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นิพนธ์ต้นฉบับ
Original Article

การศึกษาการเปลี่ยนแปลงความหนาของกระดูกด้านริมฝีปากหลังทำการผ่าตัดกรอกระดูกทึบร่วมกับปลูกถ่ายกระดูกและซีจีเอฟเพื่อการรักษาทันตกรรมจัดฟันโดยใช้ภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ลำรังสีรูปกรวย

Change of labial bone thickness in augmented corticotomy assisted orthodontics combined with concentrated growth factor (CGF): a cone-beam computed tomography study

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บทคัดย่อ **ในปัจจุบันผู้ป่วยที่เป็นผู้ใหญ่ให้ความสนใจในงานทันตกรรมจัดฟันเพิ่มมากขึ้นอย่างชัดเจน อย่างไรก็ตาม ระยะเวลาการรักษาและสภาพของกระดูกเบ้าฟันยังเป็นข้อจำกัดสำคัญที่ต้องคำนึงถึงในผู้ป่วยกลุ่มนี้ ในการศึกษานี้ได้ศึกษาถึงผลของการรักษาทันตกรรมจัดฟันร่วมกับการผ่าตัดกรอกระดูกทึบรอบรากฟันและการปลูกถ่ายกระดูกเพื่อเพิ่มความหนาของกระดูกด้านริมฝีปากและใช้ซีจีเอฟในผู้ป่วยจำนวน 8 ราย ในแง่การเพิ่มขึ้นของกระดูกด้านริมฝีปากโดยใช้ภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ลำรังสีรูปกรวย**

กำหนดวัตถุประสงค์และขอบเขตการศึกษา ได้แก่ การเปลี่ยนแปลงของกระดูกด้านริมฝีปากหลังทำการผ่าตัดกรอกระดูกทึบรอบรากฟันร่วมกับการปลูกถ่ายกระดูกและใช้ซีจีเอฟเพื่อการรักษาทันตกรรมจัดฟัน ทำการวัดความหนาของกระดูกด้านริมฝีปากที่เปลี่ยนแปลงหลังการผ่าตัดกรอกระดูกทึบร่วมกับการปลูกถ่ายกระดูกและซีจีเอฟในผู้ป่วยจำนวน 8 ราย โดยใช้ภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์ลำรังสีรูปกรวย เปรียบเทียบก่อนการผ่าตัด (ที 0) 6 เดือนหลังการผ่าตัด (ที 1) และ 12 เดือนหลังการผ่าตัด (ที 2)

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ผลการศึกษาพบว่า ค่าเฉลี่ยของความหนากระดูกด้านริมฝีปากเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติเมื่อเปรียบเทียบที่ช่วงเวลาที 0 กับที 1 แต่พบว่ามีค่าลดลงอย่างมีนัยสำคัญทางสถิติเมื่อเปรียบเทียบระหว่างช่วงเวลาที 1 กับที 2 ($p < 0.05$) เมื่อเปรียบเทียบความหนาของกระดูกด้านริมฝีปากก่อนการผ่าตัด (ที 0) และ 12 เดือนหลังการผ่าตัด (ที 2) พบว่าความเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ และกระดูกคงสภาพได้ดี อาจสรุปได้ว่าการผ่าตัดกรอกระดูกทึบร่วมกับการปลูกถ่ายกระดูกเพื่อการรักษาทันตกรรมจัดฟันเพื่อเพิ่มความหนาของกระดูกด้านริมฝีปากและใช้ซีจีเอฟให้ผลลัพธ์ที่ดีสำหรับการรักษาทันตกรรมจัดฟันในผู้ป่วยวัยผู้ใหญ่

คำสำคัญ: การผ่าตัดกรอกระดูกทึบร่วมกับการปลูกถ่ายกระดูกเพื่อการรักษาทันตกรรมจัดฟัน ซีจีเอฟ

Abstract Nowadays, adult patients have a dramatically increased interest in orthodontic treatment. However, treatment time and bone support are critical issues for this group of patients. In this study, 8 cases of orthodontic treatment using augmented corticotomy assisted orthodontics (ACAO), combined with concentrated growth factor (CGF) would show the ability to simultaneously reshape and increase the labial thickness of the supporting alveolar bone.

