Miniscrew implant-supported maxillary canine retraction with and without corticotomy-facilitated orthodontics

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Introduction: The purpose of this study was to clinically evaluate miniscrew implant-supported maxillary canine retraction with corticotomy-facilitated orthodontics. Methods: The sample consisted of 13 adult patients (5 men, 8 women; mean age, 19 years) exhibiting Class II Division 1 malocclusion with increased overjet requiring the therapeutic extraction of the maxillary first premolars, with subsequent retraction of the maxillary canines. Corticotomy-facilitated orthodontics was randomly assigned to 1 side of the maxillary arch at the canine-premolar region, and the other side served as the control. By using miniscrews as anchorage, canine retraction was initiated via closed nickel-titanium coil springs applying 150 g of force per side. The following variables were examined over a 4-month follow-up period: rate of tooth movement, molar anchorage loss, plaque index, gingival index, probing depth, attachment loss, and gingival recession. Results: The average daily rate of canine retraction was significantly higher on the corticotomy than the control side by 2 times during the first 2 months after the corticotomy surgery. This rate of tooth movement declined to only 1.6 times higher in the third month and 1.06 times higher by the end of the fourth month. No molar anchorage loss occurred during canine retraction on either the operated or the nonoperated side. There was no statistically significant difference between preoperative and postoperative measurements of plaque index, probing depth, attachment loss, and gingival recession. Conclusions: Corticotomy-facilitated orthodontics can be a feasible treatment modality for adults seeking orthodontic treatment with reduced treatment times. (Am J Orthod Dentofacial Orthop 2011;139:252-9)

The goal of orthodontic treatment is to improve the patient’s life adjustment through enhancement of dentofacial functions and esthetics. Reducing orthodontic treatment duration is an issue of importance, particularly for adults. Rapid orthodontic tooth movement with concomitant reduction in treatment time can be attained through a combination of orthodontic treatment and surgical alveolar corticotomies.1-5 Corticotomy, defined as any intentional surgical injury to cortical bone, has been claimed to dramatically reduce the treatment time because the resistance of the dense cortical bone to orthodontic tooth movement is removed.1-3,6-8 The alveolar corticotomy technique has been revised and modified to eliminate its possible risks, such as periodontal damage and devitalization of the teeth and osseous segments because of inadequate blood supply. According to Köle,1 the tooth embedded in a bony block of medullary bone served as the handle by which bands of less dense medullary bone surrounding the teeth were moved block by block. On the other hand, Wilcko et al9 attributed the increased rate of tooth movement after corticotomy-facilitated orthodontics (CFO) to a “regional acceleratory phenomenon” (RAP), which is characterized by an increase in bone turnover and a drop in mineral content.

Securing appropriate anchorage is an imperative factor for achieving the objectives of orthodontic
Anchorage loss often produces unsatisfactory treatment results, particularly in patients who require maximum anchorage, with a resultant increase in the treatment period. Skeletal anchorage has evolved as a mainstream orthodontic technique with the introduction of temporary anchorage devices. These devices give the clinician an alternative anchorage system instead of conventional extraoral appliances that require full patient compliance. Titanium screws have been used as skeletal anchors because they can provide absolute anchorage without patient cooperation, and are useful for various orthodontic tooth movements with minimal anatomic limitations and simpler placement techniques. Orthodontic treatment combined with corticotomy and placement of a temporary anchorage device might have the advantage of shortening the orthodontic treatment period, especially in maximum anchorage situations. The purpose of this study was to evaluate miniscrew implant-supported maxillary canine retraction with and without CFO.

