Acceleration of orthodontic tooth movement by alveolar corticotomy using piezosurgery

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ABSTRACT: The purposes of this study were to: (1) Identify the effect of the corticotomy-facilitated (CF) orthodontics technique on orthodontic tooth movement compared with the non surgical standard orthodontics technique. (2) Evaluate pain and discomfort levels and the levels of satisfaction of the patients during the treatment about CF orthodontics technique performed with piezosurgery versus non- surgical standard orthodontics technique. Eight patients with minor to moderate mandibular crowding with normal skeletal class I pattern were treated with corticotomy-facilitated (CF) orthodontic technique. Patients were randomly divided to two groups; group I (corticotomy group) in which Alveolar Corticotomies (ACS) were performed using PES and group II (non surgical group) in which non- surgical standard orthodontics technique was done. The desired tooth movement for mandibular de-crowding was achieved in (74.5±7.7) days in corticotomy group (group I) and (141.7±21.3) in non - surgical group (group II). Compared to conventional orthodontic approaches, the average duration of mandibular de-crowding treatment was reduced by about 50 % in group I. The total treatment time was estimated from the beginning of active orthodontic treatment till the completion of de-crowding of the lower mandibular teeth. In conclusion, this study showed that the CF increases orthodontic tooth movement with accepted degrees of pain and discomfort. Orthodontic microsurgery is associated with minimal morbidity. CF orthodontics reduces the duration of treatment compared to the non- surgical standard orthodontic techniques. Surgical control for PES was easier than conventional surgical burs for selective alveolar corticotomies. The force necessary to produce a cut was much less compared to surgical burs. Increased temperature during bone cutting with PES was avoided which reduces the risk of bone damage as a result of overheating.
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***Key words**:* Orthodontic tooth movements, alveolar corticotomies, piezoelectric surgery.

1.INTRODUCTION

Comprehensive orthodontic treatment time ranges between approximately 1.5 – 2.5 years, depending on treatment options and individual characteristics according to the American Association of Orthodontists, American Association of Orthodontists (2007). Dento-alveolar surgeries such as corticotomies and osteotomies can alter the bone biology of tooth movement, Chung et al. (2001); Yen et al. (2003; 2005).For the orthodontist, the combination of minor surgery and orthodontic tooth movement is intriguing because of case reports demonstrating rapid and difficult tooth movements, Yen et al.,(2003); Iseri et al. (2005); Sukurica et al. (2007). Corticotomies has recently become popularized which uses bone healing mechanisms in combination with orthodontic loads to decrease treatment times, Wilcko et al.,(2001) .

In a recent study with a dog model, Iino et al.,(2007) postulated that alveolar bone turnover in bone marrow cavities increased in corticotomy-assisted tooth movement, resulting in quicker tooth movements. Selective alveolar de-cortication without tooth movement has been shown to induce rapid and increased localized turnover of alveolar spongiosa, the prerequisite conditions for rapid tooth movement Sebaoun et al., (2008).

Corticotomy procedures are based on the regional acceleratory phenomenon (RAP) and normal bone-healing mechanisms, Frost (1981;1983). Under normal circumstances, any regional noxious stimulus of sufficient magnitude can evoke a RAP, Frost (1981); Esterhai et al.,(1981).Accelerated RAP processes include perfusion, growth of bone and cartilage, accelerated turnover of bone, and bone modeling, Frost(1983). Once evoked, regional soft and hard tissue processes accelerate above normal values. The main effects of RAP appear to be restricted to the region of the stimulus; even areas in close proximity seem to be relatively unaffected by the RAP response, Bogoch et al.,(1993).

Wang et al.,(2008) conducted a study on an animal model for corticotomy and osteotomy-assisted tooth movement in the rat. They found that the results of computerized tomograms demonstrated that alveolar corticotomies and osteotomies produced different bone responses. Corticotomies and corticotomy-assisted tooth movement produced transient bone resorption around the dental roots similar to what Yaffe et al.,(1994)reported as a regional acceleratory

phenomenon. This temporary loss of supporting alveolar bone around the dental roots was not observed with osteotomies or osteotomy-assisted tooth movement. Instead, a distal distraction site formed with osteotomy-assisted tooth movement.

