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**REVIEW ARTICLE**

# CORTICOTOMY AND ORTHODONTICS: A REVIEW

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**ABSTRACT**

Corticotomy found to be effective in accelerating orthodontic treatment. The most important factors in the success of this technique is proper case selection and careful surgical and orthodontic treatment. Corticotomy facilitated orthodontics advocated for comprehensive fixed orthodontic appliances in conjunction with full thickness flaps and labial and lingual corticotomies around teeth to be moved. It is an established and efficient orthodontic technique that has recently been studied in a number of publications. It has gradually gained popularity as an adjunct treatment option for the orthodontic treatment of adults. It involves selective alveolar decortication in the form of decortication lines and dots performed around the teeth that are to be moved. 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 thereafter by activation of the orthodontic appliance. Orthodontic treatment time with this technique will be reduced to one-third the time of conventional orthodontics. Corticotomy facilitated orthodontics is promising procedure but only few cases were reported in the literature. Controlled clinical and histological studies are needed to understand the biology of tooth movement with this procedure, the effect on teeth and bone, post-retention stability, measuring the volume of mature bone formation, and determining the status of the periodontium and roots after treatment. This technique has several advantages, including faster tooth movement, shorter treatment time, safer expansion of constricted arches, enhanced post-orthodontic treatment stability and extended envelope of tooth movement. The aim of this article is to present a comprehensive review of the literature, clinical techniques, indications, contraindications, complications and side effects.



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## INTRODUCTION

An increasing number of adult patients are seeking orthodontic treatment (Mathews and Kokich, 1997). There are several psychological, biological and clinical differences between the orthodontic treatment of adults and adolescents. Dental arch crowding is one of the most common form of malocclusion. Two conventional methods to resolve dental arch crowding through orthodontics are extraction and non-extraction. Extraction as a remedy for dental arch crowding is usually reserved for moderate to severe conditions. Nonextraction therapy is usually used to resolve mild to moderate crowding and usually results in proclination of the incisors. One of the main disadvantages of orthodontic treatment is time. Most of conventional orthodontic treatments require more than one year to complete. Unfortunately many potential orthodontic patients jeopardize their dental health and decline treatment, due to this long treatment times.

Adults have more specific objectives and concerns related to facial and dental aesthetics, the type of orthodontic appliance and the duration of treatment. Growth is an almost insignificant factor in adults compared to children, and there is increasing chance that hyalinization will occur during treatment (Ong and Wang, 2002). 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 in non-flexible alveolar bone (Ong and Wang, 2002). These considerations make orthodontic treatment of adults different and challenging as well as necessitate special concepts and procedures, such as the use of invisible appliances, shorter periods of treatment, the use of lighter forces and more precise tooth movements. The evidence of the success of corticotomy as an adjunct to orthodontic treatment has not been well documented, and few published reports are available. The aim

of this article is to present a comprehensive review of the literature, including the contemporary clinical techniques, indications, contraindications, complications and side effects. The development of corticotomy-assisted orthodontic treatment (CAOT) opened doors and offered solutions to many limitations in the orthodontic treatment of adults. This method claims to have several advantages. These include a reduced treatment time, enhanced expansion, differential tooth movement, increased traction of impacted teeth and, finally, more post-orthodontic stability.

