Effects on The Alveolar Bone Change Following Decortications-Facilitated Orthodontics for Mandibular Molar Protraction: A Clinical Study

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บทคัดย่อ

บทนำ ปัญหาที่พบได้บ่อยในผู้ป่วยที่มารับการรักษาทางทันตกรรมจัดฟันคือ การสูญเสียฟันกรามล่างซี่ที่1ไปเนื่องจากฟันผุ หลังถอนฟันกระดูกรองรับฟันจะฝ่อลีบ การเคลื่อนฟันผ่านกระดูกเบ้าฟันที่ฝ่อลีบหลังถอนฟัน เป็นสิ่งที่ยากและใช้ระยะเวลาการรักษานาน โดยเฉพาะอย่างยิ่งในกระดูกขากรรไกรล่างซึ่งมีกระดูกทึบที่หนา จะส่งผลให้การปรับรูปของกระดูกตามการเคลื่อนที่ของฟันเกิดขึ้นได้ช้าและยาก การเคลื่อนฟันกรามล่างซี่ที่2ไปด้านหน้าเพื่อปิดช่องว่างถอนฟันกรามซี่ที่1ถูกจำกัดโดยอัตราการปรับรูปของกระดูกทึบที่มีค่าประมาณ 0.5 มิลลิเมตรต่อเดือน นอกจากนี้การเคลื่อนฟันกรามล่างซี่ที่2ผ่านกระดูกทึบมาแทนที่ฟันกรามล่างซี่ที่1อาจเกิดภาวะแทรกซ้อนตามมาได้ ดังนี้ รากฟันละลาย เกิดรอยแยกกระดูก รากฟันโผล่ สูญเสียกระดูกรองรับฟัน สูญเสียหลักยึด ฟันตายและไม่เกิดการสร้างกระดูกขณะเคลื่อนฟัน **วัตถุประสงค์** การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาการเปลี่ยนแปลงของกระดูกรองรับฟัน และอัตราการเคลื่อนฟันกรามล่างมาทางด้านหน้าภายหลังจากการกรอกระดูกทึบร่วมกับการจัดฟัน **วัสดุและวิธีการ** กลุ่มตัวอย่างประกอบด้วยผู้ป่วยทางทันตกรรมจัดฟันจำนวน 13 ราย อายุเฉลี่ย 27.46 ปี อัตราการเคลื่อนฟันกรามล่างถูกเปรียบเทียบกับการศึกษาที่ผ่านมา 7การศึกษาที่ศึกษาการเคลื่อนฟันกรามล่างซี่ที่2มาปิดช่องว่างถอนฟันทางด้านหน้าในกลุ่มตัวอย่างที่หมดการเจริญเติบโตแล้วเช่นเดียวกัน เก็บข้อมูลการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟัน ระดับขอบกระดูก และความสูงของยอดกระดูกเบ้าฟันก่อนและ3เดือนหลังการเคลื่อนฟันกรามจากภาพรังสีโคนบีมคอมพิวเตตโทโมกราฟฟี วิเคราะห์อัตราการเคลื่อนฟันกรามล่างจากภาพรังสีวัดศีรษะด้านข้างก่อนและหลังการเคลื่อนฟัน **ผลการศึกษา** พบว่า ความหนาของกระดูกเบ้าฟันเพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p < .05$) ในขณะที่ระดับขอบกระดูก และความสูงของยอดกระดูกเบ้าฟัน ลดลงอย่างมีนัยสำคัญทางสถิติ ($p < .05$) แต่ค่าที่ลดลงอยู่ในระดับปกติที่พบได้ในการเคลื่อนฟันทางทันตกรรมจัดฟันแบบปกติ

สรุป การกรอกระดูกทึบร่วมกับการจัดฟันสามารถเคลื่อนฟันกรามล่างซี่ที่2 ผ่านช่องว่างถอนฟันที่ฝ่อลีบมาทางด้านหน้าพร้อมกับกระดูกรองรับฟัน และมีอัตราการเคลื่อนฟันที่เร็วขึ้นกว่า 3เท่า

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ABSTRACT

Introduction: A common clinical finding in adult orthodontic patient had loss of mandibular first molar due to caries. After extraction of mandibular first molar, alveolar portion starts to atrophy. Orthodontic tooth movement through atrophic extraction area is difficult and prolonged treatment time; especially in mandible that predominately cortical bone. The modeling/remodeling of alveolar bone was difficult and delayed. Mesial movement of mandibular second molar to close the mandibular first molar extraction space was limited by the rate of cortical bone remodeling which about 0.5 mm/mth. Moreover, mandibular second molar protraction through atrophic first molar extraction site took the risks including root resorption, dehiscence, fenestration, loss of alveolar bone support, anchorage loss, devitalization and no formation of new bone**. Objectives**: The aims of this study were to evaluate the alveolar bone changes and the rate of mandibular molar protraction following decortication-facilitated orthodontics. **Materials and methods:** 13 patients with the mean age of 27.46 years were included in this study. The rate of mandibular molar protraction was compared with 7 previous studied which mandibular first molar area were closed orthodontically in adult patients. Changes of alveolar bone thickness, marginal bone level and crestal bone height were assessed from pre-protraction (T_0) and 3 months post-protraction (T_2) cone beam computed tomography images. Rate of molar protraction was analyzed from pre-protraction (T_0) and post-protraction (T_1) lateral cephalometric radiographs. **Results**: The alveolar bone thickness of edentulous ridge was statistically significant increased ($p < .05$), while the marginal bone level and the crestal bone height were statistically significant decreased ($p < .05$). However, this is a normal situation of orthodontic tooth movement. **Conclusion:** Decortication-facilitated orthodontics

assisted mandibular molar protraction could be move the mandibular second molar forward through the atrophic edentulous area with the bone and the rate of protraction was increased over 3-time.

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LISTS OF ABBREVIATIONS AND SYMBOLS

mm	=	millimeter
et al.	=	and others
g	=	gram
CBCT	=	cone-beam computed tomography
NSIADs	=	non steroidal anti-inflammatory drugs
RAP	=	regional acceleratory phenomenon
PAOO	=	periodontally accelerated osteogenic orthodontics
NiTi	=	nickel titanium
TMA	=	titanium molybdenum
Fig.	=	figure
CEJ	=	cemento-enamel junction
OP	=	occlusal plane
OPp	=	occlusal plane perpendicular
MP	=	mandibular plane
S	=	sella
NSP	=	nasion-sella plane
T0	=	time before alveolar decortication
T1	=	time after mandibular molar protraction
T2	=	time after mandibular molar protraction for 3 months
%	=	percent
”	=	inch(es)
/	=	per

CHAPTER 1

INTRODUCTION

Background and rationale

A common clinical finding in the adult orthodontic patient was posterior spacing due to missing mandibular teeth. Excluding the third molars, the mandibular second premolar is the most common congenitally absent tooth[1] while the mandibular first molar is the most frequently lost tooth in adults[1-3]. When the first molar was lost, the second molar usually tips mesially[3-5], the second premolar drifts distally[3], altered gingival form[4, 5] and constriction of the edentulous ridge[2, 3, 6-9]. Under most circumstances, there are three clinical options for management of missing mandibular first molars:

1. Alignment of the abutment teeth as needed, followed by placement of a fixed partial denture (FPD).
2. Fabrication of an implant-supported crown as a single tooth replacement (STR).
3. Orthodontic space closure.

Disadvantages of a fixed partial denture and implant-supported crown are mean life span often 10 to 15 years, increases risk of caries and periodontal disease, damage to health teeth and high cost[10].

After extraction of the mandibular first molar, the alveolar portion of the jaws starts to atrophy[6, 11] because lost of bucco-lingual cortical plate, clot retraction, resorption of alveolar bone during the healing process or mastication impairment. Displacement of teeth into substantial atrophy of the alveolar ridge has considered a major limitation; especially in the posterior part of the mandibular arch, because of predominately cortical bone, less trabecular bone, less cellular, less vascular and the mandibular molar roots are extremely wide buccolingually[4, 9, 12-13]. Orthodontic tooth movement is a process whereby the application of a force induces bone resorption on the pressure side and bone apposition on the tension side[14-15]. Classically, the rate of orthodontic tooth movement depends on the magnitude and duration of the force[14], the number and shape of the roots[16], the quality of the bony trabeculae[17-20], the patient's response, and the patient's compliance. Orthodontic translation through cortical bone was limited by the linear rate of osteoclastic resorption, which is about 0.5 millimeter per month[21]. Therefore, to close the mandibular first molar extraction space that about 10-12 millimeters, mesial movement of the mandibular molar usually take long treatment time about 2 years and demand substantial anchorage[2, 3, 21]. Moreover, the longer orthodontic treatment duration takes, the more risks for the patient. Risks in orthodontic treatment include enamel demineralization, caries, periodontal disease and root resorption[22]. And the duration of orthodontic treatment is one of the things that orthodontic patients complain about most—especially adult patients[23].

Previously, parameter use clinically to evaluation of interdental bone was bitewing or periapical film[24]. This conventional dental radiograph was limited to identifying anatomic and pathologic structures of intraoral hard tissues[25] and cause of an underestimation of interdental alveolar bone loss[24, 26]. With low-dose cone-beam computed tomography (CBCT) technology, it is possible to obtain accurate radiographic images that allow clinicians and researchers to quantitatively evaluate hard-tissue changes in 3 dimensions[27-29].

Review of literatures

Some orthodontists prefer to open the atrophic extraction space by uprighting the molar and stabilized with prosthesis, fixed partial denture or implant-supported crown. For instance, Graber (1972)[12] stated that space closure of the molar area was seldom possible or desirable. Movement of molar teeth was often difficult because of the greater root surface area, the increased tissue resistance, and the anchorage needs involved. He advocated uprighting the second molar to its normal position and stabilizing it with a fixed or removable prosthesis. Kessler (1976)[4] suggested that if the buccolingual width of the second molar alveolus was wider than the adjacent edentulous ridge; the tooth should not be moved mesially because resulted in loss of the bone support, especially in adults. Because of alveolar bone surface adjacent to adult teeth were frequently aplastic that there had delayed in the formation and mobilization of osteoblasts, osteoid and bone formation in adults. Orthodontic tooth movement over long distances in adults might produce unavoidable loss of alveolar bone particularly at the alveolar crest.

While the studies of Brown (1973)[5] and Roberts (1982)[9] informed that though the tooth movement through cortical plate or atrophic extraction site was possible, the disadvantages of root resorption, dehiscence, and prolonged treatment time generally outweigh the advantages. Creation of pontic space by correction of molar inclination and stabilization improved the health of the molar periodontium, protected the inflammatory periodontal diseases and occlusal traumatism because this therapy produced significant reduction in the depth of existing periodontal defects and highly desirable changes in the gingival architecture.

Roberts, *et al*. (1994)[10] considered the long-term consequences and the total cost of conventional prosthodontics compare with orthodontic space closured, suggested that although the conventional fixed partial denture has a high rate of success initially, it had limitations relative to prosthetic longevity. Furthermore, undesirable side effects or complications could occurred, including loss of pulpal vitality, mechanical failure (fracture, loss of retention, etc.), secondary caries, and periodontal disease. It is more likely that the prosthetic options will require additional treatment (as endodontic treatment following placement of fixed partial denture) with added expense. Therefore, orthodontic space closure might proved to be the most cost-effective option overall, particularly for adolescents and young adults who usually required at least five decades of longevity. They mentioned that no prosthetic device is equivalent to a natural tooth.

