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Original Article

Can corticotomy (with or without bone grafting) expand the limits of safe orthodontic therapy?

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ABSTRACT

Purpose: To assess whether concomitant particulate bone grafting makes a difference in the ability to safely orthodontically reposition teeth outside the bony envelope after corticotomy.
Material and methods: Retrospective analysis of patients who underwent corticotomy as part of their orthodontic therapy for treatment of severe crowding. Patients were divided as: a) Group 1: corticotomy with bone grafting, and, b) Group 2: corticotomy without bone grafting. CT scan examinations were performed before and at the end of the treatment. Measurements of bone and tooth positions were obtained and differences between pre- and post-treatment values were calculated.
Results: The study sample included 20 adult patients between the ages of 25 to 58 years. A total of 144 teeth were orthodontically repositioned outside their native bony envelope after corticotomy. Average follow-up was 9 months. Teeth that were repositioned after corticotomy and bone grafting maintained the alveolar bone volume around them while corticotomy without bone grafting was not successful in maintaining bone thickness around teeth that were moved outside the alveolar housing.
Conclusions: Corticotomy in combination with guided bone regeneration has the potential to increase the scope of conventional orthodontic treatment by allowing for expansive movements beyond the traditional limits.

1. Introduction

The envelope of treatment for predictable non-surgical orthodontics has long been established. However, it is a well-known fact that during orthodontic treatment, bone resorption usually occurs in the direction of tooth movement. Reduced volume of alveolar bone is a complicating factor for orthodontic treatment and numerous previous studies have shown a greater incidence of marginal bone resorption in those areas where the tooth movement was carried out towards the cortical plate.[1] The buccal cortical plate of the alveolus has been for many years considered inviolable and it was thought that any movement beyond that line might cause bony dehiscence and eventually gingival recession.[2] With the introduction of periodontally accelerated osteogenic orthodontics (PAOO®), this concept has very recently been refuted and as shown by Williams and Murphy, the alveolar “envelope” or limits of alveolar housing may be more malleable than previously believed and can be virtually defined by the position of the roots.[3] “Surgically-assisted” orthodontic treatment is referred to in many ways in the literature depending on the type of surgery that is performed. Wilckodontics®, AOO®, and PAOO® specifically refer to corticotomy surgery when performed in combination with bone grafting which offers the ability to increase the existing alveolar volume,[4] thereby not only potentially minimizing the risk of bone dehiscence and fenestration as side effects of orthodontic movement when occurring outside the bony envelope but also correcting pre-existing dehiscences and fenestrations over vital root surfaces. This study was aimed to evaluate the ability of corticotomy, with or without bone grafting, in expanding the limits of safe orthodontic treatment.

2. Material & methods

This study is a retrospective analysis of patients who underwent corticotomy (with and without bone grafting) as part of their orthodontic therapy. The records of twenty consecutive patients treated with corticotomy-facilitated orthodontic therapy were included in this study. The study was considered exempt from

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institutional review board regulations in accordance with current regulations for research completed in a private practice located in Italy. In all patients the aim of therapy was decrodwing and the patient sample included both Angle Class I and Class II malocclusion patients. Based on a combination of orthodontic objectives and pre-operative cone beam CT scan (CBCT) examinations, only those teeth where orthodontic movement *was to be performed to move teeth outside their original bony envelope* were included in the study. The main objective of the study was to ascertain if expansive orthodontic movements which have been traditionally considered prohibitive due to lack of bone volume, and unstable due to propensity for relapse, could be performed without adverse effects after corticotomy. The primary outcome variable was the ability to expand the alveolus with corticotomy with either presence or absence of concomitant bone grafting during the corticotomy procedure. For study purposes, patients were thus divided into two groups: a) Group 1: those undergoing corticotomy with bone grafting, and, b) Group 2: patient undergoing corticotomy without bone grafting.

