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Corticotomy-facilitated Orthodontics in Adults Using a Further Modified Technique

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Abstract

Aim: To evaluate the effect of corticotomy-facilitated orthodontics (CFO) in adults using a further modified technique versus traditional therapy in orthodontic tooth movement. **Methods:** Twenty adult orthodontic patients with moderate crowding of the lower anterior teeth were randomly divided and treated with either a modified technique of corticotomy-facilitated orthodontic tooth movement (Group I) or conventional orthodontic therapy (Group II). Total treatment time was calculated in weeks from the time of activation of the orthodontic appliance immediately following the corticotomy procedure to the time of debracketing. Clinical periodontal parameters and standardized periapical radiographs were recorded at baseline, post-orthodontic treatment (time of debracketing) and six months post-operatively. The primary radiographic variables were root length and bone density. **Results:** Treatment duration for patients in both groups ranged from 14-20 weeks. There was a statistically significant difference between the two groups regarding the treatment duration: 17.5 ± 2.8 weeks in the CFO group and 49 ± 12.3 weeks in the conventional orthodontic therapy group. No significant changes occurred in clinical probing depth in either group at any time interval. The net percentage of change that occurred in bone density from baseline to six months post-treatment was not statistically significantly different between the two groups. Group I demonstrated a net decrease in bone density of 21.8%, while Group II demonstrated a net decrease of 37.2%. Group I demonstrated an average net decrease in root length of 0.02 ± 0.10 mm, while Group II demonstrated an average net decrease of 1.4 ± 0.8 mm, which was not statistically significantly different. **Conclusion:** The results of the current study suggest that corticotomy-facilitated orthodontic tooth movement using a further modified technique significantly reduces the total time of treatment. In addition, the incidence of root resorption and adverse effect on teeth investing tissues associated with orthodontic tooth movement were reduced. Moreover, the acceleration of tooth movement through the proposed technique motivated patient cooperation.

Key words: Corticotomy-facilitated orthodontics, traditional therapies, adult patients, root resorption, alveolar bone density, follow-up studies

Introduction

The use of conventional orthodontics is accomplished by moving the root of a tooth through its surrounding bone in the jaw of a patient. The medullary bone has a good blood supply and is highly populated with pluripotential cells that can convert to osteoclasts, which resorb old bone, and osteoblasts, which make new bone. This vital nature of the medullary bone gives it the ability to respond in a dramatic and timely fashion to physical insult, such as the forces used to move teeth. The alveolar bone remodels around a tooth being moved in response to pressure from one side as the tooth is pressed against it, and in response to tension from the opposite side of the tooth as the tooth moves away from the alveolar bone on that side (Proffit and Fields, 2004). So it would seem that the roots of the teeth should move rapidly during conventional orthodontic treatment because they extend down into

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the jawbone and are surrounded by the soft and vital medullary bone (Suya, 1991).

An undesirable sequela that can occur as a consequence of conventional orthodontics is referred to as apical root resorption. Apical root resorption is a function of not only pressure but also time. That is to say, the longer it takes to complete the orthodontic work, the more root resorption that can potentially be expected. This is most often seen in retraction cases, and results in an unfavorable crown-to-root ratio. Severe root resorption can lead to irreversible mobility of the teeth, and at times even the loss of the teeth themselves (Gantes *et al.*, 1990; Brezniak and Wasserstein, 1993a; Brezniak and Wasserstein, 1993b).

According to the American Association of Orthodontists (AAO), the length of comprehensive orthodontic treatment ranges between approximately 18 – 30 months, depending on treatment options and individual characteristics (AAO, 2007; Sanjideh *et al.*, 2010). Attempts to shorten the time needed for tooth movement can be divided into three categories: 1) local administration of chemicals; 2) physical or mechanical stimulation of the alveolar bone, such as the use of direct electrical current or magnets; and 3) surgery, including dental distraction and alveolar corticotomies (Oliveira *et al.*, 2010).

