

## PAOO: A REVIEW

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### Abstract

With a rising number of older patients approaching to the orthodontic clinic, the orthodontist is frequently looking for ways to shorten treatment duration, esthetics. Periodontal accelerated osteogenic orthodontics (PAOO) is a surgical approach that comprises selective alveolar corticotomy, particulate bone grafting, and the application of orthodontic forces. This technique is hypothetically based on the bone healing pattern known as regional acceleratory phenomenon (RAP). PAOO result in an enhancing alveolar bone width, shorter treatment duration, increased post treatment stability, and decreased apical root resorption. This article describes history, biology, surgical techniques, indications, contraindications and complications of PAOO.

**Key words:** Periodontics, corticotomy, osteogenic, orthodontics.

### INTRODUCTION

Periodontium considered as supporting structure of teeth, comprises of gingiva, periodontal ligament, cementum and bone. An anatomical unit is formed by supporting bone which surrounds the alveolar wall. The alveolar bone consists the cortical plates and the septa. The teeth and their supporting structures persist vigorous after the eruption period, indicates adaptation mechanisms maintaining the support and the integrity of the periodontium, which renews the tissues through progenitor cells. The orthodontic treatment is being pursued by an increasing number of adult patients.<sup>1</sup> The continuity of treatment, considerations regarding dento-facial aesthetics, and various appliances that can be used are the different requirements of these patients. As compared to children, in adults growth is an almost insignificant factor, where there is increasing chance of occurring hyalinization during treatment. As in older patients teeth restricted in non-flexible alveolar bone so they are more prone to periodontal complications.<sup>2</sup>

Upon the advent of corticotomy-assisted orthodontic treatment (CAOT), several hindrances in orthodontics have been removed, and it has offered solutions in the adult's orthodontic treatment. The newer approach i.e periodontally accelerated osteogenic orthodontics (PAOO) explained here which maximizes alveolar volume after orthodontic treatment. This technique

includes selective decortications facilitated orthodontic technique followed by bone augmentation. There are several advantages of such procedure which includes reduced treatment duration, simplify expansion, ease eruption of impacted teeth, an increase orthodontic strength after treatment. The above approach increases rate of tooth movement in lesser time which is needed for conventional orthodontic treatment.<sup>3</sup>

### HISTORICAL PERSPECTIVE:

Surgically assisted orthodontic tooth movement has been used since the 1800's. "Luxation, or the immediate method in the treatment of irregular teeth" introduced by Cunningham in 1893 at the International Dental Congress in Chicago. LC Bryan in 1893 described corticotomy, which is described as enucleation technique where only cortical bone is modified mechanically to facilitate differential tooth movement and also published his work in the textbook named "Orthodontia: Malposition of the Human Teeth, Its Prevention and Remedy" by SH Guilford. In 1931, Bichlmayr has come up with a surgical approach for expeditious improvement of extreme maxillary protrusion with orthodontic appliances. Firstly, to lessen the volume of bone, wedges of bone has to be removed through which the maxillary anterior roots preferred to be retracted.<sup>4</sup> In 1959, Kole broadened his ideas space

reduction, rectifying cross bite etc. However, his publication; performed as platform for advancement of this approach.

In Kole's belief, the continuance and increased density of bone has provided the maximum support to tooth movement. His theory depicts intruding stability of cortical bone, by creating and moving blocks of bone blocks where teeth were inserted and mentioned as "bony block movement". Kole's, technique includes full thickness flap reflection, followed by perforation of interdental through the cortical bone and narrowly piercing the medullary bone (corticotomy). In osteotomy, the subapical horizontal cuts connecting the interdental cuts and penetrating to extent of alveolus . But due to its aggressive nature, it was later put an end by many orthodontists'.<sup>4</sup>