The surgery was performed according to the principles of the orthodontically-driven corticotomy (ODC), where the surgical procedure is designed and performed in line with the proposed orthodontic treatment. In each patient, single full-thickness flap elevation was performed in the anticipated direction of the orthodontic movement.[3] In most cases, the corticotomy procedure was not full-arch but rather segmental, and performed only in the area were the anticipated orthodontic movements were to take place. Sulcular incisions were made with a #15 Bard-Parker surgical blade with a papilla preservation approach so that the base of the papilla was not elevated. When necessary, vertical releasing incisions were performed to increase flap mobility. The vertical incisions were placed at least one tooth and half away for the most mesial and the most distal area where corticotomies were performed. A combination of a rear-vented high-speed rotary surgical handpiece and bur under copious irrigation (for speed and outlining of corticotomy), and a piezoelectric scalpel (for refinement and inter-proximal corticotomies) were used as instrumentation. The inter-proximal cuts were deepened to at least 3 mm in the bucco-lingual direction, staying at least 3 mm from level of bone crest in the apico-coronal direction. Thinning of the alveolar bone surrounding the teeth to be moved was performed with the same instruments in the anticipated direction of movement.

In Group 1, 0.5 cc of xenogeneic bone of bovine origin was used over an area encompassing every 3–4 teeth for bone grafting. Following the principles of guided bone regeneration (GBR), a resorbable collagen membrane over the graft. Tension free primary closure was completed after periosteal release at the base of the flap with 5–0 Vicryl sutures. Straight wire orthodontic mechanics were used for orthodontic movement of teeth with the objective of repositioning them outside the native alveolar housing (expansive movement) following corticotomy. Orthodontic forces were initiated at the second week interval after surgery.

2.1. Radiographic examination

CBCT examinations were performed before starting the orthodontic treatment and at the end of the treatment. All the examinations were made using a 9000 3D CBCT (Carestream Health, USA) unit, equipped with a flat-panel detector. The exposed volume was 50 mm by 30 mm (voxel size = 0.679 μm–0.2 mm, depending if a "stitching" of 3 consecutive volumes was performed to represent the entire jaw), encompassing the teeth in the jaw where corticotomy was carried out. Exposure parameters were: 70 kV, 8–10 mA (based on the subject's size), and a single 360° 24 to 72 s exposure time comprising a range of 235–468 projections. CBCT were performed to evaluate the thickness of bone and the 3D positioning of the roots in the alveolar ridge before treatment. Primary data reconstructions were made using the acquisition software (CS3D Imaging, Carestream Health, USA), resulting in perpendicular slices in axial, coronal, and sagittal planes of the image volume. Subsequently, a second reconstruction was made to obtain contiguous 0.5 mm thick slices. The workstation consisted of an ASUS Computer, Intel® i5 CPU, with a graphics card [NVIDIA GeForce 9500 GT Series GPU 32-bit (NVIDIA Corporation, Santa Clara, CA, USA). Reformatting and measurements were made on 19 in. flat-panel monitor (resolution 1600 × 1200 pixels). Reconstructions were made in a way that each individual tooth/root inclined lingually or labially, would have the axial slices perpendicular to its long axis. This can be carried out irrespective of the angulation of the tooth relative to the alveolar process and/or the presence of crowding. Image slices, perpendicular to the axial ones, were automatically reconstructed. This results in optimal visualization of the MBC in relation to the cement-enamel junction (CEJ) in axial, coronal, and sagittal views, as described by Lund.[1] Using the axial view, a single reference line was placed between the CEJ's at the buccal and palatal/lingual surfaces. Parallel to that, three lines were placed at 4, 7 and 9 mm distance respectively and the thickness of the plate where the movement was carried out was measured to the nearest 0.1 mm by a single examiner (Fig. 3a and b). Post-treatment measurements were made and the difference between pre- and post-treatment values represented the change in alveolar thickness following surgery and tooth movements. Statistical test analysis was conducted using the commercial package SPSS. Student *t* test for the difference of group means was applied. A P value of <0.05.