A technique developed by the Wilckos, called the Wilcko orthodontics system or accelerated osteogenic orthodontics (AOO), is similar to a single-tooth corticotomy except that it is extended to all the teeth to be moved during orthodontic treatment (Wilcko *et al.*, 2009). The investigators suggested that the design of corticotomy and perforations was intended to maximize the trauma to the alveolus and to promote ample bleeding compared to creating blocks of bone. No luxation of teeth was performed following the corticotomy procedure, and no clinically significant periodontal problems were identified during the active treatment time. Clinically, no disruption of the vitality of teeth was observed, no alveolar crest height changes occurred, and no significant apical root resorption was detected on the periapical radiographs (Sebaoun *et al.*, 2008).

It was thought the teeth moved faster because the resistance of the cortical bone was reduced by the surgical procedure (Kole, 1959; Suya, 1991; Germec *et al.*, 2006), but it was found that surgical healing occurred mainly as reorganizing activity and accelerated bone turnover at the surgical site: this is called "regional accelerated phenomenon" (RAP), a term initially coined to describe rare cases of fracture healing (Wilcko *et al.*, 2001), and defined as the remodeling of soft and hard tissue to return the surgical site to a normal state (Yaffe *et al.*, 1994). The term "regional" refers to the demineralization of both the cut site and adjacent bone; the term "acceleratory" refers to an exaggerated or intensified bone response in cuts that extend into the marrow (Lee *et al.*, 2008). The teeth in the corticotomy group move in a manner similar to conventional orthodontics tooth movement, but at a faster rate (Wilcko *et al.*, 2001). Various researchers have focused on controlling the microenvironment of the alveolar bone by using the RAP in an attempt to reduce tissue resistance. The transient osteoporotic condition involves increased release of calcium, decreased bone density, and increased bone turnover, all of which would facilitate tooth movement. This mechanism based on the RAP differed from the classical concepts of tooth movement, such as the pressure-tension theory, the bone-bending theory, the mechanostat theory, and bony block movement (Kim *et al.*, 2009).

The mandibular anterior region is a critical site when the blood supply is considered. The periodontal angioarchitectures are different in the labial and lingual surfaces of the lower incisors, and the density of the capillary networks is unequal. Therefore, corticotomy procedures may require some modification in this sensitive area. In the mandible, where the roots of the anterior teeth are close and surgical access to the lingual aspect of the bony structures is limited, a modified corticotomy technique can be safely used (Germec *et al.*, 2006).

This study aimed to evaluate whether patients who undergo selective alveolar corticotomy using a further modified technique as part of their orthodontic treatment have similar outcomes to patients who undergo traditional orthodontic therapies.

Materials and methods

A total of 20 adult orthodontic patients (17 females and 3 males) with an age range of 18.4 to 25.6 years and with moderate crowding of the lower anterior teeth participated in the study. The participants were selected from patients seeking orthodontic treatment in the outpatient clinic of the Orthodontic Department, Faculty of Dental Medicine for Girls, Al-Azhar University-Girls Branch.

The criteria for inclusion in the study were as follows: 1) crowding of the lower anterior teeth only, ranging from 3-5 mm; 2) good oral hygiene; 3) skeletal class I; 4) adequate gingival thickness (evaluated using a periodontal probe; De Rouck *et al.*, 2009); 5) no acute periodontal involvement; 6) no previous orthodontic treatment; 7) no previous periodontal surgeries; 8) no regular administration of any medication.

The participants were divided into two groups: Group I was treated with a fixed standard edgewise orthodontic appliance accompanied by a further modified corticotomy operation in a non-extraction treatment plan. Group II was treated with a fixed standard edgewise orthodontic appliance alone in a non-extraction treatment plan. All patients were given information about the proposed treatment and were asked to sign a consent form approved by the local ethics committee.

Initial periodontal therapy consisted of full mouth scaling utilizing both hand and ultrasonic instruments under local anesthesia. Four to six weeks following the initial phase of treatment, a re-evaluation was performed to assess periodontal condition. The following data were recorded for all patients: extra-oral and intra-oral photographs, an orthodontic study model, a digital panoramic radiograph and a standardized digital lateral cephalometric radiograph.