Wang et al.,(2009) conducted histological study was to examine underlying cellular responses to corticotomy and osteotomy-assisted tooth movements in rats. They concluded that corticotomy-assisted tooth movement produced transient bone resorption around the dental roots under tension; this was replaced by fibrous tissue after 21 days and by bone after 60 days. Osteotomy-assisted tooth movement resembled distraction osteogenesis and did not pass through a stage of regional bone resorption. Mostafa et al.,(2009) conducted a study to identify the effect of the corticotomy-facilitated (CF) technique on orthodontic tooth movement compared with the standard technique, and to explore the histological basis of the difference between the two techniques. They concluded that The CF technique doubled the rate of orthodontic tooth movement. Histologically, the more active and extensive bone remodeling in the CF group suggested that the acceleration of tooth movement associated with corticotomy is due to increased bone turnover and based on a regional acceleratory phenomenon.

Drillers are the most common bone cutting instruments and until few years ago, they were the sole devices used to cut bone tissue. In recent years, piezosurgery was introduced in bone surgery. Piezoelectric surgery (PES), also simply known as piezosurgery, is a new technique for corticotomies and osteotomies created by Vercellotti (2004) utilizing an innovative ultrasonic surgical apparatus, known as the Mectron piezosurgery device. Piezosurgery was developed in response to the need to reach major levels of precision and intra-operative safety in bone surgery, as compared to that available by the traditional manual and motorized bone cutting instruments. It is claimed as ideal to perform osteotomies in thin and fragile bones.

The application of ultrasound is precise and easily handled, and the micro-vibrations allow a selective cut of only mineralized structures, creating minimal damage to adjacent soft tissues, Gonzalez-Garcia et al.,(2008).

Piezosurgery uses a modulated ultrasonic frequency that permits highly precise and safe hard tissue cutting. Nerves, vessels, and soft tissue are not injured by the micro-vibrations, which are optimally adjusted to target only mineralized tissue. The selective and thermally harmless nature of the piezosurgical instruments results in a low bleeding tendency, Vercellotti (2004). Piezosurgery has been used in the surgical removal of alveolar bone and for harvesting intra oral bone blocks or chips, Horton et al.,(1981); Sohn et al.,(2007) . In the upper jaw, piezoelectric bony window osteotomy can easily cut mineralized tissue without damaging the soft tissue, and piezoelectric sinus membrane elevation can separate the schneiderian membrane without causing perforations, Happe (2007). In the lower jaw, PES has been successfully used to mobilize the inferior alveolar nerve and ridge splitting, Bovi et al.,(2005); Sakkas et al.,(2008) .

From a biological point of view, PES has positive effects on the rate of bone repair and remodeling when surgical corticotomies and osteotomies procedures are performed and on cell viability, Chiriac et al.,(2005) Histological studies, Chung et al.,(2001); Chiriac et al.,(2005); Happe(2007) have shown minimal cellular damage to the respected bone margins, bony matrix and underlying marrow spaces. Another study concluded that piezosurgery provided more favorable osseous repair and remodelling than with conventional surgical burs with surgical ostectomy and osteoplasty procedures, Vercellotti et al.,(2005).

Therefore, the purposes of this study were to:

(1) Identify the effect of the corticotomy-facilitated (CF) orthodontics technique on orthodontic tooth movement compared with the non- surgical standard orthodontics technique.

(2) Evaluate pain and discomfort levels and the levels of satisfaction of the patients during the treatment about CF orthodontics technique performed with piezosurgery versus non surgical standard orthodontics technique.