3. Results

The study sample included 20 adult patients between the ages of 25 to 58 years (mean 45 years). A total of 144 teeth were orthodontically repositioned outside their native bony envelope after corticotomy. Average follow-up was 9 months (range 7–13 months). Group I had 13 patients (4 males and 9 females) with an average age of 37.7 years and Group 2 had 7 patients (2 males and 5 females) with an average age of 37.4 years.

Differences in bone thickness were statistically significant amongst both groups at all three different levels. The average

Table 1
Pre- and post-operative CBCT of a patient treated with surgically-assisted orthodontics (corticotomy) in combination with bone grafting.

d1 (3 mm)	Number of teeth (n)	Average Difference (Preop and Postop) mm	Standard Deviation
Group 1: Graft	79	0.86	0.25
Group 2: No Graft.	65	−0.24	0.27

A total of 144 teeth were orthodontically repositioned outside their native bony envelope after corticotomy, 79 in Group 1 (Graft) and 65 in Group 2 (No Graft). Average thickness changes of the buccal plate was found to be as follows on CBCT examination: At the 4 mm (d1): group 1: 0.86 +/−0.25, and, group 2: −0,24 +/− 0.27 ($p < 0.05$). Difference in thickness were statistically significant among groups at all three different levels.

Table 2
Pre- and post-operative CBCT of a patient treated with surgically-assisted orthodontics (corticotomy) without bone grafting.

d2 (7 mm)	Number of teeth (n)	Average Difference (Pre and Post op) mm	Standard Deviation
Group 1: Graft	79	0.95	0.22
Group 2: No Graft	65	0.26	0.35

At the 7 mm reference point (d2), values were: group 1: 0.95 +/− 0.22, and, group 2: 0.26 +/−0.35 ($p < 0.05$).

Table 3
Pre- and post-operative CBCT slices in a group 2 patient (without bone graft) showing a decrease in thickness of the cortical plate after treatment.

	Number of teeth (n)	Average Difference (Pre and Post op) mm	Standard Deviation
Group 1: Graft	79	1.39	0.62
Group 2: No Graft	65	0,70	0.54

At the 9 mm point (d3), group 1 values were: 1.39 +/− 0.62 while group 2 values were 0.70 +/−0.54 ($p < 0.05$).

thickness changes of the buccal plate was found to be as follows on CBCT examination: At the 4 mm (d1): group 1: 0.86 +/−0.25, and, group 2: −0,24 +/− 0.27 ($p < 0.05$); At the 7 mm reference point (d2), values were: group 1: 0.95 +/− 0.22, and, group 2: 0.26 +/−0.35 ($p < 0.05$); and, at the 9 mm point (d3), group 1 values were: 1.39 +/− 0.62 while group 2 values were 0.70 +/−0.54 ($p < 0.05$). Tables 1–3 show the results in tabulated form. Figs. 1, 2 and 4 demonstrate examples of the results in patients from both groups.

