Serge Dibart[1],
Alessia De Vit[1]

Piezocision™ and other Surgical Techniques to Accelerate Orthodontic Tooth Movement

Authors' affiliations:
[1] Department of Periodontology, Boston University Henry M. Goldman School of Dental Medicine, Boston, USA

Correspondence to:
Address : 100 East Newton Street Boston, MA 02118 USA
Email : sdibart@bu.edu
Phone : 617-638-4762

Keywords: Piezocision; Accelerated Orthodontics; Adult Orthodontics; Multidisciplinary Treatment.

Abstract: An increasing number of adult patients have been seeking orthodontic treatment, and a short treatment time has been a recurring request. To meet their expectations, a number of surgical techniques have been developed to accelerate orthodontic tooth movement. However, some of these techniques have been found to be quite invasive, leading to low acceptance in patients and the dental community. This topic review presents currently available surgical options that accelerate orthodontic tooth movement to treat dental malocclusions as well as facilitate multidisciplinary treatment. The introduction of an innovative, minimally invasive procedure (Piezocision™) that combining microincisions and localized piezoelectric decortication has proven quite useful in this regard as it has been well accepted by patients and dental practitioners.

Introduction

The appeal of accelerated orthodontics

The U.S. population is expected to increase by 98.1 million between 2014 and 2060, reaching 417 million in 2060. The percentage of the population under the age of 18 is expected to decrease from 23 to 20 percent while the percentage of the population over 65 is expected to increase from 15 to 24 percent[1].

Consequently there has been an increase in adult orthodontic treatment in the US and the UK[2,3,4]; from 1981 to 2013 the percentage of adult cases increased from 15.4% to 23%. The number of orthodontists offering adult treatment increased from 51% to 98.6%. As dentists, we must be aware of these changes as well as the needs and requirements of this rapidly growing new patient population.

A study conducted at the Eastman Dental Institute in the UK5 showed that the desire to straighten teeth and improve the smile were the primary factors for initiating treatment. A certain percentage of adult patients (13.3%) demanded orthodontic treatment as part of a more complex treatment plan to facilitate functional restorative outcomes. The biggest challenge the dental team was facing was the answer to the question: "How long will I be in braces?" According to Tayer[6], a high portion (33%) of adult patients undergoing orthodontic treatment were discouraged because of the treatment duration and the inconvenience and discomfort involved with the use of orthodontic appliances. Thus, length of treatment time is a major concern for adult orthodontic patients.

Purpose of the study

Introducing a new, minimally invasive procedure (Piezocision™) that helps accelerate tooth movement when

Date:
Received: May 10, 2018;
Accepted: May 31, 2018

combined with conventional orthodontics or clear aligners. Reducing drastically orthodontic treatment time and increasing patient acceptance for comprehensive oral rehabilitation and orthodontics in the adults population.

Material and Method

The solution(s)

A review of the historical literature can be found in Dibart 2016[7], more recently several surgical procedures have been developed. They all take advantage of the regional acceleratory phenomenon (RAP) that takes place after bone injury[8]. As a refresher, induction of RAP requires a noxious stimulus of sufficient magnitude to induce an effect on the surrounding tissues. The magnitude of the stimulus determines the size of the affected region and the intensity of the response. The effect on bone is a decrease in density (osteoporosis) due to an increase in the remodeling space. The duration, depending on the kind of stimulus, can last from 4 months to 2 years[8]. It is the judicious use by the orthodontist of the demineralization phase of the RAP following surgery, that allows for acceleration of tooth movement. This phase is temporary as remineralization of the site will occur after a while, bringing the healing process to an end. This is a bimodal process (resorption/apposition)[9,10].