The purpose of the study was to evaluate labial bone thickness (LBT) after ACAO combined with CGF in orthodontic treatment. This study observed the LBT in 8 orthodontic patients who received ACAO combined with CGF. The data were recorded using cone beam computer tomography (CBCT), before (T0), at 6 months (T1) and 12 months (T2) after the surgery. For the results, from T0 to T1, the mean LBT significantly increased, and then significantly decreased from T1 to T2 ($p < 0.05$). Compared the mean LBT from T0 to T2, the mean LBT significantly increased and demonstrated stable augmented bone. For conclusion, ACAO combined with CGF was considered to be a promising approach for the orthodontic treatment in adult patients.

Keywords: augmented corticotomy assisted orthodontics, concentrated growth factor

Introduction

Nowadays, as the number of adult orthodontic patients has increased, they may have many limitations in orthodontic aspect, such as density of bone that is difficult for tooth movement, long treatment time, poor periodontal status, thin gingival biotype, decreased bone support, and thin labial plate.

Several methods have been suggested to accelerate tooth movement, and consequently reduce orthodontic treatment time in adult patients. The gold standard for accelerating tooth movement is corticotomy. Recently, modern surgically assisted orthodontic treatment-augmented corticotomy assisted orthodontics (ACAO) can enhance the scope of malocclusion treatment, decrease treatment time, and improve healing of periodontium.[1-3] Moreover, ACAO can increase alveolar bone volume to support tooth. Thus, this can reduce the chance of relapse in retention phase of orthodontic treatment.[1-3] This technique is more effective especially for previously-

ตารางที่ 1 ข้อมูลของผู้เข้าร่วมงานวิจัย

Table 1 Demographic data of subjects.

Case number	Name	Gender	Age	Maxillary arch	Mandibular arch
1	C.S.	F	50	+	
2	M.M.	F	37	+	+
3	N.C.	F	50	+	+
4	A.R.	F	53	+	+
5	T.H.	M	40		+
6	W.H.	M	41	+	+
7	P.Y.	F	42		+
8	P.C.	F	59	+	+
	Total	**6F/2M**	**46.5**	**6**	**7**

periodontitis, thin labial plate, thin gingival biotype, and alveolar bone loss patients.[4]

Furthermore, the new technique, recently publicized via Sacco et al in 2006, is to use concentrated growth factor (CGF) to assist in dental surgery for many aspects, such as periodontal surgery or bone augmentation.[5] CGF can be mixed with particulate bone powder to make sticky bone which helps creating bone augmentation more effectively.[5] Likewise, CGF can be compressed with metal cover to convert to CGF membrane that can substitute other types of membrane, such as collagen membrane or titanium mesh in the surgical procedure.[5-7]

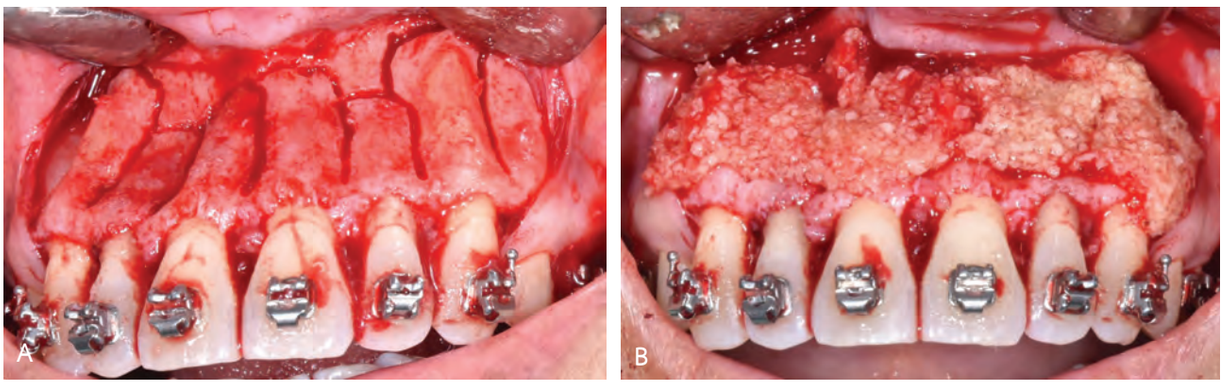
To evaluate the amount of bone gain after ACAO technique, cone beam computed tomography (CBCT) plays an important role in assessing the bone, which can be seen as 3-dimensional operative area, and can be measured directly via the 3-dimensional image.[8-10]

Thus, the purpose of this study was to evaluate the thickness of bone gain after ACAO combined with CGF in orthodontic treatment.