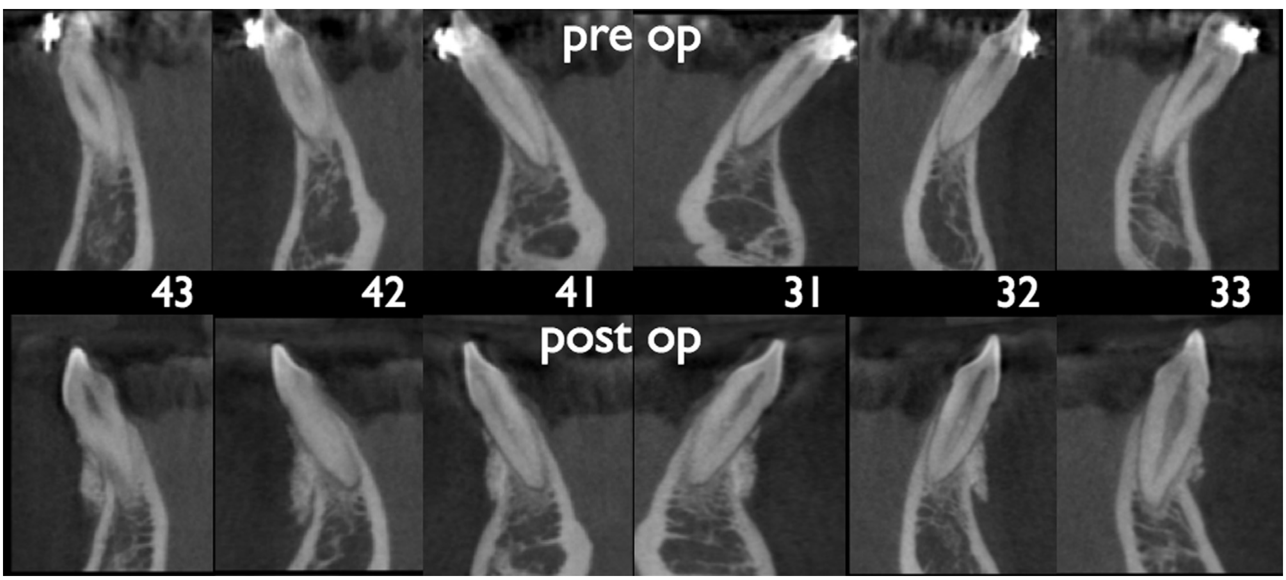

Fig. 1. Composite pictures of sections representing pre- and post-operative CBCT of a patient treated with surgically-assisted orthodontics (corticotomy) in combination with bone grafting.

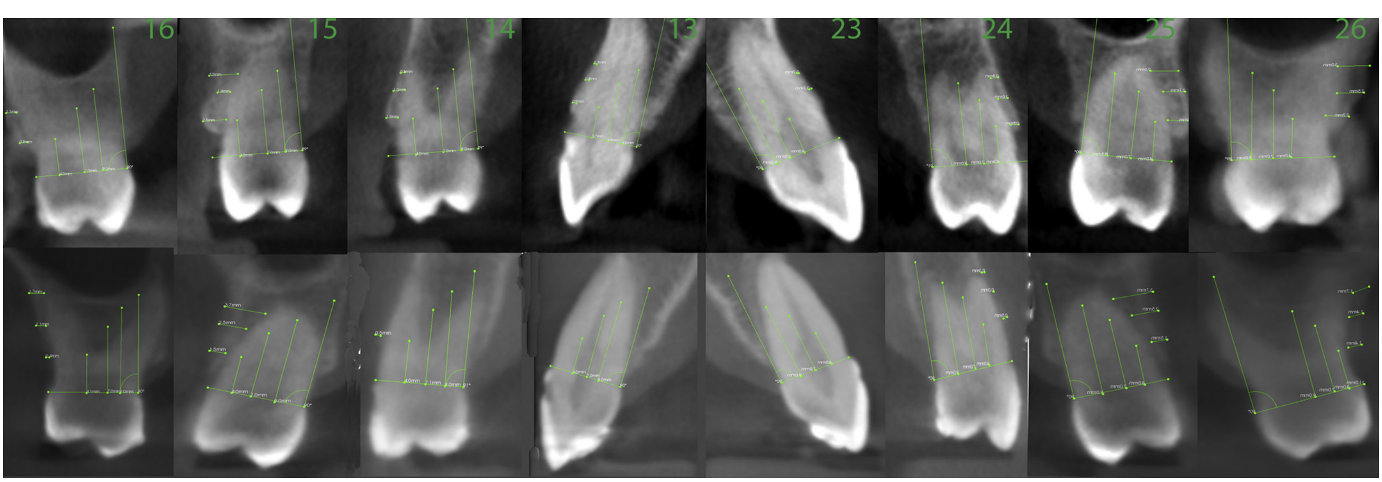

Fig. 2. Composite pictures of sections representing pre and post-operative CBCT of a patient treated with surgically-assisted orthodontics (corticotomy) without bone grafting.