Periodontally Accelerated Osteogenic Orthodontics

The Wilcko's introduced the Accelerated Osteogenic Orthodontics (AOO) technique, in which orthodontic appliances are applied one week preceding the surgery[11]. Intrasulcular incisions are made both in the buccal and lingual side of the selected area, a full thickness flap is reflected beyond the apex of the teeth and the corticotomies are performed. The vertical corticotomies are located between the teeth and connected apically. Additional decortication is performed to increase the flow of cells to facilitate the bone augmentation. Demineralized freezed dried bone allografts (DFDBA) and bovine xenograft previously wet with clindamycin are placed on the alveolar bone buccaly and lingually and the flaps are repositioned and sutured with non-resorbable sutures. This procedure although effective is time consuming and is associated with significant morbidity (discomfort, swelling, hematoma etc…)[12]

Corticision

The name of this technique, introduced by Park[13] in 2009, is a neologism which indicates "cortical bone incision". It is a minimally invasive flapless periodontal procedure which uses RAP to accelerate tooth movement. In this technique, described in a later publication in 2016[14], a reinforced scalpel is used as a thin chisel to separate the interproximal cortices transmucosally without reflecting a flap. The advantage of this technique, when compared to the PAOO surgery, is the flapless approach. However, some patients complained of dizziness related to the use of the mallet. It also does not allow for bone or soft tissue grafting.

Micro-Osteoperforations (MOP)

To further reduce the invasive nature of the surgical techniques aimed to accelerate orthodontic movements, Propel Orthodontics introduced a disposable device called Propel used to puncture bone in a process named Alveocentesis. Alikhani in 2013[15] used Propel (Propel Orthodontics,Ossining, NY) in a clinical trial in 20 adults with class II division I malocclusions. He performed three flapless microperforations under local anestesia distally to the canines 6 months after the extraction of the premolars. The authors reported an increased rate of tooth movement by 2.3-fold.

Piezocision

It was first described in 2009 by Dibart[16] who combined the advantage of grafting offered by PAOO of Wilcko and Wilcko with the flapless approach adopted by Park. The surgery is performed 1 week after the placement of the fixed orthodontic appliance. Under local anesthesia vertical interproximal incisions are made below the interdental papilla on the buccal aspect of the teeth to be moved (Figures 1 and 2). The incisions are kept minimal and go through the periosteum to reach the alveolar bone.

Where bone or soft tissue grafting is needed a small periosteal elevator is used to create a tunnel between the interproximal incisions which will accomodate the bone or soft tissue graft (Figure 3,4,5). Suturing is recommended only in areas that receive graft material and is not necessary if only corticotomy is performed. The discomfort for the patient is minimal and the advantages of this procedure include the option of grafting and short surgical time. This is a minimally invasive, versatile procedure that can be used to help treat malocclusions (pure orthodontic cases) or help facilitate the treatment of mutidisciplinary cases.

Piezocision to optimize implant dentistry

Short orthodontics could be a key addition to our armamentarium when it comes to multidisciplinary treatments.

Figure 1.
(A) Vertical interproximal incision: vertical interproximal incisions are made below the interdental papilla on the buccal aspect of the teeth to be moved.

(B) Corticotomies are performed with a Piezoelectrical surgical knife (BS1 insert, Piezotome, Satelec Acteon Group, Merignac, France) through the gingival incision in the bone with a depth of 3 mm to pass the cortical plate. This is critical as this will generate the onset of the RAP phenomenon, failure to do so will result in inconsistent outcomes.

Figure 2.
Decortication of the alveolar bone using the piezoelectric knife following interproximal soft tissue cuts with the microsurgical scalpel.

Figure 3.
The anterior needs bone grafting. This is done following alveolar decortication through the soft tissue cuts, using subperiosteal tunneling.

Figure 4.
The bone is grafted and fills the space under the periosteum. Demineralized Freezed Dried Bone Allograft used here in a collagen matrix delivered by a syringe.

Figure 5.
The bone graft is in place and the openings are sutured with a 5-0 Chromic gut suture.

Figure 6.
Full mouth panoramic radiograph. Tooth 16 is missing and the space has closed in due to mesial migration of tooth 17. This space once opened will be the site of an implant supported fixed restoration. Tooth 25 will need a class II onlay ceramic restoration, tooth 46 an onlay ceramic restoration and tooth 47 an occlusal filling.

