Corticotomy–Wilkodontics: A Gateway to Reduce the Conventional Orthodontic Treatment Duration

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Introduction

The duration of the orthodontic treatment always remains a major concern for the patients and professionals. Many a times it's the only reason for the unwillingness for the treatment by the patient. Additionally few limitations of traditional treatment like root resorption, pulpal pathosis, need of extraction of few teeth, usage of heavy appliances have motivated the researchers to find better alternatives or adjuncts to conventional orthodontic treatment (1). Henceforth several methods have been put forwarded in last few decades to be used in association with the orthodontic tooth movement. Mainly three procedures are followed: osteotomy, corticotomy and piezoincision. Corticotomy and piezoincision are based on the principle of Regional acceleratory phenomenon (RAP) and osteotomy is based on process of distraction osteogenesis(2). The aim of this article is to review and summerize the information about the corticotomy assisted orthodontics.

Phases of tooth movement: Burston (1962) described the following phases of tooth movement: (3)

a) Instantaneous tooth movement
b) Lag phase
c) Progressive linear phase

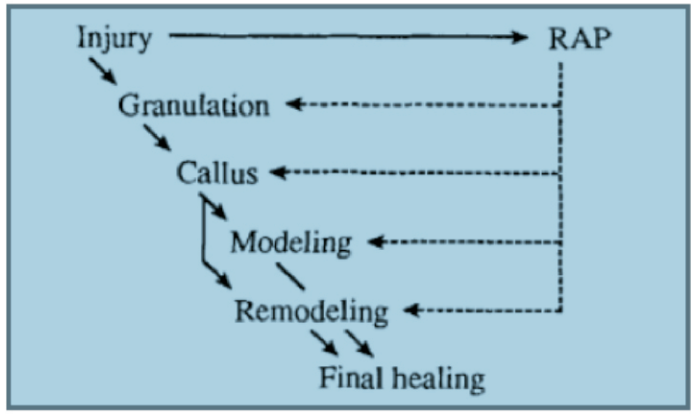
Corticotomy

It is a surgical procedure which involves fracturing and injuring the cortical bone through microperforations, vertical and horizontal cuts(4).This process increases the bone regeneration and bone healing and thereby decreasing the treatment duration and facilitating the rapid movement of teeth. Various modifications have been tried like addition of synthetic grafts and resorbable membranes(5).

Historical background: In 1892, L.C.Bryan reported the usage of corticotomy technique for the first time in association with the orthodontic treatment. Later in 1959, Heinrich Koleproposed the concept of bone block movements to accelarate the orthodontic treatment. According to him, osteotomy cuts could be performed in the cortical bone (as it provides greatest resistance) leading rapid movement of tooth. This procedure reduced the treatment time by approximately 6 to 12 weeks and was indicated for separation of single or grouped teeth. Between 1975 and 1978, a novel technique called fast orthodontics was introduced by Chung in which combination of cuts and orthopaedic forces along with use of intraosseous anchoring devices (mini implants and mini plates) were used for faster movements of teeth. In 1978, Generson proposed a modification in KOLE's technique. According to this modification, supraapical osteotomy was replaced by supraapicalcorticotomy. In 1983, Frost described the concept of Regional Accelerated Phenomenon (RAP). On the basis of this phenomenon, WILKO IN 2001 proposed the accelerated osteogenic orthodontics technique (AOO) through their two case reports. They reported that for the movement of teeth, design of cuts are not significant, rather the degree of metabolic alterations in that particular region is important. In 2001, the two wilko brothers (orthodontist and periodontist proposed the use of bone graft along with corticotomy to enhance bone volume and formation. They renamed this technique as periodontally accelerated osteogenic orthodontic (PAOO) technique. In 2006, Germec used monocorticotomy technique in which the osteotomy cuts are not placed in the difficult lingual or palatal areas which in turn reduce surgical time as well as patient discomfort. Later on few more advances and modifications were introduced which will be discussed later in the article under advances section (6).