Protraction of mandibular molar for close the extraction site:

Generally, there were two methods to close the extraction site; conventional orthodontic treatment[2, 3, 13, 30] or conventional orthodontic together with skeletal anchorage reinforcement (rigid endosseous implant [21, 31], bicortical microimplant[32], or miniscrew[33-34]). Stepovich (1979)[2] studied the changes in the edentulous ridge and adjacent teeth before and after closure of first molar spaces in the mandible using rectangular wire Bull loop retraction in an .022 slot. It was found that spaces of 10 millimeters or more in posterior mandible could closed in young adults (average treatment time was 27.8 months) as well as adults (average treatment time was 32.3 months). But the half the adult patients resisted forming any new bone during space closure. The other half developed only small amounts of new bone. The young adults had four times more bone to the width of the alveolar ridge during space closure. Loss of crestal bone height and gingival recession were seen in both groups but more evident in the adult patients.

Hom and Turley (1984)[3] studied the dental and periodontal changes occurred when mandibular first molar areas were closed orthodontically in 14 adult patients, using closing loops on rectangular wires. The treatment time ranged from 23 to 52 months. He found that every case had significant space closure (a mean of 6.2 millimeters), but only 5 of 19 quadrants had complete space closure on post-treatment models. Nine patients had crestal bone loss mesial to the second molars; however five patients showed bone addition. Half the patients showed increasing the width of alveolar ridge buccolingually 1.1 millimeters as the second molar moved forward. The other half showed narrower alveolar ridges after treatment. There was no correlation between ridge width and changed in vertical bone height. This study is in agreement with the finding of Cacciafesta and Melsen (2001)[13] which was showed that second mandibular molars can be moved forward through atrophic alveolar ridge by use of superelastic Ni-Ti springs.

A case report of Robert, *et al* (1990)[21], endosseous implant was placed in the retromolar area of the mandible as a rigid anchorage to translate mandibular molars mesially into an atrophic edentulous ridge. They claimed that a rigid endosseous implant was successfully used as the principle anchorage to intrude and mesially translate second and third molars into an atrophic first molar extraction site. However, the results showed that there was a possibility that mandibular molars could be devitalized when they were moved in great distances. And 10-12 millimeters of space closure through dense cortical bone was required approximately two years, because the rate of cortical bone remodeling was about 0.5 millimeters per months. They informed that not all atrophic ridges are candidates for space closure. In this case, there was no evidence upon on periodontal and radiographic examinations of fenestration or dehiscence. The overall mechanic approach to space closure was designed to lessen the possibility of creating a fenestration or dehiscence during space closure. Robert, *et al.* (1996)[31] used of osseointegrated retromolar anchorage to close large spaces (8 millimeters or more) for studying steady state skeletal physiology during a period of sustained tooth movement. They suggested that orthodontic translation was a physiologic manifestation of bone modeling and remodeling throughout the adjacent alveolar process and the rate of mandibular molar translation was inversely related to the apparent radiographic density of the resisting alveolar bone. During the last year of space closure, radiolucent foci were noted ahead of the distal root.

A study of Wu, *et al.*(2007)[32] performed in beagle dog, using a newly designed bicortical microimplant for mesial movement of posterior teeth in the mandibles. Because of microimplants and microscrews have advantages over conventional implants; they could placed not only in edentulous alveolar and midpalatal areas but also at alveolar segments and even around root apices. And bilateral orthodontic force system applied to the center of resistance of the molar was preferred to mesiodistal displacement of teeth. The disadvantages might including complicated placement of the bicortical microimplant and a possible intense tongue reaction.

A case report of Kyung, *et al*. (2003)[34], both mandibular second molars were moved into first molar extraction sites by two miniscrews, inserted into the lingual alveolar bone between the premolar roots and connected to a lower lingual arch with elastic chain. In this case, reported the difficult to place the screws precisely because of poor visibility and access. Superimpositions of pre- and post-treatment cephalometric tracing showed mandibular second molars translated about 9mm mesially with no appreciable retraction of anterior teeth. This study was likely with the finding of Nagaraj, *et al*. (2008)[33] which was performed by placed the titanium screws in the buccal alveolar bone between the roots of the first and second premolars and Ni-Ti coil spring were stretched between the molar hook and the titanium screw head.

Kravitz and Jolley (2008)[1] stated that anterior dental anchorage is often inadequate to protract even a single first molar without reciprocal retraction of the incisors or movement of the dental midline. Furthermore, if the buccal and lingual cortical plates in the edentulous region have collapsed, safe and effective protraction may be impossible. Potential risks of molar protraction with temporary anchorage devices through an atrophic ridge include loss of attachment (particularly in the presence of plaque), mobility, ankylosis, root resorption, devitalization, tooth morbidity, dehiscence and fenestration.

The innovative orthodontic method that offers the short treatment times and the ability to simultaneously reshaped and increased the buccolingual thickness of the supporting alveolar bone was first described in 2001 by Wilcko and Wilcko[35]. This technique performed buccal and lingual full-thickness flaps, selective alveolar decortication of the cortical plates (extended just barely reaches into medullary bone) on the teeth to be moved orthodontically, concomitant bone augmentation, and primary flap closure. After the surgery, orthodontic adjustments were made approximately every 2 weeks. They patented and trademarked their technique as Periodontally Accelerated Osteogenic Orthodontics (PAOO) or " Wilckodontics". They claimed that the incorporation of the bone augmentation into the corticotomies site because this made it possible to complete the orthodontic treatment with a more intact periodontium, created greater alveolar bone volume which eliminated bony dehiscences and fenestrations, and enhanced the stability of the orthodontic treatment result.

Several authors had described rapid tooth movement in conjunction with corticotomy surgery as movement by bony "block". Köle (1959)[36] reported combining orthodontics with corticotomy surgery and completed the active tooth movement in adult orthodontic cases in 6 to 12 weeks. The interproximal corticotomy cuts were extended through the entire thickness of the cortical layer, just barely penetrating into the medullary bone. These vertical cuts were connected beyond the apices of the teeth with a horizontal osteotomy cut extending through the entire thickness of the alveolus, essentially creating blocks of bone in which one or more teeth were embedded. Using the crowns of the teeth as handles, Köle believed that he was able to move the blocks of bone somewhat independently of each other because they were only connected by the less-dense medullary bone. He found no incidence of root resorption, no loss of tooth vitality, and no pocket formation. Similary to finding of Suya (1991)[37]which believed that tooth movements were made by moving blocks of bone using the crowns of the teeth as handles. But Suya's surgical technique differed from Köle's with the substitution of a supraapical horizontal corticotomy cut in place of the horizontal osteotomy cut beyond the apices of the teeth.

On the other hand, Wilcko and Wilcko (2001)[35] believed that the concept on rapid tooth movement after corticotomy was supported by the "regional acceleratory phenomenon (RAP)". Orthopedist Harold Frost[38] recognized that surgical wounding of osseous hard tissue results in striking reorganizing activity adjacent to the site of injury in osseous and/or soft tissue surgery. He collectively termed this cascade of physiologic healing events the regional acceleratory phenomenon (RAP). RAP healing is a complex physiologic process with dominating features involving accelerated bone turnover and decreases in regional bone densities. Trauma to cortical bone, osteotomy, bone grafting, or even flap operation have been shown to be a potentiating factor in producing a localized osteoporosis. For alveolar bone, this transient osteoporosis would facilitate more rapid tooth movement. Osteoporosis provides a favorable environment for increasing the rate of tooth movement without increasing the risk of root resorption in rats[39]. Moreover, it has been demonstrated that the residual soft tissue matrix has the ability to induce remineralization after the cessation of tooth movement[40]. All of this suggests that the dynamics of the physiologic tooth movement after osteotomy might be more appropriately described as a demineralization/remineralization process, rather than bony block movement or resorption/apposition. This perspective is substantiated by the fact that there is a growth protein component in the soft tissue matrix of bone[41]. Following cessation of the active tooth movement, this growth protein component may assist in stimulating an increase in osteoblastic activity, resulting in remineralization of the soft tissue matrix. Yaffe *et al.*[42] suggested that RAP in humans begins within a few days of surgery, typically peaks at 1 to 2 months, and may take from 6 to more than 24 months to subside. During RAP, extensive regional intra-cortical bone remodeling occurs, recruiting cellular activity necessary for activation of the subsequent healing process. Cho *et al.*[43] found that in the periodontal tissue with corticotomy, an increasing number of osteoclasts, osteoblasts, fibroblasts, cementoblasts with developed organelles were noted. The rate of tooth movement with corticotomy was 4 times greater than without corticotomy. However, 6 months after corticotomy, these cells were severely decreased in number and cellular activity.

Ferguson, et al. (2007)[44] suggested that the clinical technique involving selective alveolar decortications was a form of periodontal tissue engineering. There were three tissue engineering principles associated with the selective alveolar decortications technique.

1. Decortications surgery initiates the local tissue repair and the production of osteoprogenitor cells (signaling and angiogenesis) and osteoinductive agents (mostly from the hemorrhage)
2. Low turnover tissues were replaced with high turnover tissues that functionally normal, a reversible condition often referred to as osteopenia (diminished bone density but not bone volume)
3. High tissue turnover was promoted in a precise anatomic area; that was, immediately adjacent to the area of desired tooth movement. The tissue was formed in the alveolus surrounding the area of desired tooth movement respond effectively to biomechanical forces, and teeth move rapidly.

In summary, the contributions of periodontal therapy to orthodontic treatment via Periodontally Accelerated Osteogenic Orthodontics was increased alveolar volume and enhanced the periodontium, enhanced the stability of orthodontic clinical outcomes (less relapse), increased the scope of malocclusion treatable without orthognathic surgery, and reduced active orthodontic treatment time over 3-fold. These benefits were realized for two reasons[44]:

1. Tissues lose memory due to high hard and soft tissue turnover induced by the periodontal decortications.
2. Augmentation bone grafting increased alveolar volume and thickness of the alveolar cortices.

Up until now, the studies regarding mandibular molar protraction through the atrophic edentulous ridge had stay in place, which used conventional orthodontic methods (closing loops, closed coil spring) or reinforced anchorage for mesialized mandibular molar by endosseous implant, bicortical microimplant and miniscrews. There were not rescue to reduced the complications or increased the rate of mandibular molar protraction through the atrophic edentulous ridge. Therefore, it was interesting to search a new orthodontic method that could assist protraction of the mandibular molar with surrounding periodontium, reduce the complications and the treatment time.

Objectives

1. To evaluate the alveolar bone changes of the mandibular first molar extraction site and the mandibular second molar following decortication-facilitated orthodontics for mandibular molar protraction.
2. To evaluate rate of mandibular molar protraction following decortication-facilitated orthodontics.

Hypotheses

1. The bucco-lingual width of alveolar bone of the mandibular first molar extraction site will increase while maintain alveolar bone support of mandibular second molar following decortication-facilitated orthodontics for mandibular molar protraction.

