Periodontally Facilitated Orthodontics.

A new perspective on Alveolar Corticotomy

Dr. Raffaele Spena

ABSTRACT

Alveolar decortication has always been associated to orthodontic treatment to accelerate tooth movement and reduce treatment time. While acceleration of tooth movement has been clearly demonstrated, reduction of treatment time is still a discussed topic and is certainly unpredictable and difficult to evaluate. A different view of the biological and biomechanical orthodontic advantages of this surgical adjunct is proposed.

KEY WORDS: Accelerated tooth movement – Facilitated tooth movement – Reduced treatment time – RAP reaction

INTRODUCTION

In the past two decades, a few new devices and procedures have offered the possibility to enhance and facilitate Orthodontic Tooth Movement (OTM). Skeletal anchorage and alveolar corticotomy are among these.

Miniscrews or, better, Temporary Anchorage Devices (TADs) may give great biomechanical help to reduce or eliminate undesired tooth movements and to achieve movements difficult or impossible with conventional orthodontic appliances.

Alveolar decortication (corticotomy) has been long associated to orthodontic treatments in order to accelerate and simplify the OTM while reducing the undesired effects of root resorption, loss of vitality, periodontal problems, relapse of the corrections. However, the scientific and clinical assumptions of the early days were totally different from the more recent ones: we moved from a pure mechanical approach to a biological and physiological one.

The first reference in the literature dates back in 1892 when **L.C.Bryan**[1] in an article published in the textbook by S.H.Guilford proposed alveolar surgery to cut the alveolus with drills and fissure burs to help correcting malposed teeth in adult patients.

In 1893, **Cunningham**[2] presented at the International Dental Congress in Chicago the treatment of few adult patients where teeth had been surgically repositioned by the use of forceps, elevators or other instruments after sectioning the bony cortex with thin circular saws. The teeth were repositioned sometimes removing bone to create a way toward their final position. This technique was similar to the one described by dr. Bryan and, even if effective in moving teeth, was not without risks and side effects.

It was **Kole**[3] in 1959 that resumed the alveolar corticotomy to accelerate the OTM. In order to maintain a good blood supply, suggested to keep intact the medullary bone by avoiding a total osteotomy and the luxation of the tooth-bone blocks. Kole believed that the greatest resistance to OTM derived by the thick and dense cortical bone and its slower remodeling processes. By eliminating the continuity of the cortical bone with the vertical interproximal cuts extended to the medullary bone (corticotomies) and the deep horizontal osteotomies 1mm beyond the apices of the roots, he thought he was creating independent bony blocks he could easily and rapidly move with heavy forces. The orthodontic movements were accomplished in his patients in 6-12 months and with fewer complications compared to the previous experiences.

In 1972, **Bell e Levy**[4] tested Kole’s technique on 49 monkeys. The surgical protocol was not performed as described by Kole because they performed osteotomies and mobilized all the segments, so they found that the surgery created ischemic zones and bone necrosis with risks for the teeth and the periodontal support in the maxillary incisal area.

In 1975, **Duker**[5], in six beagle dogs, performed vertical corticotomies associated to horizontal osteotomies on the maxillary incisors. The vertical cuts were made 2 mm away from the marginal alveolar crest to reduce risks of periodontal damage risks and no corticotomy was made between the two central incisors. A movement of 4 millimeter was achieved in 8-20 days with a heavy elastic and a facebow that kept the lip away from the teeth.

Suya[6] proposed a great improvement of the Kole's surgical approach in 1983 modifying the horizontal osteotomy in a corticotomy, avoiding the alveolar crest in the vertical cuts and eliminating the luxation of the blocks. He proposed this "corticotomy facilitated orthodontics" to treat adult patients, ankylosed teeth and crowded malocclusions to avoid premolar extractions. He showed 395 adult Japanese patients treated in 6 to 12 months. Like Kole, Suya believed he was creating bony blocks and suggested to accomplish most of the movements in the first 3-4 months of treatment before the fusion of the blocks (healing of the bone).