Figure 7.
Localized mesial and distal piezocision cuts tooth 17.

Figure 8.
Selective Piezocision cuts in the lower anterior zone.

Tooth up righting, space management prior to implant placement or conventional restorative procedures are particularly useful[17]. As an example a 30 year old male came to the clinic asking for an implant to replace tooth 16 as well as resolving lower anterior crowding in the shortest amount of time possible (Figure 6). Piezocision assisted orthodontics was devised to open the space between teeth 17 and 15 (Figure 7), followed by piezocision assisted Invisalign to correct the lower crowding (Figure 8). The localized piezocision was done mesial and distal of [16]. Six months later, the space had open to measure 12 mm and was ready for implant placement (Figures 9, 10, 11). In the meantime the lower arch was prepared for piezocision assisted invisalign, as the patient was reluctant to wear braces on the lower jaw (Figure

12). After reviewing the clincheck images piezocision was done according to the protocol established by Dibart and Kesser[18]. Three months later the lower jaw crowding was resolved (Figure 13).

In this fast paced society it is important to have the necessary tools in our armamenterium to provide selective patients with what they are looking for : short treatment time, minimal trauma and optimal results (Figure 14).

Used judiciously, Piezocision assisted orthodontics can help increase patient satisfaction, communication between specialties and treatment acceptance.

Discussion:

The purpose of this review was to present different available surgical options that accelerate orthodontic tooth movement and to assess which approach offers more advantages in terms of patient discomfort and timing of treatment.

Orthodontic treatment often requires years of commitment and this can be a major issue, especially with an adult population[6]. Each of the techniques described here allows for a significant decrease in treatment duration. The duration of treatment was reduced by 1/3-1/4 of the expected time with the PAOO surgery11 and by 43% with piezocision surgery[19]. This is an advantage also in interdisciplinary treatments that are required by the adult population[5], where tooth movement is necessary to provide the patient with the ideal restorative outcome. Corticotomy procedures could in some instances represent an alternative to orthognatic surgery to patients who are not willing to undergo major procedures[20]. Some authors suggest that there is an additional advantage of protection from root resorption[21,22,23,24]. However, this concept has been challenged by Patterson[25] with a microcomputed tomography study in which an increased risk of root damage was present with piezocision. These findings need to be interpreted with a lot of caution as the study sample is

Figure 9.
Distalization of tooth 17. In 6 months the space has opened to 12 mm. A 3i Osseotite bone level 5x10 mm implant will be placed to replace the missing tooth 16.

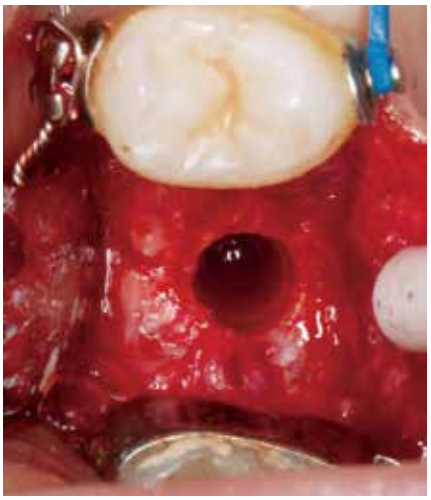

Figure 10.
Osteotomy to place implant. Notice now the ample amount of space that is available thanks to the short orthodontic treatment strategy using Piezocision assisted orthodontics.

Figure 11.
Implant 16 is restored.

Figure 12.
Lower jaw: Restorations on teeth 46 and 47 have been completed, Invisalign assisted piezocision to resolve the mild lower crowding is initiated. Interproximal reduction (IPR) will also be done between the lower incisors as part of the Invisalign treatment.

Figure 13.
Lower jaw 3 months later, treatment finished. 3 months later the treatment is completed, the crowding has resolved.