Measurements

Clinical and radiographic parameters were recorded the day of surgery, immediately post-treatment (at the time of debracketing) and six months post-treatment. Clinical measurements were made with a William's probe and recorded to the nearest millimeter. Radiographic measurements were assessed as follows: bone density (BD) was assessed using the DBSWIN software, which is a part of the recently introduced VistaScan system. The mean gray value in each region of interest was calculated (256 gray levels of color resolution) by assigning the gray value 0 to black, and the value 256 to white. To measure bone density, linear density measurements were performed by drawing a line parallel to the root surface. The line extended from the apex of the alveolar crest to the level of the apex of the root. A line was drawn midway between every two lower anterior teeth. The grey level along each line was recorded at the beginning of the line, at the middle, and at the end. The average of the three readings was calculated to obtain the mean average density (grey level) along this line (*Figure 1*). The measurement of the root length was done by measuring the distance between the cemento-enamel junction (as a reference point) to the apex of the root (*Figure 2*).

Passive installation of an orthodontic appliance was performed, including direct bond pre-adjusted brackets (Roth prescription; 0.022 x 0.028 inches) from the right mandibular second premolar to the left mandibular second premolar, using chemical cure orthodontic adhesive and banding of the mandibular first molars. The appliance was not activated pre-surgically.

The corticotomy technique used in this study for Group I is a modification of the basic corticotomy technique described by Wilcko *et al.* (2009), and it was performed under local anaesthesia: intracrevicular full thickness flaps were reflected labially from the distal surface of the lower right canine to the distal surface of the lower left canine. The flaps were reflected beyond the apices of the lower anterior teeth (*Figure 3*). Selective alveolar decortication was performed in the form of vertical grooves through the labial cortical plate of bone using a small round stainless steel surgical bur. (*Figure 4*). The vertical grooves started 1-2 mm below the alveolar crest and extended 1-2 mm below the apices of the teeth. The decortication grooves barely reached the medullary bone, and horizontal subapical cuts were not performed. Flaps were repositioned at their original pre-surgical site and sutured. Post-operative care consisted of a prescription for a systemic antibiotic, an antiedematous drug, and

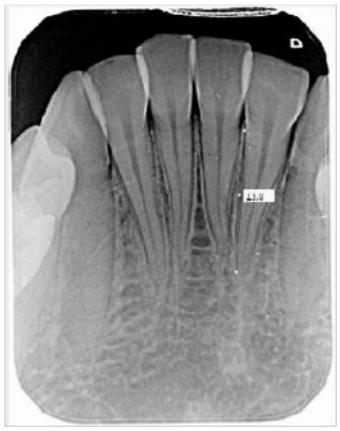

Figure 1. Radiographic measurement of bone density

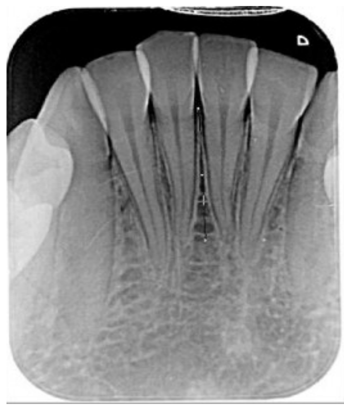

Figure 2. Radiographic measurement of root length.

Figure 3. Reflection of labial alveolar flap.

Figure 4. Interradicular alveolar decortication grooves.

analgesic for seven days (Dziak, 1993; Wilcko *et al.*, 2001; Wilcko *et al.*, 2003). Patients were instructed to rinse twice daily for two minutes for a period of two weeks using 0.12% chlorhexidine gluconate.

