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Minimally Invasive Corticotomy Facilitated Orthodontic Tooth Movement: Piezocision

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Abstract

Malocclusion is one of the most common condition occurring in oral and maxillofacial region and it affects the population worldwide. These individuals with malocclusion can benefit from either removable or fixed orthodontic treatment, but treatment duration can range from months up to 2–3 years for comprehensive treatment. Longer treatment time also increases the chances of iatrogenic trauma to the tissue and less patient compliance to complete the orthodontic treatment. To overcome these issues, periodontally accelerated osteogenic orthodontic (PAOO) treatment is gaining popularity among clinicians and patients as viable treatment option. This technique involves elevation of full-thickness flap in the buccal and lingual aspects and osteotomy cuts are placed which leads to regional acceleratory phenomenon (RAP) induced orthodontic acceleration. Piezocision is a minimally invasive localized piezoelectric alveolar decortication approach that combines both buccal micro-incision technique and minimally invasive corticotomy technique that are performed with the help of a piezotome. The major advantage of Piezocision over conventional surgical approach is its less invasive nature causing very minimal surgical trauma to the patients, which makes Piezocision technique more acceptable among patients.

Keywords: Corticotomy, Malocclusion, PAOO, Piezo-surgery, Piezotome, RAP

Introduction

Malocclusion is one of the most common diseases of the oral and maxillofacial region and it affects the population worldwide. It can negatively affect the quality of life of an individual by compromising one's aesthetics as well as

occlusal function.[1] These individuals with malocclusion can benefit from either removable or fixed orthodontic treatment, but treatment duration can range from months up to 2–3 years for comprehensive treatment,[2] this could be even longer. The time taken for treatment to complete is decided by several factors such as case severity, extraction or non-extraction approach, clinical expertise - treatment planning, patient cooperation, and individual characteristics. The time duration is one of the main reasons why patients abandon the treatment before concluding it.[3] Studies have shown that patient compliance to follow up orthodontic appointments decreases by 23% for every 6-month increase in treatment duration. Also, longer treatment durations can increase the chances of iatrogenic damage like root resorption, dental caries, white spot lesions and periodontal problems.[4,5]

However, because of the increasing demand for adult orthodontics and patients who desires for a shorter treatment duration of 6-12 months, there is a significant incentive for orthodontic providers and companies to find ways to accelerate treatment. Several orthodontic companies now offer brackets, techniques, and other appliances that claim to reduce treatment times. There has also been a dramatic increase in the number of products claiming to accelerate tooth movement.[6] The possible interventions for the treatment of malocclusion can be categorized as surgical or non-surgical. In turn, the interventions may influence two basic aspects of orthodontic tooth movement; firstly, the physics of force application (orthodontic mechanics) and secondly, the biological response of the dentoalveolar tissues to this force.[7] In the non-surgical method, the most often used techniques are Self-ligating and varying bracket designs, Customised appliances, Medication, Micro vibration, Low-intensity laser, Photobiomodulation (PBM), whereas Electromagnetic fields, Direct electrical currents are still under experimental phase. In surgical intervention techniques Micro-osteoperforation (MOP), Piezocision, Corticotomies, Osteotomies/PDL distraction are some of the more widely accepted orthodontic intervention treatment options.[8]

The concept of surgical orthodontics was introduced as early as the 1950s[9]. K¨ole was the pioneer in introducing surgery involving elevation of a full-thickness flap and removal of interdental alveolar cortical bone. He claimed that technique allows movement of bone blocks rather than moving single teeth individually, thus it is more efficient and inducing less root resorption and retention time.[9] Subsequently, the efficacy of corticotomy on promoting orthodontic tooth movement (OTM) was further validated in a series of clinical reports.[10] Recent research indicates that corticotomy- induced acceleration of OTM is associated with a regional acceleratory phenomenon (RAP).[11] This is a biological movement concept which was initially described in the orthopedic field by Frost in the year 1983 and clinically proven in later years(1989) .[12] The bone injury is followed by an increase in bone turnover and a decrease in the mineral content of the bone (Sebaoun et al. 2008)[13]. These biological findings were used by Wilcko et al. (2001) to develop a new treatment concept: periodontally accelerated osteogenic orthodontics. This technique involves elevation of full-thickness flaps in the buccal and lingual aspects and osteotomies are performed that leads to RAP-induced orthodontic acceleration.[14]—Several systematic reviews have reported the technique to be effective in accelerating orthodontic tooth movement although the RAP effect may be time-limited according to some authors.[12, 15] Due to concern about the invasiveness of corticotomy techniques, some authors have proposed flapless alternatives to the RAP technique that employ

piezoelectric devices, reinforced scalpels, and mallets, piezopuncture or micro-osteoperforations.[12]