***Historical background:*** Corticotomy facilitated orthodontics has been employed in various forms over the past to speed up orthodontic treatments. It was firstly introduced in 1959 by Kole as a mean for rapid tooth movement. He believed that the main resistance to tooth movement was the cortical plates of bone and by disrupting its continuity, orthodontics could be completed in much less time than normally expected. Kole's procedure involves the reflection of full thickness flaps to expose buccal and lingual alveolar bone, followed by interdental cuts through the cortical bone and barely penetrating the medullary bone (corticotomy style). The subapical horizontal cuts were connected interdentally, penetrating the full thickness of the alveolus. He suggested that since the blocks of bone was being moved rather than the individual teeth, the root resorption would not occur and retention time will be minimized. Because of the invasive nature of Kole's technique, it was not difficult to understand why it was never widely accepted. Duker (1975) used Kole's basic technique on beagle dogs to investigate how rapid tooth movement with corticotomy affects the vitality of the teeth and the marginal periodontium. The health of the periodontium were preserved by avoiding the marginal crest bone during corticotomy cuts. It was concluded that neither the pulp nor the periodontium was damaged following orthodontic tooth movement after corticotomy surgery (Duker, 1975). The results helped to substantiate the belief regarding the health of crestal bone in relation to the corticotomy cuts. Design of the subsequent techniques has taken this into consideration; the interdental cuts are always left at least 2 mm short of the alveolar crestal bone level (Düker, 1975). Frost found a direct correlation between the severity of bone corticotomy and/or osteotomy and the intensity of the healing response, leading to accelerated bone turnover at the surgical site. This was designated "Regional Acceleratory Phenomenon" (RAP). RAP was explained as a temporary stage of localized soft and hard-tissue remodeling that 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 (Yaffe *et al.,* 1994). This accelerated remodeling is influenced by bone density and the hyalinization of the periodontal ligament (PDL) (Yaffe *et al.,* 1994; Verna, 2000; Verna and Melsen, 2003; Goldie and King, 1984; Böhl *et al.,* 2004).

***Contemporary clinical techniques:*** A more recent surgical orthodontic therapy was introduced by Wilcko *et al*. which included the innovative strategy of combining corticotomy surgery with alveolar grafting in a technique referred to as Accelerated Osteogenic Orthodontics (AOO) and more recently to as Periodontally Accelerated Osteogenic Orthodontics (PAOO). This technique advocated for comprehensive fixed orthodontic appliances in conjunction with full thickness flaps and labial and lingual corticotomies around teeth to be moved. Bone graft consisting of demineralized freeze-dried bone and bovine bone with clindamycin was applied directly over the bone cuts and the flap was sutured in place. Tooth movement was initiated two weeks after the surgery, and every two weeks thereafter by activation of the orthodontic appliance. Wilcko *et al*. (2009) reported that this technique will reduce treatment time to one-third the time of conventional orthodontics. Alveolar augmentation of labial and lingual cortical plates were used in an effort to enhance and strengthen the periodontium, reasoning that the addition of bone to alveolar housing of the teeth, using modern bone grafting techniques, ensures root coverage as the dental arch expanded. They advocated using the PAOO for treatment of moderate to severely crowded Class I and Class II. Several reports indicated that this technique is safe, effective, extremely predictable, associated with less root resorption and reduced treatment time, and can reduce the need for orthognathic surgery in certain situations (Wilcko *et al.,* 2009; Ferguson *et al.,* 2015; Nowzari *et al.,* 2008; Wilcko *et al.,* 2008).

***Corticotomy facilitated orthodontics v/s conventional orthodontic treatment:*** Corticotomy surgery initiates and potentiates normal healing process (Regional Acceleratory Phenomena). Regional Acceleratory Phenomena (RAP) is a local response to a noxious stimulus. It describes a process by which tissue forms faster than the normal regional regeneration process. By enhancing the various healing stages, this phenomenon makes healing occur 2–10 times faster than normal physiologic healing. The RAP begins within a few days of injury, typically peaks at 1–2 months, usually lasts 4 months in bone and may take 6 to more than 24 months to subside (Wilcko *et al.,* 2009; Ferguson *et al.,* 2015). A recent histological study showed that selective alveolar decortication induced increased turnover of alveolar spongiosa. The surgery results in a substantial increase in alveolar demineralization, a transient and reversible condition. This will results in osteopenia (temporary decrease in bone mineral density). The osteopenia enables rapid tooth movement because teeth are supported by and moved through trabecular bone. As long as tooth movement continues, the RAP is prolonged. When RAP dissipates, the osteopenia disappears and the radiographic image of normal spongiosa reappears. When orthodontic tooth movement is completed, an environment is created that favors alveolar re-mineralization.

