REVIEW ARTICLE

Evolution of Corticotomy: An Insight

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ABSTRACT

In the present orthodontic scenario, many people receive orthodontic treatment which brings about better occlusion, improved oral function and harmonized facial appearance. However, a perplexing challenge that has not been completely solved in clinical orthodontics is sustained treatment time. Figuring out this challenge will dramatically improve the quality of orthodontic care. A number of attempts have been made to create different approaches both preclinically and clinically in order to achieve expeditive results, but still there are a lot of uncertainties and unanswered questions towards most of these techniques. The surgical-assisted approaches have been proved experimentally and clinically to be the most effective technique in accelerating orthodontic tooth movement (OTM). Here is a review on the evolution, biological perspectives and various techniques available for Corticotomy- a surgical technique for acceleration of OTM.

KEYWORDS: Corticotomy, Accelerated Orthodontics, Orthodontic Tooth Movement(OTM)

INTRODUCTION

A corticotomy is a surgical technique where only the outer cortical bone is cut, perforated or modified and the medullary bone is left as it is.[1] This is in contrast to an osteotomy where the surgical cut perforates both cortical and medullary bone. Corticotomy assisted orthodontics (CAO) have several advantages having reduced treatment time, increased traction of impacted teeth and post-orthodontic stability.[2]

HISTORICAL BACKGROUND

In 1893, Cunningham[3] presented "Luxation, or the immediate method in the treatment of irregular teeth" at the International Dental Congress in Chicago. He 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 surgical-orthodontic treatment have minimized the procedure time to one-third that of conventional treatment and allowed more predictable outcome in aged individuals. Fifty years later, Bichlmayr[2] classified orthognathic surgery as "major" (total or segmental maxillary and mandibular correction) or "minor" (interdental osteotomy or corticotomy), and was one of the first to described the corticotomy procedure to close diastema in patients over 16 years old. The procedure was used to correct maxillary incisor protrusion by removal of the first premolars, splitting palatal cortex overlying the incisors, and removal of alveolar bone distal to the canines.

Few surgeons combined these procedures (alveolar osteotomy and corticotomy) to minimize the duration of orthodontic treatment. Köle popularized the procedure in the English literature with his "bony block" technique.[4] He reported some cases in which interdental vertical corticotomy and subapical horizontal osteotomy were combined. He also emphasized buccal corticotomy in postero-inferior region to correct molar linguoversion and facilitate orthodontic expansion. Before the vascular supply of alveolar maxillary bone was described by Bell he relied on cortical bone shaving with intact vascular supply from trabecular bone.[5] Buccal and palatal corticotomies have also been described to correct compressed maxilla to improve the alveolar expansion and limit the buccal tilting of the posterior teeth. Bell and Levy published the first experimental study of alveolar corticotomy in 49 monkeys in 1972 where they described a model of vertical interdental corticotomy , because they mobilized all dento-osseus segments. Moreover, they demonstrated reflection of labial and palatal flaps simultaneously, which severely compromised the vascularity to the anterior teeth.[5]

A histological study showed the risk of this type of procedure (full mucoperiosteal detachment plus cutting of medullar bone) for the vascularity of dental pulp and surrounding medullar bone. They demonstrated distinct

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avascular zones that progressively recovered after 3 weeks postoperatively, except for the central incisors. Duker[4] investigated how corticotomy affected the vitality of the teeth and the marginal periodontium in beagle dogs. Realignment of the teeth within a short span after corticotomy neither damaged the pulp nor the periodontal ligament (PDL). He supported the idea of preserving the marginal crest bone in relation to interdental cuts; these cuts must always be left at least 2 mm short of the alveolar crestal bone level. These initial approaches included some types of alveolar osteotomy alone or combined with corticotomy, called "bone block movement." Traditionally, vertical and horizontal osteotomies have had an increased risk of postoperative tooth devitalization or even bone necrosis, depending on the severity of injury to the trabecular bone.[6]