Materials and methods

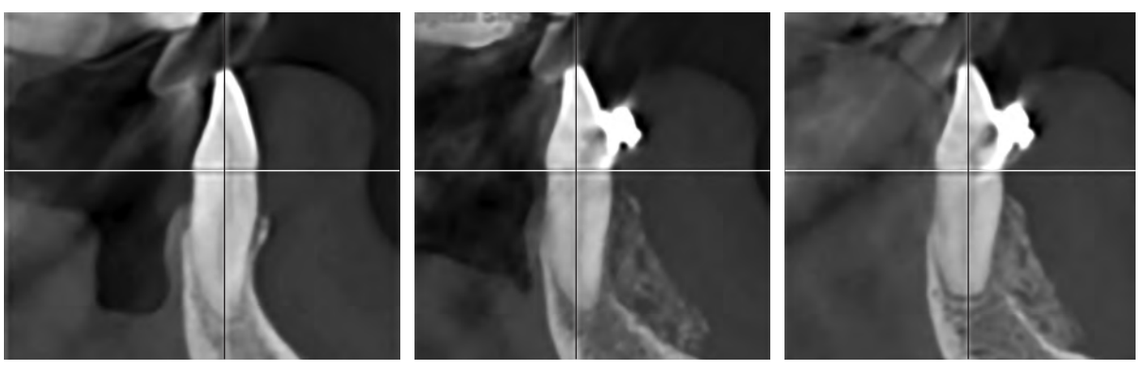
Eight patients, including 6 females and 2 males, mean age 46.5-year-old, who followed the inclusion criteria, were selected from the Orthodontic Clinic, Faculty of Dentistry, Bangkokthonburi University (Table 1). The inclusion criteria were as follows; 1) adult orthodontic patients, 2) thin labial plate or thin gingival biotype and 3) controlled mild to moderate periodontitis (according to the American Academy of Periodontology [AAP] 1999). All patients received periodontal charting, initial periodontal therapy and oral hygiene instruction before orthodontic treatment. The maintenance periodontal period was 3 to 6 months before orthodontic treatment depending on periodontist's consideration. The exclusion criteria were as follows; 1) smoking patient, 2) patient with diabetes, 3) devitalized area within bone, 4) long term use of nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroid during the study, 5) use of bisphosphonate drugs before and during the study, 6) active periodontitis, and 7) medically compromised patient which was contraindicated for surgical procedure.

Orthodontic process included bonding with self-ligated bracket (Tomy) and then loading force on 0.016" NiTi (Sentalloy, Tomy International Inc.) for at least 1 month. After the surgery, immediately loading



รูปที่ 1 *แสดงรายละเอียดการผ่าตัดกระดูกทึบร่วมกับการปลูกถ่ายกระดูก เพื่อการรักษาทางทันตกรรมจัดฟัน ในบริเวณฟันหน้าบน*
A: การกรอตัดกระดูกทึบในแนวดิ่งและแนวราบ และ B: การปลูกถ่ายกระดูกเหนียวซึ่งเป็นส่วนผสมระหว่างกระดูกวัวกับซีจีเอฟ

Fig. 1 *Showing the procedure of augmented corticotomy assisted orthodontics in maxillary anterior region.*
A: Vertical and horizontal corticotomies, B: application of sticky bone, the mixture of deproteinized bovine bone and CGF, over the corticotomy area.



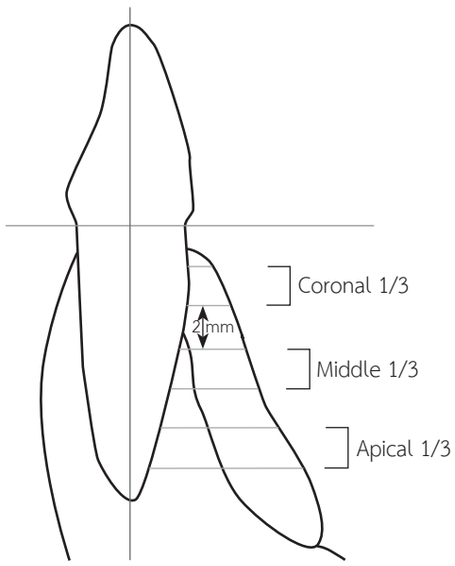
รูปที่ 2 *ภาพรังสีส่วนตัดอาศัยคอมพิวเตอร์แสดงความหนาของกระดูกด้านริมฝีปาก; ก่อนการผ่าตัด, หลังการผ่าตัด 6 และ 12 เดือน*

Fig. 2 *CBCT images demonstrated the labial bone thickness; before surgery, 6 months after ACAO surgery and 12 months after ACAO surgery.*

force on 0.016" NiTi was applied and activating was performed every month.