An experiment on dog conducted by Duker et al in 1975, which indicates about increased tooth movement achieved by orthodontic appliances through debilitating the bone.<sup>5</sup> A association in rigidity of bone corticotomy and the strength of healing response, led to expedite bone rate at surgical sitewq, was first reported by Harold Frost, an orthopaedist in 1983. This was nominated as "Regional Acceleratory Phenomenon (RAP)". He briefly explained, regional response of tissues to virulent stimuli, identified by increasing normal processes. It has been noticed that in maxilla and mandible, osteoclastic activity and ridge resorption maximizes, followed by implementation of a bony insult.<sup>6</sup>

The concept of "Bony block movement was confronted by Dr. Thomas Wilcko (Periodontist) and Dr. William Wilcko (Orthodontist) in 1995, of Erie, PA.<sup>7</sup> In 2001, the findings of Wilcko brothers were published by them in which they had amended the bony block approach and performed two cases of crowding along with selective decortication. They described in an assessment of corticotomized patients, using hospital based high resolution CT scan imaging, that the small outlined blocks of bone lost their structural integrity due to an evident demineralization of the alveolar housing over the root prominences. Closer to the circumscribing corticotomy this apparent demineralization takes place and cuts both on the pressure side of the teeth and on the tension side of the teeth. RAP is preferred over "bony block movement" as they are associated with the initial alveolar

demineralization and following remineralization was accordant with the cascading physiologic events.<sup>8</sup>

The corticotomy assisted orthodontic technique further modified by Wilcko et al in 2008 with the inclusion of bone augmentation and mentioned the technique initially as Accelerated Osteogenic Orthodontics (AOO) and more recently as Periodontally Accelerated Osteogenic Orthodontics (PAOO) which afterward patented as "Wilckodontics" based on the developing conception of Wilcko brothers.<sup>9</sup> This technique has the combination of fixed orthodontic appliances, labial and palatal/lingual corticotomies and bone grafting. After 2 weeks tooth movement was initiated subsequently by activation of the fixed orthodontic appliance. This combined active surgical orthodontic treatment is the most important feature of this technique which reduces the duration of treatment to one third that of traditional treatment and allowed more foreseeable treatment in older patients.<sup>10</sup>

#### **Physiological bone remodeling:**

The physiological process comprising osteoclast mediated bone resorption coupled with osteoblast-mediated bone formation known as bone remodeling or bone turnover.<sup>11</sup> The eventual bone mass at the bone remodelling site determined by the stability between osteoblast and osteoclast. Osteoclasts emerges from the macrophage lineage of hematopoietic stem cells in the bone marrow, whereas osteoblasts derive from mesenchymal cells within the stroma of bone marrow.<sup>11, 12</sup> The differentiation, maturation, and functional activity of osteoclasts are regulated and mediated by various biological agents comprising the receptor activator of nuclear factor  $\kappa$ B (RANK)/RANK ligand/ osteoprotegerin signaling pathways, macrophage colony-stimulating factor, parathyroid hormone (PTH), estrogen, and various cytokines<sup>13, 14</sup>

In contrast, bone morphogenic proteins (BMPs) and the Wnt/b-catenin signaling pathways activates the osteogenic transcription factors (e.g., RUNX2 and osterix), which is compelled by the differentiation and maturation of osteoblasts. Proteins such as bone sialoprotein, osteocalcin, alkaline phosphatase, and collagen type I plays a crucial role in formation of bone; and are incorporated by osteoblasts in the local microenvironment. The functional activity of

osteoblasts are stabilized by PTH, 1,25dihydroxyvitamin D, and growth factors like platelet-derived growth factor (PDGF), transforming growth factor b (TGF-b), and fibroblast growth factors (FGFs).<sup>13</sup> Osteocytes interfaced with osteoblasts along with osteocytes through gap junctions including the ends of their dendritic processes in three-dimensional lacunocanalicular network.<sup>11</sup> A gap junction is a channel that connects the two adjacent cytoplasm of cells, which permits the transit of ions and small signaling molecules. The mechanical, chemical and electrical factors synchronizes the functional activity of a gap junction.<sup>11</sup> The assembly of ECM proteins and ECM remodelling are balanced by cells through focal adhesions; importantly, the cell adhesion, migration, proliferation, differentiation, apoptosis, and biochemical cellular responses can regulated by ECM.<sup>15</sup> The various strains persuaded by firm ECM at the cellular focal adhesion domain, thus resulting in adhesion between strong cell and ECM.