There is also an increased risk of periodontal damage, mainly in cases in which the interradicular space is less than 2 mm. Corticotomy is a superior method than osteotomy. It prevents injury of the periodontium, and also prevents devitalizing of a single tooth or a group of teeth. The nutrition of the bone is maintained by spongiosa, although the bone is exposed, avoiding the possibility of bone aseptic necrosis. With these advantages and drawbacks, procedures based on corticotomy are gradually replacing osteotomy. Wilcko et al described an innovative strategy of combining corticotomy alveolar surgery with alveolar grafting in a technique referred to initially as accelerated osteogenic orthodontics (AOO) and more recently as periodontally accelerated osteogenic orthodontics (PAOO).[7]

This technique combines fixed orthodontic appliances, labial and palatal/ lingual corticotomies, and bone grafting with demineralized freeze-dried bone and bovine bone with clindamycin. Tooth movement was initiated 2 weeks after surgery, and every 2 weeks thereafter by activation of the orthodontic appliance. Wilcko *et al*[7] was first to point out that movement of tooth with corticotomy may be due to a demineralization-remineralization process rather than bony block movement.

BIOLOGICAL AND ORTHODONTIC FUNDAMENTALS

There are four different types of surgical damage in alveolar bone: Osteotomy (complete cut through cortical and medullar bone), corticotomy (partial cut of cortical plate without penetrating medullar bone), ostectomy (removal of an amount of cortical and medullar bone) and corticotectomy (removal of an amount of cortex without medullar bone). One of the main disadvantages of conventional orthodontic treatment is duration which requires more than 1 year for completion. To overcome this three options are discovered to reduce the time of treatment: (i) local administration of chemical substances, (ii) physical stimulation (*i.e.*, electrical current or magnets), and (iii) surgery (*i.e.*, alveolar corticotomy, compression, or distraction). Corticotomy-assisted orthodontics (CAO) has been practiced to speed up orthodontic treatment. CAO has many advantages, such as less root resorption, more bone surrounding teeth, due to addition of bone graft, less and slower relapse, and finally less need for extraoral appliances and orthognathic techniques. The regional acceleratory phenomenon (RAP) is a local response of tissues to noxious stimuli by which tissue regenerates faster than normal (*i.e.*, without stimuli) in a regional regeneration/remodeling process. It is an intensified bone response in which there is increased osteoclastic and osteoblastic activity, and increased levels of local and systemic inflammation markers in areas around osteotomy that extend to the marrow.[8]

This response varies directly in duration, size, and intensity with the magnitude of the stimulus, and it is considered a physiological "emergency" mechanism, which accelerates the healing of injuries that could affect survival. The duration of RAP depends on the type of tissue, and usually persists about 4 months in human bone. This phenomenon enhances bone healing by 10–50 times faster than normal bone turnover.

Corticotomy opens the underlying marrow vascular spaces, enhancing healing potential, but maintaining the segment in a stable state and creating a demineralized region. Bone block movement after osteotomy creates a dynamic microenvironment like distraction osteogenesis, but does not elicit regional demineralization in medullary bone. Wilcko et al proposed that the mechanism of tooth movement is likely to be different for those teeth included in corticotomy or osteotomy.[7] This research group described differences in molecular biology between the groups (corticotomy and osteotomy) in which the group with corticotomy and tooth movement showed three phases of bone healing: a resorptive phase on day 3 (more osteoclasts), a replacement phase on day 21 (more osteoblast-like cells), and a mineralization phase on day 60 (non-lamellar bone formation) in the compression site. The osteotomy and tooth movement group was substantially different, and had no bone resorption , but showed progressive bone formation and an increased number of blood vessels in sites distal from the osteotomy, resembling a distraction process. Some root resorption are expected in any orthodontic tooth movement, and its extent depends on the duration of force applied. Ren *et al*[9]. Have demonstrated rapid tooth movement after CAO in beagles without any severe root resorption or permanent pulp damage.

Some mild root resorption was seen after 4 weeks, which was partially corrected by 8th week. It has also been shown in beagle dogs, that corticotomy allows a greater degree of tooth movement, fourfold larger in the maxilla and two times that in the mandible, compared to conventional orthodontic movement. Teeth with cortical activation also show enhanced cellular activity. Osteoclasts, fibroblasts, cementoblasts and osteoblasts showed greater cellular activity in the PDL (Periodontal Ligament) and on both the tooth and bone surface. This increased cellular activity get reduced after 8 weeks, after

6 months this cellularity further decreases and bone matrix becomes denser and more mature after cortical activation.