***Technique of periodontally accelerated osteogenic orthodontics (*Wilcko *et al*., 2008; ferguson *et al*., 2017*):*** Orthodontic appliances are better to be placed one week prior to the surgery. Standard brackets, archwires, and normal orthodontic force level can be used after proper case selection. Surgery can be done in a normal clinical setting with or without sedation. Clinic preparation should follow the same protocol used for any oral surgical procedures. After administration of local anesthesia, crevicular incision is made buccally and lingually extending at least two to three teeth beyond the area to be treated. Full thickness (mucoperiosteal) flap is reflected on both buccal and lingual aspects beyond the apices of the teeth if possible (Fig. 1a and b). Care should be exercised not to damage any of the neurovascular bundles exiting the bone and not to disturb muscle attachments. Any interdental papillary tissue remaining interproximally should be left in place. After flap reflection, selective decortications can be performed on both buccal and lingual sides. 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). These cuts are connected beyond the apices of the teeth (when possible) with a scalloped horizontal cuts. Cortical perforation can be made at selective areas to increase blood supply to the graft material (Fig. 2). Care should be taken not to injure the anterior loop of the inferior alveolar nerve that could extend several millimeters mesial to the mental foramen and be positioned just beneath the buccal cortical plate. Bone graft materials [Autograft, mix of Autograft + Allograft, Allograft + Xenograft, or Xenograft + Alloplast] are then placed over the decorticated areas (Fig. 3a and b). Antibiotics can be mixed with bone graft. Wil cko et al. recommended the use of mix of demineralized freeze-dried bone and bovine bone with clindamycin. Care should be taken not to place an excessive amount of bone graft which might interfere with flap placement. If there is any recession in the teeth, it can be treated at the same time with connective tissue graft or acellular dermal matrix allograft (AlloDerm) (Fig. 4). The muco periosteal flap is then sutured with interrupted 4– 0 suture being careful to preserve the interdental papillae. Postsurgical instructions are the same as any standard oral surgical procedures. Antibiotics, analgesics, and antiseptic mouthwash should be given to the patient. The sutures are removed after two weeks. Two weeks post-surgery, accelerated orthodontic treatment can be resumed. The intervals for orthodontic adjustments averaged two weeks, ranging from 1 to 3 weeks. During orthodontic treatment, the patient should be in 3 months recall visits to the periodontist to assess the oral hygiene and assure good periodontal health.

***Indications and clinical applications:*** Several clinical applications for PAOO have been reported. Corticotomy was used to facilitate orthodontic tooth movement and to overcome some shortcomings of conventional orthodontic treatment, such as the long required duration, limited envelope of tooth movement and difficulty of producing movements in certain directions. These applications include the following.

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**Resolve Crowding and Shorten Treatment Time**

Corticotomy and osteotomy were used in orthodontics primarily to resolve crowding in a shorter period of time. It has been shown that corticotomy is efficient in reducing the treatment time to as little as one-fourth the time usually required for conventional orthodontics (Wilcko *et al.,* 2009). Wilcko published a report about two adult patients with severe crowding who were treated via AOO in just 6.5 months (Wilcko *et al.,* 2009). A reduced chance of root resorption, less oral hygiene-related enamel decalcification and better patient cooperation and acceptance are possible advantages when lengthy orthodontic treatment is avoided (Wilcko *et al.,* 2009; Ferguson *et al.,* 2016).

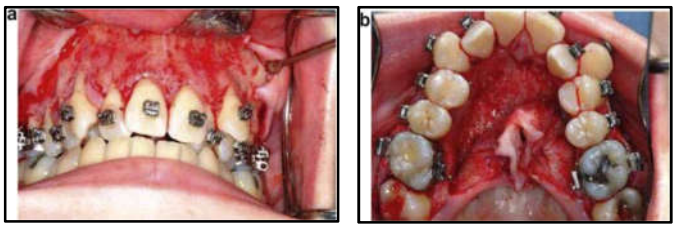

**Figure 1. (a, b) Full thickness flap is reflected on both buccal andlingual aspects beyond the apices of the teeth**

**Figure 2. Vertical corticotomy cuts are made between the roots stoping just short of alveolar crest. The cuts are connected beyond the apices of the teeth with scalloped horizontal cuts and cortical perforations are made at selective areas**