The Suya's approach was duplicated in some case reports. **Anholm et al.**[8] showed the nonextraction treatment of an adult in only 11 months and without creating periodontal problems. **Gantes et al.**[9] compared treatment results of 5 patients treated with Suya's technique with those of patients treated with conventional orthodontics. Treatment time was 14.8 months in the corticotomy group while in the control group was 28.3 months. No periodontal problem, no loss of vitality and no root resorption were detected in the experimental group.

The concepts of the corticotomy-assisted OTM drastically changed in 2001 after the publication of **Wilcko et al.**[9]. In this key case report, two adult patients received a selective corticotomy associated to alloplastic resorbable grafts to increase bone levels and avoid risks of recessions. Following full-thickness labial and lingual flaps, vertical interproximal cuts and numerous holes on the cortical bone to promote ample bleeding were made using surgical rotating burs. An accurate evaluation with CT scans before and after treatment, and the histological sections in one case, allowed the authors to formulate a new hypothesis about what really happens at the bone level after corticotomy. No movement of tooth-bone blocks, but a transient reduction of mineralization of the alveolar bone and modifications similar to those described by Frost[10-13] during the healing of fractured bones and named Regional Accelerated Phenomenon (RAP) most likely occurs.

The surgical-orthodontic protocol proposed by Wilcko et al. has been subsequently patented as Periodontally Accelerated Osteogenic Orthodontics (PAOO). The claims of the PAOO are: **1.** accelerated tooth movement with reduction of the total treatment time; **2.** osteogenic modifications with transportation of the bony matrix and final improvement of hard and soft tissue support of the teeth treated orthodontically; **3.**increase of the short- and long-term stability of the orthodontic treatment.

A large number of studies have been produced to evaluate these claims.

THE RAP REACTION

The RAP healing process, as described by Frost, is a complex cascade of events that determines two major changes in the bone: a) an accelerated hard and soft tissue turnover; b) a transient reduced regional density (osteopenia).

In normal conditions, the number of osteoclasts and osteoblasts in a specific bone area are able to maintain the basic vital functions. After an insult (either traumatic or surgical) of sufficient magnitude, this number of cells is not capable to ensure healing thus a RAP reaction is evoked. The intensity of the RAP reaction is related to the amount of the insult. The RAP is a mechanism that rapidly increases the number of cells and the needed activities: the increased osteoclastic activity brings about the reduction of the bone density and stimulates the osteoblastic activity. It starts few days after the insult, peaks in the first 30-60 days and slowly diminishes during the following 4-6 months.

What does it happen at the dentoalveolar portions and how may it influence OTM ?

Initial studies of **Verna et al**[15] showed in rats that the amount of orthodontic tooth movement is related to the turnover rate of the alveolar bone. **Shih et al.**[16] on beagle dogs and **Yaffe et al.**[17] on Wistar rats then showed that an increased bone metabolism follows mucoperiostal flap surgery.

More recently, several studies on animals have tried to elucidate alveolar bone reactions after decortication when combined to the orthodontic tooth movement. The animal models seem to differ when we consider small animals and big animals. Histological studies on rats[18-22] have shown that a dramatic increase of the osteoclastic cells, transient demineralization (osteopenia) and cortical bone porosity occur after corticotomy. This demineralization effect, however, has never been reported in dogs[23-27] and cats[28]. Differently, less undermining resorption and less hyalinization seem to happen in these animals. Corticotomy seems to provoke a RAP reaction that accelerates the intervention of macrophages responsible of a rapid removal of the hyaline tissue and increases the catabolic osteoclastic activity that allows rapid resorption of the cortical lamina dura of the alveolus and induces the bone turnover. All these changes result in a faster tooth movement.

To date, a question still remains unanswered: "Is the RAP reaction in humans similar or different from the one in animals?"

