

Periodontally Accelerated Osteogenic Tooth Movement in Orthodontics: A Review

M R Dinesh¹, Sunny Gupta², Vijay Yannawar², Kalpesh Sharma², Aarushi Agarwal², Prashanth Lagali², Ayesha M Prasad³

¹Principal and Professor, Department of Orthodontics, D.A.P.M. R.V Dental College, Bengaluru, Karnataka, India, ²Postgraduate Student, Department of Orthodontics, D.A.P.M. R.V Dental College, Bengaluru, Karnataka, India, ³Postgraduate Diploma, Department of Orthodontics, D.A.P.M. R.V Dental College, Bengaluru, Karnataka, India

ABSTRACT

Periodontally accelerated osteogenic orthodontics combines periodontal therapy with orthodontic therapy, which will minimize treatment time. This procedure is performed shortly before the application of orthodontic forces and has been suggested that this method enhances tooth movement and, hence, orthodontic treatment as a whole. With the advent of newer techniques such as corticision, piezocision and micro-osteoperforations as a supplemental dentoalveolar surgery in orthodontic therapy, accelerated tooth movement can be achieved with minimal surgical intervention. Thus, this article reviews the historical aspect of this therapeutic approach, indications, contraindications and presents the description of the technique with its advantages and disadvantages.

Keywords: Accelerated orthodontics, alveolar corticotomies, orthodontic tooth movement, orthodontic treatment, regional acceleratory phenomenon

Corresponding Author: Dr. Aarushi Agarwal, Department of Orthodontics and Dentofacial Orthopaedics, D.A.P.M. R.V Dental College, Bengaluru, Karnataka, India. E-mail: aarushi101@gmail.com

INTRODUCTION

Orthodontic tooth movement is produced by “periodontal phenomenon.”¹ The constant demand for shorter treatment time, led orthodontists to find ways to improve orthodontic treatment efficiency, one such option for reducing treatment included corticotomy-facilitated bone augmentation approach called the periodontally accelerated osteogenic orthodontics (PAOO) procedure.²

In recent years, there has been a significant increase in orthodontic treatment for adult patients. Keim *et al.* (2008), reported that in USA approximately 20% among all orthodontically treated patients are adults.³ Adult patients demonstrate altered response regarding periodontal hyalinization and alveolar flexibility compared to adolescents.⁴ Adult orthodontics is clinically challenging and lengthened in time. In adults, the average treatment period ranges from 18.7 to 31 months, which is significantly more than adolescents.^{2,5} Adult patients are also more vulnerable to root resorption and periodontal pathologies during or following active orthodontic treatment owing to narrow, aplastic, less vascular periodontal membrane and alveolar bone morphology.^{5,6} Hence, it is imperative

to modify treatment modalities to reduce the treatment time and achieve optimal clinical results.

The PAOO is a technique involving combination of selective decortication facilitated orthodontic technique and alveolar augmentation. Thus, teeth can be moved 2-3 times further in 1/3 to 1/4 the time required for traditional orthodontic therapy. While treating adult patients one is no longer at the mercy of the preexisting alveolar volume as PAOO provides an increased net alveolar volume after orthodontic treatment, along with low morbidity.⁷

HISTORICAL REVIEW

Corticotomy-related surgeries were first introduced in Europe. Its use to correct malocclusion was first described in 1892 by L.C. Bryan and Cummingham in 1893. Bichlmayr (1939), described a surgical technique for rapid correction of the severe maxillary protrusion with orthodontic appliances.⁸ This philosophy was further implemented in additional movements, including space closure and crossbite correction by Dr. Henrich Kole in 1959. He laid the foundation for modern day

corticotomy – facilitated orthodontics. Dr. Kole stated that the reduced resistance enhances an *en bloc* movement of the entire alveolar cortical segment.⁴

The term “Regional Acceleratory Phenomenon” (RAP) was coined by Dr. H.M. Frost in 1981. RAP was explained as a temporary stage of remodeling of localized soft and hard-tissue, which resulted in rebuilding of the injured sites to a normal state through recruitment of osteoclasts and osteoblasts via local intercellular mediator mechanisms involving precursors, supporting cells, blood capillaries and lymph. RAP begins within a few days of the insult, typically peaks at 1-2 months, and may take as long as 2 years to completely subside.^{6,9}

Suya specified that the golden period for orthodontic treatment is in the first 3 to 4 months after corticotomy and before fusion of the tooth-bone units.¹⁰

Until 2001, the “bony block” movement prevailed as misconception, however, Wilcko *et al.* reported that tooth movement was not the result of bony block, but rather a process of transient remineralization/demineralization, that is a concept of reversible osteopenia, in the bony alveolar housing consistent with wound healing pattern of RAP and introduced the term “bone matrix transportation.”²