Surgical process was as follows; about 40-60 ml of patient's venous blood was drawn to prepare CGF using centrifuge (Medifuge, Silfradent S.r.l., Sofia, Italy) at 2400-2700 rpm. After full-thickness mucoperiosteal flap opening, corticotomy using 010 round and fissure diamond bur (Meisinger, Germany) was performed on observed tooth. The vertical osteotomy lines were performed, 2-3 mm from the bony crest to 2 mm from the root apex. After that, connecting each vertical line with horizontal line to make a perforation for a cortical bone layer was performed, following with the sticky bone (bovine bone [Bio-oss, Switzerland] mixed with CGF fluid) (Fig. 1) and CGF membrane respectively to cover corticotomy area, observed teeth and extended one distally tooth on each side.

The operative area was scanned using CBCT (Orthophos XG, Germany, 0.5 mm focal spot, 0.027 mm pixel size) to measure augmentation of the al-



รูปที่ 3 *ภาพแสดงการวัดความหนาของกระดูกด้านริมฝีปาก*

Fig. 3 *Illustration of measurement landmarks of labial bone thickness.*

veolar bone before surgery (T0) and at 6 months (T1) and 12 months (T2) after surgery (Fig. 2). By measurement the width of labial bone from root surface of observed tooth, perpendicular to long axis of each tooth, to outer surface of labial bone, tooth in operative area was measured from cementoenamel junction (CEJ) along root length to the apex in 2 mm interval (Fig. 3). The 3-dimensional radiographic image of each case was imported to Dolphins Program (Patterson Dental Supply, Chatsworth, USA) and measured through the program according to measurement protocol by one researcher. All measurements were repeated after 1 week by the same investigator, and the mean of the 2 measurements was compared. The data will be grouped equally into 3 groups, coronal 1/3, middle 1/3 and apical 1/3, according to the level of measurement from CEJ to root apex.

Using the SAS 8.02 software package (SAS Institute, Cary, NC), the descriptive statistical analysis, one-way ANOVA and Fisher's LSD were performed to compare labial bone thickness at T0, T1 and T2.

Results

According to Table 2, from T0 to T1, the mean labial bone thickness in every level section of root length (coronal 1/3, middle 1/3 and apical 1/3 of root length) was significantly increased, and then was significantly decreased from T1 to T2 ($p < 0.05$)

According to Table 3, in upper arch, from T0 to T1, the mean labial bone thickness in upper arch significantly increased from 0.50 ± 0.03 mm to 1.26 ± 0.08 mm and then significantly decreased to 1.08 ± 0.07 mm from T1 to T2 ($p < 0.05$). In lower arch, from T0 to T1, the mean labial bone thickness in lower arch significantly increased from 1.04 ± 0.07 mm to 1.97 ± 0.12 mm and then significantly decreased to 1.81 ± 0.11 mm from T1 to T2 ($p < 0.05$).

Discussion

Many studies have reported a similar technique to our study and found positive results from this technique.[1-3,11-13] Wilcko et al reported 2 cases using the ACAO technique. In the first case, a 23-year-old man received orthodontic treatment with corticotomy and bone augmentation.[1] Alveolar bone width was assessed using CBCT and researchers found that the bone at the lower left incisor increased from 0 mm to 2.4 mm at the B point, and to 3.6 mm on lingual side. In the second case, a 47-year-old healthy woman presented with bony fenestrations.[1] After de-bracketing for 17 months, the surgical site was reentered and it was found that the previous bony fenestrations were completely filled in with 3 mm of new healthy bone.[1]

Bhattacharya et al reported changes in alveolar bone thickness using 3-dimensional radiographic films in 20 patients, with 10 patients in an accelerated group and the others in a control group.[11] The researchers found that alveolar corticotomy with bone augmentation provided a significantly increasing al-

ตารางที่ 2 ค่าเฉลี่ยความหนาของกระดูกด้านริมฝีปากจากการวัดภาพรังสี 3 มิติในแต่ละช่วงเวลา T0, T1 และ T2 และค่าการเปรียบเทียบทางสถิติในแต่ละช่วงเวลา ในขากรรไกรบนและล่าง

Table 2 The mean of labial bone thickness in T0, T1 and T2 from 3-dimentional radiographic image measurement and comparing value of labial bone thickness between T0, T1 and T2 in the maxillar and mandibular arch.