Physiological bone remodeling sets about with osteoclastic activity. It is characterized by the degradation of inorganic crystalline apatite and organic component which also releases biologically active agents (e.g., BMPs, FGFs, and TGF-b) into the local microenvironment from the organic matrix of the resorbed bone.<sup>11, 16</sup>

Eventually, the proliferation and differentiation of osteoblast precursors mediated these biological agents, along with the secretion of non-collagenous proteins and collagen fibers, to form an organized matrix followed by mineralization, consequently forming new bone.<sup>11, 16</sup>

## **Biomechanics of Wilckodontics**

### **Regional acceleratory Phenomenon (RAP):**

Herald Frost, an orthopedist admitted that surgical wounding of osseous tissue causes evident change activity close to the injury site. He concurrently entitled this cascade of physiologic healing events –“The Regional acceleratory phenomenon” (RAP).<sup>17, 18</sup> In this event, tissue rejuvenate rapidly than normal due to local response of tissues to noxious stimuli.<sup>6</sup> The duration, size, and intensity with the magnitude of the stimulus are varied directly in this response. Depending upon the category of tissue, RAP usually withstands for about four months in

bone. RAP brings about bone healing to occur 10-50 times faster than normal bone turnover.<sup>19</sup> In rat tibia, the healing phases of RAP has been studied. Initially there is an genesis stage of woven bone, which starts in the periosteal area and then increases to medullary bone, reaching its maximum thickness on day seven. The fundamental component of RAP is a cortical bridge of woven bone which provides strength of bone after injury. From day seven, this woven bone experiences remodeling to lamellar bone, but in the medullary area, woven bone results in resorption, that means transitory local osteopenia. It has been noticed that after initiation of the new formation of cortical bone, medullary bone needs to be reorganized and restore and modify to the restructure of cortical integrity (three weeks in rats). In context of systemic release of humoral factors there is a systemic acceleratory phenomenon (SAP) of osteogenesis.<sup>19</sup>

During surgical injury, RAP starts within a few days, usually peaks at 1-2 months, and recede completely in 6 to 24 months.<sup>18</sup> In healthy tissues, RAP decreases density of regional bone (osteopenia) where as the volume of bone matrix remains sustained.<sup>17</sup> RAP is maximal, when tooth movement is combined with selective decortication.<sup>19, 20</sup> Wilcko et al. in 2001, reevaluated the novel technique of bony block movement with variations. He completed cases with severely crowded dental arches, and contemplated that patients who underwent selective decortications with the dynamics of physiologic tooth movement might be due to a demineralization-remineralization process preferably than bony block movement. They recommended that this process would exhibit as role of RAP that include bony tissue after being revealed to corticotomy and during active tooth movement.<sup>3</sup>

### **PRINCIPLE OF PAOO**

Following corticotomy, RAP corroborates tissue rearrangement and healing by way of a transient burst of localized bone remodeling. At injury site, there is an increase in osteoclastic, osteoblastic activity, and levels of inflammatory markers. Duration of RAP depends on the type of tissue, and usually withstands for 4 months. This event give rise to healing occurs 10– 50 times faster than normal bone turnover.<sup>19</sup> This relative transient osteopenia in alveolar bone is due to surgical wounding.<sup>21</sup> The biomechanical resistance is reduced by this phenomenon and

through trabecular bone expeditious tooth movement takes place. This transient osteopenia phase can be extended with orthodontic appliance. This is why at every 2 weeks, it is very important to alter the orthodontic appliance.<sup>22</sup>