The duration of a RAP reaction in the alveolar bone after corticotomy is still unknown but it seems that it is limited in time. In a study on 13 adult patients[32], the rate of retraction of the maxillary canines on the decorticated side was double during the first two months, declining to 1.6 by the third month and to 1.06 (that is, similar on both sides) by the fourth month. The Authors concluded that this is consistent with the transient nature of the RAP. This transiency is confirmed by most of the studies that have evaluated at histological level the modifications in the bone after decortication.

Wilcko [33-35], Dibart[22] and Murphy[32] claimed that decortication stimulates the RAP reaction and the applied orthodontic forces, maintaining a constant mechanical stimulation, allow to prolong the transient osteopenic state and the period during which teeth can be moved rapidly. To achieve this effect, they recommended seeing patients frequently (every 2 weeks) and keep activating the applied orthodontic forces. If not, remineralization completes the healing process and brings the bone metabolism at a normal level. It must be said that these claims have never been demonstrated neither clinically nor histologically.

With the objective of prolonging the effect, other authors[65] have proposed to repeat the surgical insult several times during the treatment. **Sanjideh et al.** [28] in a split-mouth research on foxhounds where premolar spaces were closed after corticotomy only on one side, found that in the maxilla tooth movement peaked between 22 and 25 days. At the peak, the rate of tooth movement on the experimental side was 85% faster and the total tooth movement was twice as much as the control side. The rates progressively became similar on both sides. In the mandible, where a second corticotomy was performed on one side after 28 days, the higher rate of tooth movement was prolonged and produced greater total tooth movement, but the differences were small and seemed to prove that a second surgery is not justifiable.

Further studies, however, need to evaluate all these claims and proposed procedures, their potential advantages as well as their risks.

Another important aspect of the changes provoked by a surgical insult to the bone is the extension of the area and the intensity of the reaction. From the research on animals[28] it seems clear that these changes are well correlated to the amount of the insult (the greater the insult, the greater the reaction), but they seem to be restricted to the injured area. This may affect the resulting OTM.

RAP AND ORTHODONTIC TREATMENT TIME

When we try to evaluate orthodontic treatment time, different aspects must be taken into account [41-44]. The initial difficulty of the malocclusion and tooth malposition, the age of the patient, the variability of the individual response to the treatment, the quality of the end result, and patient's compliance are just few of the variables that should be considered.

At the same time, when we want to evaluate rate of tooth movement, we must recognize that there is a great variability in our patients. Studies [15,38-40] have shown that speed is influenced by bone turnover and the individual response to mechanical forces, but it is not related to the level of the forces.

Numerous case reports have been published showing how treatment time can be reduced when patients are treated with corticotomy. Case reports, however, have limited scientific validity. A randomized clinical trial where similar patients are treated with or without corticotomy, using the same appliance, and finished with the same quality of treatment result would be the only way to give the final word on this matter, but it has not been done, yet.

According to the studies previously discussed, it seems that we can rely on maximum 4-6 months of accelerated bone metabolism after decortication. For this reason, tooth movement may be accelerated but only for a limited part of the therapy.

If the predicted treatment time of a malocclusion is long if treated with conventional orthodontics (let’s say the classical 24-30 months), corticotomy will probably help to save few months. Conversely, if the predicted treatment time of a malocclusion is short, corticotomy will probably make it shorter. How much shorter? As said, the effect is highly unpredictable. Ethically speaking, speed could be an important factor in orthodontic treatments, but certainly not at the expense of a good quality end result. It should always be carefully evaluated if saving few months is worth the added expense and morbidity. We believe that “better is always more important than faster”.

At this point, one may ask: why using corticotomy? One aspect of the surgical insult and the associated RAP reaction at the alveolar bone that has been rarely addressed is the fact that the resistance to movement is reduced: the “decorticated” tooth will require less anchorage to be moved.