**MATERIAL AND METHODS**

The sample consisted of 13 adult patients (5 men, 8 women; mean age, 19 years) exhibiting Class II Division 1 malocclusion with increased overjet requiring the therapeutic extraction of the maxillary first premolars, with subsequent retraction of the maxillary canines. Ethical approval was obtained from the Ethics Review Committee of the dental school at Cairo University, Cairo, Egypt. All patients had to fulfill the following criteria: healthy systemic condition, no previous orthodontic treatment, adequate oral hygiene, probing depth values (measured as the distance from the bottom of the sulcus to the most apical portion of the gingival margin) not exceeding 3 mm in the whole dentition, no loss of periodontal attachment (measured as the distance from the bottom of the sulcus to the cementoenamel junction), and no radiographic evidence of bone loss. All patients were informed of the procedure and signed an informed consent. After placement of maxillary and mandibular fixed appliances and completion of the leveling and alignment phase of treatment, miniscrew implants (AbsoAnchor, Dentos, Daegu, Korea; diameter, 1.3 mm; length, 8 mm), used as skeletal anchor units, were placed bilaterally between the maxillary second premolar and the first molar. On the day before the corticotomy surgery, 1 maxillary premolar was extracted on a random basis (coin toss). When the patient was scheduled for the surgery, the other premolar was extracted, and CFO was performed by using the submarginal Luebke-Ochsenbein flap design. By means of a periodontal probe, 4 mm were measured from the free gingival margin following the contours of the gingiva and extending from the mesial surface of the maxillary lateral incisor to the mesial surface of the maxillary second premolar.

**Fig 2. Measurement of tooth movement on the scanned image of a dental cast. a-b: Mid palatal suture, c: medial end of right third palatal ruga, d: medial end of left third palatal ruga, e: central fossa of maxillary right first permanent molar, f: central fossa of maxillary left first permanent molar, g: cusp tip of right canine, h: cusp tip of left maxillary canine.**
irrigation, corticotomy perforations were made extending from the lateral incisor to the first premolar area. The depth of the holes approximated the width of the buccal cortical bone. Thereafter, the flap was carefully repositioned and sutured with nonresorbable 4-0 black silk by using the single interrupted technique. The maxillary archwire (0.016 × 0.022-in stainless steel) was then ligated, and nickel-titanium closed-coil springs applying 150 g on each side were used for retraction, stretched bilaterally from the miniscrews to the canine hooks.

Periodontal health was assessed by evaluating the following parameters: plaque index, gingival index, probing depth, attachment level, and gingival recession according to the method of Silness and Loe.14 Dental casts were used for the quantification of the anteroposterior movement of the canines and the first molars (Fig 2) every 30 days with the method described by Ziegler and Ingervall.15

Statistical analysis

Descriptive statistics were computed for the variables of tooth movement (canine retraction and molar anchorage loss) and periodontal indices before and after canine retraction, and the results were graphically represented (Tables I and II; Figs 3-10). A paired t test was used to determine the statistical significance of the difference between the operated and nonoperated sides for preoperative and postoperative measurements.

RESULTS

There were statistically significant differences \( P \leq 0.01 \) in the rates of anteroposterior movement of the canines between the operated and nonoperated sides at all measurement times, and the rates of canine retraction were consistently higher in the operated than in the nonoperated side. There was no statistically significant difference \( P > 0.05 \) in plaque index scores, attachment loss, gingival recession, and probing depth values between the operated and nonoperated sides measured preoperatively and at 4 months postoperatively. On the other hand, gingival index scores were significantly higher \( P < 0.05 \) on the operated side compared with the nonoperated side by the end of the study.

DISCUSSION

The subjects selected for this study all had a Class II Division 1 malocclusion. The treatment plan required the extraction of the maxillary first premolars and the subsequent retraction of the maxillary canines. We started with 15 patients, but 2 patients were excluded from the study—1 because of multiple missed appointments and the other because of poor oral hygiene. A considerable amount of patient cooperation was necessary; the patients were expected to comply with the instructions regarding strict attention to oral hygiene measures and keeping the follow-up visits.

Table I. Descriptive statistics of molar anchorage loss in operated and nonoperated subjects

<table>
<thead>
<tr>
<th></th>
<th>Operated</th>
<th>Nonoperated</th>
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<tbody>
<tr>
<td>Mean (preoperative)</td>
<td>13.79 ± 1.157</td>
<td>13.62 ± 1.062</td>
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<tr>
<td>Mean (postoperative)</td>
<td>13.73 ± 1.163</td>
<td>13.50 ± 1.100</td>
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Mean ± SD (mm).