2. The rate of mandibular molar protraction following decortication-facilitated orthodontics will faster than previous studies.

Significances of the study

1. Decortication-facilitated orthodontics can present a viable alternative solution in a treatment of mandibular molar protraction.
2. Decortication-facilitated orthodontics can reduce some problems of mandibular molar protraction.

The limitations of the study

This study was performed under the limitation of time, thus the long-term effect from this technique, such as pulpal vitality, periodontal condition, or root resorption could not be investigated.

CHAPTER 2

RESEARCH METHODOLOGY

Samples

The population for this study was defined as adult patients who intend to receive orthodontic treatment in the Orthodontic clinic, Dental hospital, Faculty of Dentistry, Prince of Songkla University. The 13 samples were selected from the new patient pool base on the inclusion criteria.

Sample size was calculated from the equation following Kittika, 1999[45]

$$\text{Sample size (n)} = \frac{(z_{(1-\alpha)} + z_{(1-ß)})^2 \, SD^2 \, \text{diff}}{(\overline{X}_2 - \overline{X}_1)^2}$$

SD diff: difference standard deviation between group = 0.5 (Saikaya *et al,* 2002)

α: significant level 0.05

1-ß: power of test = 80%

The inclusion criteria were:

1. Age 18-35 years old.
2. Loss of mandibular first molar that bucco-lingual width of medullary bone was less than bucco-lingual width of cervical1/3 of mesial root of the mandibular second molar; assessed from cone-beam computed tomography (CBCT), Fig. 1
3. After mandibular second molar was protracted, the lastest tooth in maxillary arch had occluded.
4. The patients could come to follow up and activation of appliance every 2 weeks until space closed.
5. No long term use of Corticosteroid, NSIADs, Bisphostphanate[46].
6. No sign and symptom of periodontal disease

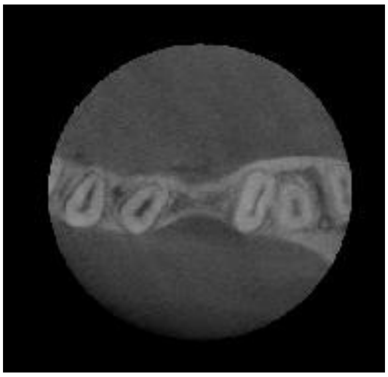


Fig. 1 CBCT indicated width of edentulous ridge was less than width of mesial root of the mandibular second molar

Each patient was informed about the study and the consent form was signed prior to the study. The patients received repeated oral hygiene instructions for the use of toothbrush and dental floss during the study.

The patients were instructed to avoid non steroidal anti-inflammatory agents in the month before appliance placement and during the study. In case of toothache due to orthodontic procedure, the patients were instructed to take acetaminophen.

Materials and methods

This study was certified by ethic committee of Faculty of Dentistry, Prince of Songkla University. Pre-adjusted edgewise appliances (Roth prescription) with 0.018”-slot in anterior teeth and 0.022”-slot in posterior teeth were used for full arch. The teeth were aligned and leveled until complete on 0.018”x0.025” stainless steel archwire. Upper and lower impressions, lateral cephalograph, and CBCT were taken for pre-operation records. From initial CBCT found that the mesial root of mandibular second molar (according to the treatment plan) was moved out off alveolar bone housing (Fig.2). Before the surgical procedure (T0), bucco-lingual width of edentulous ridge at the narrowest, bucco-lingual width of edentulous ridge that the mesial root of mandibular second molar would be moved according to the treatment plan, height of crestal bone mesial to mandibular second molar, buccal and lingual marginal bone level of mandibular second molar were assessed by CBCT. Position of mandibular second molar, position of mandibular second premolar and inclination of mandibular second premolar were assessed by lateral cephalograph. Then, Periodontally Accelerated Osteogenic Orthodontics was performed.

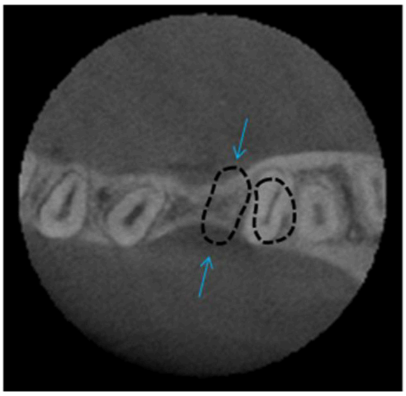


Fig. 2 CBCT before alveolar decortications, the mesial root of mandibular second molar following to the treatment plan was moved out off alveolar bone housing

Surgical procedure

The surgical procedure was performed on the edentulous area to the mandibular second molar by 1 surgeon, following these steps:

1. Local anesthesia with inferior alveolar nerve block.
2. Buccal and lingual full-thickness flaps.
3. The alveolar decortications of the buccal and lingual cortical plates (Fig.3) were done.

Fig. 3 The selective alveolar decortications of buccal and lingual cortical plates

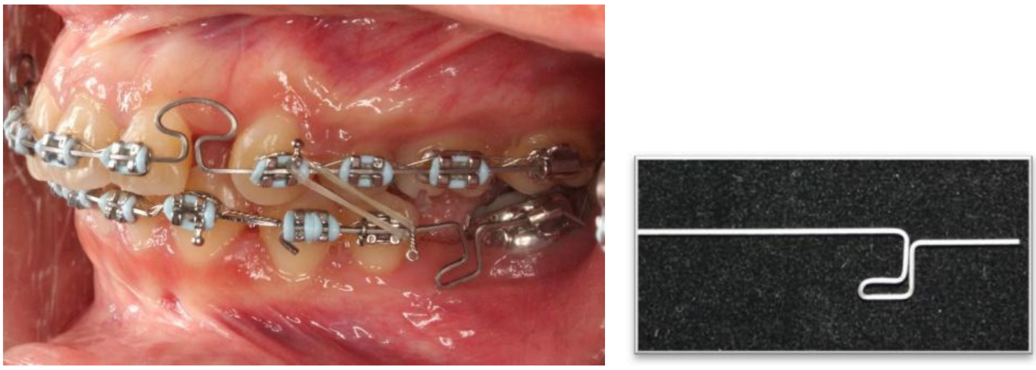
4. Bone grafting of allograft mixed with cortical autograft (from decortications) were applied to the corticotomy site.(Fig.4)
5. Primary flap closure was done.

A

B

Fig. 4 A: Mixed of allograft and cortical autograft. B: Mixed of allograft and cortical autograft was applied to the corticotomy site.

Two weeks later, segmented L-loop was used to protract the mandibular second molar and activated every 2 weeks until space closed (Fig.5A). Mandibular teeth were divided into two units, which were anchorage unit (from the second premolar of surgical side to the second molar of another side) and movement unit (the second molar distal to edentulous area). The 0.018”x0.025” stainless steel wire was engaged in anchorage unit and the 0.017”x0.025” titanium molybdenum segmented L-loop wire was overlayed on the first and second premolar and engaged to the second molar. To eliminate the occlusal interference between the upper and the lower molars during mandibular molar protraction, which might be a confounding factor to the rate of tooth movement, the segmented L-loop has step down about 1 millimeter at the distal arm (Fig.5B). To create mesial root torque and to prevent mesio-lingual rotation of the mandibular second molar during protraction, a tipback bend and toe in were applied on distal arm of the segmented L-loop. The impressions were taken every month. The intra-oral photographs were taken every 2 weeks. After space closed, lateral cephalometric radiograph was taken (T1) to assess the rate of mandibular molar protraction, amount and inclination of anchorage loss. CBCT was taken at 3 months after space closed (T2) to evaluate alveolar bone changes.



A. B.

Fig. 5 A: Mechanic was used for mandibular molar protraction. B: The 0.017”x0.025” TMA segmented L-loop wire with step down about 1 mm.

Records and data analysis

Parameters measured in this study included bucco-lingual width of edentulous ridge, height of crestal bone, buccal and lingual marginal bone level of mandibular second molar which were analyzed from CBCT. Mandibular molar movement was analyzed from lateral cephalograms.

Cephalometric analysis

To evaluate the rate of mandibular second molar protraction, the amount and inclination of anchorage loss, the lateral cephalometric radiographies were taken before alveolar decortication and after edentulous space closed. The occlusal plane (OP), occlusal plane perpendiculare (OPp) and mandibular plane (MP) from the first lateral cephalometric radiograph were used as a reference grid. The grid was transferred from the first tracing to the following tracings by superimposition of the tracing on the nasion-sella plane (NSP) with sella (S) as registering point[47]. The mandibular second molar position was measured from the most anterior contour of the mandibular second molar parallel to OP, to OPp. The mandibular second premolar position was measured from the most posterior contour of the mandibular second premolar parallel to OP, to OPp (Fig.6A). The inclination of mandibular second premolar (IP) was measured from angle between long axis and mandibular plane (Fig.6B). Rate of mandibular second molar protraction (mm/mth) was calculated from the distance of mandibular second molar movement from T0 and T1 divided with treatment time. Anchorage loss (amount and inclination) were analyzed by the changes of position and inclination of mandibular second premolar between T0 and T1.

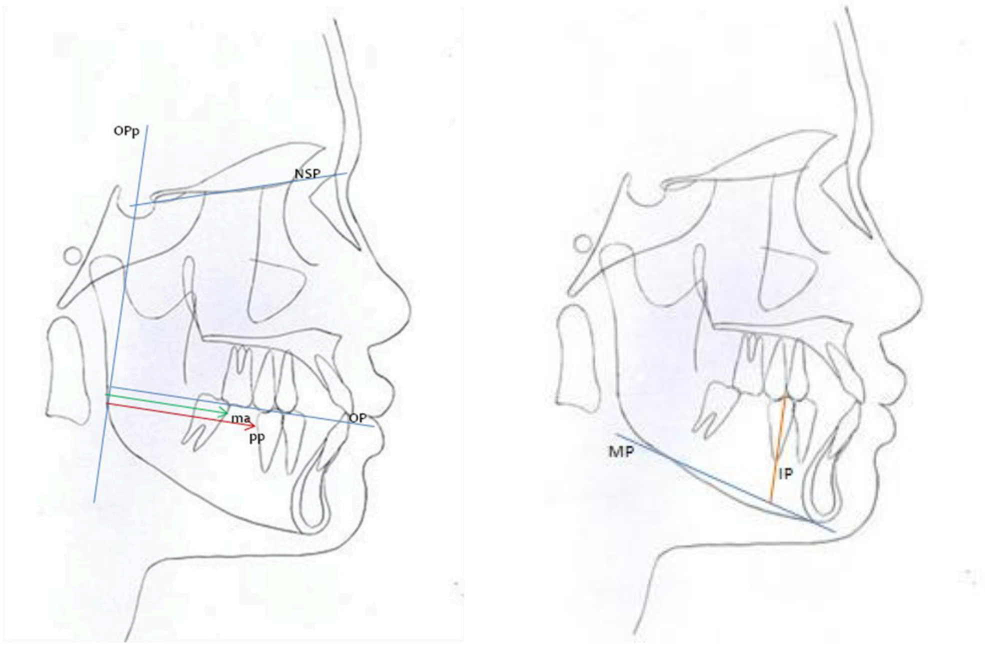
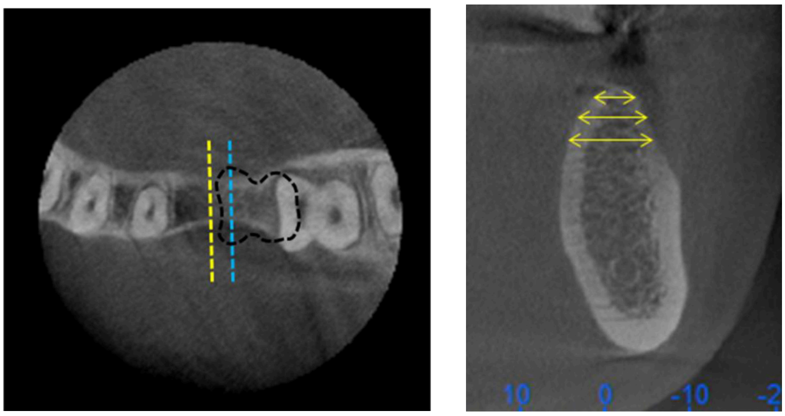


Fig. 6 The lateral cephalographs were assessed mandibular second molar position, mandibular second premolar position (A), and inclination of mandibular second premolar (B).

