, or extrusion of the adjacent teeth.

Tomaso Vercellotti et al. [19] treated patients with vertical and horizontal microsurgical corticotomy around each root with a piezosurgical micro saw to eliminate cortical bone resistance. The immediate application of strong biomechanical forces produces rapid dislocation of the root and the cortical bone together. No periodontal defects were observed in any of the patients. Compared to traditional orthodontic therapy the average treatment time with corticotomy was reduced by 60 – 70%.

Wilcko et al. [1] completed the treatment of a patient with minor to moderate anterior crowding and a Class I molar relationship, in a short period of 3 months and 2 weeks. PAOO was performed in the maxillary anterior region. The most profound demineralization was seen in close proximity to the corticotomy cuts. No apparent demineralization was seen approximately one tooth distant from the nearest corticotomy cut indicating the specific therapeutic range of the regional effect.

Wilcko et al. [20] presented 3 case reports in which PAOO was utilized to accomplish complete orthodontic treatment. All cases demonstrated rapid tooth movement and stability up to 11.5 years after treatment. PAOO is a method that produces efficient and stable orthodontic tooth movement. They concluded that teeth can be moved 2 to 3 times further in 1/3 to 1/4 the time required for traditional orthodontic therapy alone. The basis of these movements is physiologically based on principles of RAP.

AlGhamdi et al. [21] found corticotomy to be effective in accelerating orthodontic treatment. According to the author, bone graft should be applied directly over the bone cuts and the flap sutured in place. Tooth movement should be initiated two weeks after the surgery, and every two weeks there after by activation of the orthodontic appliance. Orthodontic treatment time with this technique was reduced to one-third of the time required for conventional orthodontics.

Mehra [22] performed a study to define specific indications, and data showing failure and stability of treatment results with the use of Selective Alveolar Decortication (SAD). The authors found the technique to be extremely successful for the correction of certain specific malocclusions including dental crowding, transverse maxillary constriction, and some open bite malocclusions. SAD significantly increases the scope of non-extraction orthodontic treatment and has the potential to be an alternative to traditional orthognathic surgery.

Abbas et al. [23] performed a study to identify the effect of the corticotomy-facilitated (CF) orthodontics technique on orthodontic tooth movement compared to the non surgical standard orthodontics technique and concluded that the corticotomy increases orthodontic tooth movement with accepted degrees of pain and discomfort. CF orthodontics reduces the duration of treatment compared to the non-surgical standard orthodontic techniques.

Massoud Seifi et al.[24] performed a study with the aim to enhance the orthodontic tooth movement by reducing the cortical bone layer following Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) laser irradiation, without reflection of surgical soft tissue flap. The innovated laser assisted corticotomies enhanced the rate of orthodontic tooth movement on the intervention side, significantly. Laser assisted flapless corticotomy is a useful procedure for reducing treatment time and damage to periodontal tissue. It also eliminates the necessity of the more invasive intervention of flap surgery.

Subraya Bhat et al.[25] treated six adult patients with bimaxillary protrusion in which extraction of upper and lower first premolars were planned. A modified corticotomy procedure was carried out under local anaesthesia. They concluded that corticotomy assisted orthodontics is an effective treatment alternative in adults with severe malocclusion to decrease the treatment time and increase the quality of treatment.

Preeti Bhattacharya et al. [26] conducted a study in 20 which subjects who required orthodontic treatment with upper anterior retraction space of 1st premolar were selected and divided into control and corticotomy groups. The pre and post retraction CT scans were recorded and concluded that Alveolar corticotomy not only accelerates the orthodontic treatment but, also provides the advantage of increased alveolar width to support the teeth and overlying structures.

Wilcko et al. [27] conducted a study in 35 subjects and divided into case (corticotomy) and control (with out corticotomy) groups and measured keratinized tissue height (KTH) through photographs and concluded that Orthodontic therapy combined with alveolar decortication and augmentation bone grafting resulted in a significant increase in KT height.