PAOO is an extension of previously described techniques that surgically alter the alveolar bone to decrease treatment time. It differs from prior techniques by the additional step of alveolar bone grafting. They claimed that decortication combined with augmentation grafting created greater alveolar volume, which eliminated bony dehiscences and fenestrations under most circumstances.⁷

Likewise, this addition of alveolar bone width may be the cause for enhanced long-term orthodontic stability.¹¹ Also using this technique, Wilcko reported tooth movement was at 3 to 4 times greater rate than conventional orthodontic tooth movement.²

Wilcko *et al.* developed an accelerated osteogenic technique involving three distinct steps, namely, full thickness flap reflection, selective alveolar decortication, and bone grafting.¹²

In 2007, Vercellotti and Podesta introduced monocortical tooth dislocation technique, a new approach to bone surgery with an ultrasonic piezosurgical device.¹

Corticision, a novel technique by Kim *et al.* was proposed in 2009 which is a minimally invasive technique to induce accelerated tooth movement.¹³

HISTOLOGICAL EVIDENCE

A study was done by Lei Wang *et al.* in 2009 on rats to assess the tissue responses in corticotomy- and osteotomy-assisted tooth movements, revealed:¹⁴

- Under orthodontic tension, corticotomy-assisted tooth movement produced transient resorption of bone surrounding the dental roots.
- The alveolar bone surrounding the dental roots passes through resorptive, replacement, and mineralization phases of recovery.
- The completely freed osteotomy segment produced a different bone response that more closely resembled distraction osteogenesis.

Hong *et al.* conducted a study in 2011 on beagle animal model for histologic assessment of the biological effects of PAOO. Observations which were commonly noted on the pressure sides during teeth movement in Group I (without corticotomy-controls).¹⁵

- Pressure side of the retracted maxillary incisor showed the presence of numerous osteoclasts and a few osteoblasts surrounding the alveolar bone.
- Furthermore, the areas of discontinuous cementum and periodontal ligament (PDL) revealed a few osteoclasts, leading to a rough and irregular root surface on the pressure side.
- The surface irregularity on the root surface correlated with the pattern of resorbed cementum exposing the dentin to the PDL.

On the other hand, In Group II (with corticotomy),

- Osteoclasts were not found on the cementum or dentin, although numerous osteoclasts were detected around the alveolar bone facing the palatal side of the retracted incisor.
- In addition, more intact and consistent thickness of PDL space between the surrounding alveolar bone and the root surface was noted.
- Any evidence of root resorption on the compression side of the retracted incisor was not seen.

Greater amount and faster rate of retraction was observed in Group II than in Group I. Despite of extensive retraction in Group II, no sign of any root resorption was seen, while in Group I prominent root surface irregularities were seen.

INDICATIONS

1. PAOO can contribute to increased bone volume. PAOO can prevent the formation of new fenestrations and dehiscences and correct the existing ones.¹⁶

2. Crossbites and tooth size-arch length discrepancies.¹⁶
3. Traditional orthodontics can satisfactorily address crowding up to 5 mm whereas; this can be extended to 10-12 mm if PAOO technique is utilized.¹⁶
4. Conservative approach rather than orthognathic surgery (except for severe class III skeletal dysplasia), PAOO can be used as an alternative to orthognathic surgery in some cases.¹⁷⁻¹⁹
5. Where extractions are contraindicated due to facial profile and limited expansion due to reduced buccolingual width of the alveolar ridge.²⁰
6. Moderate to severe malocclusions like severe bimaxillary protrusion²⁰ and cleft lip palate cases.²¹
7. Uprighting of tipped molars and intrusion of supraerupted molars.^{16,17,21,19}
8. To treat impaction cases at a faster rate.^{7,12}

CONTRAINDICATIONS²²

1. Active periodontal disease.
2. As an alternative for surgically assisted palatal expansion in the treatment of severe posterior cross-bite.
3. Should not be attempted in cases where the bimaxillary protrusion is accompanied with a gummy smile, which might benefit more from segmental osteotomy.
4. Severe skeletal class III – prognathic mandible.
5. Uncontrolled over-all systemic disease.

DESCRIPTION OF THE SURGICAL TECHNIQUE¹⁶

PAOO is a clinical procedure which can be divided into three basic steps:

1. Selective alveolar corticotomy,
2. Particulate bone grafting, and
3. Application of orthodontic forces.

The term “corticotomy” is different from “osteotomy.” Corticotomy is defined as a surgical procedure whereby only the cortical bone is cut, perforated, or mechanically altered. The medullary bone is not altered.^{20,23}

Careful coordination between the periodontist and orthodontist is required for successful outcomes.^{20,24}

In some Class II cases with thin cortical plates requiring extractions, PAOO procedure is indicated. In these cases, anchorage preparation should be done before the PAOO procedure is initiated so that “The RAP phenomenon” can be utilized to its full potential.^{20,22,25}

FLAP DESIGN¹⁶

The flap design depends on the following criteria.

