Alveolar Bone and Root Length Changes Following En-masse Retraction with

Corticotomy assisted Orthodontic Treatment

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I hereby certify that this work has not been accepted in substance for any degree, and is not being currently submitted in candidature for any degree.

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ชื่อวิทยานิพนธ์ การเปลี่ยนแปลงกระดูกเบ้าฟัน และรากฟัน ภายหลังจากการผ่าตัดกระดูกทึบ
ร่วมกับการรักษาทางทันตกรรมจัดฟัน ในผู้ป่วยที่มีลักษณะฟันยื่นในขากรรไกร
บนและล่าง

ผู้เขียน นางสาวสาธินี นฤปกร

สาขาวิชา วิทยาศาสตร์สุขภาพช่องปาก

ปีการศึกษา 2559

บทคัดย่อ

บทนำ การผ่าตัดกระดูกทึบเป็นวิธีการเพิ่มอัตราการเคลื่อนฟันในทางทันตกรรม
จัดฟันที่มีประสิทธิภาพอีกวิธีหนึ่ง นอกจากเพิ่มอัตราการเคลื่อนฟันแล้ว การผ่าตัดกระดูกทึบยังถูก
เสนอให้ใช้เพิ่มปริมาณของกระดูกเบ้าฟัน และลดการละลายของรากฟันด้วย ผู้ป่วยที่มีลักษณะฟัน
ยื่นในขากรรไกรบนและล่าง มักมีกระดูกเบ้าฟันที่บางและไม่สมบูรณ์ การดึงฟันในกระดูกเบ้าฟันที่
บางและไม่สมบูรณ์นั้น อาจทำให้เกิดช่องกระดูกโหว่ รอยกระดูกที่เปิดแยกมากขึ้น รวมทั้งเสี่ยงต่อ
การละลายของรากฟัน ดังนั้นการดึงฟันหน้าร่วมกับการผ่าตัดกระดูกทึบ จึงเป็นอีกทางเลือกหนึ่งที่
มีประสิทธิภาพในการลดความเสี่ยงที่จะทำให้เกิดช่องกระดูกโหว่ รอยกระดูกที่เปิดแยกที่มากขึ้น
และลดการละลายของรากฟันได้ **วัตถุประสงค์** เพื่อเปรียบเทียบกระดูกเบ้าฟัน และความยาวรากฟัน
ก่อนและหลังการผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟัน ในผู้ป่วยที่มีลักษณะฟัน
ยื่นในขากรรไกรบนและล่าง **วัสดุและวิธีการ** ผู้ป่วยจำนวน 14 คน ที่มีความจำเป็นต้องรับการรักษา
ทางทันตกรรมจัดฟัน ร่วมกับการถอนฟันกรามน้อยซี่หนึ่งทั้งสี่ซี่ และการผ่าตัดกระดูกทึบ ใช้โคน
บีมคอมพิวเตดโทโมกราฟฟีในการหาความหนาของกระดูกเบ้าฟัน ในระดับยอดกระดูกเบ้าฟัน
กึ่งกลางราก และปลายรากฟัน ความสูงของกระดูกเบ้าฟัน ด้านใกล้กลาง ไกลกลาง ริมฝีปาก และ
ลิ้น และความยาวรากฟัน นำข้อมูลมาเปรียบเทียบกันในฟันหน้าแต่ละซี่ ระหว่างก่อนและหลังการ
ผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟัน **ผลการศึกษา** ความหนาของกระดูกเบ้าฟัน
ด้านริมฝีปากของฟันหน้าบนและฟันหน้าล่างเฉลี่ยเพิ่มขึ้น 65.0 และ 58.0 มิลลิเมตร ตามลำดับ
แต่ความหนาของ ความหนาของกระดูกเบ้าฟันด้านลิ้นของฟันหน้าบนเฉลี่ยลดลง 18.0
มิลลิเม 27.0 กระดูกเบ้าฟันด้านลิ้นของฟันหน้าล่างเฉลี่ยเพิ่มขึ้นตร ไม่พบความแตกต่างระหว่าง
ความสูงของกระดูกเบ้าฟันก่อนและหลังการรักษา โดยความสูงของกระดูกเบ้าฟันบนและฟันล่าง
เฉลี่ยลดลง 18.0 และ 19.0 มิลลิเมตร ตามลำดับ และพบว่าความยาวรากฟันลดลงอย่างมีนัยสำคัญ
มิลลิเมตร 01.1 ทางสถิติ โดยเฉลี่ยลดลง **สรุปผลการศึกษา** การผ่าตัดกระดูกทึบร่วมกับการรักษา
ทางทันตกรรมจัดฟันในผู้ป่วยที่มีลักษณะฟันยื่นในขากรรไกรบนและล่าง นอกจากเพิ่มอัตราการ

เคลื่อนฟันในทางทันตกรรมจัดฟันแล้ว ในการศึกษานี้พบว่า สามารถเพิ่มความหนาของกระดูกเบ้า
ฟันได้ ยกเว้น ความหนาของกระดูกเบ้าฟันด้านลิ้นของฟันหน้าบน โดยไม่พบความแตกต่าง
ระหว่างความสูงของกระดูกเบ้าฟัน แต่พบว่าความยาวรากฟันลดลงอย่างมีนัยสำคัญทางสถิติ

