Corticotomy-facilitated Orthodontics Using Piezosurgery versus Rotary Instruments: An Experimental Study

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Abstract

Objective: The aim of this study was to evaluate corticotomy-facilitated orthodontics (CFO) using piezosurgery versus conventional rotary instruments.

Materials and Methods: Ten healthy adult male mongrel dogs of comparable age with a complete set of permanent dentition with average weights between 13–17 kilograms were used. CFO using conventional rotary instruments versus piezosurgery was performed on each dog in a split mouth design. For every dog, mandibular 2nd premolar retraction on each side was attempted after extracting 3rd premolars followed by corticotomy-facilitated orthodontics using conventional rotary surgical burs on the left side and an ultrasonic piezosurgery system on the right side of the same animal. Intraoral measurements of the rate of tooth movement were taken with a sliding caliper. Measurements were performed by the same operator at the time of surgery (appliance delivery) and every month for six months. The dogs were sacrificed after six months from initiation of tooth movement to evaluate the amount of tooth movement for both conventional rotary and piezosurgery corticotomy techniques.

Results: A statistically significantly higher mean amount of tooth movement for conventional rotary instrument versus the piezosurgery corticotomy technique was observed at all time intervals.

Conclusions: Tooth movement was 1.6 times faster when CFO was done using conventional rotary instruments as compared to a piezosurgery device.

Keywords: Corticotomy, piezosurgery, rotary instruments

Introduction

Conventional orthodontic treatment in adults may be associated with problems such as marginal bone loss, gingival recession, root resorption, and prolonged treatment time (Midgett *et al*., 1981; Sharpe *et al*., 1987; Behrents, 1988; Melsen, 1991). To avoid these complications, and meet patients' demands for a shorter treatment time, corticotomy-facilitated orthodontics was considered (Köle, 1959; Generson, 1978; Suya, 1991).

Corticotomy procedures are based on the regional acceleratory phenomenon (RAP) and normal bone healing mechanisms (Frost, 1981; Frost, 1983). Under normal circumstances, any regional noxious stimulus of sufficient magnitude can evoke a RAP (Frost, 1981; Esterhai *et al.,* 1981), which accelerates soft and hard tissue remodeling above normal values but is restricted to the region of the stimulus (Bogoch *et al.,* 1993).

Susan *et al.* (2011) tested if corticotomy induces osteoclastogenesis and bone remodeling concomitant with orthodontic tooth movement and if selective alveolar decortication enhances the rate of tooth movement. It was found that alveolar decortication enhances the rate of tooth movement during the initial tooth displacement phase; this resulted from a coupled mechanism of bone resorption and bone formation during the earlier stages of treatment, and explained the rapid orthodontic tooth movement.

Mostafa *et al.* (2009) used a corticotomy-facilitated (CF) technique to accelerate orthodontic tooth move-

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ment. The aim of the study was to identify the effect of the CF technique on orthodontic tooth movement compared with the standard technique, and to explore the histological basis of the difference between the two techniques. The teeth on the corticotomy side moved approximately twice as far (4.7 mm vs 2.3 mm) as the premolars on the control side. Differences in tooth movements were statistically significant. Their histomorphometric analyses showed that bone remodeling was more active on the corticotomy side.

Recently, piezosurgery was introduced in bone surgery as an alternative to rotary instruments. Piezoelectric surgery (PES) is a new technique for corticotomies created by Vercellotti in 2004. The major advantage of this tool is that micro-vibrations allow a selective cut of only mineralized structures, creating minimal damage to adjacent soft tissues (Gonzalez-Garcia *et al.,* 2008).

Although the results of using piezosurgery in corticotomy have been encouraging, no study has been conducted yet to compare corticotomy-facilitated orthodontics using conventional rotary instruments versus piezosurgery. Thus, the purpose of this study was to evaluate corticotomy-facilitated orthodontics using piezosurgery versus rotary instruments.

Material and Methods

The current study comprised ten healthy adult male mongrel dogs. They were selected with a complete set of permanent dentition. The average weight of all dogs was between 13 - 17 kilograms. They were caged individually and fed soft dog chow and water *ad libitum*. All experimental procedures, including the surgery and clinical examinations, were performed using intramuscular sodium pentobarbital (25 mg per kilogram of body weight) for anesthesia. The dogs were humanely sacrificed with intravenous injections of pentobarbital (50 mg/kg). The Animal Ethics Committee of Cairo University approved the animal protocol and surgical procedures.