Figure 14.
Final view of the patient 6 months after the start of the treatment.

very small and these finding might be related to improper surgical technique, resulting in direct damage to the root, rather than the effect of the procedure on the remodeling of the root surfaces.

Contraindications to treatment are mainly related, but not limited to, patient factors that do not allow for surgical procedures. Root proximity might be an obstacle when planning for periodontally accelerated tooth movement, for the increased risk of root damage. Adequate pre-operative x-rays are necessary to plan for the surgical procedure and to avoid any risk of damaging tooth structure or compromising tooth vitality.

Studies on the effects of these techniques are mainly case reports and case series. Animal and human case studies are variable in terms of study design and subject population and this constitutes a limit to a direct comparison of the different techniques. However, we can draw some conclusions as to the advantages and disadvantages of each procedure.

The PAOO™ procedure introduced by Wilcko and Wilcko[11] constituted a new approach to the corticotomy procedure, applying the concept of RAP to orthodontic tooth movement. The transient biological effect of the injury allows reduction of the lag phase of orthodontic tooth movement, and thus a decrease in total treatment time[24]. The addition of bone grafting on the day of surgery offers the advantage of preventing the formation of new fenestrations and bone dehiscences[26] and allows for the filling of pre-existent ones, while thicknening the alveolar housing[27]. The duration of treatmet can be decreased up to 75%[28,29] while reducing undesirable effects such as root resorption[24] and relapse[28] with no effect on gingival indices[30].

Disadvantages of the PAOO™ technique are related to patient discomfort and invasiveness of the surgical procedure. These disadvantages were overcome by the introduction of Corticision[14]. The flapless approach decreases the posto-operative discomfort and the use of a reinforced scalpel with a mallet to create the injury recreates conditions necessary for RAP in the area, heading to a shortening of the lag phase thanks to a faster removal of hyalinization products[13]. The main limitations of this procedure lay on the impossibility of bone grafting and on the intrasurgical use of the mallet that can produce vertigo and be psychologically challenging for the patient.

The Piezocision™ procedure introduced by Dibart[16] combined the advantages of PAOO™ and Corticision. The possibility of grafting is an adjunctive to the benefits offered by a minimally invasive flapless surgery. The surgical procedure can be performed with limited chair time[16] with minimal patient discomfort. When root proximity or other anatomical features are a concern digital planning of the position of the incisions can be an additional advantage to the surgery[31]. Human studies[19,32] confirmed that piezocision decreased total treatment duration without compromising tooth mobility and gingival indices.

Propel is the most recently introduced technique. As Corticision, it offers a minimally invasive flapless approach, but does not allow for additional grafting. The use of the Propel device makes the procedure easy to perform by any operator as there is no need for incisions, but can be very time consuming if the cortical bone is thick. Patient discomfort and chair time are definetly decreased compared to any other procedures previously described but where the thickness of the alveolar bone is a concern other approaches such as PAOO™ or Piezocision™ should be considered.

Each of these techniques uses a different instrument to produce the injury in the surgical site and the kind of instrument could influence the bone remodeling rate.

Dibart in 2016[33] investigated differences between the piezoelectric knife, bur and hand held screw device on bone remodeling activity on a calvarial bone model. Osteoclastic bone resorption, osteoblastic differentiation and bone formation were surprisingly high in the sham piezotome group suggesting that vibration can produce a response similar to a direct injury. The piezotome injury group showed the greatest area of bone resorption and formation extending to the controlateral side of the calvaria. This is probably due to the combined effect of injury and vibration. The bur injury group had significant remodeling activity, but limited to the area of injury, while the hand held screw device injury produced the least amount of osteoclastic and osteoblastic activity. The author concluded that piezotome had the greatest impact on bone resorption and formation and suggested that the high frequency vibrations could amplify the natural response to injury. His findings are in accordance with Alikhani[34] observations that not only the injury per se, but vibration also has an influence in mineralization of alveolar bone.

Conclusion:

Corticotomies are relatively new procedures and only few cases have been reported in the literature. Controlled clinical trials are necessary to evaluate and compare the effectiveness of the different available techniques.