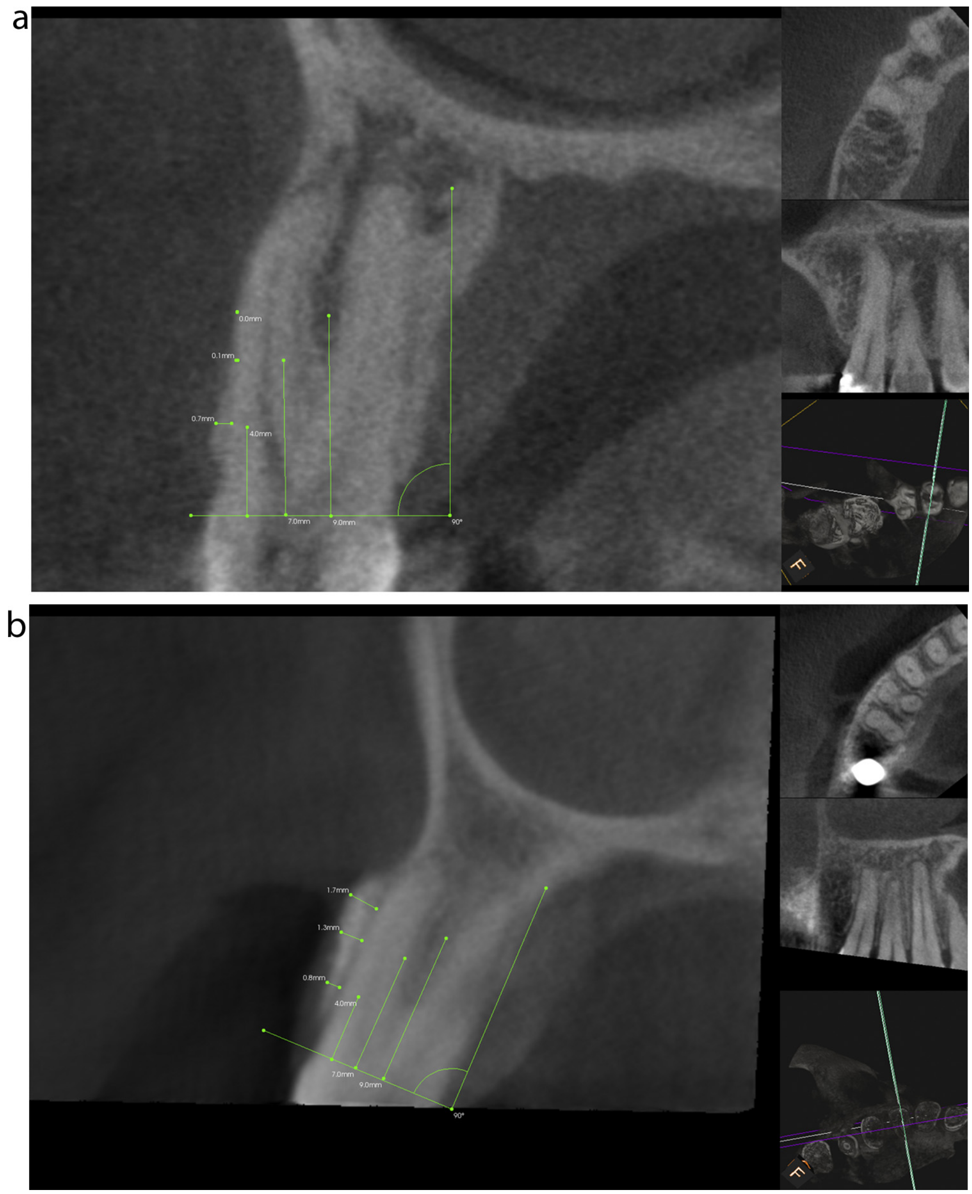

Fig. 3. (a) Using the axial CBCT view, one reference line was placed between the CEJ's at the buccal and palatal/lingual surfaces. Parallel to that line, three separate lines were placed at 4, 7 and 9 mm away distances respectively. At each of these points, the thickness of the cortical plate where the orthodontic movement was carried out was measured. (b) The 4,7 and 9 mm reference point measurements of a group 1 patient showing increase in bone plate thickness despite orthodontic movement outside the original bony envelope.