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ABSTRACT

Introduction: Corticotomy is an effective method of accelerating the orthodontic treatment and has been proposed to increase the volume of the alveolar process and decrease root resorption. Patients with dentoalveolar protrusion usually have thin alveolar bone and bony defect. Pushing the tooth against the thin cortical bone may cause alveolar bone defect and root resorption. So retraction of the anterior teeth combined with corticotomy of the alveolar bone can offer an effective alternative option that minimize the risk of movements of the anterior teeth and root resorption. **Objectives:** To compare alveolar bone and root length before and after en-masse retraction with corticotomy in bimaxillary protrusion patient. **Materials and methods:** 14 subjects were selected from patients who required the removal of first premolars in upper and lower arches, en masse retraction and corticotomy as a part of their orthodontic treatment. Cone beam computed tomography analysis was used to compare alveolar bone width at crestal, mid-root and apical level, alveolar bone height at mesial, distal, labial and lingual sides and root length changes between pretreatment and postretention in all anterior teeth **Result:** Maxillary and mandibular labial bone thickness increased 0.58 mm., 0.65 mm. respectively .Maxillary lingual bone thickness decreased 0.18 mm. but found increased 0.27 mm. in mandibular lingual bone thickness. No significant alveolar bone height changes were found in all anterior teeth. Maxillary and mandibular alveolar bone height decreased 0.19 mm., 0.18 mm. respectively. Significant root resorption occurred in all anterior teeth. Average root resorption in all anterior teeth was 1.01 mm. **Conclusions:** Corticotomy not only accelerates the orthodontic treatment but also provides the advantage of increased alveolar width. This study showed an average increase in alveolar bone width following corticotomy. However, there were also sites, maxillary lingual bone thickness, in which there was a decrease in alveolar width. No significant alveolar bone height changes were found. But significant root resorption occurred in all anterior teeth

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CHAPTER 1

INTRODUCTION

Background and rationale

Nowadays, not only children and adolescent seek for orthodontic treatment. Late adolescent and adult patients are increasing and it's quite challenging because adult patients always expect short treatment time.[1, 2] Orthodontists are looking forward to any alternative options for accelerating orthodontic tooth movement. Among the five interventions which are corticotomy procedure, pulsed electromagnetic fields, low-level laser technique, electrical current process and periodontal distraction, corticotomy is effective and safe to accelerate orthodontic tooth movement.[3, 4]

If discrepancies are borderline or beyond envelope of tooth movement and no longer possible for growth modification, orthognathic surgery might be necessary to obtain treatment objectives.[5] By an osteotomy procedure, the trabecular and cortical bone is cut and the surgeon move the segments as needed, then the nerves and blood supply damage may be occur and leading to many complications. For mild dentoskeletal discrepancies patients, appropriate option may not be an orthognathic surgery. Corticotomy has been proposed, the cuts are made only on shallow surface of the cortical alveolar bone, that it is different from an osteotomy. Orthodontic force is applied shortly after surgery. It has been claimed that tooth move faster, and that the treatment results are more stable following a corticotomy with minimal risk of complications.[6]

Corticotomy with bone augmentation has been proposed to increase the volume of the alveolar process, to accelerate tooth movement, to prevent dehiscences and fenestrations and to increase the metabolic response during orthodontic treatment.[7, 8] A retrospective study by Rothe[9] show that decreased bone thickness, bone mass, bone density and size on panoramic and lateral cephalograms are shown to be a risk factor for orthodontic relapse. It is further interesting questioned that increased bone thickness might improve stability because it is related with increased bone volume. So alveolar bone size might relate to stability following orthodontic

treatment. Many studies claimed that orthodontic relapse after corticotomy-facilitated treatment is minimal because of increased root support after healing and loss of tissue memory by the high turnover and remodeling processes,[2, 6-8, 10] and also found better score of American Board of Orthodontics objective grading system and a more stable treatment result in the corticotomy group.[11, 12] Recently, clinical trials address about corticotomy enhancing 10 years long-term stability in non-extraction cases.[13]

Corticotomy is quite safe for periodontium and shows little risk of root resorption.[4, 14] The explanation of decreased root resorption in the corticotomy is that localized selective decortication combined with orthodontic tooth movement casues a rapid alveolar bone remodeling or "Regional Acceleratory Phenomenon" in bone marrow cavities, decreases bone density, decreased hyalinization of the periodontal ligament and leads to absence of the lag phase during later stages of orthodontic tooth movement.[15]

Bimaxillary protrusion is common in Asian and African American populations.[16] There are two treatment options for bimaxillary protrusion. The first is conventional orthodontic treatment and the second is anterior segmental osteotomy. Conventional orthodontic treatment is the most common treatment of bimaxillary protrusion. There are many side effects in conventional orthodontic treatment such as gingival recession, bone dehiscence, bone fenestration and root resorption. To overcome the limitations of conventional orthodontic treatment, sometimes anterior segmental osteotomy is recommended. Anyway, there are many disadvantages from postoperative complications of anterior segmental osteotomy such as delayed wound healing, ischemic necrosis, wound dehiscence and non-vital teeth beside the osteotomy site.[17] So the most recent treatment method for bimaxillary protrusion is corticotomy-assisted orthodontic treatment, which is introduced as a compromise option between anterior segmental osteotomy and conventional orthodontic treatment.[18] By corticotomy, the reducing cortical bone allows the anterior alveolar segment to bending when retraction force is applied.

Fuhrmann[19] stated that retraction of the upper anterior tooth cause dehiscence and fenestration in alveolar bone around the roots. And alveolar bone modeling and remodeling during retraction and intrusion of upper incisors are limited[20]. So it is necessary to evaluate dentoalveolar changes during incisor retraction and intrusion. Three-dimensional evaluation is necessary for this purpose, which could provide three dimensional displacements.[21] Risk of alveolar bone loss should

be cautioned during incisor retraction and intrusion, several treatment techniques are suggested.[22] For example, distance of tooth movement and bone quantity limitation should be considered, light force should be used, direction should be controlled, periodontal injury should be routine evaluated and corticotomy with bone graft is another alternative way of decreasing the anatomical limitation.[23, 24] Corticotomy can decrease the alveolar bone dehiscence and maintain the health, function, and esthetics of the periodontium in the orthodontic treatment.