Within the limitations of this review, we can draw the following conclusions:

1. All the techniques described accelerate orthodontic movement. Not enough data is available to effectively compare the amount of time saved with these different approaches.
2. Corticotomies have a protective role against root resorption. Clinical trials should be designed to compare and evaluate the effect of the different approaches on root resorption and hyalinization.
3. Piezocision™ and PAOO™ offer the advantage of grafting at time of surgery which allows for thickening of the alveolar bone and filling of pre-existing dehiscences.
4. Piezocision™, Propel and Corticision are flapless approaches and are less invasive than PAOO™. The use of the mallet in Corticision could be stressful for the patient.
5. The use of the Piezoelectric knife, as seen on the ex-vivo model, has a greater impact on bone metabolism and creates a greater RAP when compared to the other techniques allowing for more versatility while being less surgically invasive.

Piezocision™ seems to be the procedure of choice in terms of versatility, ease of application, patient comfort, possibility of grafting and profound effect on bone remodeling.

References

1. Colby SL, Ortman JM. Projections of the size and composition of the US population: 2014 to 2060: Population estimates and projections;2015.
2. Cedro MK, Moles DR, Hodges SJ. Adult orthodontics—who's doing what? *J Orthodontics* 2010;37:107-117.
3. Christensen L, Luther F. Adults seeking orthodontic treatment: expectations, periodontal and TMD issues. *Br Dent J* 2015;218:111.
4. Keim, R. G., Gottlieb, E. L., Nelson, A. H. & Vogels, D. S. 2013 JCO Orthodontic Practice Study. Part 1: trends. *J Clin Orthod* 2013;47:661–680
5. Pabari S, Moles DR, Cunningham SJ. Assessment of motivation and psychological characteristics of adult orthodontic patients. *Am J Orthod Dentofacial Orthop* 2011;140:e263-e272.
6. Tayer BH, Burek MJ. A survey of adults' attitudes toward orthodontic therapy. *Amer J Orthodontics* 1981;79:305-315.
7. Dibart S. Piezocision ™ : Accelerating Orthodontic *Tooth Movement* While Correcting Hard and Soft Tissue Deficiencies. In: Tooth Movement. vol. 18: Karger Publishers, 2016:102-108.
8. Frost H. The regional acceleratory phenomenon: a review. *Henry Ford Hosp Med J* 1983;31:3.
9. Dibart S, Yee C, Surmenian J, et al. Tissue response during Piezocision-assisted tooth movement: a histological study in rats. *Eur J Orthodont* 2013;36:457-464.
10. Frost H. The biology of fracture healing. An overview for clinicians. Part II. *Clin Orthop Relat R* 1989:294-309.
11. Wilcko WM, Wilcko MT, Bouquot J, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. *Int J Periodontics Restorative Dent* 2001;21:9-20.
12. Viwattanatipa N, Charnchairerk S. The effectiveness of corticotomy and piezocision on canine retraction: A systematic review. *Korean J Orthod* 2018;48:200-211.
13. Kim S-J, Park Y-G, Kang S-G. Effects of corticision on paradental remodeling in orthodontic tooth movement. *Angle Orthod* 2009;79:284-291.
14. Park YG. Corticision: A flapless procedure to Accelerate tooth movement. In: *Tooth Movement*. vol. 18: Karger Publishers, 2016:109-117.
15. Alikhani M, Raptis M, Zoldan B, et al. Effect of micro-osteoperforations on the rate of tooth movement. *Am J Orthod Dentofacial Orthop* 2013;144:639-648.
16. Dibart S. Piezocision: Minimally Invasive Periodontally Accelerated Orthodontic Tooth Movement Procedure. *Practical Osseous Surgery in Periodontics and Implant Dentistry* 2011:193-201.
17. Dibart S, Keser E, Nelson D. Piezocision ™ -assisted orthodontics: Past, present, and future. In: *Semin Orthod*. vol. 21: Elsevier, 2015:170-175.
18. Keser EI, Dibart S. Piezocision-assisted Invisalign treatment. *Compend Contin Educ Dent* 2011;32:46-48, 50-41.
19. Charavet C, Lecloux G, Bruwier A, et al. Localized piezoelectric alve-

olar decortication for orthodontic treatment in adults: a randomized controlled trial. *J Dent Res* 2016;95:1003-1009.