1. To provide access to the alveolar bone wherein the corticotomy procedure is to be performed.
2. To provide sufficient coverage for the particulate graft.
3. To maintain the height and volume of the interdental tissues.
4. To increase the esthetic appearance of the gingival contour where necessary.

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. The purpose of the split-thickness dissection is to provide mobility of the flap so that it may be sutured with minimal tension.^{2,22} Mesial and distal extension of the flap beyond the corticotomy areas is suggested to reduce the need for vertical releasing incisions. Preservation of the interdental gingival tissues is critical for a successful esthetic outcome.¹⁶

FULL THICKNESS FLAP

Retention of a lingual or palatal gingival collar of tissue is preferred to maintain a collateral blood supply to the papillary tissue.¹⁶

DECORTICATION

The decortication initiates “the RAP response” and unlike osteotomy does not create movable bony segments. By use of a No. 1 or No. 2 round burs decortications are made in the alveolar bone.¹⁶ Vertical corticotomy cuts are made between the roots using a diamond round bur (size 2) stopping just short of the alveolar crest (about 3 mm). Generally, a vertical groove is placed in the interradicular space, midway between the root prominences in the alveolar bone. This groove extends from a point 2-3 mm below the crest of the bone to a point 2 mm beyond the apices of the roots. These cuts are connected beyond the apices of the teeth (when possible) with scalloped horizontal cuts.²⁶ If the alveolar bone is of sufficient thickness, solitary perforations may be placed in the alveolar bone over the radicular surface. However, if this bone is estimated to be less than 1-2 mm in thickness, these perforations are omitted to ensure no damage to the radicular surface.¹⁶

Corticotomy Design²⁷

There are three basic types of corticotomy that might be planned in adult patients:

1. Traditional or circumscribed corticotomy: Vertical and horizontal cuts are made in the cortical bone of 2 mm circumscribing the teeth to be moved. It can be used in cases of thin bony root coverage.
2. Triangular corticotomy: Triangular portions of the buccal and lingual cortical plates. It can be

performed when the buccal cortical bone is too thin for decortication or indentation.

3. Indented decortications: It's a modification of Wilcko's technique, which is performed by making several perforations on the buccal and lingual surfaces of the cortical plate with a round bur.

PARTICULATE GRAFTING

Grafting is required in most of the corticotomy procedures.¹⁶ The commonly used graft materials are deproteinized bovine bone, decalcified freeze-dried bone allograft, autogenous bone, or a combination of these. A typical volume of graft material used is 0.25-0.5 mL per tooth.¹⁶ 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.^{16,26}

CLOSURE TECHNIQUES AND PATIENT MANAGEMENT

Primary closure of the gingival flaps without excessive tension and graft containment are the therapeutic endpoints of suturing. The sutures are usually left in place for 1-2 weeks. Antibiotics and pain medications are administered at the clinician's preference.¹⁶

Orthodontic treatment can be resumed 2 weeks post-surgery. The interval between subsequent orthodontic appointments should be ranging from 1 to 3 weeks. Patient should be recalled in 3 months to assess the oral hygiene and assure good periodontal health.²⁶

MODIFICATIONS AND VARIOUS TECHNIQUES PIEZOCISION

According to Schlee *et al.*, Conventional corticotomy procedures involve the elevation of a full-thickness mucoperiosteal flap, which may cause reduction in the alveolar bone height and can also lead to dehiscence, in areas where the alveolar bone is thin according to Yaffe *et al.*²⁸

Considering the above demerits a new procedure was introduced by Dibart termed as "piezocision." It is a flapless alveolar decortication procedure where buccal vertical incisions are made through the soft tissue between every tooth, not including the papilla. Piezoelectric osseous cuts are made through the buccal cortical layer only, using modulated ultrasonic instruments.²⁸

CORTICISION

"Corticision" was introduced in orthodontic therapy to achieve accelerated tooth movement. Reinforced scalpel

is used as a thin chisel to separate the interproximal cortices transmucosally without reflecting a flap.²⁹

ALVEOCENTESIS (MICRO-OSTEOPERFORATIONS [MOPS])

Teixeira *et al.*, introduced MOPs on alveolar bone during orthodontic tooth movement can stimulate the expression of inflammatory markers, leading to increases in osteoclast activity and the rate of tooth movement. Alveocentesis technique by using PROPEL System decreases orthodontic treatment time by 50-60%.^{29,30}

