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Surgical Approaches to Accelerate Orthodontic Tooth Movement

A Review

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ABSTRACT

Surgical technique to accelerate the rate of orthodontic tooth movement has been recognized in many case reports. It is a clinically successful method used for mature patients, where time of orthodontic treatment may be important in preferred groups of patients. The alveolar bone remodeling and PDL are the significant factors in orthodontic tooth movement, and bone turnover is identified to enlarge after fracture, bone grafting, and osteotomy. Various surgical procedures are there to accelerate the orthodontic tooth movement such as distraction osteogenesis, corticotomy, osteotomy, micro-osteoperforations and piezocision technique.

Keyword: - Corticotomy, Micro-Osteoperforations, Orthodontics, Tooth Movement.

1. INTRODUCTION

According to the American Association of Orthodontists, the length of comprehensive orthodontic treatment "can range from one to three years." Studies on treatment time have found durations ranging from 21-27 months for non extraction treatment and 25-35 months for extraction treatment. [1-7] Treatment times are influenced by many factors including type of malocclusion, amount of tooth movement required, mechanics utilized, and patient compliance. [2, 8, 9]

With prolonged orthodontic treatment time comes increased risk of root resorption,[10,11] decalcification,[12] and periodontal problems.[13] In an effort to minimize these risks, orthodontists are continually trying to reduce treatment time while providing treatment results equal to or better than those currently being delivered.

2. VARIOUS APPROACHES

2.1 Regional acceleratory phenomenon

Through the regional acceleratory phenomenon (RAP) bone remodeling rates can be increased and bone density can be decreased. Coined by Frost, [14-16] the RAP is a sequence of tissue reactions during healing of injured bone. Frost described the RAP as a "complex reaction of mammalian tissues to diverse noxious stimuli…[it] occurs regionally in the anatomical sense, involves both hard and soft tissues, and is characterized by an acceleration and domination of most ongoing normal vital tissue processes." Noxious stimuli he identified include crushing injuries, fractures, and bone operations, to name a few. Since then it has also been shown that even orthodontic forces can stimulate the RAP. [17]

The response of the RAP is an acceleration of normal hard and soft tissue processes that are associated with healing; these processes include increased bone turnover and modeling, cellular metabolism, and growth of hard and soft tissues. Frost reported that from a single stimulus/injury, the RAP occurs for approximately four months in bone. [14] In bone, the RAP causes a temporary increase in bone remodeling and decrease in regional bone density. This decrease in regional bone density might be expected to produce faster tooth movement during orthodontic treatment.

2.2 Corticotomies

Corticotomies, surgical cuts made into the cortex of the alveolar bone, have been used to enhance the rate of orthodontic tooth movement dating back to Kole in 1959. [18-20] the procedure was originally believed to enhance the rate of tooth movement through displacement of bony segments. [18-22] It was not until 2001 that the Wilcko brothers associated the faster tooth movement produced with corticotomies with the RAP rather than block bone movement. [23] In their original protocol, orthodontic appliances are placed, full-thickness mucoperiosteal flaps are elevated from a coronal approach, and vertical corticotomies are made between the teeth extending from 2-3 mm apical of the alveolar crest to 2 mm beyond the tooth apices and connected by a scalloped subapical corticotomy; this process is done on both the labial and lingual aspects. In cases where the bone is at least 2 mm thick over the roots, perforations are also made in the cortical bone in a stippling pattern. After all cuts have been completed, bone allograft is applied and the tissues are reapproximated. Using this protocol they have reported cases with treatment times as short as six months. Although the Wilcko brothers report faster tooth movement, their conclusions are drawn from case studies without controls. [23-25]

A randomized clinical trial that assessed the effect of corticotomy on tooth movement was performed by Fischer in 2007. [26] It pertained to six consecutive patients with bilateral palatally impacted canines. A split-mouth design was utilized in which one side had a traditional canine exposure and the other side had the canine exposed with cortical perforations made to the mesial and distal of the canine; both canines were then retracted orthodontically. The canines with corticotomies showed a 28-33% reduction in treatment time, with no difference in final periodontal status.