20. Keser EI, Dibart S. Sequential piezocision: a novel approach to accelerated orthodontic treatment. *Am J Orthod Dentofacial Orthop* 2013;144:879-889.
21. Wilcko MT, Wilcko WM, Pulver JJ, Bissada NF, Bouquot JE. Accelerated osteogenic orthodontics technique: a 1-stage surgically facilitated rapid orthodontic technique with alveolar augmentation. *J Oral Maxil Surg* 2009;67:2149-2159.
22. Murphy C, Kalajzic Z, Chandhoke T, Utreja A, Nanda R, Uribe F. The effect of corticision on root resorption with heavy and light forces. *Angle Orthod* 2015;86:17-23.
23. Goldie RS, King GJ. Root resorption and tooth movement in orthodontically treated, calcium-deficient, and lactating rats. *Am J Orthod* 1984;85:424-430.
24. Iino S, Sakoda S, Ito G, Nishimori T, Ikeda T, Miyawaki S. Acceleration of orthodontic tooth movement by alveolar corticotomy in the dog. *Am J Orthod Dentofacial Orthop* 2007;131:e441-e448.
25. Patterson BM, Dalci O, Papadopoulou AK, et al. Effect of piezocision on root resorption associated with orthodontic force: A microcomputed tomography study. *Am J Orthod Dentofacial Orthop* 2017;151:53-62.
26. Nowzari H, Yorita FK, Chang H-C. Periodontally accelerated osteogenic orthodontics combined with autogenous bone grafting. *Compend Contin Educ Dent* 2008;29:200-206.
27. Wilcko, M. T., Wilcko, W. M., Pulver, J. J., Bissada, N. F. & Bouquot, J. E. Accelerated Osteogenic Orthodontics Technique: A 1-Stage Surgically Facilitated Rapid Orthodontic Technique With Alveolar Augmentation. *J Oral Maxil Surg* 67, 2149–2159;2009.
28. Wilcko, M. T., Wilcko, W. M., Omniewski, K. B., Bouquot, J. E. & Wilcko, J. M. The Periodontally 'Accelerated Osteogenic Orthodontics'™ (PAOO™) Technique: Efficient Space Closing With Either Orthopedic or Orthodontic For
29. Fischer T. Orthodontic treatment acceleration with corticotomy-assisted exposure of palatally impacted canines: a preliminary study. *Angle Orthod* 2007;77:417-420.
30. Aboul SMBE-D, El-Beialy AR, El-Sayed KMF, Selim EMN, El-Mangoury NH, Mostafa YA. Miniscrew implant-supported maxillary canine retraction with and without corticotomy-facilitated orthodontics. *Am J Orthod Dentofacial Orthop* 2011;139:252-259.
31. Milano F, Dibart S, Montesani L, Guerra L. Computer-guided surgery using the piezocision technique. *Int J Periodontics Restorative Dent* 2014;34.
32. Aksakalli S, Calik B, Kara B, Ezirganli S. Accelerated tooth movement with piezocision and its periodontal-transversal effects in patients with Class II malocclusion. *Angle Orthod* 2015;86:59-65.
33. Dibart S, Alasmari A, Zanni O, Salih E. Effect of Corticotomies with Different Instruments on Cranial Bone Biology Using an Ex Vivo Calvarial Bone Organ Culture Model System. *Int J Periodontics Restorative Dent* 2016;36.
34. Alikhani M, Khoo E, Alyami B, et al. Osteogenic effect of high-frequency acceleration on alveolar bone. *J Dent Res* 2012;91:413-419.