Bilateral alginate impressions were taken using sectional trays that were previously adapted on a dry dog mandible to fit the area of the 2nd and 4th premolars. The models obtained were used to fabricate precisely fit crowns on the 2nd and 4th premolars. The 3rd premolars in the mandibular quadrants were extracted. CFO using conventional rotary instruments and using piezosurgery were performed in each dog in a split mouth design.

Surgical technique

All animals received an antibiotic course for three days preoperatively through an intramuscular injection for eradication of any septic foci. The used antibiotics were procaine penicillin 300,000 units, penicillin G 100,000 units and streptomycin 0.5 gm (Streptopencid: CID Laboratories, A.R.E).

All animals were fasted twelve hours before the operation to avoid aspiration of gastric contents during sedation. The mouth was opened using a canine mouth gag. Antiseptic solution was used to disinfect the operative field.

All surgeries were performed under local anesthesia. Lidocaine hydrochloride (2%) with 1:100,000 epinephrine (for hemostasis) was injected locally at the proposed extraction and osteotomy site. Vital signs were monitored and maintained within normal physiologic ranges.

After administration of local anesthesia, crevicular incisions were made buccally and lingually extending from the mandibular 2nd premolar to the 1st molar with a Bard Parker blade No. 15. Full thickness mucoperiosteal flaps were reflected on both buccal and lingual aspects beyond the apices of the teeth.

Each 3rd premolar was hemi-sectioned, elevated, and delivered via forceps. At the right mandibular quadrant vertical and horizontal cortical bone cuts were done using the ultrasonic piezosurgery system (Mectron Medical Technology, Carasco, Genova, Italy; *Figure 1A*). The corticotomy was done in the form of vertical and horizontal cuts using the desired insert tips. The flaps were closed with black silk sutures following surgery (*Figure 1A*).

In the left mandibular quadrant of the same dog, on the buccal surface adjacent to the 3rd mandibular premolar socket, small corticotomy perforations (approximately 1 - 2 mm deep) were drilled in the buccal cortical bone. There were 8 to 10 perforations, depending on the area of the alveolar process in each dog. The corticotomy perforations were made with a #2 long-shank round bur in a high-speed hand piece with copious water irrigation and extended just into the spongy bone (*Figure 1B*).

Orthodontic tooth movement assembly

The following orthodontic procedures were performed on both the right and the left sides of the mandible of each dog using custom-made tubes soldered to customized metal crowns that allow teeth to move only by sliding (bodily movement) on a straight 1.5 mm stainless steel wire segment. They were cemented using resin cement on the 2nd and 4th mandibular premolars in both right and left mandibular quadrants. A calibrated nickel titanium coil spring with a force of 150 g was attached to the hooks of the soldered molar tubes on the 2nd and 4th premolar crowns to move the 2nd premolar tooth into the edentulous segment created by extraction of the 3rd premolar. Coil springs used for tooth movements were checked *in situ* every week.

In the tooth movement phase measurements were taken by the same operator from the mesial aspect of the 2nd premolar buccal tube to the buccal groove of the

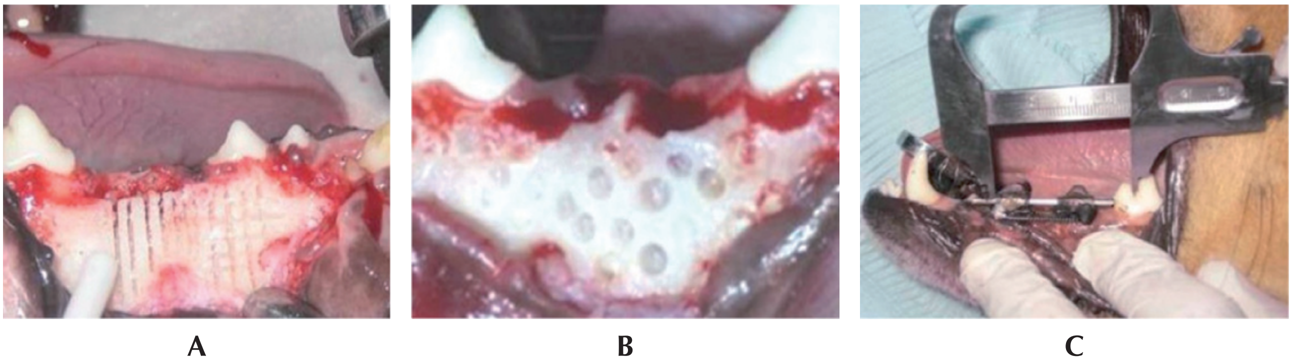

Figure 1. A) Corticotomy using piezosurgery unit; B) Corticotomy cuts made using conventional rotary instruments; C) Measurements taken using a sliding caliper

1[st]molar to estimate the amount and rate of tooth movement. The records were taken using a sliding caliper (Dentaurum, Germany) at the time of surgery (appliance delivery) and every month for six months (*Figure 1C*).