LASERS

Lasers are also used as non-invasive procedure for reducing treatment time and damage to periodontium. It reduces the cortical bone layer following irradiation by Erbium, Chromium doped Yttrium Scandium Gallium Garnet laser, without surgical flap reflection.³¹

MONOCORTICAL TOOTH DISLOCATION AND LIGAMENT DISTRACTION TECHNIQUE

Vercellotti and Podesta introduced this technique where two different dental movements that work separately but simultaneously on opposite root surfaces take place. Vertical and horizontal microsurgical corticotomies are performed around each root surface of the tooth in the direction of desired root movement with a piezo surgical microsaw. Applied strong biomechanical forces produce rapid distraction of ligament fibers leading to faster tooth movement.¹

DISCUSSION

In the comprehensive treatment of some patient's occlusal and esthetic needs, PAOO can play a major role. PAOO is an extension of previously described techniques that surgically alter the alveolar bone to decrease treatment time.⁷

Intramembranous autogenous bone grafts have been used in the restoration of osseous volume as the gold standard of alveolar ridge reconstruction. Intraoral donor sites include the maxillary tuberosity, mandibular symphysis, angle of the mandible, ramus, and exostosis.¹⁸

Wilcko *et al.*² described alveolar augmentation with DFDBA/Xenograft (bovine bone) or alloplastic graft (bioactive glass) to increase bony support for teeth with Corticotomy-assisted orthodontic tooth movement and to cover any fenestrations and dehiscences.

Movement of any outlined single-tooth bony blocks (luxation) is contraindicated and can lead to intrapulpal and intraosseous morbidity. Selective alveolar decortications results in a transient osteopenia and increased tissue turnover. This is a condition that favors tooth movement with reduced root resorption.³²

As stability is concerned, Ferguson³² states, "PAOO has contributed greater stability of orthodontic clinical outcomes and less relapse." Summarizing, he states, "immediate post orthodontic treatment results following non-extraction therapy are statistically the same with or without PAOO. However, during retention, the clinical outcomes of PAOO patients improved and did not demonstrate relapse."

According to Hajji,³³ an average treatment time was reduced to one-third to one-fourth of traditional orthodontic treatment for the PAOO procedure. Sebaoun *et al.*³⁴ reported that selective alveolar decortication injury resulted in an overwhelming stimulus for both the catabolic process (resorption response) and the anabolic process (formation response) in the periodontium. This bone modeling behavior peaked at 3 weeks after decortication surgery during which the catabolic response (osteoclastic count) and anabolic response (apposition width and rate) were 3-fold higher.

Dr. Kole⁴ described the en bloc movement of the entire alveolar cortical segment, whereas Wilcko *et al.*,² advised corticotomy to be performed only at the buccal aspects of alveolar bone which was in agreement with Germec *et al.*,³⁵ who reported rapid tooth movement when corticotomy was performed at the buccal aspects of alveolar bone. They noted that by avoiding the palatal and lingual corticotomy, the length and the extent of the surgery was reduced.

Advantages of PAOO³³

- Decreased overall treatment time to one-third the time of conventional orthodontics.
- Increased bone support due to the addition of bone graft
- Reduced root resorption due to decreased resistance by cortical bone
- Increased limits for envelop of discrepancy.³⁶
- It can be used to expedite the rate of movement of individual teeth or dental segments, i.e. canine and incisor retraction.
- Low relapse reported.

Disadvantages of PAOO³³

- Mildly invasive surgical procedure, and like all surgeries, it has its risks.
- Post-surgical crestal bone loss and recession may occur.

- Extra-surgical cost.
- Some pain and swelling is expected, and the possibility of infection.
- 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.²³ 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 is no randomized controlled trials to substantiate reduction in orthodontic treatment time has been reported until date.

CONCLUSION

The recent popularity of PAOO among patients and doctors is due to reported faster tooth movement (at 3-4 times greater rate than conventional orthodontics), decreased treatment time and increased range of treatment capabilities. PAOO created greater alveolar volume, which eliminated bony dehiscences and fenestrations under most circumstances. Likewise, this addition of alveolar bone width may be the cause for enhanced long-term orthodontic stability.

Further research, controlled clinical and histological studies are needed is recommended for an in-depth evaluation of the long-term stability which is claimed to be advantageous in this technique.

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How to cite this article: Dinesh MR, Gupta S, Yannawar V, Sharma K, Agarwal A, Lagali P, Prasad AM. Periodontally Accelerated Osteogenic Tooth Movement in Orthodontics: A Review. *Int J Adv Health Sci* 2015;1(11):32-37.

Source of Support: Nil, **Conflict of Interest:** None declared.