Advantages of CAO[7]:-

When comparing conventional orthodontics, the advantages of the corticotomy are:

1. Greater application in orthodontic treatments (reduction of dental movements and lesser requirement for extractions)
2. Reduction in treatment duration
3. Increase in the volume of alveolar bone and comprehensive maintenance of the periodontium (preexistent bone dehiscences and fenestrations, corrected with the use of bone grafts)
4. Alveolar remodeling to improve a patient's profile if the case so warrants
5. Simultaneous use with other procedures (impacted teeth)

Disadvantages of CAO[7]:-

1. Extra-surgical cost.
2. Invasive surgical procedure it carries its own risks. Post-surgical crestal bone loss and recession may occur.
3. Some pain and swelling is expected, and the possibility of infection.
4. Not applicable to all cases, proper case selection is necessary to attain a good result..

SURGICAL TECHNIQUE AND CASE SELECTION

CAO can be applied in most scenarios where traditional fixed appliance orthodontic therapy was previously used. This phenomenon has been proven effective in the treatment of Class 1 malocclusions with moderate to severe crowding, Class 2 malocclusions requiring expansion or extractions, and mild Class 3 malocclusions. In all these cases, the orthodontist will plan the tooth movement based on the teeth that will provide anchorage and teeth that will be expanded or contracted. And after this a plan for areas requiring corticotomies is developed. It requires meticulous multidisciplinary planning between surgeon and orthodontist. Patient should also be informed about the aesthetic outcomes. For example, a patient with gingival recession in an area requiring corticotomy, a connective tissue graft can be placed in conjunction with the surgery.[10]

The surgical technique for corticotomy can vary from author to author as can the method of force application during the orthodontic phase. The technique described below is commonly used (Figure 1);

Anaesthesia: Local anaesthetia, sedation or a general anaesthetia can be used for the surgical phase of the CAO.

Flap design: The flap design should provide adequate access to the alveolar bone where the corticotomy needs

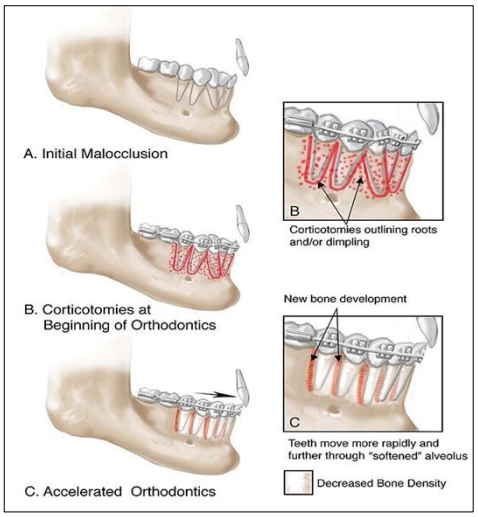

Figure 1:- Surgical procedure of corticotomy[13]

to be performed. It should also provide coverage after surgical procedure and coverage for any grafting material to be used, maintain height and volume of the inter-dental tissues. Basic flap design is nothing but a combination of a full thickness flap in the most coronal aspect with a split-thickness dissection in the apical portions. This increases the mobility of the flap and allows suturing with minimal tension. The periosteal layer should be carefully elevated from the alveolar bone surface. The flap should be extended at least one tooth width beyond the corticotomy areas, both mesially and distally. It should be raised on both surfaces of the alveolus. Preservation of papilla and inter-dental gingival tissues is very crucial for a successful aesthetic outcome and many uses papillae preserving flaps. Utmost care should be taken in handling soft tissues as an adequate blood supply is very critical for the success of corticotomies.