Case	Arch	T0 (mean ± SD)	T1 (mean ± SD)	T2 (mean ± SD)	T0-T1 (mean ± SD)	T1-T2 (mean ± SD)	T0-T2 (mean ± SD)
Over all 8 cases	Max	0.503 ± 0.029	1.258 ± 0.078	1.114 ± 0.076	+0.755 ± 0.074*	-0.144 ± 0.034*	+0.611 ± 0.073*
	Mand	1.037 ± 0.070	1.969 ± 0.117	1.810 ± 0.107	+0.932 ± 0.091*	-0.159 ± 0.043*	+0.773 ± 0.084*

*significant difference ($p < 0.05$)

ตารางที่ 3 ค่าเฉลี่ยความหนาของกระดูกด้านริมฝีปาก จากการวัดภาพรังสี 3 มิติในแต่ละช่วงเวลา T0, T1 และ T2 และค่าการเปรียบเทียบทางสถิติในแต่ละช่วงเวลาในแต่ละระดับของความยาวรากฟัน

Table 3 The mean of labial bone thickness in T0, T1 and T2 from 3-dimentional radiographic image measurement and comparing value of labial bone thickness between T0, T1 and T2 in each level of the root length.

Arch	Level of root length	T0 (mean ± SD)	T1 (mean ± SD)	T2 (mean ± SD)	T0-T1 (mean ± SD)	T1-T2 (mean ± SD)	T0-T2 (mean ± SD)
Upper	Coronal 1/3	0.364 ± 0.057	0.607 ± 0.070	0.490 ± 0.062	+0.243 ± 0.073*	-0.117 ± 0.047*	+0.126 ± 0.061*
	Middle 1/3	0.561 ± 0.041	1.387 ± 0.103	1.187 ± 0.092	+0.826 ± 0.103*	-0.200 ± 0.051*	+0.626 ± 0.094*
	Apical 1/3	0.550 ± 0.051	1.737 ± 0.163	1.559 ± 0.169	+1.1187 ± 0.157*	-0.178 ± 0.074*	+1.009 ± 0.163*
Lower	Coronal 1/3	0.387 ± 0.058	0.525 ± 0.072	0.446 ± 0.058	+0.138 ± 0.072	-0.079 ± 0.042	+0.059 ± 0.064
	Middle 1/3	0.709 ± 0.095	1.783 ± 0.131	1.502 ± 0.111	+1.074 ± 0.144*	-0.281 ± 0.070*	+0.793 ± 0.144*
	Apical 1/3	1.970 ± 0.118	3.485 ± 0.215	3.378 ± 0.186	+1.515 ± 0.186*	-0.107 ± 0.096	+1.408 ± 0.161*

*significant difference ($p < 0.05$)

veolar width to support the teeth and overlying structures without any complication.[11]

In another study, by Wang et al, 10 patients received ACAO treatment.[12] The researchers measured labial bone thickness from 3-dimensional radiographic films, 3 months after augmented corticotomy and 2 years after orthodontic debonding, but there was no significant difference in labial bone thickness at 3/5 of the root length before surgery and 2 years after orthodontic debonding. However, the mean value of labial bone thickness at 4/5 of the root length increased from before surgery to 3 months after surgery and then decreased by 2 years after orthodontic debonding. In the apical area of the tooth, there was an increased mean of labial bone thickness between before surgery and 3 months after surgery, and no significant difference was found for the apical area between 3 months after surgery to 2 years after orthodontic debonding, which meant that the effect of the augmented procedure was stable in the apical area of the tooth.[12,13] The researchers recommended further study on improved surgical techniques and the local introduction of growth factors in order to achieve a favorable bone augmentation. Our study, as suggested, used CGF in the augmented area. In the present study, either augmented corticotomy assisted orthodontic treatment or ACAO was chosen with a combination of the recent innovation of CGF. Our results were, in agreement with the studies of Wilcko, Bhattacharya et al, and Wang et al, showing that the corticotomy

procedure combined with bone augmentation significantly improved labial bone support.[1-3,11-13]

According to our results, the labial bone thickness, in both the maxilla and mandible, was highest in T1 and then the thickness decreased in T2. It could be supposed that the bone remodeling process was involved in this bone thickness change. Thus, the labial bone thickness decreased at T2, which was the end state of bone remodeling process.