Munoz et al.[28] conducted a pilot prospective observational study involving a cohort of 11 patients. A wilcko's modified PAOO technique with L-PRF (incorporated into the graft and as covering membrane) was performed with informed consent. Post- surgical pain, inflammation and infection were recorded for 10 days post-operatively, while the overall orthodontic treatment and post-treatment were followed up to 2 years and concluded that combination of L-PRF with traditional bone grafts reduced post- surgical pain, inflammation, infection and increased post orthodontic stability over a 2 years period.

Surgical technique and advances in surgical techniques: After profound anaesthesia with bilateral Infraorbital nerve block for the buccal aspect of the maxillary anterior region and Nasopalatine and bilateral Greater Palatine nerve block for the palatal aspect, crevicular incisions were given with the help of No.15 surgical blade in Bard and Parker handle (B. P.Handle) extending from the distal surface of extraction space on one side to the contra lateral side. A full thickness mucoperiosteal flap was then elevated extending 3-4 mm beyond the mucogingival junction. With the help of piezo/straight carbide bur no.2 in the high speed hand piece, under proper cold saline vertical grooves were placed in the inter radicular space, midway between the root prominences in the alveolar bone from the distal surface of canine on one side to the distal surface of canine on the other side. These grooves extended from a point 2 to 3 mm away from the crest of the bone to a point approximately 2 mm beyond the apices of the roots. [4]

Semi lunar corticotomy cuts were made joining these vertical cuts beyond the apices of the roots. If the alveolar bone was of sufficient thickness, solitary perforations were made in the alveolar bone over the radicular surface with the help of round carbide bur. However, if this bone was estimated to be less than 1 to 2 mm in thickness, these perforations were omitted to ensure no damage to the radicular surface. Same procedure is repeated on palatal side. [4]

Particulate Grafting: The volume of the graft material use dictated by the direction and amount of tooth movement predicted the pre-treatment thickness of the alveolar bone, and the need for labial support by the alveolar bone. No objective data was existed comparing one grafting material with another in terms of superiority. The most commonly used materials are deprotienzed bovine bone, autogenous bone, decalcified freeze-dried bone allograft, or a combination of these material. The use of a barrier membrane is not suggested. The grafting material is placed with an effort not to place an excess amount. A typical volume used is 0.25to 0.5 mL of graft material per tooth. The decorticated bone acts to retain the graft material. [4]

Closure Techniques: Primary closure of the gingival flaps without excessive tension and graft containment were the therapeutic endpoints of suturing and these were achieved with Nonresorable Interrupted black braided silk sutures. No packing is required. The sutures were left in place for 7-8 days. **[Fig 1a-1d]**

Post operative management: PAOO takes several hours for complete of the procedure. Use of short term steroids provides comfort to patient. Antibiotics and pain medications administration is based on clinician preference. Long term administration of non steroidal anti inflammatory drugs is discouraged because it interferes on RAP. The most commonly reported postsurgical complications are oedema and ecchymosis, both of which are self-limiting. The patient will return for postsurgical evaluation and gentle prophylaxis every week for the first month and then monthly thereafter. [4]

Post operative indications: Following Indications were given to the subjects: Fresh and soft diet, avoid chewing on the operated area, use 0.12% chlorhexidine mouthwash twice a day and warm saline rinses 5-6 times daily after 24 hours. Avoid brushing the affected site until sutures are removed. [4]

Recent advances in surgical technique: Corticision: Kim et al.[29]introduced the corticision technique as a minimally invasive alternative to create surgical injury to the bone without flap reflection. In this technique, the authors use a reinforced scalpel and a mallet to go through the gingiva and cortical bone, without raising a flap buccally and lingually. The surgical injury created is enough to induce the RAP effect and move the teeth rapidly during orthodontic treatment. This technique, although innovative, has two drawbacks: the inability to graft soft or hard tissues during the procedure to correct inadequacies and reinforce the periodontium, and the repeated malleting, which may cause dizziness after surgery.