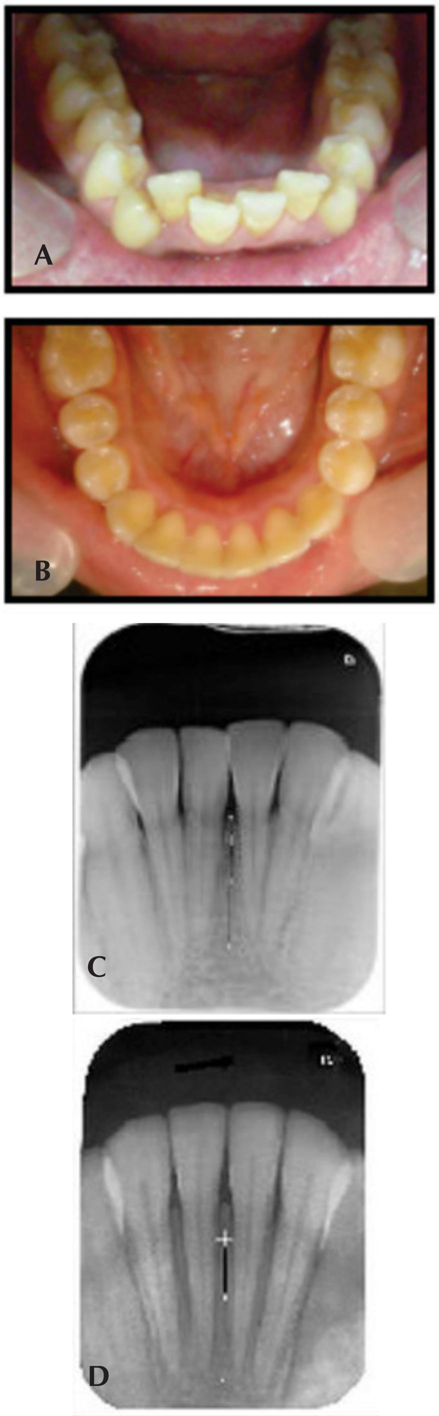

Figure 5. Case presentation: A) Pre-treatment intra-oral photographs; B) Post-treatment intra-oral photographs; C) Pretreatment bone density analysis using DBSWIN software; D) Post-treatment bone density analysis using DBSWIN software and six months post-treatment, demonstrating a net increase in bone density.

Orthodontic tooth movement was initiated immediately after the surgical procedure by installation of a nickel-titanium archwire 0.012". Orthodontic adjustments were performed every 2 weeks. Nickel-titanium archwires 0.012", 0.014", 0.016", and 0.018" were used for leveling and alignment. Stainless steel archwires up to size 0.019" x 0.025" were used for finishing (*Figure 5*).

The second group was treated conventionally with standard edgewise orthodontic appliances alone in a non-extraction treatment plan. The first molars on both sides were banded and brackets were bonded on the premolars, canines and incisors. A nickel-titanium archwire was passed through the teeth of the mandibular arch in an attempt to align them.

The orthodontic appliances, once activated, are adjusted periodically, as needed, to move the teeth toward their desired positions. With this procedure there is a three to four month window of opportunity to complete the major orthodontic movements at an accelerated rate. After that point, the teeth move at conventional orthodontic rates. Thus, the orthodontic appliances must be adjusted frequently enough to complete the major orthodontic movements within the first two to four months of treatment. Satisfactory movement has occurred with adjustments approximately every two weeks. Before debonding, the dentition was stabilized with rigid arch wires.

Statistical analysis

The collected data were tabulated and statistically analyzed using SPSS analytic software (SPSS, IBM Company). Student's *t*-test was used to test the effect of group on different measurements within each interval. Paired *t*-tests were run to test the effect of intervals on different measurements within each group.

Results

Total treatment time was calculated in weeks from the time of activation of the orthodontic appliance immediately following the corticotomy procedure to the time of debracketing. Treatment durations for patients were a mean of 17.5 weeks and 49 weeks for Group I and Group II respectively. There was a statistically significant difference in total treatment time between the two groups (*Figure 6*).

Probing depth

Within each group, there was a significant difference in probing depths at different time intervals. However, within Group I there was no significant difference in probing depths during the retention period (immediately post-treatment to six months post-treatment). In both groups there was a significant difference in probing depths between the beginning of treatment and six months post-treatment (*Table 1 and Figure 7*).