Decortication: An initiation of the RAP response is the main purpose of the decortications. A mobile bony segment should not be created. A round bur is usually preferred for perforation of the cortex while the corticotomies are usually performed with a piezoelectric surgery unit. To our knowledge, there are no concrete evidences, regarding any specific pattern, depth or extent of corticotomy being superior to others, available in the literature. The corticotomies are performed on both the buccal and lingual aspects of the alveolar bone. Most authors usually recommend a vertical groove in the inter-dental space, midway between the root prominences in the alveolar bone. The grove should extend from a point 2-3mm below the alveolar crest to a point 2mm beyond the apices of the roots. The vertical corticotomies are then connected with a horizontal circular shaped corticotomies. All neurovascular structures must be preserved.

Selective alveolar decortication is then carried out in the form of decortication cuts of 0.5mm in depth. Some authors have also recommended selective medullary penetration to enhance bleeding.[11] (Figure 2)

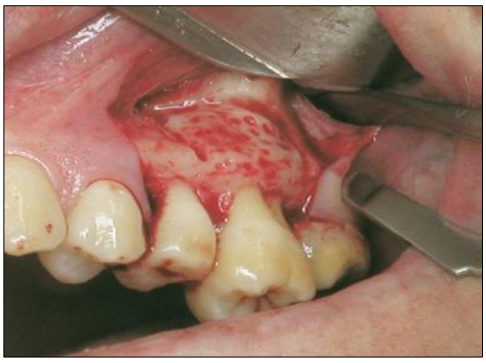

Figure 2:- Corticotomy in the form of lines and points

Closure: Primary closure of the gingival flaps without excess tension must be achieved. Sutures should be left in place for a minimum of two weeks. Tooth movement should be started within one or two weeks after surgery.

Murphy et al[10] suggested the administration of steroids at the time of the surgical procedure to enhance patient comfort and clinical healing. Antibiotics and analgesia are prescribed at the surgeon's discretion. Theoretically, non-steroidal anti-inflammatory drugs should be avoided as they interfere with the RAP.[12]

Orthodontic Phase: One week before the surgical phase, the orthodontic brackets and light arch wires are placed. However some authors suggest bracket placement after surgery that enables easier flap manipulation and suturing. Application of orthodontic force should be started within 2 weeks after surgery to make the full advantage of RAP. The orthodontic appliance needs to be activated every two weeks, unlike conventional orthodontics. (Figure 3)

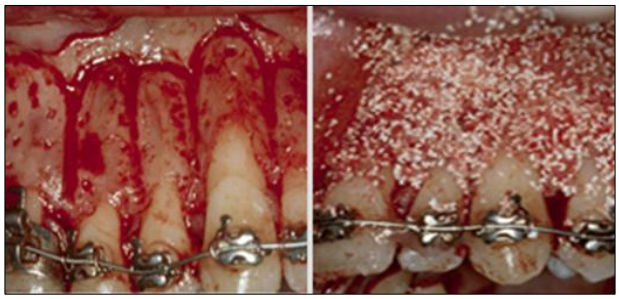

Figure 3:- Orthodontic phase

The accelerated orthodontic tooth movement should be completed within a time period of 4-6 months. Finishing phase would then occur at normal speeds. The amount of force to be applied still remains a topic of debate. Usually heavier forces and frequent reactivation are needed, compared to conventional orthodontic treatment. The anchorage methods also vary depending upon the tooth movement and amount of orthodontic force applied. [6]

Contemporary Techniques: Wilcko et al[7] later incorporated alveolar augmentation and connective tissue grafting with corticotomy technique. They renamed it as "Periodontal Accelerated Osteogenic Orthodontics (PAOO)". In most of the areas that have undergone corticotomies can be grafted, but the type of tooth movement determines the volume of the graft material to be used. To our knowledge, not studies are conducted that compares grafting material in conjunction with corticotomy. Deproteinised bovine bone and autogenous bone are the two most commonly used materials for grafting.

PAOO can be combined with gingival augmentation, particularly in the adult patients with gingival recession where the root surface can be covered by a subepithelial connective tissue graft.

CONCLUSION

Corticotomy can accelerate the orthodontic movement around two times faster than the conventional method and it is quite significant immediately after surgical procedure. Corticotomy is an useful adjunct to shorten the orthodontic treatment time with better patient compliance and it is a fast emerging method in contemporary orthodontics.

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