Piezocision is a minimally invasive localized piezoelectric alveolar decortication approach that combines both buccal microincision technique and minimally invasive corticotomy technique that are performed with the help of a piezotome. This technique can also be implemented with tunneling hard and soft tissue augmentations.[13] The biological process of piezocision and the facilitation of tooth movement have been studied in rat models. Bone demineralization and the number of osteoclasts were found to be significantly higher with combined piezocision and tooth movement as compared with piezocision or tooth movement applied independently. This suggests a synergistic relationship between piezocision and tooth movement.

Applications of piezocision

Piezocision can be used to

- Accelerate orthodontic treatment in a generalized, localized or sequential manner (including localized " boosters")
- Enhance the scope of tooth movement through grafting (i.e., posterior buccal expansion, decrowding without extractions due to the increased alveolar volume)
- Achieve differential tooth movement by altering anchorage value by changing the bone density at certain areas
- Enhance the patient's profile in certain cases by altering the labiomental fold
- Repair the alveolar cortical bone fenestrations and dehiscence, and improve the periodontium strength by adding hard or soft tissue grafting
- Possibly enhance the stability of the orthodontic treatment through stronger alveolar cortices, when grafted.

INDICATIONS

Indications for using the piezocision technique include the following:

- Class I malocclusions with moderate to severe crowding (extraction and non-extraction).
- Selected class II malocclusions (end-on).
- Selected class III malocclusions (dental).
- Correction of deep bite.
- Correction of open bite.
- Rapid adult orthodontic treatment.
- Orthodontic treatment with clear aligners(i.e., Invisalign®).
- Rapid intrusion and extrusion of teeth.
- Simultaneous correction of osseous and mucogingival defects.
- Prevention of mucogingival defects that may occur during or after orthodontic treatment.
- Multidisciplinary treatments.

Contra-Indications

- Medically compromised patients.
- Patients taking drugs modifying normal bone physiology (i.e. bisphosphonates, corticosteroids, etc.).
- Any bone pathology.
- Ankylosed teeth.
- Noncompliant patients.
- Mixed dentition.
- Piezoelectric units must not be used if the patient and/or the operator has a pacemaker or any other active implant (e.g., a cochlear implant).

Armamentarium

The equipment needed to perform a piezocision include the following:

1. Topical and local anesthetic
2. A scalpel with blade #15C
3. Periosteal elevator
4. Piezotome with insert BS1
5. Bone allograft or xenograft
6. 5-0 Chromic gut suture
7. Castroviejo needle holder
8. Surgical scissors
9. Peri-acryl, cyanoacrylate glue
10. Coe Pack if soft tissue grafting is needed