Statistical analysis

The collected data were statistically analyzed using a paired *t*-test to compare the two techniques. The present study is a split-mouth design, so a paired *t*-test was also used to study the changes within each group. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Results

Clinical findings

All of the animals tolerated the surgical procedure and ate without problems. Wound dehiscences were observed with no fenestrations in three different animals: two dogs with CFO using conventional rotary instruments and one dog with CFO using piezosurgery. No infections were reported and the dehiscences were managed with oral chlorhexidine irrigation twice daily until healing was complete.

Statistical analysis

The amount of retraction after one month showed no statistically significant difference between CFO with rotary instruments and CFO with piezosurgery. After 2, 3, 4, 5 and 6 months; the conventional rotary technique showed statistically significantly higher mean amount of retraction (8.60 mm) than the piezosurgery technique (5.10 mm) over the evaluation period (*Figure 2*). The conventional rotary technique also showed a statistically significantly higher mean rate of retraction (1.43 mm/month) than the piezosurgery technique (0.85 mm/month, *Figure 3*).

Discussion

The ability to accelerate tooth movements is advantageous for orthodontists because treatment duration has been linked to an increased risk of gingival inflammation, decalcification, dental caries (Ristic *et al.,* 2007), and especially root resorption. In recent years, numerous efforts have been made to make orthodontic therapy faster with simplified clinical procedures. One of these efforts has utilized "corticotomies," which may shorten and improve the bone regeneration process (Segal *et al.,* 2004).

In the current study, dogs were chosen as the experimental model because their tissues have been proven to react similarly to human tissues concerning the rate of tooth movement, which has been reported by many studies, in addition to their ability to tolerate the surgical procedures as well as different environmental conditions (Ren *et al.,* 2004). Moreover, the size of the dentition approximates that of humans (Ren *et al.,* 2007) and studies have shown that tooth movements in dogs occur most efficiently when subjected to forces that approximate human clinical conditions (Cirelli *et al.,* 2003).

Ultrasonically moved knives have the ability to cut hard tissues, such as teeth and bone. In contrast, soft tissues as gingiva, blood vessels, nerves and sinus membranes are preserved from injury because they vibrate with the tip. This makes piezoelectric surgery particularly suitable for surgical applications (Seshan *et al.,* 2009; Bovi *et al.,* 2010). Healing following the use of a piezosurgery microsaw is rapid, with minimal morbidity (Abbas and Moutamed, 2012).

On the other hand, a rotary bur is reported to cut faster and produce a deeper cut than a piezoelectric device. The cutting efficiency of a piezoelectric device depends on the adjustment of the instrument tip (Khambay and Walmsley, 2000).