2.MATERIALS AND METHODS:

2.1.Materials:

2.1.1.Sample:

Eight female patients, aged 19 to 25 years, with a mean age (22.3± 2.26) years were used in this study. The selected patients were scheduled for one-stage surgically accelerated tooth movement technique with orthodontic corticotomy. The selected patients were indicated for mandibular arch decrowding.

Criteria of selection included patient with minor to moderate mandibular crowding with normal skeletal class I pattern, no periodontal, no bony defect, no systemic disease, with favorable oral hygiene.

The patients were informed of the risks, advantages, and disadvantages of the experiment and they decided to undergo orthodontic treatment after corticotomy and signed a consent form. All patients were selected from Orthodontic department, Faculty of Oral and Dental medicine, Ain Shams University. The pre-treatment screening for all selected patients included medical history, analysis of the study casts, cephalometric analysis, dental radiography,

periodontal examination, and oral hygiene instructions. The cephalometric analysis was performed to evaluate the discrepancies in the maxillary and mandibular positions to limit patient selection to Class I skeletal pattern with Favorable mandibular incisor plan angle. Cast analysis was used to eliminate the presence of any Bolton discrepancy and limit the selection to cases of minor to moderate crowding. Periapical radiographs were used to determine the correct design of the corticotomy.

2.2.Methods:

2.2.1.Study design

Patients were randomly divided to two groups; group I (corticotomy group) in which Alveolar Corticotomies (ACS) were performed using PES and group II (non surgical group) in which non surgical standard orthodontics technique without corticotomies was done.

After proper case selection, placement of maxillary and mandibular fixed appliances during the week preceding the surgery was carried out. Normal orthodontic force levels were used. Alveolar corticotomies in the current study for accelerated Osteogenic Orthodontics (AOO) or CF Orthodontics technique were performed in an outpatient setting according to Wilcko et al.,(2003; 2008).

2.2.2.Surgical procedures

In corticotomy group (group I), all surgeries were performed under local anesthesia 4% Articaine hydrochloride with 1/200,000 epinephrine (Septanest N, Septodont, Cairo, Egypt) of the inferior alveolar nerve, lingual nerve and the buccal nerve, without premedication or sedation. After administration of local anesthesia, crevicular incision was made buccally and lingually extending at least two to three teeth beyond the area to be treated. Full thickness mucoperiosteal flap was reflected on both buccal and lingual aspects beyond the apices of the teeth. After flap reflection, selective decortications can be performed on both buccal and lingual sides where vertical corticotomy cuts were made between the roots using PS ultrasonic tips (*VarioSurg, NSK*) stopping just short of the alveolar crest (about 3 mm). These cuts were connected beyond the apices of the teeth with scalloped horizontal cuts. Copious isotonic saline irrigant was used to counter heat generation produced by the inserts. VarioSurg Multiple impacts SG4 or SG1 insert used to perform the vertical and horizontal corticotomies.

Then cortical perforation was made at selective areas to increase blood supply to the graft material. Care was taken not to injure the anterior loop of the inferior alveolar nerve that could extend several millimeters mesial to the mental foramen and be positioned just beneath the buccal cortical plate. Bio-glass granules (Glass research department; National Research Center (NRC), Cairo, Egypt) as bone graft material were then placed over the decorticated areas. The mucoperiosteal flap was then sutured with interrupted 3-0 mono filament non absorbable sutures (Dafilon; Braun/Aesculap, Tuttlingen, Germany).

The duration of each surgery was recorded in minutes from the moment of the incision until wound closure. Postsurgical instructions were the same as any standard oral surgical procedures.

In group II patients (non surgical group) standard orthodontics technique without corticotomies was done.The postoperative treatment protocol for all patients in corticotomy group (group I) included prescription of Declofenac Potassium 50 mg tablet (Cataflam, produced by novartis pharma, Cairo, Egypt) every 8 hours and Augmentin 625 tablet (500 mg amoxicillin and 125 mg clavulanate potassium, produced by Medical Union Pharma, under license from GlaxoSmithKline, Ismailia, Egypt) every 8 hours for 5 days after surgery.