The etiology of root resorption still remains unclear, complex and multifactorial,[25] both genetic and environmental factors are involved.[26, 27] And root resorption is quite common during orthodontic tooth movement. The explanation of the decreased root resorption in the corticotomy area is that decortication results in a rapid alveolar bone remodeling in bone marrow cavities, leads to absence of the lag phase during later stages of orthodontic tooth movement and decreased hyalinization of the periodontal ligament.[15] However, there is only limited evidence in the orthodontic literature that demonstrates a root resorption in corticotomy procedures.[28]

This study is therefore undertaken to evaluate alveolar bone and root length changes after corticotomy in bimaxillary protrusion group.

Review of literatures

Corticotomy-facilitated tooth movement

Corticotomy-facilitated tooth movement was first stated by L.C. Bryan in 1893 as a surgical approach to facilitate orthodontic treatment with incisions to the cortical alveolar bone to splint teeth into new positions. However it was first introduced in 1959 by Kole[6], corticotomy was reintroduced as a surgical procedure to facilitate orthodontic treatment by penetrating the buccal and palatal cortical layers while leaving the spongiosa intact. Kole explained that this method was used to move teeth faster than usual, leading to a shorter orthodontic treatment period because the teeth are moved together with the bone block. However, Kole's technique involves the full thickness flaps reflection to expose both labial and palatal alveolar bone, followed by

interdental cuts through the cortical bone and penetrated the medullary bone. Connecting the interdental by the subapical horizontal cuts were osteotomy style, penetrating the full thickness of the alveolar bone. It was never widely accepted due to invasive technique.

Wilcko et al.[7, 8] have noted that orthodontic tooth movement is accelerated by decrease of bone density and increase of bone turnover by increased osteoclasts and osteoblasts, which called a regional acceleratory phenomenon (RAP) that first described by Frost HM in 1983[29], Frost found a direct relation between the intensity of the healing process and the severity of bone injury, leading to accelerated bone turnover at the surgical area. The duration of RAP depends on the tissue type and usually stay around four months in human bone. This RAP phenomenon causes faster bone healing than normal bone turnover 10–50 times.

Wilcko introduced a recent surgical orthodontic technique[8, 10] which combined corticotomy technique with alveolar grafting, which called Accelerated Osteogenic Orthodontics (AOO) and more recently with periodontally accelerated osteogenic orthodontics (PAOO). Several studys indicated that PAOO is safe, effective, extremely predictable, less root resorption occured and short treatment time. This technique also could reduce the need for orthognathic surgery in some situations.[8, 30-32]

In addition to faster treatment time, corticotomy treatment provide a healthier periodontium than would be achieved with traditional orthodontics. In their original article,[8] the Wilcko brothers claimed no periodontal pocketing and no significant apical root resorption. They believe that a greater extent of movement can be achieved with corticotomy, thus reducing the need for extractions while providing increased support to the periodontium.[33] Shoreibah[34] showed similar results, twenty adult patients who presented with 3-5 mm of lower anterior crowding were equally divided into two groups. Group 1 treatment included corticotomy-facilitated orthodontic therapy alone, whereas group 2 treatment involved the addition of bone grafting to the corticotomy site. Pre-surgical, post-treatment, and 6 months post-treatment measurements of bone density and clinical probing depths were obtained for comparison. Their results demonstrated no significant difference in treatment time between the two groups as well as a significant reduction in probing depths in both groups from pretreatment to 6 months post-retention. With the augmentation of bone following corticotomy, a obviously increase in labiolingual alveolar cortical width has been

observed radiographically and remains stable at two-years post-treatment.[35] And also eliminate of pre-treatment fenestrations and dehiscences.

Another often claimed advantage of corticotomy-facilitated orthodontic treatment is a decrease in apical root resorption. It has been hypothesized that the osteopenia induced by corticotomies allows for diminished osseous resistance to tooth movement. Therefore, less strain on the cemental surface of the root may result in a decreased incidence of root resorption. Interestingly, a diminished extent of hyalinization of the PDL occurs during tooth movement after corticotomies[36] and hyalinization has been known to be a precursor to root resorption.[37] To assess root resorption, Shoreibah[34] compared root length between pre-treatment and post-treatment from the cementoenamel junction to the tooth apex on periapical films. Their results showed no significant root resorption in patients treated with corticotomy. These results are similar with report by Wang[38] who using CBCT, found no significant difference of root length between pre-treatment and post-treatment in their corticotomy group, but an average of 1.55 mm resorption in patients treated with orthodontic therapy alone.

Orthodontic stability is dependent on the ability of the periodontium to regenerate, reorganize, and adapt to the final position of the teeth. Due to the increased tissue turnover that occurs at the corticotomy site, increased alveolar thickness from grafting and tissue memory after dramatic tissue turnover, researchers evaluated post-treatment stability after corticotomy.[13]

As all mentioned above, there are many clinical applications for corticotomy with bone graft have been addressed.[8, 30, 39, 40] This technique use to accelerate orthodontic tooth movement and to overcome conventional orthodontic treatment limitations such as the long treatment time and envelope of tooth movement. The corticotomy procedure can be use for shorten treatment time, crowding correction, increased alveolar bone support, accelerate canine retraction, reinforced anchorage, open bite correction, decreased risk of root resorption and improve stability.[41]

Contraindications include patients with active periodontal disease and gingival recession. Moreover, corticotomy should not be for severe posterior cross-bite surgically and should not be used in cases which bimaxillary protrusion is combined with a gummy smile.[30]

Bone grafting and corticotomy

There are three types of bone graft material. Autografts, the first one, are get from their own hosts. The second type, allografts, are derived from the same species as the host. The third type is xenografts which are taken from another species. And the last one is alloplasts which are synthetic materials. The gold standard is autogenous bone for the defects of the facial area.[42] Because of three potential biological processes in autogenous bone. The first process is osteogenesis which new bone are formed from osteocompetent cells. is Osteoinduction, the second process is the formation of new bone from osteoprogenetor cells. The third one is osteoconduction, the formation of new bone at the recipient site along a scaffold of osteocompetent cells.[43] Autogenous bone can be harvested from intraoral sites for example mandibular ramus and maxillary tuberosity. And from extraoral sites such as the iliac crest, tibia, rib and calvarium.