Principle of corticotomy/ PAAO technique(7): The roots of corticotomy procedure lie in the regional acceleratory phenomenon (RAP) firstly described by an orthopaedic surgeon HAROLD FROST (1983). It is a local response of bony tissue to the noxious stimulus applied on it which increases the formation of bone 2-10 folds than the normal bone formation. This in turn fastens the healing of bone. It starts few weeks after the surgery, peaks at 12 months and takes around 6-24 months to subside. This phenomenon lasts for about 4 months in the bone.

During RAP, initially demineralisation takes place which helps in the faster movement of tooth supported by orthodontic forces. As RAP starts dissipating, the bone begins to take its normal form and an environment is created which results in remineralisation of the bone.



Regional Accelaratory Phenomenon (RAP): Frost (1989)

Histological and Clinical Fundamentals: There are four types of surgical damage which can be created in alveolar bone:

a. Osteotomy (complete cut through cortical and medullar bone),
b. Corticotomy (partial cut of cortical plate without involving medullar bone),
c. Ostectomy (removal of an amount of cortical and medullar bone) and
d. Corticotectomy (removal of an amount of cortex without medullar bone).

Corticotomy-assisted orthodontics has been shown to decrease the duration of orthodontic treatment. Reduction of treatment

time by one-third compared with conventional treatments has been shown by various clinical.It is based on the regional acceleratory phenomenon (RAP) which is a local response of tissues to noxious stimuli which promotes tissue regeneration. There is increased osteoclastic and osteoblastic activity along with increased levels of local and systemic inflammation markers in the areas around surgical cuts which extend to the marrow. This response is directly proportional to the magnitude of the stimulus, and is known as physiological "emergency" mechanism. RAP remains for 4 months in human bone. This phenomenon enhances bone healing by 10–50 times than normal bone (8).

Healing Phases of RAP (studied in Rat Tibia)

There is formation of woven bone which begins in the periosteal area and then extends to medullar bone. Its maximum thickness is achieved by day 7. This woven bone provides mechanical stability to the bone after injury. From day 7, the woven bone in the cortical area undergoesremodeling to lamellar bone and woven bone in the medullary area undergoes resorption, which results in transitory local osteopenia (9).

Clinically, bone resorption results due to the exposure of bone after flap reflection. The degree of resorption was greater in the lingual plate than buccal, and reaches maximum in 3 weeks post-surgery in rats. Transient osteopenia in alveolar bonereduces the biomechanical resistance and causes rapid tooth movement through trabecular bone (10). Transient osteopenia have to be prolonged by orthodontic forces due to limited window period that limits the RAP over a range of period of 3–4 months. This is the reason to adjust the orthodontic appliance in every 2 weeks (11).

Hyalinization (tissue necrosis) is caused due to excessive compression of the PDL caused by excessive pressure. This hyalinized tissue attracts neutrophil, granulocytes and macrophages by chemotaxis and must be removed and remodeled before starting bone resorption by osteoclasts and subsequent orthodontic tooth displacement. When the PDL is compressed, the vascular access of osteoclasts to the PDL–lamina–dura interface is limited. Prolonged hyalinization of the PDL results in slower tooth movement. This period of hyalinization has been called as the lag phase or arrest phase (12-13).Von Böhl et al. reported that hyalinized areas appear between 4 and 20 days and between 40–80 days of tooth movement as a continuous process. This leads to direct bone resorption and faster tooth movement. The rate of tooth movement directly related to force magnitude, type of movement (bodily tooth or tipping movement) or the individual bone metabolic capacity (bone density, systemic and genetic factors).It was suggested that corticotomy results in opening of underlying marrow vascular spaces, which enhances healing potential, and maintains the segment in a stable position, thus creating a demineralized region. Bone block movement forms a dynamic microenvironment just like distraction osteogenesis, but does not cause regional demineralization in medullar bone (14).