The sutures were removed after 10 days. Two weeks post-surgery, accelerated orthodontic treatment was resumed. The intervals for orthodontic adjustments averaged two weeks, ranging from 1 to 3 weeks. During orthodontic treatment, the patient was recalled every 3 months to assess the oral hygiene and assure good periodontal health.

2.2.3.Orthodontic biomechanics

The orthodontic treatment plan included orthodontic expansion of the arches to relief crowding and achieve proper mandibular anterior position.

3.RESULTS

Postoperatively in group I, slight oral swelling of the soft tissues of the face was visible on day 3 after surgery, but no inflammation of the oral tissues was present.

During the active tooth movement, patients were checked by the periodontist at least once each month, and no significant periodontal problems were noted. Post-treatment evaluation of patients revealed no probing depths greater than 3 mm, good preservation of the interdental papillae, and no loss of tooth vitality as teeth registered vital to ice, no significant reduction in the radiographic height of the crestal bone after orthodontic-microsurgical therapy, and no radiographic evidence of any significant apical root resorption. No gingival recession was noted. Patients were pleased with the esthetic results (Figures1-4).

Figure 2 (A and B): Photographs showing another case of the selected patientsin group I (corticotomy group); (A) Pre-treatment anterior view and (B) Post-treatmentanterior view of the same patient on the day that the debracketing was completed.

Figure 1 (A and B): Photographs showing one of the selected patients in group I (corticotomy group), (A) Pre-treatment lingual view of the mandibular anterior teeth and (B) Post-treatment lingual view of the mandibular anterior teeth on the day that the debracketing was completed

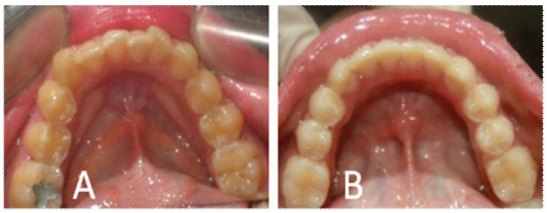

Figure 3(A and B): Photographs showing one of the selected patients in group II (non surgical group); (A) Pre-treatment lingual view of the mandibular anterior teeth and (B) Post-treatment lingual view of the mandibular anterior teeth on the day that the debracketing was completed

Figure 4 (A and B): Photographs showing another case of the selected patients n group II (non surgical group); (A) Pre-treatment anterior view and (B) Post-treatment anterior view of the same patient on the day that the debracketing was completed

The desired tooth movement for mandibular decrowding was achieved in (74.5±7.7) days in corticotomy group (group I) and (141.7±21.3) days in non surgical group (group II) as shown in (Figures 5 and 6) and (Table 1).

Table (1): data of the treated patients in Piezosurgery and conventional groups

Patients data / Groups	PT*/sex	Case presentation	Treatment time (days)**
Cortico-tomy group (group I)	1/F	A female, age 19, presented with minor to moderate anterior crowding and a Class I molar relationship.	66
	2/F	A female, age 23, presented with moderate anterior crowding and a Class I molar relationship.	82
	3/F	A female, age 20, presented with minor to moderate anterior crowding and a Class I molar relationship.	70
	4/F	A female, age 25, presented with moderate anterior crowding and a Class I molar relationship.	80
Non surgical group (group II)	1/F	A female, age 22, presented with minor to moderate anterior crowding and a Class I molar relationship.	117
	2/F	A female, age 24, presented with moderate anterior crowding and a Class I molar relationship.	134
	3/F	A female, age 25, presented with moderate anterior crowding and a Class I molar relationship.	149
	4/F	A female, age 21, presented with minor anterior crowding and a Class I molar relationship.	167