Table II. Mean rates of anteroposterior position of the maxillary canines in the corticotomy and control sides per month (mm)

<table>
<thead>
<tr>
<th>Month</th>
<th>Operated</th>
<th>Nonoperated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month 1</td>
<td>1.89</td>
<td>0.75</td>
</tr>
<tr>
<td>Month 2</td>
<td>1.83</td>
<td>0.86</td>
</tr>
<tr>
<td>Month 3</td>
<td>1.07</td>
<td>0.93</td>
</tr>
<tr>
<td>Month 4</td>
<td>0.89</td>
<td>0.85</td>
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Fig 3. A, Class I canine relationship achieved 2 months after retraction on the operated side; B, Class I canine relationship not achieved on the nonoperated side.
In this study, it was hypothesized that the corticotomy technique could be used to reduce treatment time by facilitating tooth movement. CFO has been claimed to dramatically reduce the treatment time because the resistance of the dense cortical bone to orthodontic tooth movement is removed.\textsuperscript{3,6,16,17} In this study, cortical perforations were made in the buccal cortical plate of bone only without vertical or subapical cuts and without the reflection of a palatal flap. The justification of this is the assumption that the RAP induced by the buccal corticotomy would readily involve the noncorticotomized palatal side. Moreover, the main purposes of adopting this conservative technique were to reduce operation time and postoperative patient discomfort by eliminating exposure of the patient to the risks of an additional palatal surgery. The submarginal Luebke-Ochsenbein flap was used instead of the conventional flap design of the corticotomy surgery, which uses an intrasulcular incision. In this flap design, 2 mm of attached gingiva must remain apical to the depth of the gingival sulcus, and there must be enough tissue remaining to allow suture placement. The relieving incisions were placed vertically to prevent compromising the blood supply of the nonflapped tissue.\textsuperscript{13} These modifications attempted to optimize the treatment outcome of the surgical procedure with minimal if any effects on the periodontium.

It is well known that, in most orthodontic extraction patients, anchorage reinforcement is of prime importance. Effective and reliable anchorage will dramatically improve the results of treatment.\textsuperscript{18} In this study, mini-screw implants were used as skeletal anchorage during canine retraction because of their simpler placement technique and the possibility of eliminating the reliance on patient compliance. Assessment of miniscrew mobility after loading showed no mobility during canine

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**Fig 4.** Cumulative mean changes of anteroposterior position of the canines in the corticotomy and control sides.

**Fig 5.** Mean changes of anteroposterior position of the canines in the corticotomy and control sides per month.
retraction except for 2 miniscrews. One screw became loose 1 month after loading and the other 1.5 months after loading. These miniscrews were immediately repositioned between the maxillary first and second molars, and canine retraction was resumed. These findings showed that the success rate of miniscrews in this study was approximately 93%, which is in accordance with previous reports.18-20

The miniscrews selected had a diameter of 1.3 mm and a length of 8 mm. This was based on the recommendations of Kuroda et al.11 The rationale was to optimize the mechanical retention of the screws and eliminate any risks of root proximity or contact that might contribute to failure during treatment. The placement site of the miniscrews, between the maxillary second premolar and the first molar buccally, was selected based on the recommendations of Schnelle et al,21 who advocated this site as bone stock for safe miniscrew placement in the maxillary arch. Placement of the miniscrews was performed in the attached gingiva rather than the nonkeratinized mucosa because we expected that the success rates would be higher, placement and retrieval would be simpler, and the likelihood of tissue proliferation around the miniscrews would be eliminated. The fact that the miniscrews were placed in tight soft tissue, where no incisions were required, might have contributed to the relatively high stability of the screws with better patient acceptance to the overall procedure. These

Fig 6. Preoperative and postoperative changes of the plaque index scores in the corticotomy and control sides.

Fig 7. Preoperative and postoperative changes of the gingival index scores in the corticotomy and control sides.
findings are in accordance with the report of Kuroda et al., who reported that miniscrews implanted without flap surgery have higher success rates with less pain and discomfort than those placed with flap surgery.

Nickel-titanium springs were used for retraction to permit constant force application. The medial end of the third palatal rugae was used as the reference point to construct reference planes for measurement of tooth movement and quantification of changes in tooth position on the dental casts.14,23-26

The results in this study have demonstrated that it is possible to rapidly retract the canines by using CFO. The anteroposterior changes in the position of the canines were significantly higher on the corticotomy side than on the control side during the first and second months of the follow-up period (Fig 3). During the first 2 months after the corticotomy surgery, the average monthly rate of canine retraction was significantly higher: approximately 2 times faster on the corticotomy side compared with the control side. On the other hand, during the third and fourth months, this mean monthly rate, though still higher on the corticotomy than the control side, declined to only 1.6 times higher in the third month and 1.06 times higher by the end of the fourth month (Fig 5). This information is consistent with the transient nature of the RAP.