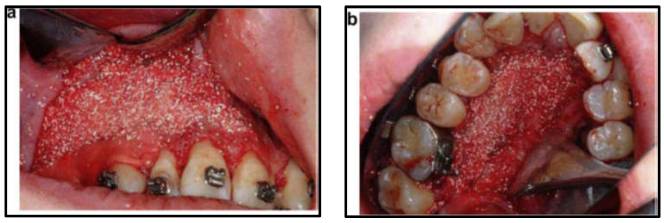

**Figure 3 (a, b) Bone graft materials are placed over the decorticated areas**

**Figure 4. Soft tissue graft (acellular dermal matrix allograft in this case) can be used simultaneously with corticotomy to treat recession**

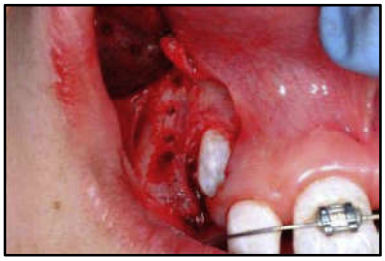

**Figure 5. Corticotomy can be used to expedite the movement ofindividual teeth (impacted canine in this case)**

***Accelerate Canine Retraction after Premolar Extraction:*** Canine retraction after premolar extraction is a lengthy step during the extraction stage of orthodontic treatment. Canine retraction was accelerated by corticotomy in two animal studies. Both studies demonstrated faster canine retraction

when compared to conventional orthodontic retraction of the canines ( Ren *et al.,* 2007; Mostafa *et al.,* 2009).

***Enhance Post-Orthodontic Stability:*** Stability after orthodontic treatment may not always be achievable. Little has shown that 10 years after orthodontic treatment, only 30% of patients had satisfactory alignment of the mandibular incisors. Stability was reported as one of the advantages of corticotomy-assisted orthodontics. Corticotomy- facilitated orthodontic treatment was found to result in better retention compared to conventional orthodontic treatment. The improved stability was attributed to the increased turnover of tissues adjacent to the surgical site (Little, 1990; McFadden *et al.,* 1989).

***Facilitate Eruption of Impacted Teeth:*** Surgical traction of impacted teeth, especially the canines, is a frustrating and lengthy procedure. A study by Fischer showed that under the same periodontal conditions, the corticotomy-assisted approach produced faster tooth movement during traction of palatally impacted canines compared to conventional canine traction methods at the end of either treatment (Fischer, 2007).

***Facilitate Slow Orthodontic Expansion:*** A limited number of successful techniques is available for the treatment of maxillary arch constriction; these include surgically-assisted rapid palatal expansion (SARPE) and slow palatal expansion. These techniques are aggressive in nature and less accepted by patients. The presence of non-growing alveolar bone that confines the teeth in the predetermined space available in the alveolus limits transverse tooth movement (Fischer, 2007; Vanarsdall, 1999; Yen *et al.,* 2003).

***Molar Intrusion and Open Bite Correction:*** PAOO has also been used in the treatment of severe anterior open bite in conjunction with skeletal anchorage. Moon et al. achieved sufficient maxillary molar intrusion (3.0 mm intrusion in two months) using corticotomy combined with a skeletal anchorage system with no root resorption and with no patient compliance required. Olivieriaet al.also reported 4 mm of molar intrusion in 2.5 months using corticotomy in one patient and 3 to 4 mm in 4 months in another patient. Hawang and Lee demonstrated intrusion of supra-erupted molars using corticotomy, full-time use of magnetic appliances and night-time use of a vertical-pull chin-cup (Yen *et al.,* 2003; Kanno *et al.,* 2007; Moon *et al.,* 2007; Oliveira *et al.,* 2008; Hwang and Lee, 2001).