Table 1. Comparison of pocket depths in the two groups

Group / Period	Group I			Group II			*p*
	Mean	SD	SE	Mean	SD	SE	
Pre-operative	1.28	0.47	0.15	1.82	0.48	0.15	0.059
Post-operative	1.12	0.42	0.13	1.76	0.46	0.15	0.175
6 months	1.86	0.15	0.05	1.70	0.32	0.10	0.329

Group I, corticotomy-facilitated orthodontic tooth movement; Group II - corticotomy-facilitated orthodontic tooth movement and bone grafting material.

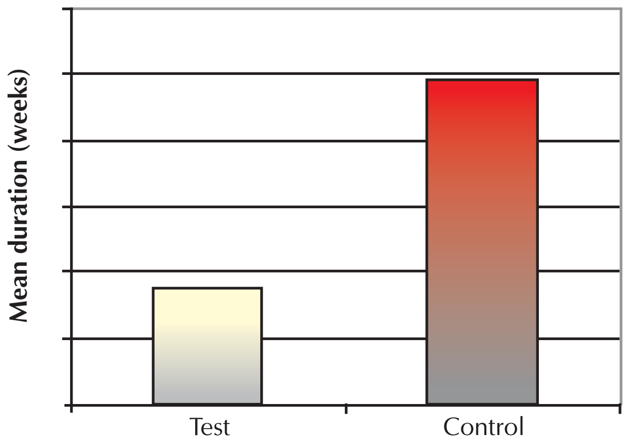

Figure 6. Mean treatment duration values in the two groups.

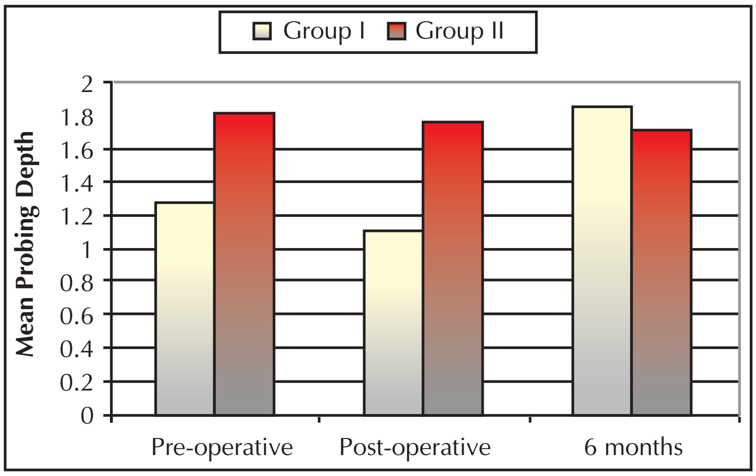

Figure 7. Mean changes in probing depth in the two groups.

There was no statistically significant difference between the two groups in probing depths at each time interval. Six months post-treatment, Group I demonstrated an average net decrease in probing depth of 1.86 ± 0.15 mm, while Group II demonstrated a mean net decrease in probing depth of 1.70 ± 0.32 mm.

Bone density and root length

Within the two groups, there were no significant differences in the amount of change in bone density during different time intervals. The difference between the two groups regarding the amount of decrease in bone density from immediately post-treatment to six months post-treatment was not statistically significant. The mean decrease in bone density for Group I was 29.4%, while it was 46.0% for Group II (*Table 2* and *Figure 8*). The net percentage change in bone density from the beginning of treatment to six months post-treatment was not statistically different between the two groups. Six months post-treatment, bone density values of Group I treated with the modified corticotomy technique were 21.8% less than pretreatment values, while bone density values of Group II treated with

Table 2. Changes over time in bone density of each group

Group	Period	Mean difference (%)	SD	*p*
	Pre-operative – Post-operative	-29.4	23	0.026*
Test	Post-operative – 6 months	7.6	10.8	0.096
	Pre-operative – 6 months	-21.8	14.9	0.041*
	Pre-operative – Post-operative	-46.0	20.3	< 0.001*
Control	Post-operative – 6 months	8.8	7.3	0.070
	Pre-operative – 6 months	-37.2	19.2	0.004*