In corticotomy, bone grafting material is needed quite small volume. So if autogenous bone is chosen, intraoral sites are usually harvested to decrease morbidity. Nowadays, allografts are most frequently used during corticotomy because of elimination of donor site morbidity, ease of use, and accessibility. Although there are only potential osteoinductive and osteoconductive properties. In the oral surgery, many studies reveal that there are advantage outcomes from allografts. Allografts are usually harvested from cadaveric bone in human, but may also get from live human donors and can be prepared as many processes such us fresh, frozen, freeze-dried, mineralized and demineralized. Grafts are processed by different ways such as ultrasonic, physical debridement, antibiotic washing and freeze-drying to make sure that no remaining diseases to the recipient. When the graft is processed, it relates to osteoinductive properties. For example, demineralization of the freeze-dried bone result in more bone morphogenic proteins created, which are important for bone formation. So freeze-dried bone is mostly osteoconductive, but demineralized freeze-dried bone provides osteoinduction in addition to an osteoconductive scaffold.[44, 45] From reasons mentioned above, the most commonly allograft for the corticotomy augmentation procedure is demineralized freeze-dried bone allograft.

Xenografts are taken from the inorganic portion of bone in different species. Bovine bone is the most common used in this type. Xenografts will be complete deproteined by high temperature procedure to eliminate risk of immune response.[43] The crystalline structure of

xenografts is similar to human cancellous bone. Total resorption of the xenografts had taken place with new bone formation by 14 weeks.[46] Alloplasts are synthetic materials used as bone substitutes and include various combinations such as hydroxyapatite and calcium carbonate. For new bone growth, only osteoconductive properties are available in alloplasts.[42] The major disadvantage of alloplasts is the lack of osteoinductive properties.

Rate of resorption and new bone formation depend on the physical and chemical properties of graft materials.[47] Incorporation of bone grafts are expected, the first process involves the bony union along the edges of the graft and native bone segments followed by the gradual resorption of the graft material itself and replacement by new bone.[48, 49] Duration and amount of incorporation into host bone depends on multiple factors such as graft type, processing method particle size, porosity, crystallinity and the pH of surrounding tissues. All factors play a role in the resorption rate. For example, the larger the particle size, the longer the material will remain at the site. A cortical graft may never be fully resorbed due to incomplete vascular penetrance into the tightly packed lamellar bone. Because of the great variability in grafting materials, it is difficult to definitively define an exact time to full graft resorption and bone replacement. One study showed that within 8 weeks, most of the graft has been remodeled.[50] However, another study reported the presence of grafting granules even after 44 months.[51] Despite the range in numbers, most of orthopedic and dental literature agrees that the majority of cancellous bone graft replacement occurs in 3-4 months.

The process of incorporation of new bone within the implanted grafting material is biologically similar to normal bone healing with a reactive, reparative, and remodeling phase. Like long bone healing, adequate blood supply and stability are imortant for graft survival, and periosteal preservation has been documented to enhance incorporation of the graft.[52] Urist first described the five stages of graft incorporation in 1976.[53] Stage one, the inflammatory stage, immediately follows bone grafting. A blood clot forms to stop the bleeding. Necrosis of the graft occurs and a subsequent inflammatory response is established. During the second stage, the osteoblast stage, osteoblasts, lymphocytes and plasma cells are attracted by platelet derived growth factor. Granulation tissue forms together with capillary buds bringing macrophages and mesenchymal cells. A fibrovascular stroma develops with an influx of osteogenic precursors and blood vessels. Osteoblasts and osteoclasts are stimulated and the osteoclasts initiate graft

resorption. Stage three is the osteoinductive stage, whereby mesenchymal cells differentiate into osteoblasts and new bone is laid down by endochondral ossification. Next is the osteoconduction stage, during which the graft serves as a passive template for ingrowth of vascular and cellular activity. Lastly, stage five is the remodeling stage where final incorporation and remineralization occurs. It is important to recognize that these final three stages are closely entwined and occur simultaneously during graft healing.

In the grafting procedure known as guided bone regeneration, a resorbable or non-resorbable membrane is used as a mechanical barrier to stabilize particulate graft material while simultaneously maintaining space around the bony defect to discourage in-growth of soft tissue at the osseous healing site. A graft has the potential to lose up to 25% of its volume after 4 months when a membrane is not used.[54] In general, both resorbable and non-resorbable membrane materials are equally effective in attaining adequate bony defect fill, but the use of a resorbable membrane does not require a second removal surgery.[55] In a systematic review of bone replacement grafts used in the treatment of intrabony periodontal defects, increases in bone level and in clinical attachment levels, as well as decreases in probing depths were found, when compared to simply open flap.[56] Additionally, when compared to grafting alone, grafting with a barrier membrane increases clinical attachment level and decreases probing depth.[56]

Traditionally, particulate bone grafts are used in dentistry to fill bony defects or gain additional bone height and width. Jensen and Terheyden[57] reported a mean increase in horizontal and vertical dimensions of 2.6 mm and 3.6 mm, respectively, following the guided bone regeneration technique. There is no consensus in the literature, however, on the biological events that take place after grafting with DFDBA. Smukler[58] demonstrated the presence of residual DFDBA particles within a network of newly bone formation. They concluded that it may take many months or years for complete particulate resorption and total replacement by new bone.