4. Discussion

Gingival recession has always been clinical concerns with orthodontic treatment. Wennstrom et al. found that lingual positioning of teeth results in an increase in the gingival height on the facial aspect with a coronal migration of the soft tissue margin [5]; in contrast, the opposite occurs when teeth are moved to a more facial position in the alveolar process.[5] While some researchers have found that there is a higher incidence of gingival recession in patients who are orthodontically treated for transverse discrepancy,[6] others have failed to correlate expanding movement and vestibular recessions and found no higher incidence of increased length of clinical crowns post therapy.[7] One hypothesis that has been popularized is that orthodontics per se does not directly cause recession but it creates marginal bone resorption when the tooth is moved outside the bony envelope of the alveolar process, which then leads to soft tissue migration and loss of gingival attachment. This may be observed, for example, even in untreated patients with dental crowding. In these cases, the discrepancy between tooth size and the space available may force some of the teeth outside the bony alveolar housing. Staufer and Landmeser showed that in cases of more than 5 mm of crowding, recession was twelve times more likely to occur.[8] This clearly underlies the importance of achieving proper 3-D positioning of the roots inside the bony alveolar housing after orthodontic treatment. A more recent study evaluated the long-term development of labial gingival recessions during orthodontic treatment and retention phase.[9] In particular, the lower incisors seemed to be more at risk.

Most studies on alveolar bone changes in patients who have undergone orthodontic treatment in he past have used bitewing and/or periapical radiography, thus restricting the assessments to proximal bone surfaces.[10–12] Recently, CBCT's have been employed in tis area and it has been demonstrated that during orthodontic tooth movement, teeth may be inadvertently repositioned beyond the bony alveolar housing with resultant dehiscence and