Computed Tomographic analysis

The changes of alveolar bone was evaluated from CT scan (Veraviewepocs J Morita MPG (80 kv, 5mA)) according to study of Fuhrmann RAW et al[48]. To evaluate the bucco-lingual width, CBCT sections were perpendicular to occlusal plane. To evaluate the height of crestal bone and buccal-lingual marginal bone level, CBCT sections were parallel to the mandibular second molar.

The bucco-lingual width of edentulous ridge was measured two areas (Fig. 7A), at the most narrow and at the point that mesial root of mandibular second molar was moved following the treatment plan. Measurement between the outer surface of buccal and lingual plates at the level of 2mm, 4mm, 6mm and 8mm below to cement-enamel junction (CEJ) of mandibular second premolar (Fig. 7B) because the root was taper from coronal to apical while the alveolar bone support was wider apically. The bucco-lingual width of edentulous ridge at 8mm below to CEJ of all subject in our studied had wider than the width of molar roots, then we were measured until 8mm below to CEJ. The first CBCT section perpendicular to the occlusal plane was at distal surface of mandibular second premolar and sectioning every 1.5 mm to mandibular second molar.



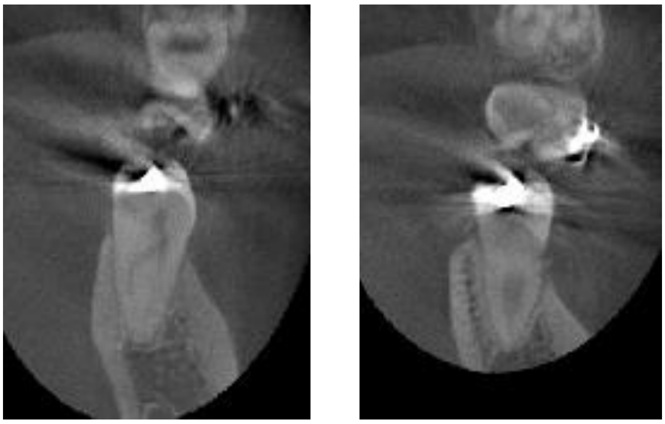
A. B.

Fig. 7 CBCT section at the narrowest of edentulous ridge and at the area that mesial root of mandibular second molar was moved following the treatment plan (A). The bucco-lingual width of alveolar ridge was measured at 4mm, 6mm and 8mm below CEJ (B).

The bucco-lingual width of mesial root of mandibular second molar was measured at the level of 2mm, 4mm, 6mm and 8mm below to cement-enamel junction (CEJ) of mandibular second molar (Fig. 8)

The buccal and lingual marginal bone level at mid-mesial root and mid-distal root of mandibular second molar (Fig. 9) were measured from CEJ to the apical limit of the bone defect (Fig 8).

Fig. 8 The bucco-lingual width of mesial root of mandibular second molar was measured from buccal to lingual borders, C2. The marginal bone level was measured from CEJ to the apical limit of the bone, C3.



A. B.

Fig. 9 CBCT were assessed the buccal and lingual marginal bone level at mid-mesial root (A) and at mid-distal root (B).

The height of crestal bone mesial to mandibular second molar was measured from CEJ to highest point of crestal bone (Fig. 10) according to study of Baxter DH[49] (Fig. 11).

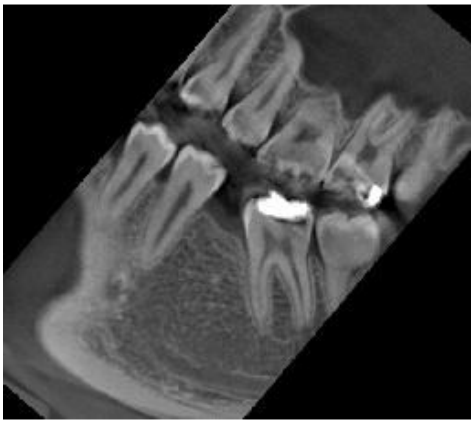


Fig. 10 CBCT (sagittal section) assessed the height of crestal bone mesial to mandibular second molar, from CEJ to highest point of crestal bone.

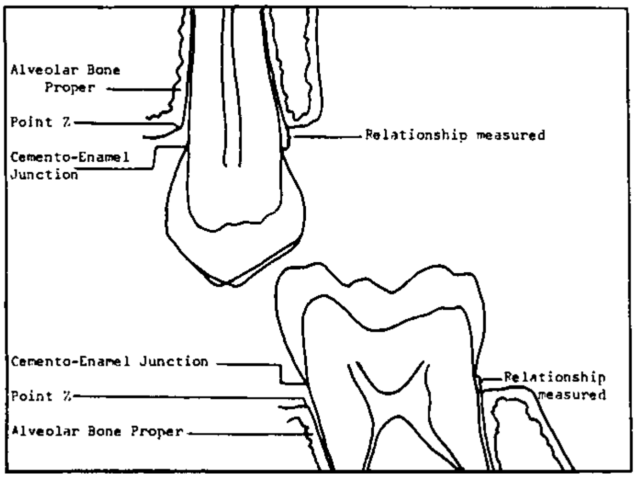


Fig. 11 Schematic drawing of structures studied in intraoral bitewing roentgenograph. Alveolar crest is the most occlusal edge of the alveolar bone proper, as point Z[49].

Statistical analysis

The measurements of all samples were repeated twice and averaged. Paired t-test and Dahlberg's formula were used to determine the intraobserver reliability. Shapiro-Wilk normality test was used to test normal distributed population. Unpaired t-test was used to compare the rate of mandibular molar protraction between this study and 7 previous studies which had age of subjects and mechanic close to this study. While paired t-test was used to compare the alveolar bone changes (bucco-lingual width, buccal marginal bone level, and crestal height) of subject between before molar protraction and 3 months after space closed. The values of $p < .05$ were evaluated as statistically significant.

CHAPTER 3

RESULTS

The 13 samples in this study included 9 females and 4 male. Their mean age at the start of the treatment was 27.46 ± 5.59 years, range from 22-35 years. Mean extraction space was 5.88 ± 2.01 millimeters, range from 3.5-11.5 millimeters. Mean mandibular second molar movement was 5.04 ± 1.97 millimeters, range from 3.5-10.5 millimeters. Mean treatment time was 4.00 ± 1.37 months, range from 3-6.5 months. Mean rate of mandibular molar protraction was 1.21 ± 0.29 millimeters/month, range from 0.71-1.66 millimeters/month. (Table 1)

Measurement error analysis

All measurements were repeated 2 weeks apart and calculated to determine the intraobserver reliability. Dahlberg's error[50] was calculated from eqution;

$$ME = \sqrt{(\sum D^2) / 2N}$$

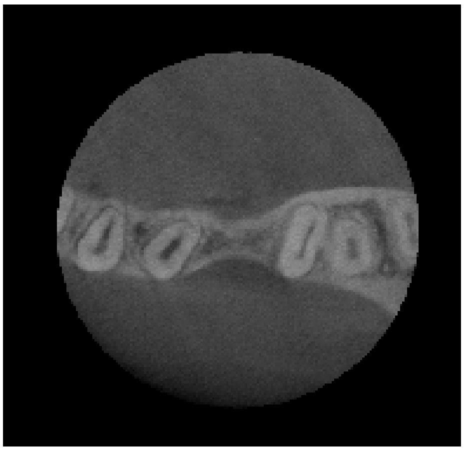
Where ME is the error of measurement, D is the difference between repeated measurement and N is the number of double measurements. The error in this study was 0.24 mm, ranging from 0.00 to 0.35 mm for the distance measurement from computed tomography, 0.10 mm, ranging from 0.00 to 0.20 mm for the distance measurement from lateral cephalometric radiographs. Paired t-test showed no significant difference between two series of measurements.

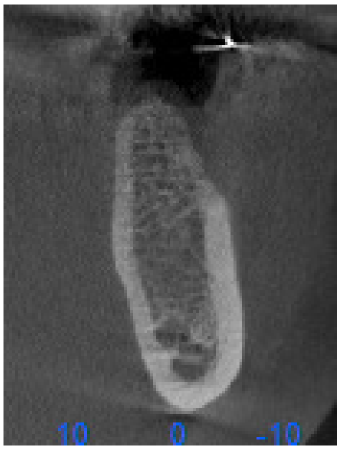
Table 1 Gender, age, extraction space, mandibular second molar movement, treatment duration and rate of molar protraction of each subject in this study.

Subject	Gender (Male / Female)	Age (Year)	Extraction space (mm.)	Mandibular molar movement (mm.)	Treatment duration (mth)	Rate of molar protraction (mm./mth)
1	F	35	11.5	10.5	6.5	1.55
2	M	22	6	5.5	4	1.37
3	M	23	7.5	7	6	1.16
4	F	35	5	5	5	1.00
5	F	35	6	6	6	1.00
6	M	28	3.5	3.5	3.5	0.71
7	M	35	6.5	4.5	3	1.50
8	F	24	5	4	3	1.50
9	F	25	4.5	3.5	3	1.00
10	F	22	6.5	5	3	1.66
11	F	28	5.5	4	3	1.33
12	F	23	4	3.5	3	1.00
13	F	22	5	3.5	3	1.00
Mean ± SD		27.46 ± 5.59	5.88 ± 2.01	5.04 ± 1.97	4.00 ± 1.37	1.21 ± 0.29

The bucco-lingual width of edentulous ridge

When mandibular molar was extracted, the alveolar ridge became atrophy both bucco-lingual and occluso-gingival dimensions. The CBCT data of every subject were shown that shape of edentulous ridge was concavity from second molar to second premolar (axial section; fig.12A) and gradually decreased occlusally (coronal section; fig. 12B).





A. B.

Fig. 12 Shape of alveolar ridge when mandibular molar was extracted; concavity from second molar to second premolar (A) and bucco-lingual width gradually decreased occlusally (B).