In 2001, Wilcko introduced the use of the afore-mentioned particulate bone grafts following a corticotomy procedure.[8] The case report described a patient with severe maxillary transverse constriction whose premolars were expanded over 3 mm. The authors claimed an increase in the buccolingual thickness of the cortical bone. A bone biopsy taken two years post-retention qualitatively revealed the presence of lamellar bone. Later, in 2008, Nowzari[31] published the first case report using autogenous particulate bone as the grafting material after a corticotomy

procedure. One year after treatment was complete, the surgical sites were reentered and a visual report of both resorption and remodeling of the particulate material grafted from the patient's mandibular ramus and lingual exostoses was described. They claimed no loss in alveolar height. Since the Wilckos' first augmentation procedure with corticotomy, many others are also using bone grafting to supposedly build bone. Recently, Shoreibah[34] has conducted the only study comparing corticotomy with and without bone augmentation. One aim of their study was to evaluate the effect of bone grafting on the periodontium. Using bioactive glass as their grafting material of choice, they sought to assess bone density in patients receiving either corticotomy or corticotomy with bone grafting. Measurements of bone density were obtained through calculation of mean gray value in an area of interest by periapical radiographs. As expected, they found a mean decrease in bone density following the corticotomy surgery. By 6 months post-treatment, a significantly greater percent increase in bone density was discovered in the group receiving bone augmentation. When comparing the groups from the start of orthodontic treatment and six months into retention, however, no significant differences in bone density changes could be noted. However, using periapical radiographs to measure bone density is not accurately quantified and it does not provide clear information on the condition of the grafted bone.

Dehiscences and fenestrations

The bony defects of the alveolar bone that found on the labial or lingual side of a tooth and may extend over 2 mm. below the cementoenamel junction to the apex of the root with normal interproximal bone levels, it is called dehiscences.[59]

There are 2 types of gingiva. The first type is thin and scalloped, the second type is thick and flat.[60] The first type, scalloped and thin gingiva. This thin gingiva takes much more risk for gingival recession. Because the thin gingiva loss easily when the base of the dehiscence is reached. The etiology of dehiscences and fenestrations is multifactorial. Severe anterior crowding and ectopically positioned of the teeth which make the tooth outside the alveolar bone often leading to dehiscences.[19,61] Inappropriate eruption that the roots erupt more labially compared to the crown results in a dehiscence, especially found in lower anterior teeth.[61] Frenum attachments also cause dehiscenses,[61] they can create pressure on the bone and finally result in bone recession.

The upper and lower mid-labial frenum often result in the recession on the central incisors.[61] The traumatic occlusion strongly relates with periodontal defects and can cause bone destruction.[62] There is a significant reduction in periodontal destruction when traumatic occlusion is removed.[62,] [63] Patient habits are another cause of dehiscences and fenestrations such as the use of smokeless tobacco products. Iatrogenic treatment also cause the defects such as the orthodontic treatment move teeth outside of the alveolar bone or the dental restoration invade through the biologic width.[64]

The normal attachment of the gingiva combines with one millimeter of sulcular depth, one millimeter of epithelial attachment and one millimeter of connective tissue attachment above the crestal alveolar bone. If this distance is invaded, the bone and epithelial attachment will move apically to maintain the biologic width. Inappropriate tooth brushing and aging also cause recession of bone and also gingiva.[61] The etiology of periodontal breakdown can be multifactorial factors or just one factor.[61] The dehiscences and fenestration correlated with thin alveolar bone.[65] The dehiscences and fenestrations are found around twenty percent in the population.[59] Dehiscences were found quite often at mid-labial side of the lower canines. Before orthodontic treatment, CBCT scans is needed for the detection and measurement of dehiscences.[66] Because of a long junctional epithelial attachment of the gingiva to the cementum, although the probing depth level and gingival margin is examined as normal, dehiscences and fenestrations often presented. The study showed that the depth of the gingival recession does not always relate with the depth of the dehiscence.[67] So the orthodontist must aware about dehiscences and fenestrations in orthodontic treatment plan.

Periodontium and orthodontics

The orthodontic treatment plan depends on each individual patient, one of the most important factor is periodontium. The buccal and lingual alveolar bone need to be evaluated, the orthodontists must know the limitation of the alveolar bone.[68]

Unwanted results may happen during orthodontic treatment, although the periodontium has effective regenerative properties. From a systematic review of the literature, there is no reliable study presenting positive results of periodontal health during orthodontic

treatment. The report about periodontium during orthodontic treatment compared with no treatment was related with gingival recession around 0.03 mm., 0.23 mm. of increased pocket depth and 0.13 mm. of alveolar bone loss.[69]

The most important about periodontal tissue respones is the type of the gingiva. Thin gingiva takes much higher risk for gingival recession and periodontal problems.[60] If gingival recession is presented and attached gingiva is less than 2 mm., grafting should be done before orthodontic treatment.[70, 71] If the grafting is proposed for esthetic aspectes, so the grafting should be done after orthodontic treatment.[70] Lower incisors inclination may cause gingival recession and also bone loss. But most of the studies do not agree and found that proclination does not significantly relate the gingival level.[72, 73] Anyway, many studies compare models between pre-treatment and posttreatment. Measurments were made at the heights of gingiva but the underlying bone may changed significantly.

Handleman[68] determined that there was orthodontic wall, these walls were the thickness of the alveolar bone. The alveolar bone widths should be considered before orthodontic treatment. And it is useful for orthodontic treatment plan about space available to tooth movement. Long face type usually presents less alveolar bone width than short face type.[74] Thin alveolar bone were often found in lower incisors area in high angle patients and in upper central incisors area in high angle class II patients. Considerably iatrogenic effects may be occured by tooth movement that beyond the limits of the alveolar bone housing.[68]

Several patients developed alveolar bone loss that may not visible from visual inspection or 2D film. Sarikaya[75] used CBCT scans to evaluate the 3D alveolar bone thickness after retraction of maxillary and mandibular incisors in orthodontic treatment with first premolar extractions. This study showed that bone thickness following retraction on the lingual side in both arches reduced and also found at the alveolar crest on the buccal of the lower incisors. When the alveolar bone housing for tooth movement is limited, the root movement may move against the cortical plate and may cause adverse effects.[19, 75] There are studies show that the effects of orthodontic treatment on the underlying bone may not always relate the overlying gingiva.[76, 77] During excessive tooth movement, the dehiscences and fenestrations may repair if the teeth are moved back to the alveolar bone housing.