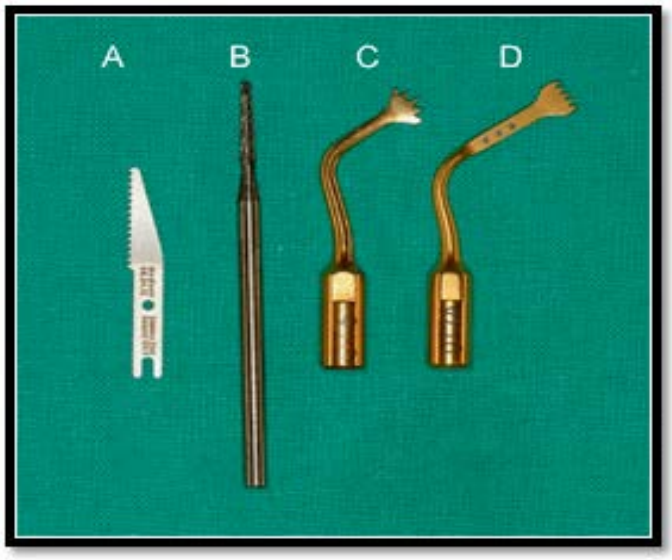

Figure : Piezo inserts

Technique

Piezocision procedure is generally performed 1 week after the placement of orthodontic appliances. The patient is anesthetized using a local anesthetic solution containing epinephrine. Once the surgical area is completely anesthetized, a small vertical incision is made on buccally and inter-proximally in the attached gingiva or mucosa. The incision into the attached gingiva is preferred as it will give less visible postoperative scarring of the soft tissue. Then a mid-level incision between the roots of the teeth involved is made, keeping in mind that the soft tissues and the periosteum need to be cut to create an opening that will allow for the insertion of the piezoelectric knife. At this point it is important to emphasize the following concept: Piezocision has a localized and selective effect on the teeth. Only the teeth or arch (es) to be moved need to be operated upon. The areas which have not been operated upon possessing a higher anchorage value, since they are not affected by the demineralization process, hence can be used as such in the comprehensive treatment plan. Once the vertical interproximal incisions are made on the maxillary and mandibular arches or in localized segments of these arches, the tip of the Piezotome (BS1) is inserted in the openings previously made and piezoelectrical corticotomy step is carried out. Care must be taken to restrict the

corticotomy cuts to 3 mm. The first mark on the BS1 insert can be used as the landmark for the decortication depth as it is located 3 mm from the tip (the decortications has to pass the cortical layer and reach the medullary bone to get the full effect of the RAP). Extra care must be taken to ensure not to cause any accidental damage to the roots of adjacent teeth; if the care is not taken during this step there are high chances to cause irremediable damage to these structures. In the areas with thin gingiva &/or gingival recessions or with thin or no cortical buccal bone (dehiscence, fenestration), hard and soft tissue grafts can also be added via a tunneling procedure. For tunnel preparation clinician can insert periosteal elevator (24G, Hu-Friedy, Chicago, IL) from one of the vertical openings between the periosteum and the bone, and blunt dissection is then carried out. This will create a tunnel that will host a soft tissue or a bone graft. Once the tunnel has been created, the piezoelectric corticotomy is done in between the roots of the teeth, and bone graft or soft tissue graft is then added. This procedure may get little tricky in the mandibular anterior region, as only three vertical incisions in the soft tissue are made: between canines and laterals and between the two lower central incisors. This allows for a longer pouch, helping with the retention of the bone graft. Once the procedure is completed, only the areas that have been tunneled will require suturing with a 5-0 chromic gut interrupted sutures. Cyanoacrylate glue (PeriAcryl) can also be used to protect these sutures. The remaining areas (verticals with corticotomy that have not been tunneled) do not need suturing. The patient is seen a week after the surgery for a follow-up visit and 2 weeks post-surgery to start the active phase of the orthodontic treatment. It is very critical for the patient to be seen every 2 weeks thereafter by the orthodontist to benefit from the temporary demineralization phase created by Piezocision and allow for faster tooth movement and early completion of treatment.[16]

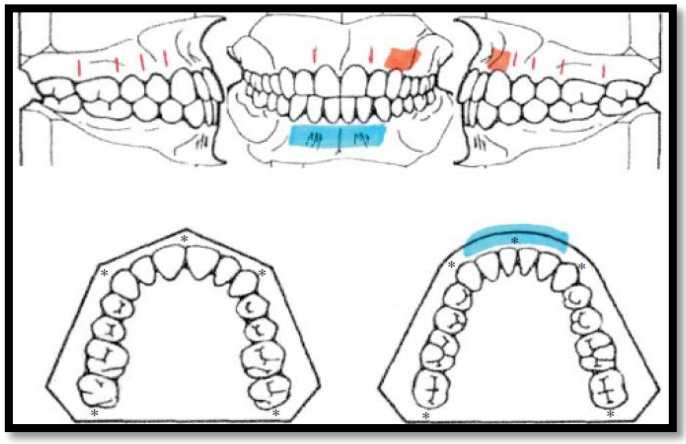

Figure : Surgical sheet (“road map”) indicating where the cuts will be placed (red), the bone graft (blue) and the soft tissue graft (dark red).