Before decortications-facilitated mandibular molar protraction was performed, the bucco-lingual width at the narrowest of edentulous ridge and the bucco-lingual width of edentulous ridge that the mesial root of mandibular second molar would moved following the treatment plan were defined and measured. The bucco-lingual width of edentulous ridge in both area of each subjects found that no alveolar bone support at 2 mm below to CEJ. The means of bucco-lingual width at the most narrowest of edentulous ridge at 4, 6 and 8 mm below to CEJ were 5.03 $\pm$ 1.59 mm, 6.49 $\pm$ 1.87 mm and 7.68 $\pm$ 1.71 mm respectively. Three months after extraction space closed, measured the bucco-lingual width of alveolar ridge at the same point, found that also no alveolar bone support at 2 mm below to CEJ. The means of width of alveolar ridge at 4, 6 and 8 mm below CEJ were 6.82 $\pm$ 1.75 mm, 8.09 $\pm$ 1.99 mm and 9.36 $\pm$ 1.85 mm respectively (Table 2). There was a statistically significant difference between the means of bucco-lingual width at the narrowest of alveolar ridge before decortications and 3 months after extraction space closed as shown in Table 3 and Fig. 13.

The means of bucco-lingual width of alveolar ridge in the area that the mesial root of mandibular second molar would moved following the treatment plan at 4, 6 and 8 mm below to CEJ were 5.47 $\pm$ 1.29 mm, 6.58 $\pm$ 1.17 mm and 8.11 $\pm$ 1.18 mm respectively. Three months after extraction space closed, measured the bucco-lingual width of alveolar ridge at the same point, found that also no alveolar bone support at 2 mm below to CEJ. The means of width of alveolar ridge at 4, 6 and 8 mm below CEJ were 7.21 $\pm$ 0.99 mm, 8.05 $\pm$ 1.16 mm and 9.08 $\pm$ 1.46 mm respectively (Table 4). There was a statistically significant difference between the means of bucco-lingual width of alveolar ridge in the area of mesial root of mandibular second molar before decortications and 3 months after extraction space closed as shown in Table 5 and Fig. 13.

Table 2 The bucco-lingual width at the narrowest of edentulous ridge of each subject in this study.

Subject	**The B-Li width at the narrowest of edentulous ridge**					
	At 4 mm below CEJ		At 6 mm below CEJ		At 8 mm below CEJ	
	Before	After	Before	After	Before	After
1	-	-	7.25	10.75	9.25	12.00
2	3.75	7.88	6.25	8.50	7.88	9.75
3	3.88	5.00	6.13	7.25	6.40	8.38
4	-	-	5.63	7.63	7.75	10.00
5	5.13	7.63	6.75	8.50	6.88	8.63
6	7.25	8.33	8.63	9.82	8.75	10.00
7	-	-	2.38	3.50	4.20	5.25
8	5.00	6.38	6.00	8.13	7.88	9.75
9	5.50	8.00	7.13	8.38	7.38	9.50
10	7.25	9.00	9.50	10.13	10.00	11.00
11	2.13	3.25	4.25	5.13	5.50	6.75
12	6.00	7.00	8.50	9.50	10.25	11.63
13	4.40	5.75	6.00	8.00	7.75	9.00

Note: At 2mm below CEJ, all subjects were no alveolar bone both before and after decortications-facilitated mandibular molar protraction.

Table 3 Comparision of means of the bucco-lingual width of alveolar ridge at the narrowest between before decortications and 3 months after extraction space closed.

B-Li width of ridge	Before	After	Paired t-test
At 4 mm below CEJ	5.03 ± 1.59	6.82 ± 1.75	**
At 6 mm below CEJ	6.49 ± 1.87	8.09 ± 1.99	**
At 8 mm below CEJ	7.68 ± 1.71	9.36 ± 1.85	**

** Statistically significant, $p < 0.01$

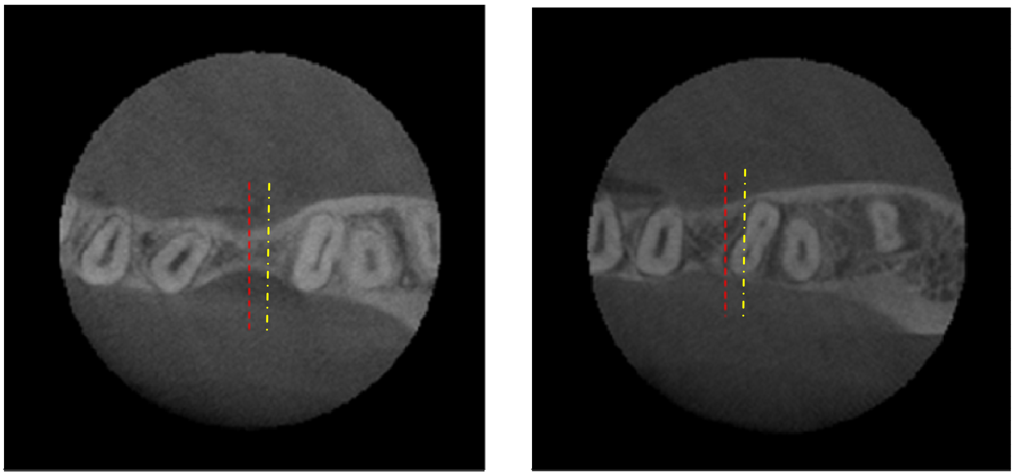
Table 4 The bucco-lingual width of alveolar ridge in the area of mesial root of mandibular second molar of each subject in this study.

Subject	**The B-Li width in the area of mesial root of mandibular second molar**					
	At 4 mm below CEJ		At 6 mm below CEJ		At 8 mm below CEJ	
	Before	After	Before	After	Before	After
1	-	-	7.25	10.25	9.25	12.62
2	5.25	8.38	7.15	9.25	8.63	10.25
3	4.38	6.13	6.13	7.50	7.63	9.15
4	-	-	5.63	6.00	8.20	9.33
5	5.50	7.18	7.25	8.00	8.18	8.50
6	8.38	8.88	9.00	9.13	8.88	9.25
7	-	-	4.75	7.00	6.00	7.13
8	5.00	8.13	6.50	8.77	8.38	9.25
9	5.50	6.50	7.13	7.88	7.75	8.75
10	7.25	7.87	8.38	8.72	10.00	10.50
11	3.88	6.25	5.38	7.00	6.38	7.15
12	6.00	7.87	8.50	9.12	10.25	11.00
13	4.88	6.25	7.00	7.12	8.25	9.00

Table 5 Comparision of means of the bucco-lingual width of alveolar ridge in the area of mesial root of mandibular second molar between before decortications and 3 months after extraction space closed.

B-Li width of ridge	Before	After	Paired t-test
At 4 mm below CEJ	5.52 ± 1.29	7.25 ± 0.99	**
At 6 mm below CEJ	6.61 ± 1.17	8.10 ± 1.16	**
At 8 mm below CEJ	8.33 ± 1.18	9.40 ± 1.46	**

** Statistically significant, $p < 0.01$



A. **B.**

Fig. 13 CBCT (axial section) was used to compare the bucco-lingual width of edentulous ridge before decortications (A) and 3 months after extraction space closed (B), at the narrowest (red line) and at the mesial root of mandibular second molar (yellow line).

The bucco-lingual width of edentulous ridge VS the width of mesial root of mandibular second molar

The means width of mesial root of mandibular second molar at 2, 4, 6 and 8 mm below to CEJ were 8.07 ± 0.73 mm, 7.15 ± 0.66 mm and 8.11 ± 1.18 mm respectively (Fig. 14). Before decortications-facilitated mandibular molar protraction, the bucco-lingual width of alveolar bone in the area that the mesial root of mandibular second molar would be moved following the treatment plan at 2, 4 and 6 mm below to CEJ were narrower than width of mesial root of mandibular second molar (Fig. 15). Three months after extraction space closed found that the bucco-lingual width of alveolar bone at 4 and 6 mm below to CEJ were increased and wider than width of mesial root of mandibular second molar (Fig. 16).

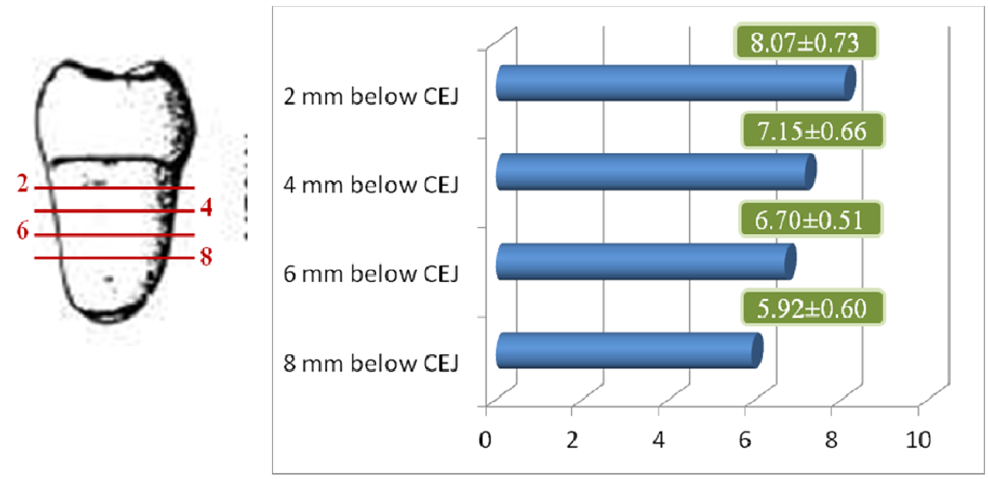


Fig. 14 The means width of mesial root of mandibular second molar at 2, 4, 6 and 8 mm below to CEJ of mandibular second molar.

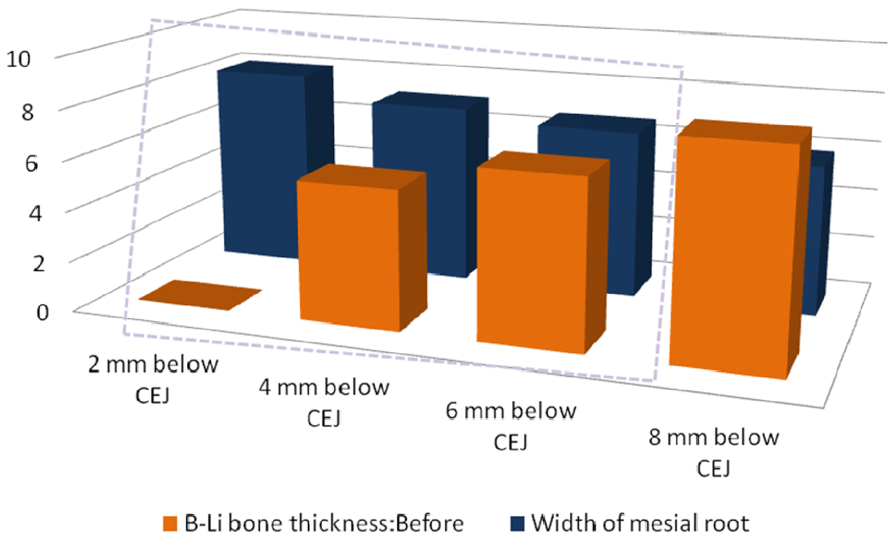


Fig. 15 Comparision of the bucco-lingual width of alveolar bone before decortications and the width of mesial root of mandibular second molar.