Periodontium and CBCT

Vandenberghe[78] found that conventional radiography presented more bone details. And CBCT provided a better morphologic data of both alveolar bone and periodontal defects.[78] So intraoral radiography got better image for bone quality, contrast and lamina dura consideration. But periodontal defects were detected better from CBCT.[78]

Intraoral radiography, conventional CT and CBCT were compared in measurements of 14 dehiscences, 14 fenestrations and 14 intrabony defects on human skulls and dry pig.[79] The mean difference of the CT for all defects was 0.16 mm and 0.19 mm for CBCT. For 12mm high and 3mm wide dehiscences measured by CBCT, the deviations were 0.28 for height, 0.21 for width and 0.88 for depth. Another similar results from study using dental implants in dry pig mandibles found that the dehiscence construction was not thinned as natural dehiscences. Mengel concluded that CBCT provided better image quality than CT.[80] At least one alveolar defect found on 78% of subjects.

Dehiscences are the most common periodontal defect. And dehiscences were found most often on the mid-labial of the lower canines. So, the detection and measurement of dehiscences before orthodontic treatment is necessary.[66] CBCT scans provide an important data for the orthodontic treatment plan based on alveolar bone support. When the alveolar bone was limited, the orthodontic wall, the treatment plan must be concern about tooth movement amount and direction. The orthodontic mechanics would be cautioned to reduce the movement of teeth outside of the alveolar housing. The 3D scans provided adequate data to orthodontist, so these data could help orthodontist to reduce iatrogenic effects.

Willerhausen and Kasaj conclude that CBCT was the low dosage and superior image quality when using for periodontal problems detection, especially for intra-bony defect,cyst recognition dehiscence and fenestration.[81]

Recently, CBCT has the opportunity to gradually replace conventional radiography. And provide diagnostic decisions based on the bony envelope found on the 3D data.[82]

Marginal alveolar bone and orthodontics

There are many adverse side effects occurred during orthodontic tooth movement such as gingival recession, dental caries progression, tooth mobility, tooth vitality, root resorption and alveolar bone loss. Most research mainly focused on root resorption that resulted from inflammatory process during orthodontic treatment.[83] Anyway, factors that can cause root resorption may also make the alveolar bone loss in all directions.[19, 84]

Bitewing and periapical radiography have mostly used to evaluate alveolar bone changes in orthodontic patients for long time. 2D conventional radiograph has its limitation including the proximal bone surfaces assessment due to structure superimposition.[85]

In orthodontically treated patients, marginal bone loss has been found more than in untreated patients. But the amount of bone loss between studies are quite different. A marginal bone loss was more in orthodontic treated patients, the study found that marginal bone loss more than 2 mm. was occurred in 16.2% of 14 years old orthodontically treated patients and in 4.3% of untreated patients.[86] One reason why marginal bone loss was found more in orthodontically treated is that marginal widening of the periodontal ligament space was included as bone loss. Another study showed that both control and treatment groups did not suffer from marginal bone loss of more than 2 mm over 5 years during orthodontic treatment.[87]

CBCT scans provide an important data for the orthodontic treatment plan based on alveolar bone support. CBCT was the low dosage and superior image quality when using for periodontal problems detection. Fuhrmann[19] concluded that 2D conventional radiography is not clearly visualized for marginal bone assessments because of superimposed structures. When examining thin structures, a smaller voxel size and a smaller field of view cone beam computed tomography (CBCT) that commonly used for orthodontic purposes should be used.[88] Alveolar bone height measurements can be made with good to excellent intra-rater and inter-rater repeatability by CBCT. When the bone thickness or bone height was smaller or similar to the voxel size of CBCT, the measurement could be overestimated. The measurement accuracy was improved when decrease in voxel size from 0.4 to 0.25 mm.[89]

Root resorption and corticotomy

The etiology of root resorption still remains unclear, complex and multifactorial.[25] Both genetic and environmental factors are involved.[26, 27] Root resorption is quite common during orthodontic tooth movement. This problem of root resorption as a consequence of orthodontic treatment was first discussed in 1927.[90] The risk for root resorption associated with the length of orthodontic treatment, history of trauma[91], orthodontic treatment plan with premolar extraction, the use of intermaxillary elastics, thin, tapered and dilacerated root[92] and root resorption from previous orthodontic treatment may result in further root shortening.[93]

Corticotomy has been proposed for accelerating the rate of tooth movement for over 100 years.[94] (Wilcko, 2003). Corticotomy increases rate of orthodontic tooth movement by the activation of a regional acceleratory phenomenon. The RAP occurs within a few days of injury, peaks at 1 to 2 months and lasts for 2 to 4 months with up to 6 to 24 months.[94, 95] The corticotomy accelerates tooth movement by producing temporary osteopenia in the bone surrounding the roots. The activated area gets more rapid and extensive alveolar bone and periodontal ligament turnover.[96] Corticotomy can increase the rate of orthodontic tooth movement 2 to 3 times.[97, 98] Moreover, corticotomy is safe for periodontal structure and causes little risk of root resorption.[4, 14] The explanation of the decreased root resorption in the corticotomy area is that decortication results in a rapid alveolar bone remodeling in bone marrow cavities, leads to absence of the lag phase during later stages of orthodontic tooth movement and decreased hyalinization of the periodontal ligament.[15] However, there is only limited evidence in the orthodontic literature that demonstrates a root resorption in corticotomy procedures.[28, 34]

15

Conceptual framework

Bimaxillary protrusion

- Thin alveolar bone support

- Maximum anchorage

En-mass retraction

En-mass retraction

+

Corticotomy

Alveolar bone modeling and

remodeling are limited.