***Manipulation of Anchorage:*** PAOO was used in the treatment of bimaxillary protrusion as an adjunct to manipulate skeletal anchorage without any adverse side effects in only one-third of the regular treatment time (Iino *et al.,* 2006). PAOO was also used to achieve molar distalization. After performing segmental corticotomy around the molars, the anchorage value and resistance of the molars to distal movement were effectively reduced without the use of any extra anterior anchorage devices (Iino *et al.,* 2006; Spena *et al.,* 2007).

***Contraindications and limitations:*** Patients with active periodontal disease or gingival recession are not good candidates for PAOO. In addition, PAOO should not be considered as an alternative for surgically assisted palatal expansion in the treatment of severe posterior cross-bite. CAOT also should not be used in cases where bimaxillary protrusion is accompanied with a gummy smile, which might benefit more from segmental osteotomy (Lee *et al.,* 2007).

***Complications and side effects:*** Although PAOO may be considered a less-invasive procedure than osteotomy-assisted orthodontics or surgically assisted rapid expansion, there have still been several reports regarding adverse effects to the periodontium after corticotomy, ranging from no problems to slight interdental bone loss and loss of attached gingiva, to periodontal defects observed in some cases with short interdental distance. Subcutaneous hematomas of the face and the neck have been reported after intensive corticotomies. In addition, some post-operative swelling and pain is expected for several days (Iino *et al.,* 2006). No effect on the vitality of the pulps of the teeth in the area of corticoto my was reported. Long-term research on pulpal vitality after rapid movement has not been evaluated in the literature. In an animal study, Liou et al. demonstrated normal pulp vitality after rapid tooth movement at a rate of 1.2 mm per week. However, pulp vitality deserves additional investigation. It is generally accepted that some root resorption is expected with any orthodontic tooth movement. An association between increased root resorption and duration of the applied force was reported. The reduced treatment duration of PAOO may reduce the risk of root resorption. Ren *et al*. (2007) reported rapid tooth movement after corticotomy in beagles without any associated root resorption or irreversible pulp injury. Moon et al. reported safe and sufficient maxillary molar intrusion (3.0 mm intrusion in two months) using corticotomy combined with a skeletal anchorage system with no root resorption. Long-term effect of PAOO on root resorption requires further study (McFadden *et al.,* 1989; Harry and Sims, 1982).

**Advantages**

- Reduced treatment time: this technique will reduce treatment time to one-third the time of conventional orthodontics (Wilcko *et al.,* 2008)
- Less root resorption due to decreased resistance of cortical bone (Wilcko *et al.,* 2008; Ferguson *et al.,* 2017)
- More bone support due to the addition of bone graft (Ferguson *et al.,* 2017).
- History of relapse reported to be very low (Wilcko *et al.,* 2008).
- Less need for extra-oral appliances and headgear (Wilcko *et al.,* 2008)
- The technique has its roots in orthodontic research and treatments (Nowzari *et al.,* 2008; Wilcko *et al.,* 2008).
- In the ten years since PAOO was first applied, the patients' outcomes were good (Nowzari *et al.,* 2008; Wilcko *et al.,* 2008).
- It can be used to expedite the rate of movement of individual teeth or dental segments, i.e. canine (Fig. 5) and incisor retraction.

**Disadvantages**

- Extra-surgical cost.
- Mildly invasive surgical procedure, and like all surgeries, it has its risks. Post-surgical crestal bone loss and recession may occur.
- Some pain and swelling is expected, and the possibility of infection.
- Not applicable to all cases, proper case selection is necessary to attain a good result. Maxillary and mandibular arch decrowding with normal skeletal

relationship and incisors retraction are the main indications.

## Conclusion

PAOO is relatively new procedure; only few cases were reported in the literature. Controlled clinical and histological studies are needed to understand the biology of tooth movement with this procedure, the effect on teeth and bone, post-retention stability, measuring the volume of mature bone formation, and determining the status of the periodontium and roots after treatment. PAOO is promising procedure; it may be a solid part of the future of orthodontic treatment.This procedure enhances and accelerates tooth movement if followed by a short period of orthodontic appliance treatment. PAOO effects and mechanism were confirmed by recent well designed histological studies. However, further randomized testing in humans is still needed to confirm the claimed advantages of this technique and to evaluate the long term effects.

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