$^*p \leqslant 0.05$

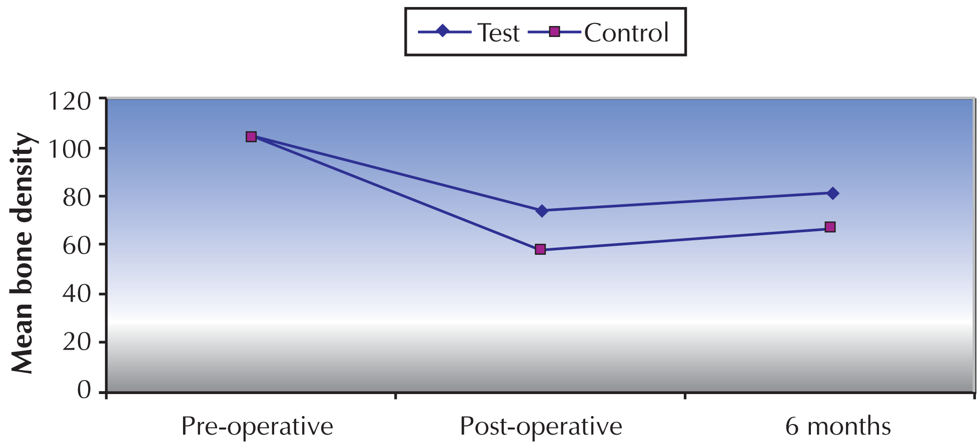

Figure 8. Changes in mean bone density of the two groups over time.

Table 3. Changes in root length in the two groups

Period \ Group	Test Mean	Test SD	Test SE	Control Mean	Control SD	Control SE	*p*-value
Pre-operative – Post-operative	-1.5	0.8	0.3	-13.5	4.9	1.6	0.002*
Post-operative– 6 months	-1.3	2.5	0.8	-1.8	3.4	1.1	0.784
Pre-operative– 6 months	-1.5	0.9	0.3	-10.7	9.5	3	< 0.001*

$^*p \leqslant 0.05$

conventional orthodontic therapy were 37.2% less than pretreatment values (*Table 2* and *Figure 8*).

With regard to root length, Group I showed a statistically significantly higher mean percent decrease in root length than Group II through the whole study period (pre-operative to six months post-treatment). Group I demonstrated an average net decrease in root length of 1.5 ± 0.9 mm, while Group II demonstrated an average net decrease in root length by 1.7 ± 9.5 mm (*Table 3* and *Figure 9*).

Discussion

Corticotomy has been employed for several decades in an attempt to shorten orthodontic treatment times. Treatment of a large group of adult patients using this modified surgical procedure was reported in 1991 and

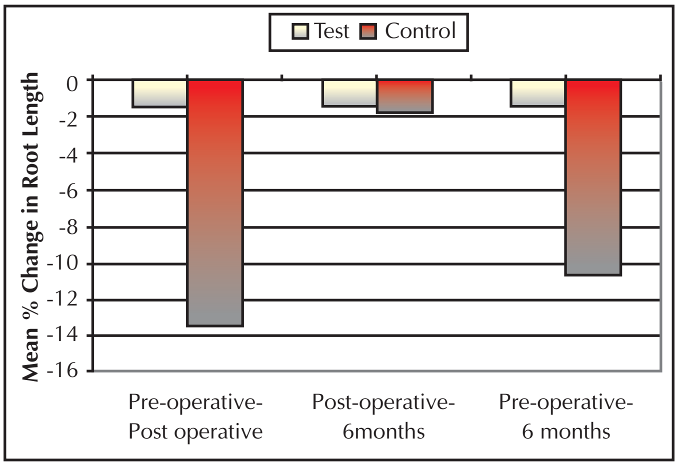

Figure 9. Mean percentage change in root length in the two groups

was referred to as "corticotomy-facilitated orthodontics" (Sebaoun *et al.*, 2008).