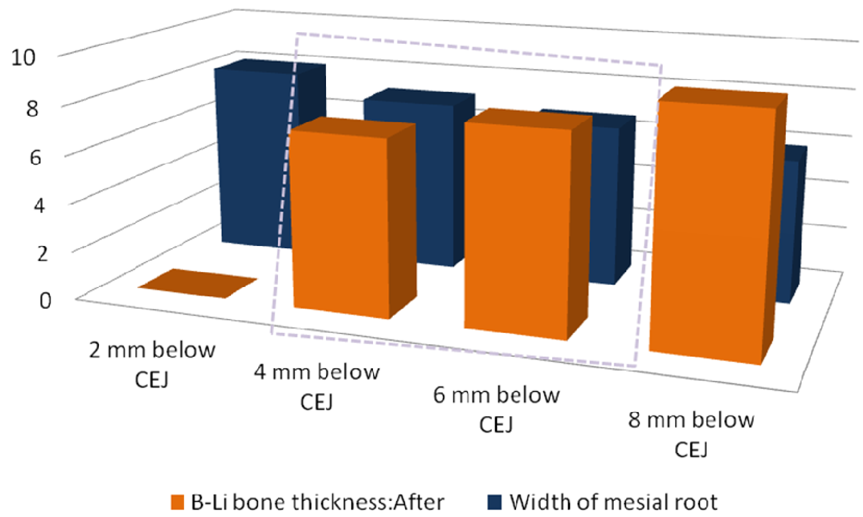


Fig. 16 Comparision of the bucco-lingual width of alveolar bone at three months after extraction space closed and the width of mesial root of mandibular second molar.

The buccal and lingual marginal bone level

Before decortications-facilitated mandibular molar protraction was performed, the buccal and lingual marginal bone level of each subject was measured (Table 6). Means of the buccal marginal bone level at mid-mesial root was 4.01 $\pm$ 1.43 mm and at mid-distal root was 3.35 $\pm$ 1.32 mm. Means of the lingual marginal bone level at mid-mesial root was 2.18 $\pm$ 0.65 mm and at mid-distal root was 1.97 $\pm$ 0.55 mm. Three months after extraction space closed found that means of the buccal marginal bone level at mid-mesial root was 3.90 $\pm$ 1.53 mm and at mid-distal root was 3.40 $\pm$ 1.51 mm. While means of the lingual marginal bone level at mid-mesial root was 2.58 $\pm$ 0.58 mm and at mid-distal root was 2.36 $\pm$ 0.50 mm. No statistically significant difference between means of the buccal marginal bone level at mid-mesial root and mid-distal root before decortications and 3 months after extraction space closed but there were a statistically significant difference between means of the lingual marginal bone level at mid-mesial root and mid-distal root before decortications and 3 months after extraction space closed as shown in Table 7 and Fig 17.

Table 6 The buccal and lingual marginal bone level of mandibular second molar of each subject.

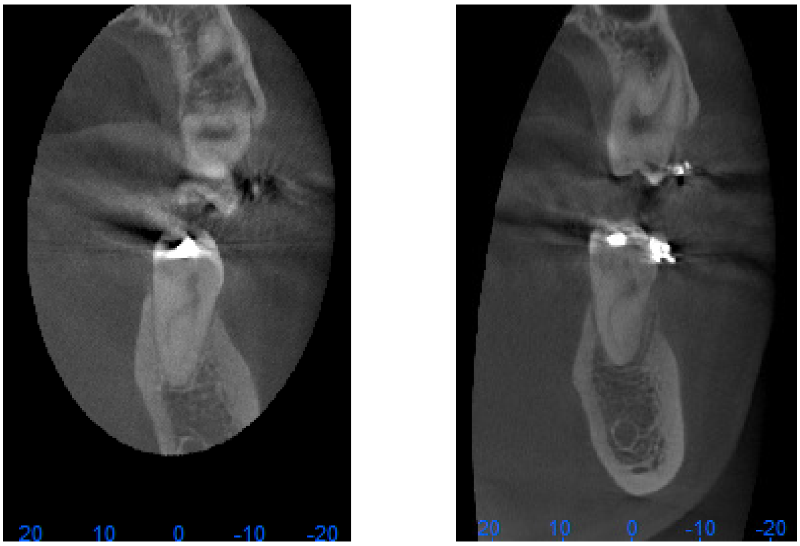
Subject	The buccal marginal bone level (mm)				The lingual marginal bone level (mm)			
	At mid-mesial root		At mid-distal root		At mid-mesial root		At mid-distal root	
	Before	After	Before	After	Before	After	Before	After
1	1.95	1.67	2.50	2.23	2.00	2.20	2.20	2.50
2	2.51	2.21	2.78	2.51	1.00	1.88	1.22	1.50
3	4.46	4.73	3.62	4.00	1.75	2.00	1.50	2.21
4	5.01	4.85	5.01	4.73	3.11	3.50	2.50	2.66
5	4.80	4.46	3.90	3.65	1.75	2.00	1.66	2.12
6	2.51	2.20	1.50	1.39	1.50	2.00	1.34	1.98
7	5.84	5.29	5.57	5.28	3.34	3.50	3.20	3.33
8	4.46	3.90	2.79	2.51	2.55	2.75	2.20	2.62
9	6.41	6.68	5.00	6.20	2.78	3.38	2.50	3.12
10	2.23	1.95	1.39	1.11	2.22	2.44	1.67	1.92
11	5.02	5.29	3.62	4.18	2.23	2.66	1.95	2.22
12	3.34	3.50	2.23	2.51	2.00	2.52	1.67	2.00
13	3.61	4.00	3.61	3.90	2.12	2.75	2.00	2.51

Table 7 Comparision of means of the buccal and lingual marginal bone level between before decortications and 3 months after extraction space closed.

Marginal bone level		Before	After	Paired t-test
Buccal	At mid-mesial root	4.01 ± 1.43	3.90 ± 1.53	**NS**
	At mid-distal root	3.35 ± 1.32	3.40 ± 1.51	**NS**
Lingual	At mid-mesial root	2.18 ± 0.65	2.58 ± 0.58	**
	At mid-distal root	1.97 ± 0.55	2.36 ± 0.50	**

NS, no statistically significant,

** Statistically significant, $p < 0.01$



A. B.

Fig. 17 CBCT (coronal section) was used to compare the buccal and lingual marginal bone level before decortications (A) and 3 months after extraction space closed (B).

The height of crestal bone

Before decortications-facilitated mandibular molar protraction was performed, the height of crestal bone mesial to mandibular second molar of each subject was measured (Table 8). Mean of the height of crestal bone was 2.00 $\pm$ 0.15 mm. Three months after extraction space closed, mean was 2.24 $\pm$ 0.24 mm. There was a statistically significant difference between before decortications and 3 months after extraction space closed as shown in Table 9 and Fig. 18.

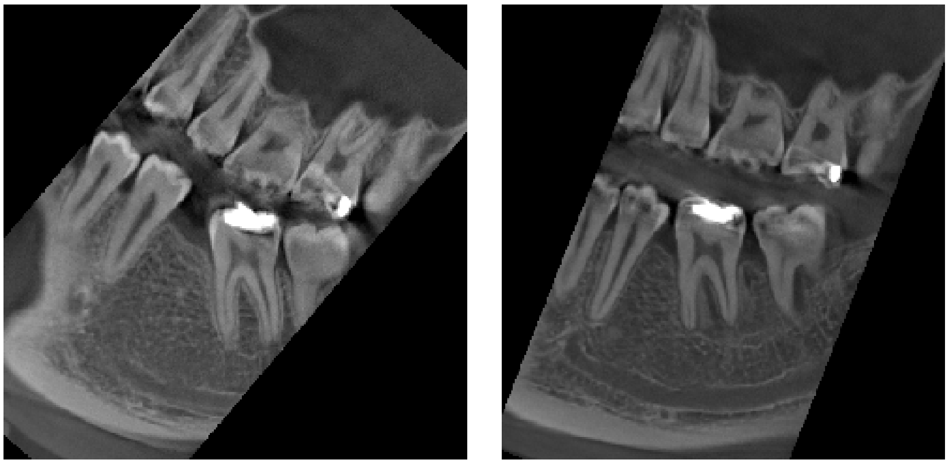
Table 8 The height of crestal bone mesial to mandibular second molar of each subject.

Subject	The height of crestal bone (mm)	
	Before	After
1	1.89	2.18
2	1.88	2.39
3	2.00	2.23
4	2.00	2.28
5	2.20	2.50
6	1.77	1.95
7	1.88	2.01
8	1.88	2.00
9	1.97	2.23
10	2.13	2.25
11	1.91	1.94
12	2.20	2.79
13	2.23	2.38

Table 9 Comparision of the means of height of crestal bone mesial to mandibular second molar between before decortications and 3 months after extraction space closed.

	Before	**After**	**Paired t-test**
Height of crestal bone (mm.)	2.00 $\pm$ 0.15	2.24 $\pm$ 0.24	**

** Statistically significant, $p < 0.01$



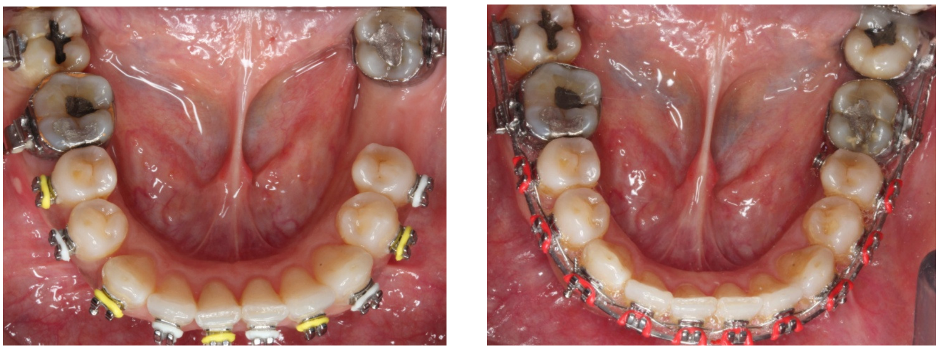
A. **B.**

Fig. 18 CBCT (axial section) was used to compare the height of crestal bone between before decortications (A) and 3 months after extraction space closed (B)**.**

CHAPTER 4

DISCUSSION

The findings in this study indicate that mandibular second molar could be protracted through mandibular first molar extraction site with conventional orthodontic appliance (segmented L-loop). Similarly, many previous studies[2-3, 13, 21, 30-34] also showed that second molars can be moved forward through edentulous areas but mostly required TADs for anchorage reinforcement. This is in contrast to Graber[12] and Kessler[4], suggested that space closure of the mandibular first molar area is seldom possible, especially in adults. In this study, edentulous space of all subjects could be closed completely (Fig. 19) with a mean of 5.88 mm (3.5-11.5 mm).



A. **B.**

Fig. 19 Subject no.1, extraction space of 11.5 mm. could be closed completely. A; Before alveolar decortications, B; After extraction space was closed.