Figure: Systematic representation of micro osteo perforations and corticotomy

Differences between conventional orthodontics and Piezocision orthodontics

The main objective of Piezocision is to accelerate orthodontic treatment and at the same time improve the periodontium by hard and/or soft tissue grafting. As mentioned above, it combines micro-incisions limited to the buccal gingiva that allows for the use of the piezoelectric knife to decorticate the alveolar bone without flap elevations and initiate RAP. This also has the advantage of allowing for hard and/or soft tissue grafting via selective tunneling if/when needed. Virtually all aspects of the accelerated orthodontic treatment utilizing Periodontally Accelerated Osteogenic Orthodontics™ (PAOO) also apply to the Piezocision procedure, and

therefore the orthodontic considerations concerning both procedures are very similar. When the bone is injured, a very dynamic healing process occurs at the site of the bone injury that is proportional to the extent of the surgical insult.[17] There is a localized increase in osteoclastic and osteoblastic activity, in the early stages of the process this leads to a decrease in bone density with increased bone turnover. The RAP begins within a few days of the surgery and usually reaches its peaks in 1–2 months and then slows down and eventually disappears once the remineralization begins. Various animal experiments have confirmed that alveolar decortication induced a RAP response.[18] More recently, similar research has been done to show the effects of Piezocision on the alveolar bone and tooth movement[11] It has been shown that a similar RAP effect is produced when decortications are done by the piezoelectric knife. From these various findings, it can be suggested that, in addition to accelerating the treatment, the RAP changes the orthodontic treatment planning in two major ways: (1) in anchorage planning, by creating a more “pliable” bone due to the transient osteopenia, and (2) the treatment timing and progress during the “window of opportunity,” where the teeth move faster.[19] Piezocision can also be considered as another tool for creating differential anchorage during orthodontic treatment.

Window of opportunity

The theory behind accelerated tooth movement is that injury to the alveolar cortex induces a bimodal response in the alveolar bone (RAP) that can demineralize the bone around the injured area (i.e. dental roots). While reviewing the literature it has been postulated that, once the bone has demineralized following corticotomy done via surgical bur, there is a 3–4 month period known as the window of opportunity to move teeth rapidly through the demineralized bone matrix before the alveolar bone remineralization starts.[20] The effect of Piezocision on the length of this window of opportunity has been investigated & Preliminary results indicate that due to the more extensive nature of the demineralization that is caused by the piezoelectric knife this RAP could last up to 6 months.[16]

Various authors have done studies to evaluate the effectiveness of piezocision procedure in reducing the total time required for orthodontic treatment and have concluded that following piezocision the time required for tooth movement reduces by 3-4 months without any soft tissue defects. However, they have also reported that low-quality evidence suggests that piezocision is an effective surgical procedure in accelerating the rate of canine retraction in the first two months and reducing the treatment duration. However, this effect appears to be clinically insignificant.[21, 22, 23]

The orthodontic tooth movement beyond the confinement of the labial or lingual alveolar plate may lead to dehiscence formation and put the patients at higher risk for recession.[24, 25] This can be avoided by using bone graft materials during the surgical procedure, Bone grafting increases alveolar volume, thereby increasing the scope of orthodontic tooth movement. During the Piezocision procedure, the graft can be placed without the need for a flap elevation. The area where bone graft is needed can be tunneled, the graft material can be placed with a syringe and sutured, and the alveolus of that area can be expanded. Piezocision can be used in a localized manner when the malocclusion is limited to a segment or only to one arch. Anchorage requirements are the key factor and hence should be well planned before deciding what type of Piezocision should be performed. Piezocision can also be combined with clear orthodontic aligners such as Invisalign. When piezocision is planned with aligners the sequence is: The first aligner should be worn and later

piezocision can be performed 1 week after the patient starts to wear the first aligner. Several modifications are done in wearing aligner protocols when they are combined with piezocision, such as after piezocision the aligners are changed every 5 days instead of normal 2 weeks.[16]

Possible complications

Complications related to surgery are:

1. Loss of the interdental papilla. This may happen if the incision and Piezocision are done too close to the interdental papilla. It is of paramount importance to stay away from the papilla and place the incisions at the mid root level.
2. Damage to the roots. This may happen when not using the proper tip or not evaluating properly the underlying anatomy. In the case of close root proximity, it is best, if unsure, to skip that site.