?

- Alveolar bone dehiscence

- Alveolar bone fenestration

- Root resorption

- Alveolar bone dehiscence

- Alveolar bone fenestration

- Root resorption

CBCT

- **Alveolar bone changes**

- **Root length changes**

T_0 Pre-treatment

T_1 Post-retention

Objectives

       1. To compare alveolar bone width and height before and after en-masse retraction with corticotomy in bimaxillary protrusion patient.

       2. To compare root length before and after en-masse retraction with corticotomy in bimaxillary protrusion patient.

Hypothesis

       En-masse retraction with corticotomy increase alveolar bone width and height and reduce root resorption in bimaxillary protrusion patient.

Significances of the study

       1. To basically understand alveolar bone and root length changes following en-masse retraction with corticotomy in bimaxillary protrusion patient.

       2. To provide the information for clinical application in bimaxillary protrusion patient.

CHAPTER 2

RESEARCH METHODOLOGY

Samples

This study was approved by Ethics committee on human experimental of Faculty of Dentistry, Prince of Songkla University. The subjects selected from patients who received orthodontic treatment at orthodontic clinic, faculty of dentistry, Prince of Songkla University.

The inclusion criteria

1. Age at beginning of treatment between 18-35 years.

2. Healthy patients

- No allergy or medical problems especially uncontrolled osteoporosis or other bone disease

- No long term use of medications such as anti-inflammatory, immunosuppressive, or steroids.

- No long-term use of bisphosphonates.

3. No active periodontal disease.

4. No sign and symptoms of temporomandibular disorders.

5. Bimaxillary protrusion (The patients required the removal of first premolars in upper and lower arches as a part of their orthodontic treatment.)

- Interincisal angle $< 117°$

- Class I malocclusion

6. Treatment plan required maximum anchorage.

7. Well-aligned maxillary and mandibular incisors with minimal crowding ($\leq$ 3 mm.)

8. Treatment plan required anterior retraction more than lingual bone thickness of the lower anterior teeth at the level of the incisor apices.

9. The orthodontic treatment completed at least 1 year.

10. CBCT was available at pretreatment and postretention.

The exclusion criteria

1. Medical problems especially uncontrolled osteoporosis or other bone diseases.

2. Long-term use of medications that are anti-inflammatory, immunosuppressive, steroid or bisphosphonates.

3. CBCT was unavailable at pretreatment and postretention.

Materials and Methods

1. Initial record included (T0)

   - Extraoral and intraoral photos.

   - Lateral cephalometric radiographs.

   - Cone beam computed tomography scan.

2. 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 0.016"x0.022" stainless steel archwire.

3. The patients referred to oral surgery clinic for alveolar decortications and bone graft with the same surgeon. The surgical procedures were performed following these step:

   - The surgical procedures were performed under local anesthesia and conscious oral sedation (Diazepam 5 mg.)

   - The mucoperiosteal incision were made along the buccal and lingual mucosa, the bone was exposed.

   - First premolars were extracted

   - After the mucoperiosteum had been undermined, vertical decortications were made across both first premolar sites with the proper size of round carbide burs in

difference areas. The horizontal decortications were made 2 cm. below the apices of anterior teeth. (Figure 1.)
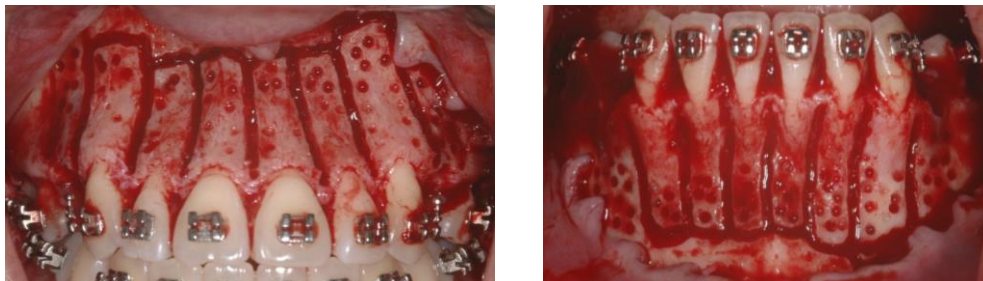
Figure 1. The decortications

- Bone grafting with allograft (Freeze dried bone from Faculty of Medicine, Siriraj Hospital) and autogenous bone (from decortications procedure) were adjusted to the corticotomy site. (Figure 2.)
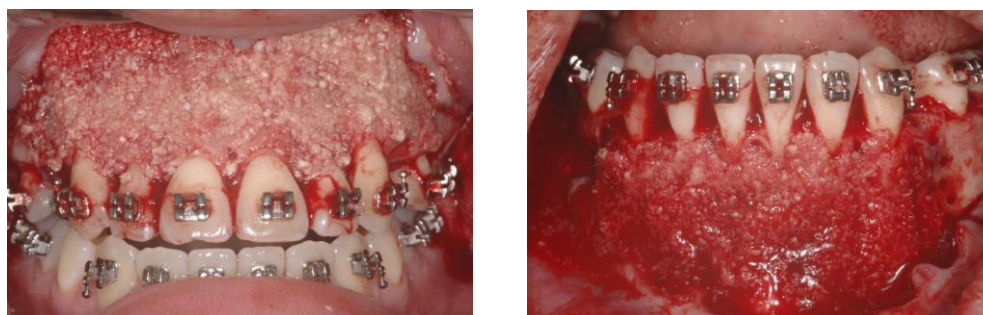
Figure 2. Bone grafting on the alveolar decortication area

- Flap repositioning and suturing were made using a vertical double mattress technique. (Figure3.)