## **INDICATIONS**

- A. Reduce treatment duration and settle crowding.
- B. Enable retraction of canine after premolar extraction.
- C. Increase orthodontic stability after treatment
- D. Ease the impacted teeth eruption
- E. Simplify orthodontic expansion
- F. Enable intrusion of molars and open bite correction

## **CONTRAINDICATIONS**

- A. Patients with chronic periodontitis.
- B. Patients with poorly treated endodontic problems.
- C. Patients on long term medications which decreases bone metabolism, such as bisphosphanate, steroid therapy and NSAIDs. NSAIDs reduced osteoclastic activity and disturbing bone remodeling due to prostaglandin inhibition.

## **COMPLICATIONS**

PAOO contemplated as a novel approach than osteotomy-assisted orthodontics, to date several reports are evaluated about destructive effects to the periodontium after corticotomy, it has also been noticed about mild loss of interdental bone and attached gingiva, with short interdental distance.<sup>8</sup> After thorough corticotomies, subcutaneous hematomas of the face and the neck, post-operative discomfort has been noted.<sup>23</sup>

Liou et al. indicated about normal pulp vitality after rapid tooth movement at a rate of 1.2 mm per week in an animal study. It has been evaluated about correlation between resorption of root and duration of the applied force and

believed that resorption of root is anticipated with orthodontic tooth movement. A correlation between resorption of root and duration of the applied force was evaluated. The risk of root resorption reduced by treatment duration of PAOO.<sup>24</sup> In beagles Ren et al. reported that following corticotomy, rapid tooth movement without any associated resorption of root.<sup>25</sup> Moon et al evaluated adequate intrusion of maxillary molar (3.0 mm in two months) by using corticotomy including skeletal anchorage system.<sup>26</sup> Advance research will enliven the activity of root resorption on the long-term effect of PAOO.

## **PATIENT SELECTION CRITERIA**

Patient selection plays a key role for success of the procedure. Both the orthodontist and the periodontist should agreed for the requirement of corticotomy, treatment plan and the extent and location of the decortication cuts.<sup>27</sup> The age choice for PAOO can be from 11 years to 77 years of age due to healthy periodontium.<sup>3</sup> Following cases are contraindicated for this procedure:

1. Patients with chronic periodontitis is not a candidate for PAOO.
2. Patients having alveolar bone loss, root resorptions should not be considered for PAOO .
3. Patients on having regular doses NSAIDs therapy (due to rheumatoid arthritis) may not be suitable for PAOO.
4. Patient having bimaxillary protrusion with a gummy smile should not be considered for PAOO. Segmental osteotomy is a preferred choice.
5. PAOO should not be used as an alternative for surgically assisted palatal expansion in treatment of cross bite .
6. PAOO is not applicable for Class III condition.

## **DISCUSSION**

### **Technique of Periodontally Accelerated Osteogenic Orthodontics**

Under local anesthesia, crevicular incision is given buccally and lingually extending up to two teeth beyond the primary area to be treated after suitable case selection and placement of orthodontic bracket (before 1 week of surgery).<sup>28</sup>

**Flap Full-thickness:** flap is raised labially and lingually in the coronal area, whereas a partial-thickness flap is reflected to allow mobility of flap during suturing in the apical area. The interdental papilla is conserved for esthetics in maxillary central incisor area. After the reflection of flap thorough debridement and curettage is done.<sup>9</sup>

**Decortication:** By using number 1 or 2 round bur or piezoelectric knife selective decortications are done for alveolar bone activation.