Anterior bite control

The orthodontist should pay extra attention to the anterior vertical relationship during the initial leveling and alignment stage of the orthodontic treatment when alveolar decortication is done at the anterior segment. If necessary precautions are not taken, as the bone is demineralized at the decorticated areas, the proclination effect of the initial archwires on the anterior segment would be exaggerated and the bite will open.[26]

Advantages of Piezocision compared with other alveolar decortication techniques

Piezocision is a flapless surgical procedure, in other words, it only requires placement of minimal incisions on the buccal aspect, by doing so the time required for surgical procedure itself is reduced dramatically, this in turn reduces the postoperative discomfort, pain, and swelling to the patients, which makes it more acceptable to the patient when compared to conventional corticotomy procedures where the full-thickness flap has to be elevated to gain access to the underlying alveolar bone. The sequential approach of this technique also makes it possible to apply it at different time points throughout the orthodontic treatment. Even though it is a flapless technique, hard and soft tissue grafting can also be achieved through tunneling.

To summarize, the advantages of Piezocision:

1. Minimally invasive, innovative procedure.
2. Minimal post-operative discomfort.
3. Short surgical time.
4. Allows concomitant soft and/or hard tissue augmentation.
5. Very versatile. It can be used in orthodontic therapy or can be included as part of a comprehensive interdisciplinary treatment approach (large perio-prosthetic-implant rehabilitations).
6. High patient acceptance.
7. Can be repeated several times during treatment to reactivate the RAP if necessary

Vercellotti *et al.* (2005) investigated the use of a piezoelectric instrument vibrating in the ultrasonic frequency range for its potential use in periodontal resective therapy. They compared the rate of postoperative wound healing in a dog model following surgical ostectomy and osteoplasty done with the piezoelectric knife, a carbide bur, or diamond bur. They reported a bone loss in the surgical sites treated by the carbide or diamond burs, while the surgical sites treated by the piezoelectric knife revealed gain in the alveolar bone level. They also noted that the use of the piezoelectric knife provided more favorable osseous repair and remodeling than the bur when surgical ostectomy and osteoplasty procedures were performed.[27]

Dibart et al (2014) investigated the tissue response during piezo surgery assisted tooth movement in the rat model. He observed that the Piezocision stimulates the alveolar bone turnover through the increased osteoclastic activity

as early as 1 day and leads to the RAP, which forms the basis of rapid tooth movement compared to the conventional orthodontic treatment, he also noted that Piezocision leads to a faster and more profound demineralization of the bone surrounding the teeth which in turn increases the orthodontic tooth movement when compared to tooth movement that is being carried out without surgical intervention. Piezocision-assisted tooth movement also allows to 'bypass' the lag phase of the orthodontic tooth movement following the displacement phase that is characteristic of the tooth movement which is generally seen during conventional orthodontics. Tooth movement, when helped by Piezocision, would transit smoothly from the displacement phase to the acceleration and linear phase.[28]

In surgically assisted orthodontic treatment it is important to remember that this is an orthodontically guided surgical procedure, designed by the orthodontist and performed by the periodontist. After data collection and analysis by the orthodontist, the orthodontist and the periodontist discuss the surgical treatment planning of the case. At this point, the orthodontist has already made a diagnosis and treatment plan. He will tell the periodontist which teeth or segments are going to move and where, and the areas that may or may not require hard or soft tissue augmentation. The periodontist will then offer his input regarding the feasibility of the procedure, the "blueprint" of the surgical procedure, and the bone graft material that he is going to use. The outcome of this meeting is the creation of a surgical "road map" that the periodontist will bring in the operating room and will follow.

From this current evidence, it can be concluded that Piezocision is an innovative, minimally invasive technique that allows dentists to achieve rapid orthodontic tooth movement without the downside of the extensive and traumatic classical surgical approach. Because of minimally invasive nature and minimal morbidity, the surgical procedure can be repeated several times during the same treatment to reactivate the RAP when specific movements are required. In this context Piezocision proves to be efficient from the patients' as well as clinicians' standpoints and offers advantages that should lead to greater acceptance in the dental and patient communities.

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