Spena et al. [60-61] in two studies made on a total of 12 adult patients with Class II malocclusions treated with distalization of the upper molars showed how upper molars could be bodily distalized with simple buccal mechanics and no anterior anchorage. Corticotomy was performed only on the teeth to move thus reducing their resistance to distal forces and the anchorage needs.

Oliveira et al [77] stated that corticotomies, although primarily indicated to shorten orthodontic treatment time, should be used to “…facilitate the implementation of mechanically challenging orthodontic movements and enhance the correction of moderate to severe skeletal malocclusions”. We totally agree with this statement: the alveolar decortication should not be combined to orthodontic treatments with the only objective of accelerating

OTM and reducing treatment time. A faster treatment may be considered a secondary "bonus" and can be obtained in a substantial way only in those "simple" orthodontic cases that require a naturally short treatment.

Periodontally Facilitated Orthodontics

The term Periodontally Facilitated Orthodontics (PFO) is used to describe a procedure that has the primary goal to "simplify", "enhance" and "improve" OTMs that are difficult or risky from a biomechanical and biological point of view. The surgical procedure, the associated orthodontic treatment and biomechanics depend on the initial problems and the goals of every single specific treatment.

The surgical procedure

A.CORTICOTOMY

Open flap surgery is preferred in most of the cases. The design of the flap can be easily modified according to the patient's periodontal situation and needs. The goal is to provide easy access to the area of decortication, optimal coverage of the grafting and final gingival esthetics. On the buccal side, the coronal part of the flap is full-thickness extended 2-3 mm beyond the apical area (area that will be decorticated) and split-thickness in the remaining part to allow mobility of the flap. A tension-free flap closure must be achieved at the end of the surgery to provide optimal coverage of the decorticated area, the grafted material and to enhance final soft-tissue healing. At the end of the surgery, the flap is closed with Gore-Tex non-resorbable sutures that are left for at least 10-14 days.

Decortication of the alveolar bone is performed with calibrated piezo blades. Piezosurgery has become widely used in periodontal and maxillo-facial surgery at the beginning of the new century. The blades cut the bone with low-frequency ultrasonic waves and allow micrometric selective cuts. The cavitation effect created by the oscillating tip and the ample irrigation helps avoiding creation of heated and necrotic areas. Studies on animal models[44-47] have shown that alveolar bone surgery with piezo blades stimulates subsequent more active osteogenesis and in-growth of vital bone-forming tissue, with less inflammation when compared with rotating burs. Recently, an evaluation of a large number of patients[50] has shown that significantly less fenestrations and dehiscences were present after piezoelectric decortication. Moreover, piezosurgery is less traumatic and risky for the patient: another reason why the use of the drills has been discontinued is the risk of damaging the soft tissues or cutting vessels and nerves.

Decortication is made only on the teeth that need enhanced movement. Interproximal vertical cuts from 2 mm below the alveolar crest to 1-2 mm beyond the root apices are connected to horizontal cuts in the supra-apical area (Fig.1-2). The depth of the cuts is approximately 2-3 mm, just slightly extended into the medullary bone. Scraping of the cortex instead of the numerous holes is to stimulate a vast RAP reaction and create a bleeding bed that will eventually host the grafting.

As already said, extension of the area of the reaction seems to be restricted to the injured area[28]. This factor may influence the type of tooth movement: corticotomy should be performed on both buccal and lingual side if a bodily movement is desired, while should be just in the direction of the movement (on the compression side) if a different movement is required.

This is why corticotomies do not need to be always the same. They have to be planned by both the orthodontist and the surgeon based upon patient's periodontal initial conditions and biomechanical and biological considerations.