Some amount of root resorption is generally expected with any type of orthodontic tooth movement, and its extent depends on the duration of force application. Ren et al. found that the rapid tooth movement after CAO in beagles is not associated with severe root resorption or irreversible pulp damage. Some mild root resorption was reported after 4 weeks, which was partially repaired by week 8 (15).

It was also reported that corticotomy causes greater degree of tooth movement, four-times rapidly in the maxilla and two times in the mandible, compared to traditional orthodontic movement. More cellular activity was observed at corticotomy sites. Osteoclasts, fibroblasts, cementoblasts, and osteoblasts in the PDL are very active on both the tooth and bone surface. This increased cellular activity last for 8 weeks, and after a further 6 months this high activity of cells starts decreasing markedly which results in dense bone matrix (16).

One more histological study in rats concluded that there was increased turnover of alveolar spongiosa immediately adjacent to the decortication areas, without any orthodontic force being applied. Trabecular bone surface area decreased to half and periodontal ligament surface area increase by two times. Catabolic and anabolic activities were increased by three times at 3 weeks after surgery which decreases gradually until the 7th week and then reached at steady-level by the 11th week after surgery (17)

Systemic Effects of RAP:

Mueller et al (1991) studied the effect of RAP on systemic bone metabolism in animal model of rat and reported that there is increased formation and mineralisation of bone when tibia and femur of rat were injured with bur (18)

Schilling et al (1998) also reported increase in systemic inflammatory mediators in association with local RAP (19)

Thus split mouth study between corticotomy assisted orthodontic treatment and conventional orthodontic treatment is not suitable as the effects of RAP is not limited upto surgical site only.

Indications

Orthodontic Indications

- Class-I and class-II malocclusions
- Crowding
- Intrusion of molars
- Distalisation of molars
- Cooperative patients

Periodontal indications

- Healthy periodontium
- Minimum bone loss
- Not worse than grade-I furcation involvement
- No Temporo mandibular joint problems

Contraindications

- Ankylosed teeth
- Impacted teeth
- Class-III malocclusion
- Periodontally compromised teeth with active periodontal pathologies and gingival recession.
- Medically compromised patients.
- Uncontrolled osteoporosis or other bony pathologies.(20)
- Patients on immunosuppressive and anti-inflammatory drugs.(20)
- Patients on bisphosphonate therapy.(20)

Advantages

- It increases the remodelling of trabecular bone by increasing catabolic as well as anabolic activity at the corticotomy site (21).
- It accelerates the movement of teeth. Bhattacharya et al (2014) conducted a study on 20 patients and concluded that corticotomy assisted orthodontics accelerate the teeth movement and increases the alveolar bone thickness as well (22)
- Corticotomy assisted orthodontic treatment results in 50% less chances of root resorption on completion of treatment when compared with conventional orthodontic treatment (21).
- Evidences suggest that the corticotomy facilitated orthodontic treatment rapidly displays the desired results and thereby reduces total treatment time as compared to conventional orthodontic treatment (21)
- Prolong retention and less chances of relapse have been claimed with corticotomy (21)
- Reduces the need of extractions (21).
- Expansion of narrow arches can be obtained safely (21).
- More bone volume due to addition of bone graft (20).
- Reduces the need of heavy orthodontic appliances like

headgears and expansion appliances (20).