**Grooving :** In the interradicular spaces, vertical grooves are placed which extends from 2 to 3 mm below the alveolar crest up to 2 mm beyond root apex. Afterwards circular-shaped horizontal corticotomy connected through these vertical corticotomies.<sup>9</sup>

**Particulate Bone Grafting :** On activated bone particulate bone grafting material is placed, wet by clindamycin phosphate or bacteriostatic water solution 5 mg/mL or platelet-rich plasma, because facilitates the ease of placement. Bone graft such as DFDBA, autogenous bone, deproteinized bovine bone, or a combination are used.<sup>9</sup>

**Flap Closure:** Flaps are approximated with interrupted loop sutures by using non resorbable material. The epithelial attachment establishment takes place in 2 weeks, after which suture is removed.<sup>29</sup>

**Postsurgical management:** Antibiotics, analgesics, mouthwash, and ice pack application (postoperative discomfort) advised.<sup>29</sup>

**Orthodontic Adjustments :** Within 2 weeks, orthodontic treatment should be started, and a heavy orthodontic force must be applied on the teeth following flap repositioning.<sup>29</sup>

Wilckodontics is superior than the conventional orthodontic treatment as it takes lesser time to attain the results. There is less evidence of root

resorption and history of relapse. Depending upon the cases many orthodontic appliances such as headgear were reduced. It has been declared that after corticotomy with minimal risk of complications, orthodontic treatment progresses faster and the results are more stable.<sup>30</sup>

Wilcko in 2001 suggested bone augmentation with corticotomy to increase the volume of the alveolar process, to prevent fenestrations, to facilitate arch development, and to increase the metabolic activity during orthodontic treatment.<sup>3</sup> A non-extraction treatment of crowding, reducing treatment duration, increasing post orthodontic stability, extrusion of ankylosed teeth, closing anterior open bites, enables retraction of canine in extraction patients, are indications for corticotomy-facilitated orthodontics. Contraindications include patients with chronic periodontitis, poorly treated endodontic problems, patients on long term medications such as bisphosphonates, steroid therapy and NSAIDs.<sup>29</sup> In split mouth study designs, effects of alveolar corticotomies on the rapid tooth movement were reported in rats, dogs, cats and humans. These experiments resulted increase in rate of tooth movement on the corticotomy treated site. Alveolar decortication without subapical osteotomy with rapid orthodontic treatment used for open bite malocclusion.<sup>20</sup> This modified surgical approach was reported in 1991 and was mentioned as corticotomy facilitated orthodontics. In 1991, Suya evaluated 395 adult Japanese patients for surgical orthodontic treatment with an enhanced surgical technique and referred as corticotomy facilitated orthodontics. Suya's surgical technique differed from Kole's with the substitution of supra apical corticotomy cut in place of horizontal osteotomy cut beyond the apices of the teeth and varied this technique with traditional orthodontics. Less painful, less root resorption and relapse found in this technique.<sup>31</sup>

A tunnel approach with piezoelectric bone cuts allows placement of the bone graft, as reported by Dibart et al. Through piezo-electric vertical corticotomies, many vertical incisions are performed on the attached gingival and also settles crowding was within 17 weeks of active treatment.<sup>22</sup>

The American Board of orthodontics has described grading system to evaluate the orthodontic treatment quality.<sup>32</sup> In a favour of wilcko's concept, issued data documented that bone grafting increases the orthodontic treatment

stability. Computed Tomographic Scans shows increased volume of bone reported by various cases. However, the fibroosseous material of bone enclosed on the outside of the cortical plate was evaluated. Moreover, disadvantage of this approach are cost morbidity, invasive nature related with the surgery.<sup>8</sup>

## CONCLUSION

The procedure of Wilckodontics has transformed adult orthodontics into an actual existence. The treatment can be attained within a shorter duration which is applicable to the Regional Acceleratory Phenomenon (RAP). The procedure avoid the conventional orthodontic treatment effect such as resorption of root or dehiscence. In contrast to conventional orthodontic treatment, this technique reveals increased alveolar thickness due to the incorporation of bone grafts, better post orthodontic stability and less incidence of root resorption. As Wilckodontics is a relatively newer approach, so increase in sample size with long term follow up studies need to validate this procedure into surgical orthodontics.

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