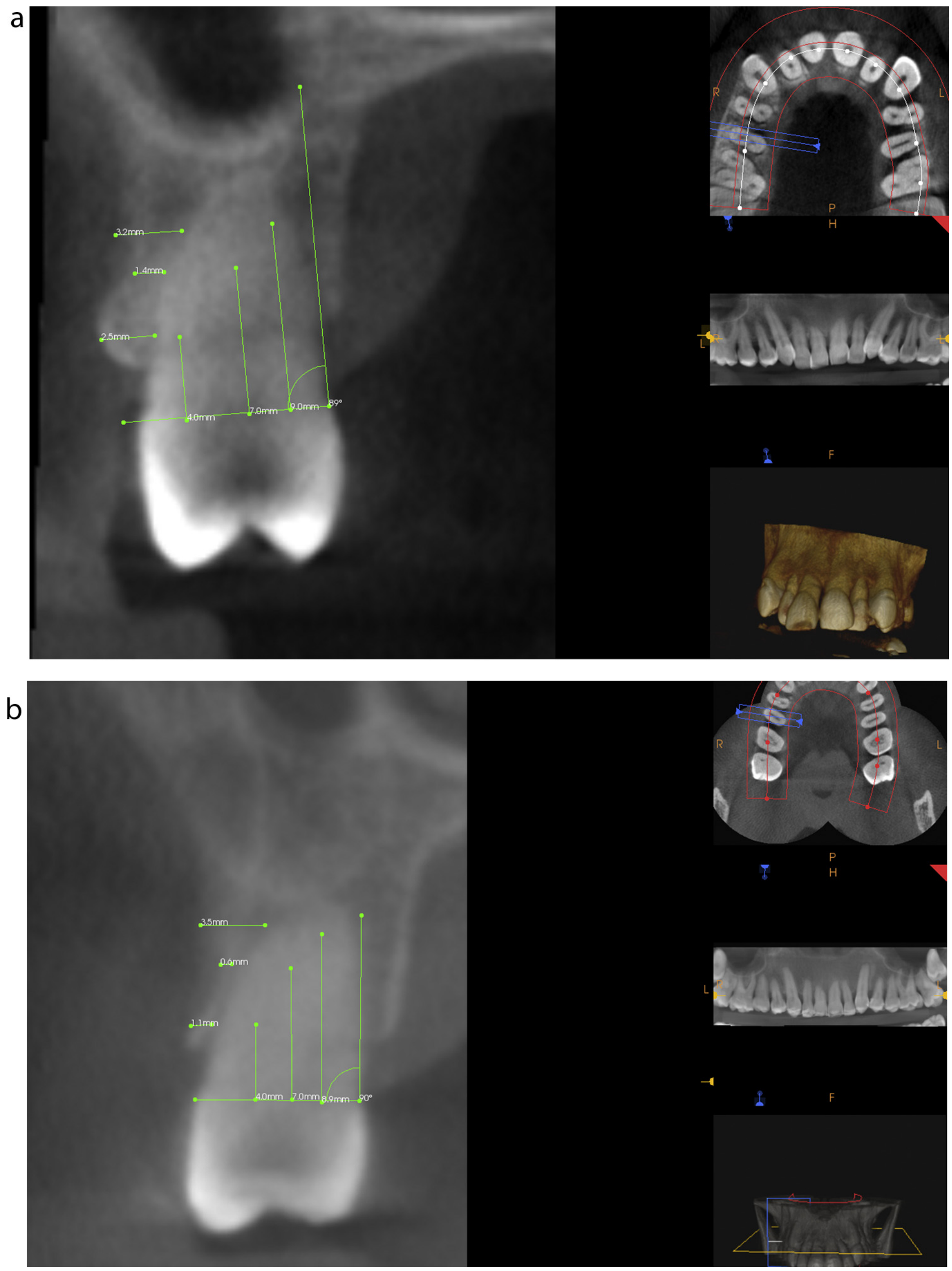

Fig. 4. Pre-and post-operative CBCT slices in a group 2 patient (without bone graft) showing a decrease in thickness of the cortical plate after treatment.

fenestration formation.[1] Garib et al. also showed a correlation between rapid palatal expansion and thinning of the vestibular plate up to almost 1 mm.[13] 3-dimensional positioning of the roots inside the bony envelope at the end of the treatment becomes then an asset of future orthodontic treatment planning.[14–18]

If the orthodontic treatment is expected to have root movement outside the bony envelope of the original anatomy, orthodontists have historically considering modifying the treatment plan. The combination of corticotomy and GBR (bone graft and membrane) may the ability to augment the existing topographical anatomy so that such "historically considered unfavorable root movements" can be predictably completed.[17,19] In our retrospective case series, we found that the possible detrimental effects of orthodontic movements on periodontal tissues can be overcome even when the movements are outside the original alveolar anatomy using a combination of corticotomy and grafting. If corticotomy is performed alone (without GBR), existing alveolar bone volume in not consistently preserved, let alone its augmentation.

5. Conclusions

3-D positioning of the roots inside the bony envelope at the end of the treatment is one of the pillars for stability of orthodontic treatment. Many orthodontists now obtain CBCT examinations prior to initiating treatment and these scans can be utilized to review the topographical anatomy of the alveolar bone housing. We have found that corticotomy in combination with guided bone regeneration can increase the scope of conventional orthodontic treatment by allowing for expansive movements beyond the traditional envelope of predictability. The technique of corticotomy with concomitant bone grafting seems to be an effective method to minimize the risk of marginal bone resorption and fenestration when a tooth is orthodontically inclined or moved toward, or even outside the cortical plane. In contrast, corticotomy by itself, without concomitant bone grafting does not yield similar results.

Conflict of interests

None.

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None.

Ethical approval

Approval by the Institutional Review Board of Boston University.

Approval #: H- 36878.

Consent

Not required.

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