Disadvantages

- Invasive procedure (20)
- Postoperative complications may include swelling, pain and facial edema. (23)
- Slight interdental bone loss and gingival recession may occur postoperatively (23)

Evidences of Clinical Implications of Corticotomy:

Animal Researches

- Duker (1975) for the first time conducted experiments on beagle dogs and concluded that there is no harm to periodontium and pulp by corticotomy procedures (24).
- Cho et al (2007) conducted protraction of third premolars and found out increase in cellular activity of the formative and resorptive cells (25).
- Iino et al. (2007) concluded that there was rapid orthodontic movement of tooth in initial stages of the treatment when corticotomy was performed in beagle dogs. Decrease in hyalinization of the periodontal ligament was suggested for this finding (26)
- Similarly Mostafa et al (2009) suggested that there was increased pace in the orthodontic treatment when corticotomy assisted orthodontic treatment was compared with conventional orthodontic treatment alone in experimental dogs (27).
- IrfanQamruddin et al (2015) in a systematic review suggested that corticotomies, low level laser therapy and mechanical vibrations are the emerging techniques to be used as an adjunct to orthodontic treatment.(28)

Human Researches

Currently the evidences are mainly available in the form of case reports.

- Wilco et al (2001) reported the series of 3 cases where they suggested various advantages of the corticotomy facilitated orthodontic treatment which included rapid tooth movement, less root resorption, shortened treatment duration, possibility of non-extraction cases, etc (29).
- Long et al (2012) systematically reviewed the procedure and found that its safe and should be incorporated into clinical practice (30).
- Laura Fernandez-Ferrer et al (2016) conducted a systematic review and concluded that corticotomy assisted orthodontics reduces the treatment time and no periodontal damage was found in the included short term studies. (31)

Evidences on Limitations of the Corticotomy Procedure

- Reichenbach (1965) suggested the possibility of formation of the pocket and necrosis of alveolar bone caused by corticotomy.
- Bell & Levy (1972) called corticotomy as destructive procedure (32).
- Recently Cassetta et al (2012) reported increased oral health impact profile scores which indicated that the subjects faced functional disabilities (33).

Technique

Orthodontic appliances are given 1 week prior to the surgery.

Surgical phase involves following 5 steps (6)

1. Raising the flap: Proper flap design is essential for access of bone wherein corticotomy has to be performed. Administration of local anaesthesia should be followed by raising the full thickness flap buccally and lingually by giving crevicular incisions[2].

2. Decortication: vertical cuts are made in the interproximal area penetrating into the cortical bone and horizontal cuts are given joining the vertical cuts in the subapical region. These cuts should be deep enough to initiate the regional acceleratory phenomenon. Care should be taken that these cuts do not lead to movable bony blocks or injure any blood vessels or muscle attachments.

3. Particulate grafting: synthetic grafts (allograft, xenografts, alloplasts or the combinations of these) can be placed at the surgical site inorder to increase the bone volume and facilitate the rapid healing of the bone. Excessive amount of graft can interfere with the healing.

4. Closure: flaps should be approximated and sutured atraumatically with 4-0 suture. Interdental papilla should be preserved. Analgesics and antibiotics are prescribed followed by suture removal after 7 days.

5. Orthodontic force: Orthodontic treatment is resumed in 2 weeks post-surgery. Patient should be examined for periodontal health and oral hygiene status in every 3 months interval.

Other Methods to Accelerate the Orthodontic Treatment (34-43)

1. Surgical Methods
2. Mechanical stimulation methods.
3. Pharmacological method

1. SURGICAL METHOD: It is mainly indicated in adult patients with the aim of reducing total treatment time. The basic principle behind this method is to increase the bone turn over by injuring the bone through corticotomy and fractures. Corticotomy and piezoelectric methods are used for this purpose. Details of this method are discussed further in the article.

a) Cyclic forces: In this method light alternate forces are placed using mechanical radiations. Vibration impulses ranging from 20-30 Hz are applied for 20 minutes every day on the teeth which causes the movement of teeth at a rate of 2-3mm/ month. The commercial device 'ACCLEDENT' is commercially now available for applying such forces.