Another clinical trial by Lee et al [27] studied a sample of 65 Korean adult female patients. The patients were randomly assigned by the clinician to three groups: no treatment (n = 29), maxillary corticotomy assisted orthodontics with skeletal anchorage and mandibular anterior segmental osteotomy (n = 20), or maxillary and mandibular anterior segmental osteotomy (n = 16). The authors noted greater upper lip change in the corticotomy group compared to controls as well as a shortened treatment time. However, the three groups were not equivalent prior to treatment and randomization of treatment assignment was unclear.

Better able to control confounding variables, several animal studies have been performed to evaluate the effects of corticotomies. In 2007, Cho et al [28] conducted a split mouth study in two beagle dogs. The second premolars were extracted and allowed to heal for four weeks prior to the experiment. Full-thickness mucoperiosteal flaps were then elevated and cortical perforations were created in the buccal and lingual cortical plates in the areas of the maxillary and mandibular third premolars on the experimental side. A 150 g force was then applied with a NiTi closing coil to protract the third premolars. At the end of eight weeks, experimental teeth had moved approximately four times further than control teeth in the maxilla (6.4 vs. 1.5 mm) and two times further in the mandible (3.3 vs. 1.4 mm). They also showed that it was approximately at two weeks when the velocity of the experimental teeth increased versus the control teeth. However, small sample size limited the results of this study.

Using twelve dogs, Iino et al [29] extracted mandibular second premolars and protracted mandibular third premolars. On their experimental side, a full-thickness mucoperiosteal flap was elevated on the buccal and lingual areas over the third premolar. On both the buccal and lingual, vertical corticotomies were made mesial and distal to the third premolar and connected by a horizontal subapical corticotomy. The flaps were then reapproximated and 0.5 N of protractive force was applied with a NiTi closed coil spring. They found that velocity of tooth movement was significantly increased on the side with corticotomies compared to the control side during the first two weeks of the experiment. Velocity of tooth movement during the first week was approximately two times faster in the experimental group. During the second week, the experimental group had a tooth movement velocity approximately five times faster than the control. By the end of the four-week experiment, they found that experimental teeth had moved approximately twice the distance as control teeth.

Sanjideh et al [30] studied tooth movement in foxhound dogs after one or two corticotomy procedures. In their study, mandibular third and maxillary second premolars were extracted on the same day as corticotomy procedures. One mandibular quadrant had buccal and lingual flaps and corticotomies performed around the second premolar. In the maxilla, both quadrants had buccal flaps and corticotomies performed around the third premolars. After four weeks, a second corticotomy procedure was performed in one maxillary quadrant. Beginning after the first surgery, coil springs of 200 g force were used to retract the mandibular second premolars and protract the maxillary third premolars. Tooth movement rates appeared to peak at 22 days in the mandible and at 25 days in the maxilla. After eight weeks, mandibular tooth movement was significantly greater on the experimental side than on the control side (2.4 mm and 1.3 mm respectively). In the maxilla, there was significantly more overall tooth movement on the side that had two corticotomies (2.3 mm) versus the side that had one corticotomy procedure (2.0 mm), albeit the difference was small. They concluded that the corticotomy procedure significantly increased orthodontic tooth movement and that performing a second corticotomy procedure can produce an additional boost in tooth movement, but that the effect from the second corticotomy was substantially less and could not be clinically recommended.

In a study to examine the effects of increased surgical trauma on the rates of tooth movement, Cohen et al [31] and McBride et al [32] performed a randomized split-mouth study in foxhound dogs. On one side of the maxilla, the first premolar was extracted and interseptal bone mesial to the second premolar was undermined (designated the RAP side). On the other side, designated RAP+, the first premolar was extracted, a fullthickness flap was elevated, and the buccal plate between the canine and second premolar was removed; a vertical osteotomy extending to the lingual cortex was then made distal to the second premolar. They found that the RAP+ side experienced a significant increase of 62% in tooth movement due to the increased nature of the surgical trauma. They also showed that the RAP+ side had significantly less material density and bone volume fractions in select regions compared to the RAP side and that the RAP+ side had significantly more trabeculae that were thinner and with less trabecular separation compared to both the RAP side and control bone.

2.3 Flapless Corticotomies

In an effort to reduce the surgery required during the corticotomy procedure, recent research has focused on performing so-called flapless corticotomies to produce the RAP and accelerate tooth movement.