** PT: Patient; **Total treatment time from bracketing to debracketing in days*

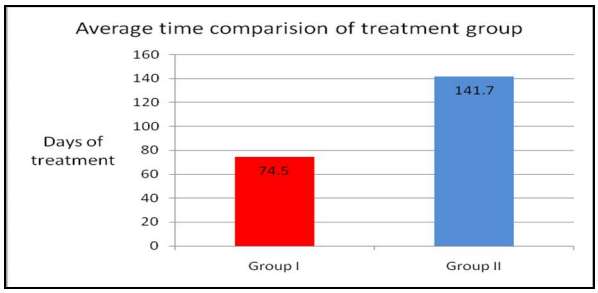

Figure 5: Average treatment time by group

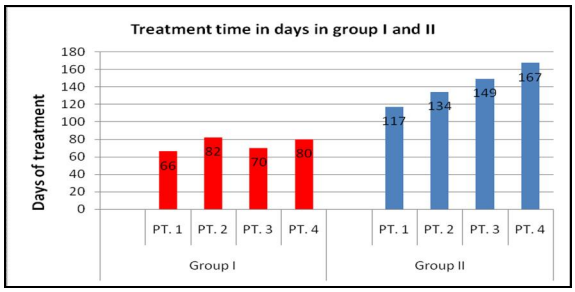

Figure 6: Treatment time in days in all treated patients

Compared to standard non surgical orthodontic approaches, the average duration of mandibular decrowding treatment in CF orthodontics in group I was reduced by about 50 %. The total treatment time was estimated from the beginning of active orthodontic treatment till the completion of decrowding of the lower mandibular teeth.

4. DISCUSSION

This study was undertaken to investigate the influence of CF technique on orthodontic tooth movement. Our results showed that the CF orthodontics significantly accelerated tooth movement. The rate of tooth movement in the CF was about 2 times compared to non surgical standard orthodontic techniques. These results agree with those of Iino et al., (2007) who reported significant acceleration of tooth movement in their animal study. The findings corroborate the clinical observations of Wilcko et al. (2001;2003) who reported significant reductions in treatment time with CF orthodontics.

In conventional orthodontic therapy, movements occur via crestal bone resorption. Although this biomechanical movement is effective, its application is limited in adult patients. Prolonged and/or strong compression of the periodontal ligament may produce histologic modification of the fibers, as well as ligament ankylosis and root resorption. Orthodontists treating adult patients generally prefer to apply light biomechanical forces to avoid the risk of periodontal damage. However, this method requires a lengthy therapeutic period, Vercellotti and Podesta(2007).Corticotomy-facilitated(CF) orthodontics simplifies orthodontic treatment in adult patients and makes it possible to accomplish complex movements in relatively short periods.

The precision of the piezosurgery micro-saw permits a safe corticotomy around the root.

The micro-invasive osteotomy is characterized by precision, maximum surgical control, selective cutting action and facilitates the preservation of the root integrity. Because of the instrument's precision, bone regeneration is more likely. Healing following the use of piezosurgery micro saw is rapid, with minimal morbidity.

Radiographic and periodontal examinations have confirmed that corticotomy-facilitated orthodontics technique does not damage tissue. Moreover, corticotomy-facilitated orthodontics has been shown to be a reliable, quick and painless technique.

No significant differences were detected between corticotomy group and non surgical group regarding pain and discomfort. This result agrees with this of Vercellotti and Podesta (2007).

CONCLUSION

This study shows that the alveolar corticotomy procedure increases orthodontic tooth movement with accepted degrees of pain and discomfort. Orthodontic microsurgery is associated with minimal morbidity and offers a promising means of improving and simplifying orthodontic therapy in adult patients. Corticotomy-facilitated orthodontics reduces the duration of treatment compared to non surgical standard orthodontic techniques. CF orthodontics reduces the duration of treatment compared to the non surgical standard orthodontic techniques. No periodontal or osseous defects were observed in all patients. Surgical control for PES was easier than conventional surgical burs for selective alveolar corticotomies. The force necessary to produce a cut was much less compared to surgical burs. Increased temperature during bone cutting with PES was avoided which reduces the risk of bone damage as a result of overheating.

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