Several procedures like Corticision[62-63] and Piezocision[64-65] have been proposed with the intent to reduce the invasiveness of the decortication and reducing the possible post-operative discomfort with raising a flap. Even if attractive, they seem to have surgical and biomechanical limitations. The surgical limitations include risks when performed in crowded arches, limited visibility when producing the cuts, limitation of the cuts to the interproximal areas and to the middle third of the roots, difficult control of the grafting in the apico-coronal direction, need of optimal extension of the attached gingiva in the area of decortication. The biomechanical limitations are strictly related to the fact that corticotomy is made only on the buccal side and middle third of the roots. The RAP reaction may not be extended to the entire root and the resulting OTM is an uncontrolled tipping instead of a bodily movement. Figures 3-6 show a case treated with Piezocision on the upper canine that needed to be moved toward the lateral incisor to create proper space for implants in the premolar area. Note the resulting movement: canine tipped mesially.

Moreover, are they really minimally invasive surgeries as claimed by the authors?

B.GRAFTING

The grafting is usually planned before surgery based upon initial clinical and radiological evaluation, desired OTM, short and long-term periodontal considerations. It is not always needed.

In situations of thin bone and thin gingival biotype, when risky movements like expansion, labial proclination or anteroposterior movements in reduced bone volumes, grafting may be indicated to reduce/eliminate fenestrations and dehiscences, produce additional support for the roots, improve final esthetics and stability. Fenestrations and dehiscences are very frequent in any malocclusion (Fig.7) with a higher incidence in premolar and molar areas in Class II and hyperdivergent cases [82-83].

Grafting may include hard tissue, soft tissue and autologous growth factors. Quality and quantity may be modulated at the surgery depending on the clinical conditions of the surgical site.

As a general rule, composite bone grafts where allogenic bone (bone from human cadavers that is freeze-dried to reduce antigenicity and demineralized to expose the underlying collagen and its growth factors like BMP) with osteoinductive properties is mixed with xenogenic bone (bone usually from bovine animals that provide a physical matrix or scaffold suitable for deposition of new bone and that prevents its rapid resorption) with osteoconductive properties are preferred (Fig.8).

Soft tissue grafts are added to bone graft when a thin biotype or gingival recessions are present. If the area to regenerate is small, autologous connective tissue graft is the gold standard procedure. On the other end, large areas are better managed with allogenic human acellular dermal matrices[53] that are available in different sizes and thicknesses. Soft-tissue grafts are sutured with resorbable sutures (Fig.9).

Both bone and soft tissue grafts are coupled with autologous growth factors. With aging, the number of stem cells rapidly decreases. These cells are important in case of injury and healing processes. Studies[55] have shown that growth factors from platelet-concentrated plasma (PDGF, VEGF, TGF-β1, TGF-β2) may rapidly increase the number of the available stem cells and stimulate their activity. Reduction of inflammation and pain during the healing processes is another advantage of the growth factors.

Two methods have been used in our patients when grafting after corticotomy: the PRF (Platelet Rich Fibrin)[56-57] and the PRGF (Platelet Rich in Growth Factors)[58-59]. Both are blood centrifugations that allow separation of the plasma platelets from the white and red cells.

PRF contains also leucocytes and produces membranes with a light compression of the centrifugated fraction. PRGF allows the separation of three fractions with different concentrations of platelets. They may be mixed with bone grafts (increasing its viscosity and adherence to the surgical site thus facilitating its application) and soft-tissue grafts. Activating and heating the PRGF fraction produces clots/membranes of fibrin (Fig.10) that are placed on the bone grafts stabilizing their position.

The use of bone grafts alone or with non-resorbable membranes [78-79] may not give good control of the graft in apico-coronal direction and necessitates of a second surgery. An increase of the bone volume may happen at the apical level instead of a much more desirable increase of the alveolar crest height at the cementoenamel junction.

C. THE ORTHODONTIC TREATMENT

Orthodontic treatment associated with PFO may be carried out with any fixed or removable appliances. It is our choice to combine PFO procedures with fixed active self-ligating appliances (Inovation ©) with the new prescription of the CCO System[82]. The management and wire changes are similar to any orthodontic case. No initial heavy force is necessary. There is no rule as far as timing of the bonding: in some cases appliances are placed at the suture removal while in other (for example, when distalizing upper molars or repositioning impacted teeth) several months before corticotomy. The enhanced tooth movement deriving from the RAP reaction is obtained when needed. The major difference is that, after the periodontal surgery, the visits are every 2 weeks instead of the usual 6-8 weeks.