The selective alveolar decortication induces increased turnover of alveolar spongiosa. The surgery resulted in a substantial increase in alveolar demineralization, a transient and reversible condition that will result in osteopenia. The osteopenia enables rapid tooth movement because teeth are supported by and moved through trabecular bone. When orthodontic tooth movement is completed, an environment is created that favors alveolar re-mineralization (Sebaoun *et al.*, 2008).

The results of this study revealed that the conventionally treated group had a mean treatment duration of 49 weeks while the corticotomy-facilitated group had a mean treatment duration of 17.5 weeks. This correlates with previous studies that indicated that the initial acceleratory phase is much greater in the corticotomy group than in the control group, with differences in tooth movement evident during the first weeks. In the study reported by Sanjidehet *et al.* (2010), the corticotomy side showed twice as much tooth movement compared with the control side by the tenth day.

Kole (1959) said that most cases with corticotomy are completed in twelve weeks or less, but upon examination of the cases it appeared that the fine finishing movements that are employed before an orthodontic case would be considered completed were absent (Lino *et al.*, 2006).

The modifications in corticotomy-facilitated orthodontic tooth movement reduce both the amount of removed bone and the operation time (Germec *et al.*, 2006). Participants in Germec's study presented with crowding of the lower anterior teeth that ranged from 3-5 mm. Crowding was resolved and orthodontic treatment was completed by dental expansion only, without using any other means of gaining space, in 14-20 weeks. Their result is equivalent to results reported in previous studies in which moderate and severe crowding was treated without extraction by corticotomy/osteotomy-assisted orthodontics and in shorter periods of time (Hajji *et al.*, 2001 and Wilcko *et al.*, 2001). This finding could be explained by the expansion of the envelope of tooth movement following corticotomy, which was suggested in a study by Ferguson *et al.* (2006).

In the present study, patients treated with conventional orthodontics showed higher rates of apical root resorption than patients treated with corticotomy-facilitated orthodontics. These results were in agreement with previous studies, in which almost all of them agreed that there is always less apical root resorption in the corticotomy cases (Kole, 1959; Germec *et al.*, 2006). Kole (1959) had attributed this to the bone block theory, where the creation of a thin layer of bone over the root surface in the direction of the intended tooth movement will facilitate the movement. The same physiologic conditions that provide for the facilitated tooth movement will also provide for decreased apical root resorption. The obvious decrease in apical root resorption rates may also be attributed to the reduction of treatment duration and, subsequently, the periods of force application over the teeth and their roots.

No difference in bone density was detected in the two groups of the present study. Although the initial decortication protocol of AOO that was used by the Wilcko brothers did not include augmentation alveolar grafting, the retention images demonstrated that a minimally adequate amount of mineralized alveolar bone would return if the soft tissue periodontal envelope remained intact (Ferguson *et al.*, 2007).

El-Mangoury *et al.* (1987) has suggested that crowding in the anterior region of the mandibular arch is a predisposing factor for the initiation and progression of periodontal diseases. Difficulty in maintaining oral hygiene can result in a greater accumulation of dental plaque, which is considered a primary etiologic agent in inflammatory periodontal disease. The existing evidence suggests that orthodontic therapy results in small detrimental effects on the periodontium. In general, the evidence does not seem to support the claim that orthodontic therapy results in overall improvement in periodontal health (Dannan, 2010).

Furthermore, Wilcko *et al.* (2001) and Gantes *et al.* (1990) showed that there is no loss of alveolar bone and no periodontal pocketing accompanying corticotomies. This is in agreement with the results of the present study and the results of other studies, like those of Kole (1957) and Fischer (2007), for example. In the present study, the absence of pockets and bone loss may be attributed to the strict oral hygiene measures applied to all patients, a gingival biotype ⩾ 1 mm, and further modifications of the corticotomy technique, in addition to the treatment of crowding.

Conclusions

The further modified corticotomy used in the present study significantly enhanced the rate of tooth movement, reduced patient complaints and reduced treatment time. Moreover, apical root resorption was greatly reduced and the modified corticotomy did not affect bone density any more than conventional orthodontics.

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