Chung How Kau et al studied the clinical effects of a cyclical force generating device on tooth movement and overall orthodontic treatment time. The levels of patient compliance and patient satisfaction were evaluated. Patients undergoing active orthodontic treatment were included in the study. The patients were instructed to use the device for 20 minutes daily for a period of 6 consecutive months. Rates of tooth movement, patient compliance, and patient perception data were evaluated. The patient compliance rate indicated 67% compliance rate. Overall patient satisfaction with the device increased over the course of treatment time for most variables as indicated by the mean scores. Authors concluded that the rates of teeth movement were increased with the use of the device; patient compliance was 67%; and patient acceptance and compliance with the device was clinically significant.

b) Low level laser: Saito and Shimuzi found that the low level laser therapy cause bone regeneration. They enhance proliferation of osteoblasts, osteoclasts, fibroblasts and thus causing increased bone formation. Various reserchers have tried variable wavelength, frequency and power of low level laser required for increasing the rate of tooth movement. Recently, Gauri Mehta et al (2013) conducted a split mouth study where they applied diode laser at wavelength of 800 nm for 10 secs on the canine region at the experiment site. They have found significant increase in rate of movement of teeth on the experiment side when compared with control side with the mean increase of 54% and 58% in maxillary and mandibular arch respectively.

c) Piezoincision: Dibart et al (2009) introduced the corticotomy by piezoincision technique in order to decrease the patients' morbidity. Surgery was planned 1 week after the placement of fixed orthodontic appliances. After administration of local anaesthesia, vertical gingival incisions with scalpel no 15 under interdental papilla, mostly in attached gingiva, deep enough to penetrate periosteum and contacting the cortical bone were placed only buccally. Through these incisions ultrasonic tips were used to perform the corticotomy cuts (depth – 3mm) on the cortical bone. Areas requiring bone augmentation need to be

tunnelled. With the help of elevators, space is created between the incisions to place the graft material. Suturing is required only to stabilize the graft. Advantage of the technique is less invasive and doesnot require suture placement which further increases the acceptance of the procedure by the patient. Blindly performed incisions and corticotomies can cause root damage which is a limitation of this technique. In order to overcome this limitation, Jorge et al (2013), proposed the use of metal wire as a guide for placing gingival incisions and corticotomy cuts. Radiographs with the metal wires ensure the correct placement of incisions and cuts and prevents the root damage.

Jianru Yi et al (2017) in their systematic review on use of piezoincision technique for accelerating tooth movement concluded that there are weak evidences in support of its usage. Additionally they supported that there is no harmful effects on periodontal health and no negative effects on pain perception in short term. Due to non-standardization of available studies, the effect on root resorption, anchorage and patient satisfaction remain inconclusive.

d) Microosteo-perforations: The invasive nature of surgical irritation of bone was attempted with a device called Propel, introduced by Propel Orthodontics. The process was called as Alveocentesis, which means to puncture the bone.It consists of

- An adjustable depth dial: The adjustable depth dial can be adjusted to 0 mm, 3 mm, 5 mm and 7 mm of the depth of puncturing the bone based on the required depth of operation.In the anterior region, the depth of puncturing the bone is 3 mm, in premolar region, it is 5 mm, and in the molar region, the depth is 7 mm
- An indicating arrow on the body of the device.

Alikhani studied the effect of micro-osteoperforations on the rate of tooth movement and the expression of inflammatory markers. They selected 20 adults with Class II Division 1 malocclusion and divided into control and experimental groups. Maxillary canines were retracted in both the groups, and movement was measured after 28 days. The expression of inflammatory markers was measured in gingival crevicular fluid. Pain and discomfort were monitored with a numeric rating scale.Micro-osteoperforations significantly increased the rate of tooth movement by 2.3-times along with significant increase in the levels of inflammatory markers. The patients reported no significant pain or discomfort during or after the procedure, or any other complications and thus they concluded that micro-osteoperforation is an effective and comfortable for rapid tooth movement and thereby reducing the treatment duration.

e) Minimally Invasive Rapid orthodontic Procedure (MIRO): It results in speedy orthodontics described by Jorge et al. in 2013. As it is flapless, it reduces both trauma and convalescence. Corticotomy can be carried out with the help of radiographs and surgical guides so that vital structures can be saved.