PFO may be easily associated to skeletal anchorage devices. The TADs are to increase anchorage, while the corticotomies are to reduce anchorage.

In this article, seven different cases are shown.

Case 1 is one the first group of cases treated with segmental corticotomy [61-62]. The adult patient presented a Class II malocclusion and refused both orthognathic surgery and extractions. Initially, all four wisdom teeth were extracted. Corticotomy was performed buccally and palatally only on the upper first and second molars after inserting a working stainless steel rectangular wire. At that time, in these cases, corticotomy was performed with surgical burs. Vertical interdental cuts were associated to horizontal supra-apical cuts and numerous perforations of the buccal and lingual alveolar cortex. Today, scraping with piezo blades instead of these risky perforations are preferred. Bone graft was with bovine bone only on the buccal side to cover dehiscences and perforations. No soft tissue graft is usually needed in this area. Bodily distal movement was obtained with just compressed NiTi coils between second premolars and first molars. No anterior anchorage was used thus confirming that corticotomy reduced the molar resistance to distal forces. Space closure and overjet reduction was achieved with a Begg-type mechanics.

Case 2 is a young adult male patient with missing upper and lower first permanent molars. The lower and upper extraction alveolar segments presented reduction in volume and needed treatment[85-86]. The decided treatment was mesialization of the molars with minimum anchorage. Lower first permanent molar space closure presents biomechanical problems: the expected rate of OTM is about 0.30-0.50 mm per month and may be associated with loss of anterior anchorage and midline coordination[88-89]. Alveolar decortication was performed buccally and lingually on the lower second molars and the alveolar ridge of the missing first permanent molars. Bone grafting with growth factors was added on the buccal aspects of the path of molar mesialization. Space closure with fixed self-ligating appliances started 10 days after the surgery. No anterior anchorage was used. By the end of space closure, it was decided to rotate the anterior brackets 180° to express +6° instead of -6° of torque. This helped controlling the final lower incisor position[90].

Case 3 and 4 are two cases of transposition: one is an upper canine/first premolar transposition and one is a lateral incisor/canine transposition. The correction of transpositions has controversial opinions in the literature[91-94]. The combination of PFO procedures and miniscrews as skeletal anchorage could a therapeutic possibility. In the first case, the mesialization of the upper canine was obtained torqueing the root of the premolar palatally with a lower second premolar bracket with -22° of torque.

Case 5 has been treated with aligners based on specific requests of the patient that could not wear any fixed appliance because of his profession. In these situations, the aligners are changes every 6-7 days instead of the conventional 2 weeks.

Case 6 and 7 are probably the most complex clinical situations in this article. Orthodontic treatments were combined with extended alveolar corticotomy, massive bone and soft-tissue grafting trying to solve recessions and regenerate bone levels. Severe skeletal discrepancies were nicely corrected without complex biomechanics and patient's compliance.

As shown, indications for PFO may be the most diverse and depend on the final treatment objectives. It is up to the orthodontist and the periodontist to identify the wide possibilities of this procedure, inform the patient about the advantages and risks of the surgery and manage the cases in the best sound way.

Conclusions

In a recent systematic review, Long et al. [95] evaluated five interventions for accelerating tooth movement. From the available literature, corticotomy resulted as safe and effective. Claims related to reduction of treatment time, osteogenic capabilities and stability have still no scientific evidence[97-98].

Periodontally Facilitated Orthodontics is a procedure where alveolar decortication is used with the primary goal of enhancing OTM and reducing anchorage needs. It may be or may be not associated with grafting. Clinically speaking, corticotomies are not all the same and are not for every patient. Further studies are still needed to evaluate indications, contraindications and risks. The procedure will be certainly evolving with the improvement of the materials, the devices and appliances utilized.