Conventional Piezocision: Vercelotti and Podesta [19] introduced the uses of piezosurgery in conjunction with the conventional flap elevations to create an environment conducive to rapid tooth movement. Although effective, these techniques require flap elevations. They have the potential to generate post-surgical discomfort as well as post-operative complications. Because of these shortcomings they have not been widely embraced by the patient or dental communities.

Novel Piezocision: A new minimally invasive procedure called Piezocision™ is introduced by Diebart et al. [30] This technique combines micro-incisions limited to the buccal side that will allow for the use of the piezoelectric knife and selective tunneling that allows for hard or soft tissue grafting.[29]

Piezocision is performed 1 week after the placement of orthodontic appliances. The patient is anesthetized using Xylocaine 2%with 1/100 000 epinephrine in infiltration. Once complete anaesthesia is achieved, a small vertical incision is performed buccally and interproximally in the attached gingiva or mucosa. The incision into the attached gingiva is preferable as it will give less visible postoperative scarring. A mid-level incision between the roots of the teeth involved is made, keeping in mind that the soft tissues and the periosteum need to be cut to create an opening that will allow for the insertion of the piezoelectric knife. [30]

Once the vertical interproximal incisions are completed on the maxillary and mandibular arches or in localized segments, the tip of the Piezotome (BS1) is inserted in the openings previously made and a 3 mm piezo electrical corticotomy is done. [30]

The first mark on the BS1 insert can be used as the landmark for the decortication depth as it
is located 3 mm from the tip .One has to be very careful not to be too close to the interproximal papilla or to the roots, as irremediable damage may occur. In the areas with thin or little gingiva (recessions) or with the in or no cortical buccal bone (dehiscence, fenestration), hard and soft tissue grafts can be added via a tunneling procedure. [30]

From one of the vertical openings a periosteal elevator is inserted between the periosteum and the bone and a blunt dissection is carried forward. This will create a tunnel that will host a soft tissue or a bone graft. Once the tunnel has been created, the piezoelectric corticotomy is done in between the roots of the teeth, and a bone graft or soft tissue graft is then added. [30]

Once the procedure is finished, only the areas that have been tunneled will require suturing with a 5-0chromic gut interrupted sutures. A few drops of cyanoacrylate glue can also be useful to protect these sutures. The remaining areas (verticals with corticotomy that have not been tunneled) do not need suturing or gluing. The patient is seen a week after the surgery for a follow-up visit and 2 weeks post surgery to start the active phase of the orthodontic treatment. **[Fig.2a-2e].** [30]

Alveocentesis: It is also called micro osteoperforation technique. It is performed by using PROPEL system. It is safe and micro invasive technique which accelerates the tooth movement by about 50%-60%. It does not require any additional training and applied to individual teeth and components of teeth for accelerating tooth movement. Patient can perform daily activities as the recovery time from surgery very minimal. [31]

Photobiomodulation: In this technique, laser is used. It has capability of stimulating osteoblast lineage and osteoclast lineage which are helpful in bone remodelling process. Unlike piezo and burs, there is no physical contact between laser and operated tissue in this technique so the discomfort is very minimal. Recent literature shows that laser assisted flapless corticotomy eliminates the requirement of flap elevation to speed up the orthodontic tooth movement. It accelerates the tooth movement by about 30%. Salman and Ali conducted a split mouth study on 15 patients and concluded that laser assisted corticotomy was resulted faster orthodontic tooth movement. [32]

AcceleDent: It is non invasive procedure based on vibrations micro impulses to hasten tooth movement. This is a simple to use, hands free device. It contains a mouthpiece that is inserted around the existing braces and the activator is turned on for 20 min every day to generate small vibrations. It is a portable device that can be charged and accelerates tooth movement up to 106% during initial phase and 50% during active phase of orthodontic tooth movement. Hence, this is recently introduced; long term search is required to determine its advantages. [33]

Conclusion: PAOO does result in significantly decreased treatment time. By decreasing treatment times, PAOO effectively increases a patient's access to orthodontic therapy by decreasing an obstacle to treatment. Only after careful consultation and between an orthodontic therapist and periodontal therapist will give predictable results in PAOO.

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