2. Mechanical stimulation methods: These methods are less invasive as compared to surgical methods. These methodsinclude direct electric current, resonance vibrations, static magnetic field, low level laser therapy, pulsed electromagnetic field, etc. It is based on the principle of bioelectric potential. Through these methods there is generation of bioelectric field leading to negative and positive charges on the bone. Negative charges on concave side of bone attract osteoblasts whereas positive charges on the convex side of the bone attract osteoclasts.

3. Pharmacological Methods

Drugs which have been tried to increase the movement of teeth are vitamin-D, prostaglandins, parathyroid hormone, interleukins,mesopristol etc. These drugs have variable effects on the bone and adverse effects systemically so till date no single drug has been proved to be a choice for accelerating tooth movement.

a) Vitamin-D: 1,25dihydroxycholecalciferol regulates the homeostasis between calcitonin and parathyroid hormone which are found to influence the bone apposition and resorption. Collins et al (1988) conducted an experiment on rats to study the influence of vitamin-D on orthodontic treatment and found that there is 60% rapid movement of teeth when compared with control. Histologically, increased presence of osteoclasts resulting in more bone resorption on the pressure side was found.

b) Parathyroid hormone: Soma et al (1999) have shown the effects of parathyroid hormone on teeth movement in an animal study of rats. They observed that there is increase in the teeth movements by 2-3 folds due to increased recruitment of osteoclasts on the pressure side of the periodontal ligament causing enhanced resorption of bone.

c) Relaxin: Liu et al (2005) observed the effects of administering the relaxin hormone on teeth movement in rats and concluded that it can enhance the teeth movement in early stages of orthodontic treatment.

d) Osteocalcin: Hashimoto et al and Kobayashi et al studied the effect of administering the osteocalcin on the tooth movement and found thet it increases osteoclasts and trap- positive multinuclear cells in the early phases of orthodontic treatment.

Future Prospectives

Animal researches are carried worldwide to improve the orthodontic treatment by administration of biomolecules like parathyroid hormone, relaxins, vitamin-D3, etc. human studies are very scarce in this aspect as long term side effects are yet to be found out. Low level laser therapy is one of the promising approaches in future of orthodontics as it has advantage of being less invasive, painless and more patient cooperation and comfort towards the treatment. Long term clinical trials are required to draw a definitive conclusion.Surgical approach is definitive but it is invasive, may lead to some reversible complications and this makes it a less chosen option among the patients.Piezoincision is also one of the most accepted techniques and hold good results in future.

Level of Acceptance By Patient

Khalid H Zawawi (2015) studied patients' acceptance of corticotomy-assisted orthodontics. He prepared the two sets of questionnaires of which first one included questions about the age, sex, level of education and few questions about the orthodontic treatment. Second set contained the questions regarding corticotomy assisted orthodontics. Before answering second set of questions, patients were educated with a short description about the corticotomy procedure with the help of clinical photographs. Out of 150 subjects, 129 agreed for answering the questions (72 male and 57 female). Out of these, 7.8 % were in favour of corticotomy in place of extraction. The reason for not selecting corticotomy procedure was most commonly fear from surgery followed by fear from pain. Prior knowledge of the procedure and level of education didn't make any significant difference in the results. Author concluded that the acceptance for corticotomy procedure as an adjunct to orthodontic treatment was low. Fear from the surgery was the most common reason for low acceptance. Patient's level of education or sex did not influence the level of acceptance (44).

Conclusion

Corticotomy assisted orthodontics can be considered a major breakthrough especially in case of adult orthodontics. It can be a promising mode of treatment for both clinician and patients in future. Various advantages served by it must be taken into consideration. Long term research trials are necessary to be conducted before introducing it into regular clinical practice. Efforts and trials should also be there to limit its limitations.

References:

References are available on request at
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