In 6 patients (approximately 45%), a Class I canine relationship was achieved in 4 patients after 2 months and in 2 patients after 3 months of retraction. On the other hand, no canine on the control side was retracted

**Fig 8.** Preoperative and postoperative changes of the probing depth values in the corticotomy and control sides.

**Fig 9.** Preoperative and postoperative changes of the attachment loss values in the corticotomy and control sides.
to a Class I canine relationship until the end of the study.

The findings in this study agree with those of Wilcko et al,9 Iino et al,17 Ren et al,27 and Mostafa et al,2 who reported that tooth movement velocity on the corticotomy side was 2 to 3 times faster than that on the control side. On the other hand, the reason for the rapid canine retraction can only be speculated, since no histologic study was carried out. Because the lingual cortical bone was left intact and bone blocks surrounding the teeth were not made, the rapid rate of tooth movement seemed to depend mostly on a RAP rather than bony block movement. However, further histologic studies with longer follow-up periods are required to investigate the underlying biologic background of the corticotomy procedure.

No significant molar anchorage loss occurred during canine retraction on either the corticotomy or the control side (Table I). These results showed that titanium microimplants can function as simple and efficient anchors for canine retraction especially when moderate to maximum anchorage is desired. These results agree with the findings of Thiruvenkatachari et al,18,28 who advocated the use of implants as anchorage during the retraction of canines as a viable alternative to conventional molar anchorage.

Several reports have been published regarding the adverse effects to the periodontium after CFO. These reports range from no problems to slight interdental bone loss, decrease of attached gingiva, and periodontal defects observed in some cases with short interdental distances.6,9,12 Bell and Levy2 reported a damaging effect to the periodontium around the incisors after corticotomy cuts at the premolar and incisor regions in 4 rhesus monkeys. According to the authors, alteration of the circulation could reduce the viability of the bone and teeth, affect the healing capacity of the mobilized bone, and have a destructive effect on the periodontium. On the other hand, Düker,4 Gantes et al,6 and Suya8 speculated that, by keeping the vertical corticotomies 1.5 mm shy of the crest of the marginal bone, there would be less chances of damaging the marginal periodontium. In this study, we observed no hazardous side effects from the corticotomy surgery on the periodontium. Assessment of probing depths, attachment loss, and gingival recession in particular showed no significant differences between the operated and nonoperated sides (Figs 8-10). These results agree with the findings of Anholm et al,29 Gantes et al,6 Suya,8 Wilcko et al,9 and lino et al,12 who reported rapid tooth movement and reduced treatment times without clinically noticeable adverse periodontal effects from the CFO.

In our study, the conventional flap design of the corticotomy surgery, with an intrasulcular incision, was replaced with the submarginal Luebke-Ochsenbein flap.13 The fact that the marginal bone was not incised during the surgery and an intrasulcular incision was not made could have resulted in optimization of the periodontal condition after the surgery. The reason for the absence of any effects on the periodontium after the corticotomy procedure could be attributed to the manner of bone removal, because the corticotomy was not done as a true osteotomy, with a block of bone removed. The procedure only perforated the bone, leaving the original bony architecture intact. This allowed the resorption-deposition cellular process to proceed in the existing bony architecture. On the other hand, Yaffe et al30 reported that RAP begins a few days after the surgery, peaks between 1 and 2 months, and takes from 6 to 24 months to resolve completely. These findings might explain the higher gingival index scores on the corticotomy side compared with the control side in this study.

![Fig 10. Preoperative and postoperative changes of the gingival recession values in the corticotomy and control sides.](image-url)
when the longer times required for complete resolution of the RAP after the corticotomy surgical procedure might have contributed to elevated gingival index scores.

CONCLUSIONS

On the basis of the results obtained from this study, the following conclusions can be drawn.

1. CFO can be an effective method for patients who desire shortened orthodontic treatment durations.
2. The Luebke-Oechsenbein flap design is a feasible and an applicable modification to the original corticotomy flap design.
3. Miniscrew implants can function as viable alternatives to conventional molar anchorage. They are simple and efficient anchors for canine retraction, especially in moderate to maximum anchorage situations.

REFERENCES