The rate of mandibular molar protration in this study was about 4 times greater than previous studies, 1.21 mm/mth and 0.37 mm/mth respectively (Fig. 20). Because previous studies without dentoalveolar surgery, the rate of mandibular molar protration was consistent with the rate of resorption for osteocloasts during cortical bone remodeling that was about 0.5 mm/mth[21]. This study was incorporate dentoalveolar surgery including selective alveolar decortications and bone graft augmentation according to Wilcko and Wilcko 2001[35]. The mechanism of rapid tooth movement facilitated with dentoalveolar surgery has been explained by regional acceleratory phenomenon (RAP) after bone injury (periodontally accelerated osteogenic orthodontics) [35]. RAP is a complex physiologic process with dominating features involving accelerated bone turnover and decreases in regional bone densities (as transient osteopenia)[38]. This transient osteoporosis provides a favorable environment for increasing the rate of tooth movement without increasing the risk of root resorption[39]. During RAP, extensive regional intra-cortical bone remodeling occurs, recruiting cellular activity necessary for activation of the subsequent healing process. The range of rate of molar protraction in this study was 0.71-1.66 mm/mth. The slowest rate (subject no.6, table 1) was faster than the previous studies (0.37 mm/mth) but slower than normal orthodontic tooth movement (1 mm/mth) because of the maxillary molar, opposite to protracted tooth, was distalized. Cuspal interference during maxillary and mandibular molar movement might cause of slow rate of mandibular molar protraction in this case.

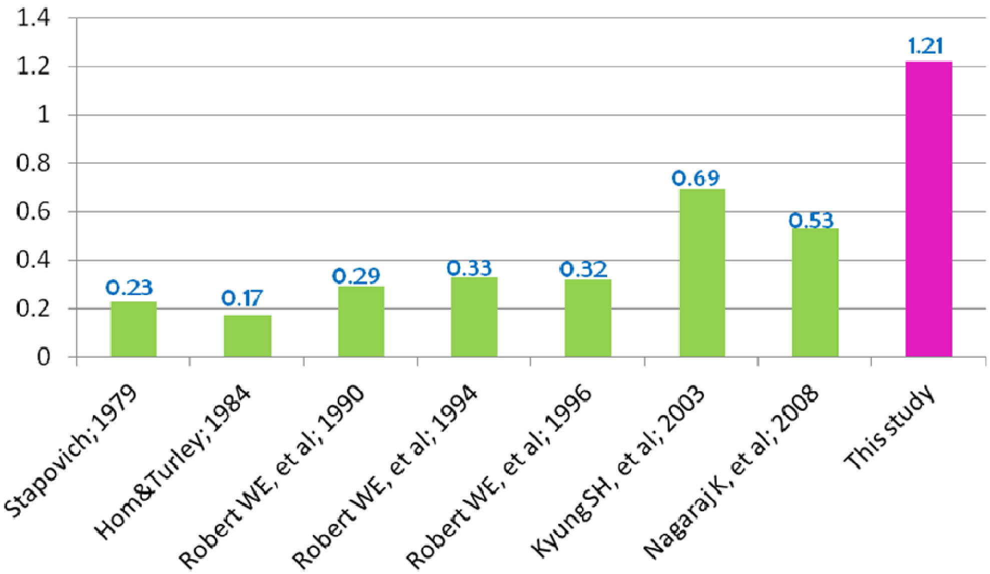
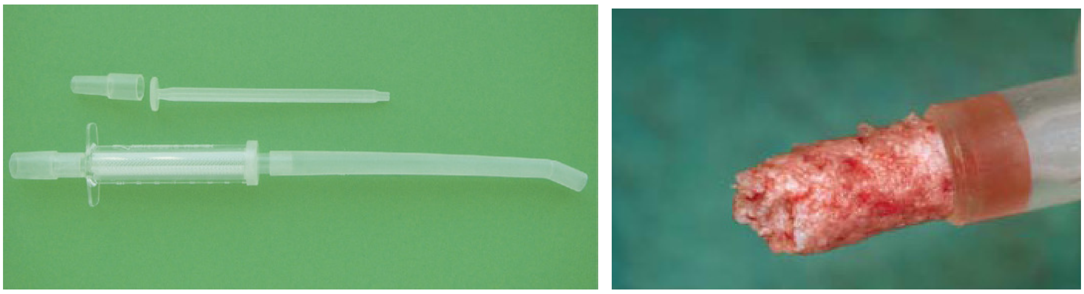


Fig. 20 The rate of mandibular molar protration (mm/mth) in this study was compared with 7 previous studies.

Allograft, demineralized freeze dried bone was used in this study. Its advantage was less toxicity (less infection and rejection) while its disadvantages include weaker mechanical properties and lack of rich osteoinductive potential[51, 52]. However, osteoinductive property has important to stimulate new bone production in bone-forming cells and promote cell growth by hinding to specific receptors. This property obtained by blood-borne proteins, peptides, growth factors and cytokines from decortications surgery (mostly from the hemorrhage) [44, 51]. In addition to allograft, cortical autograft from bone collector (Fig. 21) during decortications surgery was transplanted. Thus, decortications surgery incorporate with augmentation bone grafting performed in this study could produce osteoconduction (scaffold from allograft), osteoinduction (growth factors, cytokines from surgical procedure) and osteogenesis (osteoblast and osteoclast precursors from cortical autograft) cause of modeling/remodeling of alveolar bone, the results was increased bucco-lingual width of alveolar bone during orthodontic tooth movement through edentulous ridge. This is in contrast to studies of Stepovich[2], Hom[3], Robert[10], Kravitz and Jolley[1] which not had surgical intervention and augmentation bone grafting, found that the half the adult patients resisted forming any new bone during orthodontic space closure while the other half developed only small amounts of new bone and had potential risks of dehiscence and fenestration after molar protraction through atrophic ridge.



A. **B.**

Fig. 21 A; Bone collector B; Cortical autograft from bone collector

Three months after extraction space closed, the lingual marginal bone level of mandibular second molar was decreased 0.1-0.4 mm. Because the mandibular second molar moved into decreased alveolar bone housing (both width and height) and the pressure from tongue, cause of less bone modeling and remodeling. Moreover, the marginal bone level decreased due to "bone matrix transformation" phase of alveolar bone housing. The demineralization of the alveolar housing over the root surfaces apparently leaves the collagenous soft tissue matrix of the bone, which can not detected from CT csan. Similarly to study of Wilcko et al[53] which use 3D CT scan, found that the bony dehiscence and fenestration were increased after 2.5 months of orthodontic treatment but fully reversible alveolus after 2 years of retention.

Three months after extraction space closed, the crestal bone height mesial to mandibular second molar was decreased 0.24 mm because the mandibular second molar was tipping movement during protracted. Tipping movement created maximum pressure to alveolar crest which less cellular and less vascular, hyalinization and undermining resorption arised that cause of creastal bone lost. Similarly to study of Stepovish[2] and Hom[3], found that crestal bone height loss was seen after mandibular molar protraction. Proffit[54] stated that lost of alveolar crest height less than 0.5 mm are observed on orthodontic patients.

The first clinical observation, extraction spaces were closed and mandibular second molar could be protracted with less tipping and rotation because we could applied the tipback bend, step down or toe in at distal arm of segmented L-loop to control tipping and rotation of mandibular second molar. The second clinical observation was the mandibular third molar could be translate following the second molar without apply orthodontic force to it (Fig. 22). Possible causes were RAP from alveolar decortications produce transient osteoporosis and decreased the bony resistance[55]. And protraction force from transeptal fibers was occured mesial to the third molar.

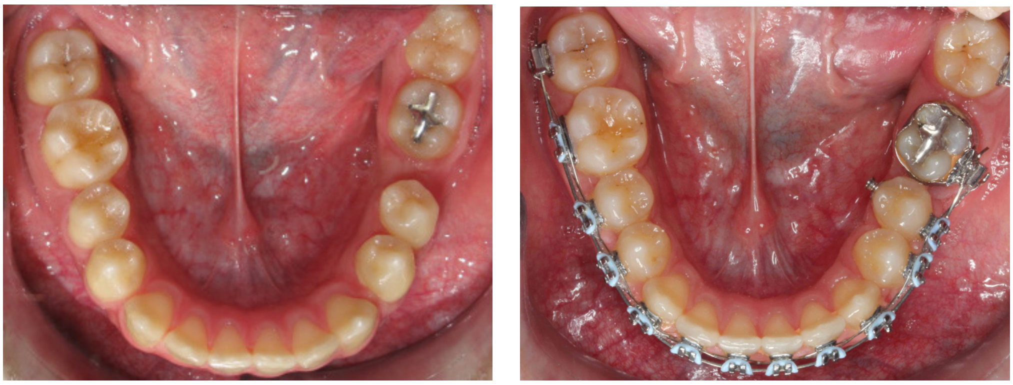


Fig. 22 Subject no.2, the mandibular second molar was protracted 6 mm and the third molar was mesialized about 3 mm. A; Initial, edentulous space of 6mm B; After extraction space was closed, remaining space between second and third molar about 3mm.

In order to assess dentoalveolar morphology in both sagittal and vertical dimensions, orthodontists often use cephalometric tracings. However, this fails to assess bone thickness. Compared with conventional dental radiograph, CBCT permits accurate identification and measurement in multiple plane[56]. Fuhrmann *et al* [48] recently showed that quantitative evaluation of alveolar bone plates is accurate to a minimum bone thickness of 0.25 mm. Lascala *et al*[57] found that, although the CBCT image underestimated the real distances between skull sites, the differences were significant only for the skull base; therefore, it was reliable for linear evaluation measurements of other structures more closely associated with dental and maxillofacial imaging. Lagravere *et al*[58] evaluated the accuracy of measurements made on CBCT images compared with measurements made on a coordinate measuring machine; they found no significant statistical differences between the linear and angular measurements from the coordinate measuring machine and the NewTom 3G (Aperio Services, Verona, Italy) images. Hence, they concluded that the NewTom 3G produces a 1-to-1 image-to-reality ratio. CBCT findings have proven to be statistically similar to histologic measurements. Moreover accuracy and reliability of CBCT measurements are not affected by changing the skull orientation.[59-60] Therefore, this study was designed to use CT measurements to more accurately evaluate bone thickness changes.

The limitations of this study were the mandibular second premolar that used as reference might be moved and could not defined the movement of mandibular second molar, tipping or bodily movement.

CHAPTER 5

CONCLUSION

Decortication-facilitated orthodontics assisted mandibular molar protraction could be move the mandibular second molar forward through the atrophic edentulous area, the following concluded were

1. The rate of mandibular molar protraction (1.21 mm/mth) was a statistically significant faster than previous studied (0.37 mm/mth) and normal orthodontic tooth movement through cortical bone (0.5 mm/mth) over 2-time.
2. Three months after mandibular first molar areas were closed, a statistically significant increased in the bucco-lingual width of atrophic alveolar ridge.
3. The marginal bone levels of mandibular second molar after protracted were decreased about 0.1-0.4 mm.
4. The crestal bone height of mandibular second molar after protracted were decreased about 0.24 mm, which can be observed in orthodontic tooth movement.