In a study by Safavi et al, [33] five dogs were used to study the effect of flapless bur decortications on tooth movement. Maxillary first premolars were extracted on the day of surgery and using a split mouth design, one side of the arch had small holes drilled through the attached gingiva and into the buccal cortical table. On each experimental side, 25 holes 2 mm deep were created using a surgical handpiece. The holes were placed on the experimental side mesial and distal to the second premolar and on the buccal cortical table of the extracted tooth. On both sides of the maxilla, a 150g force was applied to protract the second premolars with NiTi coil springs. They repeated the decortications at the end of the first month and at the end of the second month. They found that during the first month, the second premolars on the decortication side moved 0.82 mm more than on the control side, which was statistically significant. However, during the second month the difference was small (only 0.04 mm) and not significant. During the third month, the control side moved significantly further than the experimental side by 1.15 mm. The difference between total amounts of tooth movement on the two sides after three months was not statistically significant.

Kim et al [34, 35] studied the effects of corticision and low-level laser therapy (LLLT) on tooth movement. The corticision procedure used a reinforced surgical blade and mallet to penetrate through gingiva and into alveolar bone. In this study, twelve dogs were divided into four groups of three dogs each. Only the corticision and control groups pertain to this review. In the corticision group, corticision was performed on the mesiobuccal, distobuccal, mesiopalatal, and distopalatal sides of the maxillary second premolar. The blade used penetrated 10 mm through the gingiva and into cortical and medullary bone. Maxillary second premolars were then protracted with NiTi springs of 150 g for eight weeks. They showed that the corticision group moved 3.75 times more than the control group. However, it is important to emphasize that their injuries penetrated much further than traditional corticotomy.

One tool currently on the market for performing micro osteoperforations is the Propel system. In a recent study by Alikhani et al, [36] twenty adults with Class II Division 1 malocclusions requiring premolar extractions were randomly divided into control and experimental groups. After extraction of teeth, orthodontic leveling and aligning was performed. Once canine retraction was ready to begin, the experimental group received micro-osteoperforations using the Propel device on one side of the maxilla. The device was set to deliver perforations 1.5 mm wide and 2-3 mm deep. Three perforations were made distal to the canine on the experimental side. Retraction of canines was then performed, using a 100 g NiTi coil spring that extended from the canine to a MSI placed mesial to the first molar. The authors reported a 2.3-fold increase in the rate of tooth movement on the experimental side, which was statistically significant ($p<0.05$). They also measured cytokine and chemokine levels from the gingival crevicular fluid of the patients 24-hours after canine retraction was initiated. While there was a trend for the experimental group to have elevated levels of these inflammatory markers, there was no statistically significant difference between experimental and control groups.

Again, animal based experiments must be performed in order to better elucidate the bone reaction to microfractures. In a split-mouth experiment performed by Swapp et al, [37] the effects of bone-awl induced injuries (puncture holes and microfracture of surrounding bone) on tooth movement were evaluated using seven foxhound dogs. Mandibular second premolars were extracted on both sides of the arch and a bone awl was used on the experimental side to create 60 bone injuries on the buccal and lingual cortical plates. Using 5 mm and 6 mm bone awls, a grid of injury sites was created over the area of the roots of the mandibular third premolar, as well as 5-6 mm mesial to the tooth both on the buccal and lingual cortical plates. The mandibular third premolar was then mesialized against the mandibular canine with a 200 g NiTi coil spring. No difference was found in the rate of tooth movement between experimental and control sides. Micro CT showed differences in the cortical bone, but not the medullary bone through which the teeth were moved. Tooth movements were the same because medullary bone volume fraction and bone density on the experimental and control side were the same. The experimental side showed significant cortical bone remodeling in the area of injury while the control side demonstrated almost no remodeling. In other words, the RAP was limited to the cortex.

3. CONCLUSIONS

Orthodontic patients ask for shorter orthodontic treatment duration, and at present, we have various methods that can enhance orthodontic tooth movement securely with less adverse effects. However focusing the spotlight more on how to use them more efficiently and effectively in orthodontics is needed, further studies should be carried out to search new surgical procedures which are less invasive.

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