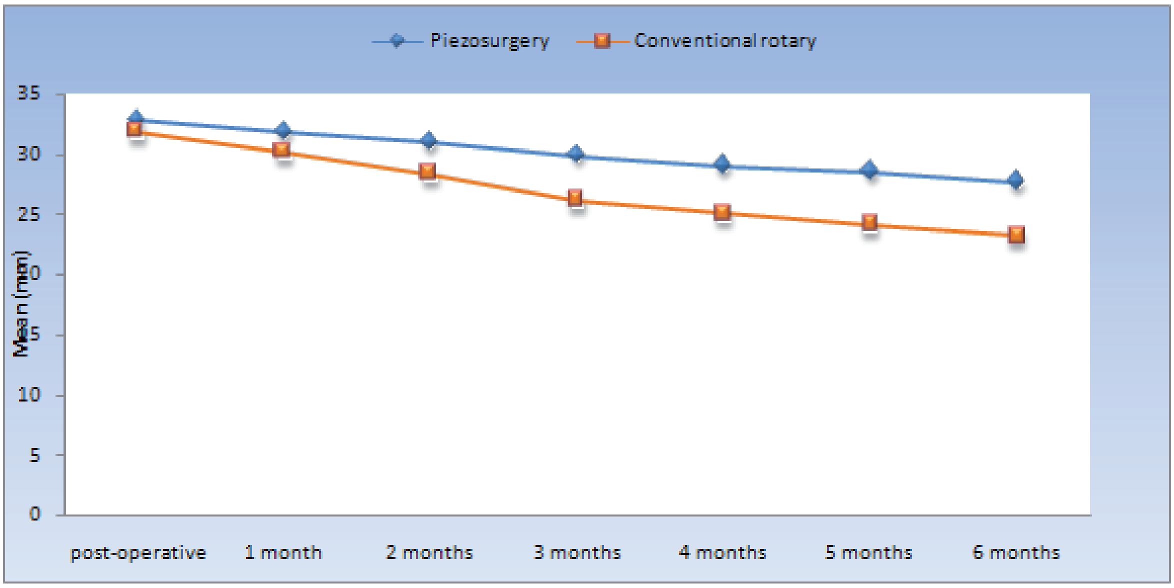

Figure 2. Line chart showing faster tooth movement with corticotomy-facilitated orthodontics (CFO) using conventional rotary instruments compared to piezosurgery, as reflected by greater reduction in the extraction space between 2nd the premolar and 1st molar.

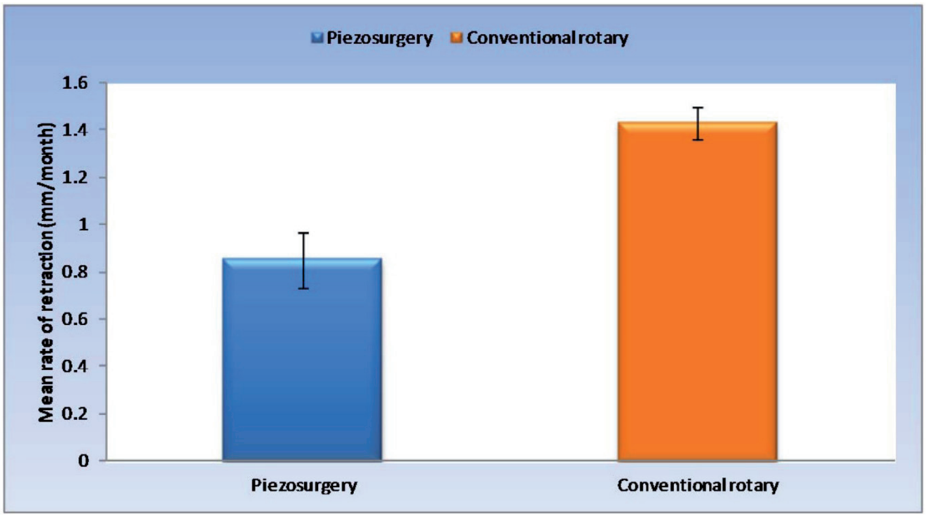

Figure 3. Bar chart representing rates of retraction exhibited by corticotomy-facilitated orthodontics (CFO) versus piezosurgery techniques.

The tooth movement assembly consisted of two custom-made casted crowns on the 3rd and 4th premolars to which two molar tubes were soldered that allowed a rigid 1.5 mm stainless steel wire to slide freely. This was to guarantee a perfect fit and retention of the tooth movement assembly to the cone-shaped premolar teeth in addition to permitting only bodily tooth movement. A similar approach was employed by Nakamoto *et al.* (2002), who used 1.1 mm stainless steel wire in a tube soldered on custom-made crowns on the 2nd and 4th premolars.

Selective alveolar decortication induces a localized increase in turnover of alveolar spongiosa (Sebaoun *et al.,* 2008), suggesting that the dramatic acceleration of demineralization and remineralization dynamics could be the mechanism underlying the rapid tooth movement after selective alveolar decortication (Wilcko *et al.,* 2001). Accordingly, selective alveolar decortication enhances the rate of tooth movement by increasing the bone turnover compared with conventional tooth movement.

The results of the current study indicated that conventional rotary CFO showed a statistically significantly higher mean amount of tooth retraction movement than piezosurgery CFO. This was explained by faster alveolar bone remodeling on the conventional rotary side compared to the piezosurgery side.

Moreover, the rate of orthodontic tooth movement associated with corticotomy using piezosurgery was comparable to that using conventional orthodontics only. On the other hand, the rate of orthodontic tooth movement following corticotomy using rotary instruments showed remarkable enhancement of the rate of tooth movement. This could be due to the fact that bone trauma induced by rotary instruments is greater than that induced by piezosurgery insert tips. This trauma could aggravate the tissue reaction associated with orthodontic tooth movement, as described by Heinemann *et al.* (2012).

Conclusions

Within the limits of this study, corticotomy-facilitated orthodontics using rotary instruments resulted in tooth movement that was 1.6 times faster than when using piezosurgery.

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