Our results demonstrated that labial bone, both maxillary and mandibular arches, at the apical 1/3 of the root length significantly increased due to the regenerative effect of bone augmentation combined with CGF, and had a better regenerative capacity than the augmented bone in the coronal 1/3 of the root length. One of the reasons for this might be the surgical technique used, including a suturing pressure and flap design.[14] The increased soft tissue tension from suturing after the surgical procedure might press an augmented bone material around the coronal level of the root length, leading to vertical bone loss at the coronal level of the root length. The augmented bone near the apical level of the root was far from the suturing pressure, leading to lower pressure and lesser bone loss at apical level of the root.[12-14]

In addition, the gingival morphology between the coronal and apical levels of the root were different. At the coronal level of the root length, gingival morphology was keratinized tissue that contained numerous collagen fibers and less blood supply from the vascular tissue compared with the soft tissue at apical level of the root.[12] Keratinized tissue is unfavorable for bone augmentation, as less room for augmented bone particles led to less enhanced osteoactivity from the vascular tissue.[12] In contrast, the apical area of the root length presented relatively loose and movable nonkeratinized alveolar mucosa and a high blood supply from the vascular tissues surrounding it.[12] That nonkeratinized tissue provided adequate space for augmented bone and provided grafting material stability.[12] Moreover, osteoactivity at the apical level of the root was also enhanced due to good blood supply from vascular tissues surrounding the apical area of the root. This resulted in promoting the osteoconductive ability of the bovine bone mineral.[12]

Many studies have evaluated the effectiveness of CGF. The results suggested that CGF could efficiently stimulate the proliferation and differentiation of osteoblast cells, resulting in an improved healing process, bone regeneration, and accelerated osseointegration.[15-18]

Fuhrmann et al[9] claimed that CBCT is a proven method statistically similar to histological measurements. Many studies have also shown that the quantitative evaluation of alveolar bone thickness provided accuracy to within a minimum bone thickness of 0.5 mm.[9,10]

Our study showed a difference between bone thickness in the 3-dimensional radiographic films and direct observations in the surgical procedure after the flap opening. Radiographic bony fenestration or dehiscence was present in some teeth in our observed cases, but there was no clinically bony fenestration or dehiscence in those areas. This might be the result of the overestimation of fenestration and dehiscence that occurs in 3-dimensional radiographic films.[19,20]

According to our measurements, the labial bone-thicknesses were in the range between 0.1 and 0.5 mm. That thickness range cannot be quantified accurately and is within the margin of error. The overestimation of fenestration and dehiscence in 3-dimensional radiographic films might provide a valuable reminder to orthodontists that even if the situation is not so bad,

we must remain cautions.[19,20]

In addition, Sirikaya et al[21] found that the tooth movement after bone remodeling was not 1 : 1 at 3 months after tooth movement ceased and that compensatory remodeling did not always match the amount of tooth movement. This might cause bony dehiscence and fenestration at the coronal and mid-root levels, especially in teeth presented at the thin labial bone. Thus, the overestimating that occurs in 3-dimensional radiographic films provided a valuable advantage to orthodontists.

Our results showed that bone density at T1 was reduced compared with that at T0. The labial cortical bone in T1 seemed to disappear from observed area. However, the bone density increased and returned to normal at T2. This might indicate bone healing after corticotomy followed by a regional accelerated phenomenon in the observed area.

In our study, there were no severe postoperative complication, such as irreversible endodontic lesion, nerve injury, root injury, or periodontal iatrogenic sequelae, during observation period.

Eventhough there was tooth movement from orthodontic force during observed period, this study used a long axis of the tooth as reference. The change of tooth angulation did not affect the results of this study.

In conclusion, ACAO combined with CGF can create bone during orthodontic treatment and demonstrate stable bone augmentation, especially at the bone apical 1/3 of root length. This technique considered a promising approach for the orthodontic treatment in adult patients.

Recommended for future study

The control group, ACAO without CGF, should be added to compare the result of this technique.

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