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APPENDICES

ใบเชิญชวน

ขอเชิญเข้าร่วมโครงการวิจัยเรื่อง การศึกษาอัตราการเคลื่อนฟันและผลต่อกระดูกรองรับฟันจากวิธีการรักษาโดยการกรอกระดูกทึบร่วมกับการจัดฟันเพื่อเคลื่อนฟันกรามล่างไปทางด้านใกล้กลาง

เรียน ท่านผู้อ่านที่นับถือ

ข้าพเจ้า ทพญ.ศุภางค์ สมานสุขุมาล กำลังศึกษาระดับปริญญาโท สาขาทันตกรรมจัดฟัน ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ใคร่ขอเล่าถึงโครงการวิจัยที่กำลังทำอยู่ และขอเชิญชวนท่านเข้าร่วมโครงการดังนี้ โครงการวิจัยนี้จะทำการศึกษาอัตราการเคลื่อนของฟันกรามล่าง และศึกษาการเปลี่ยนแปลงของกระดูกรองรับฟันหลังจากการกรอแต่งกระดูกทึบร่วมกับการจัดฟันเพื่อเคลื่อนฟันกรามล่างไปทางด้านใกล้กลางด้วยวิธีการตามปกติ หลังจากสิ้นสุดการวิจัยแล้วผู้เข้าร่วมการวิจัยจะได้รับการรักษาทางทันตกรรมจัดฟันด้วยวิธีการตามปกติต่อไป

ผู้เข้าร่วมการวิจัยจะได้รับการเก็บข้อมูลเบื้องต้นตามปกติ ได้แก่ การพิมพ์ฟันเพื่อทำแบบจำลองฟัน ถ่ายภาพภายในช่องปาก ถ่ายภาพรังสีกะโหลกศีรษะเพื่อวางแผนการรักษา หลังจากนั้นจะได้รับการติดเครื่องมือจัดฟันชนิดติดแน่นและปรับเครื่องมือทุก 1 เดือนจนกระทั่งฟันอยู่ในตำแหน่งที่เหมาะสม ก่อนการกรอแต่งกระดูกทึบผู้เข้าร่วมการวิจัยจะได้รับการถ่ายภาพรังสีกะโหลกศีรษะและถ่ายเอกซเรย์คอมพิวเตอร์เพื่อประเมินตำแหน่งของฟันกรามล่างและรูปร่างของกระดูกเบ้าฟัน จากนั้นผู้เข้าร่วมการวิจัยจะได้รับการกรอแต่งกระดูกทึบร่วมกับการปลูกกระดูก หลังการกรอแต่งกระดูกทึบผู้เข้าร่วมการวิจัยจะต้องมาปรับเครื่องมือทุก 2 อาทิตย์เป็นเวลา 6 เดือน หรือจนกว่าช่องว่างจะถูกปิด และจะได้รับการถ่ายภาพรังสีกะโหลกศีรษะและถ่ายเอกซเรย์คอมพิวเตอร์เพื่อประเมินตำแหน่งของฟันกรามล่างและรูปร่างของกระดูกเบ้าฟันอีกครั้งจึงสิ้นสุดการวิจัย

ถ้าท่านตัดสินใจเข้าร่วมโครงการนี้จะมีขั้นตอนของการวิจัยที่เพิ่มเติมขึ้นมาจากการจัดฟันตามปกติดังนี้

1. พิมพ์ฟันเพิ่มเติม ได้แก่ ก่อนกรอแต่งกระดูกทึบ และระหว่างการเคลื่อนฟันกรามเดือนละ 1 ครั้ง

2. ถ่ายภาพรังสีกะโหลกศีรษะด้านข้างเพิ่มเติม ได้แก่ ก่อนกรอแต่งกระดูกทึบ และเมื่อสิ้นสุดการเคลื่อนฟันกราม

3. ถ่ายเอกซเรย์คอมพิวเตอร์เพิ่มเติม ได้แก่ ก่อนกรอแต่งกระดูกทึบ และ3 เดือนหลังสิ้นสุดการเคลื่อนฟันกราม

จากการทบทวนวรรณกรรมที่ผ่านมาพบว่าการกรอแต่งกระดูกทึบร่วมกับการปลูกกระดูกเพื่อเคลื่อนฟันกรามล่างไปทางด้านใกล้กลางมีความปลอดภัย ประสบผลสำเร็จและลดระยะเวลาในการรักษาทางทันตกรรมจัดฟันได้ โดยจะใช้กระดูกที่ได้มาตรฐานและมีการรับรองแล้วว่าสามารถเข้ากันได้ดีกับมนุษย์ อาจมีความเสี่ยงเกิดขึ้นในลักษณะเดียวกับการผ่าฟันคุดซึ่งมีการกรอกระดูกเช่นกัน ได้แก่ ความเสี่ยงต่อการเกิดการอักเสบของแผล (ปวด บวม) และการติดเชื้อ อย่างไรก็ตามในงานวิจัยนี้มีมาตรการป้องกันโดยกระทำภายใต้หลักวิชาการและมาตรฐานของโรงพยาบาลเพื่อป้องกันความเสี่ยงต่างๆ ที่อาจเกิดขึ้นและมีการติดตามผลเป็นระยะ และหากเกิดผลแทรกซ้อนขึ้นคนไข้จะได้รับการดูแลจากทันตแพทย์ผู้เชี่ยวชาญเป็นอย่างดี โดยผู้วิจัยจะเป็นผู้รับผิดชอบค่าใช้จ่ายในการรักษาทั้งหมด

ไม่ว่าท่านจะเข้าร่วมในโครงการวิจัยนี้หรือไม่ ท่านจะยังคงได้รับการรักษาที่ดีเช่นเดียวกับผู้ป่วยคนอื่นๆ และถ้าท่านต้องการที่จะถอนตัวออกจากการศึกษานี้เมื่อใด ท่านก็สามารถกระทำได้อย่างอิสระ

ถ้าท่านมีคำถามใดๆ ก่อนที่จะตัดสินใจก่อนเข้าร่วมโครงการนี้ โปรดซักถามคณะผู้วิจัยได้อย่างเต็มที่

ขอขอบคุณเป็นอย่างสูง

ทพญ.ศุภางค์ สมานสุขุมาล

หมายเหตุ: กรุณาอ่านข้อความให้เข้าใจก่อนเซ็นชื่อยินยอมเข้าร่วมโครงการ

แบบยินยอมเข้าร่วมการศึกษา

โครงการวิจัยเรื่อง การศึกษาอัตราการเคลื่อนฟันและผลต่อกระดูกรองรับฟันจากวิธีการรักษาโดยการกรอกระดูกทึบร่วมกับการจัดฟันเพื่อเคลื่อนฟันกรามล่างไปทางด้านใกล้กลาง

วันที่_______เดือน___________________พ.ศ._______

ข้าพเจ้า____อายุ_____________ปี
อาศัยอยู่บ้านเลขที่_________หมู่_______ ถนน__________________ตำบล__________________
อำเภอ___________________จังหวัด_____________________ ได้รับการอธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

หากข้าพเจ้ามีข้อสงสัยประการใด หรือเกิดผลข้างเคียงจากการวิจัยจะสามารถติดต่อกับ ทพญ.ศุภางค์ สมานสุขุมาล ได้ที่ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ หมายเลขโทรศัพท์ 074-429876 หรือเมื่อมีปัญหาใดๆ เกิดขึ้นเนื่องจากการทำวิจัยในเรื่องนี้ ข้าพเจ้าสามารถร้องเรียนได้ที่คณบดี คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287510

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่มีปิดบัง

ข้าพเจ้ามีสิทธิ์ที่จะของดการเข้าร่วมโครงการวิจัย โดยจะแจ้งให้ทราบล่วงหน้า โดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการได้รับบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่อย่างใด

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ จะไม่เปิดเผยข้อมูลหรือผลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชน จะเปิดเผยได้ในรูปที่เป็นสรุปผลการวิจัย หรือการเปิดเผยข้อมูลต่อผู้มีหน้าที่ที่เกี่ยวข้องกับการสนับสนุนและกำกับดูแลการวิจัย

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ จึงได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ โดยผู้วิจัยได้ให้สำเนาแบบยินยอมที่ลงนามแล้วกับข้าพเจ้าเพื่อเก็บไว้เป็นหลักฐานจำนวน 1 ชุด

ลงชื่อ...ผู้ยินยอม

( )

ลงชื่อ……………………………………………ผู้รับผิดชอบโครงการวิจัย

(ทันตแพทย์หญิงศุภางค์ สมานสุขุมาล)

ลงชื่อ………………..………………..………….บิดา/ผู้ใช้อำนาจปกครอง

( )

ลงชื่อ…………………………..……..……….มารดา/ผู้ใช้อำนาจปกครอง

( )

ลงชื่อ………………………..………………..………..………….พยาน

( )

ลงชื่อ……………………...……....………..………..………….พยาน

( )

ที่ ศธ 0521.1.03/ 235

คณะทันตแพทยศาสตร์
มหาวิทยาลัยสงขลานครินทร์
ตู้ไปรษณีย์เลขที่ 17
ที่ทำการไปรษณีย์โทรเลขคอหงส์
อ.หาดใหญ่ จ.สงขลา 90112

หนังสือฉบับนี้ให้ไว้เพื่อรับรองว่า

โครงการวิจัยเรื่อง "การศึกษาผลต่อกระดูกรองรับฟันจากวิธีการรักษาโดยการกรอกระดูกทึบร่วมกับการจัดฟันเพื่อเคลื่อนฟันกรามล่างไปทางด้านใกล้กลาง"

หัวหน้าโครงการ ทันตแพทย์หญิงศุภางค์ สมานสุขุมาล

สังกัดหน่วยงาน นักศึกษาหลังปริญญา ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

ได้ผ่านการพิจารณาและได้รับความเห็นชอบจากคณะกรรมการจริยธรรมในการวิจัย (Ethics Committee) ซึ่งเป็นคณะกรรมการพิจารณาศึกษาการวิจัยในคนของคณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ แล้ว ในคราวประชุมครั้งที่ 1/2553 เมื่อวันที่ 29 มกราคม 2553

ให้ไว้ ณ วันที่ 15 มีนาคม 2553

(รองศาสตราจารย์ ทพ.นพ.ธงชัย นันทนรานนท์)
รองคณบดีฝ่ายวิจัย
ประธานกรรมการ

....กรรมการ
(ผู้ช่วยศาสตราจารย์ ดร.ทพญ.สุวรรณา จิตภักดีบดินทร์)

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(ผู้ช่วยศาสตราจารย์ ทพ.นพ.สุรพงษ์ วงศ์วัชรานนท์)

....กรรมการ
(ผู้ช่วยศาสตราจารย์ นพ.พรชัย สถิรปัญญา)

....กรรมการ
(ผู้ช่วยศาสตราจารย์ ดร.ทพญ.อังคณา เธียรมนตรี)

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Work-Position and Adress

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List of Publication and Proceeding

Samansukumal S, Samruajbenjakum B, Charoemratrote C, Leepong N. Rate and anchorage loss following decortication-facilitated orthodontics for mandibular molar protraction: A clinical study. Proceedings of the 23rd National Graduate Research Conference; 2011 December 23-24; Nakhon Ratchasima, Thailand. Faculty of Sciences and Liberal Arts, Rajamangala University of Technology Isan; 2011