Figure 3. Flap repositioning and suturing

4. Two weeks after alveolar decortications (Two weeks was optimal interval for sufficient healing and less patient anxiety), the maxillary and mandible anterior teeth and

anchorage unit were fixated into a single unit with ligature wire, T-loop was used to en-masse incisors and canines retraction. (Figure 4.)

Figure 4. T-loop was used to en masse retraction

5. T-loop were reactivated every 2 weeks until space was closed.

6. After the orthodontic treatment completed at least 1 year. Cone beam computed tomography scan was taken including (T1)

Cone beam computed tomography analysis

Light beam of a machine was guided to set the head position in all 3 planes. The longitudinal light beam was set at the center of glabella and filtrum. And the transverse light beam passed through the lateral eye canthus. Cone beam computed tomography are obtained at 80kV, 5mA (Varaviewpocs, J. morita, Kyoto, Japan)

Cone-beam computed tomography records at pretreatment (T0) and postretention (T1) were used for measurement of parameters. For each tooth, alveolar bone thickness (labial, palatal and total thickness) at crestal, mid root and apical level, alveolar bone height (mesial, distal, labial and lingual side) and root length were measured by OneVolumeViewer.

Parameters

1. Alveolar bone thickness of upper and lower anterior teeth.

- Labial alveolar bone thickness at crestal level, mid root level and apical level.

- Palatal alveolar bone thickness at crestal level, mid root level and apical level.

- Total thickness of alveolar bone at crestal level, mid root level and apical level.

2. Alveolar bone height of upper and lower anterior teeth.

- Alveolar bone height at mesial, buccal, palatal and distal side.

3. Root length of upper and lower anterior teeth.

Alveolar bone thickness

The analysis of bone thickness was taken at the labial and palatal site of the root in 3 slices separated by 3 mm., crestal level (S1), mid root level (S2), apical level (S3) was the level 3, 6, 9 mm. from cementoenamel junction, respectively. (Figure 5.) These levels were specified along the long axis of the tooth. Measurement are taken at the site adjacent to the widest point of the labio-lingual root surface in cross sectional image of each level. (Figure 6.) Each measurement was repeated two times by the same researcher.

Alveolar bone thickness measurement that used in computed tomography analysis was as follow:

The thickness of the labial alveolar plate was measured as a line passing from the outer surface of the labial plate to the mid labial root.

L1: Labial alveolar bone thickness at crestal level (S1)

L2: Labial alveolar bone thickness at mid root level (S2)

L3: Labial alveolar bone thickness at apical level (S3)

The thickness of the palatal alveolar plate was measured as a line passing from the outer surface of the palatal plate to the mid palatal root.

P1: Palatal alveolar bone thickness at crestal level (S1)

P2: Palatal alveolar bone thickness at mid root level (S2)

P3: Palatal alveolar bone thickness at apical level (S3)

The thickness of the total alveolar plate was measured as a line passing through the center of the pulp from the outer surface of the palatal plate to the outer surface of the labial plate.

T1: Total alveolar bone thickness at crestal level (S1)

T1: Total alveolar bone thickness at mid root level (S1)

T1: Total alveolar bone thickness at apical level (S1)
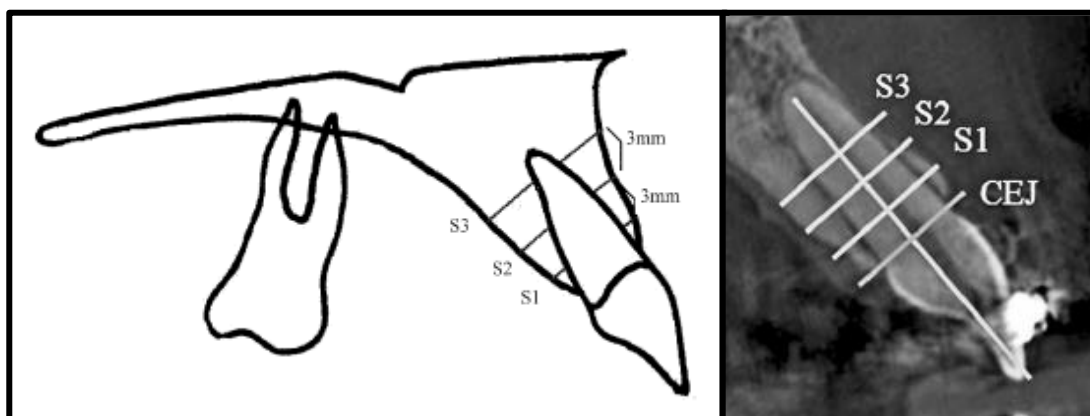
Figure 5. Location of bone thickness measurement pretreatment and postretention.
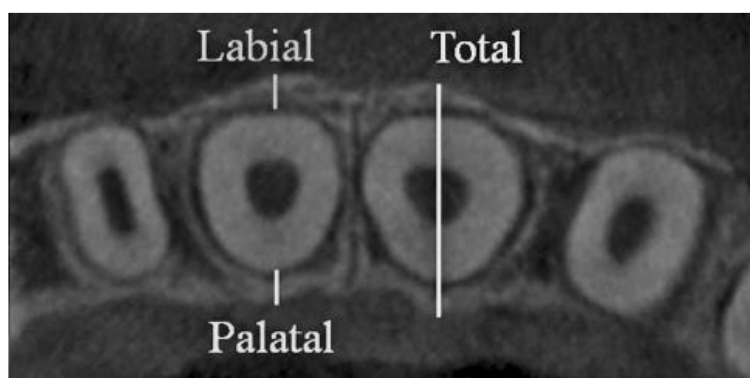
Figure 6. Measurement of bone thickness

Alveolar bone height

The same position set in three dimensional. Three planes were set through and perpendicular to the long axis of the tooth. Alveolar bone height was measured in four positions of the mesial, buccal, palatal and distal sides of each tooth. The landmarks for alveolar bone height measurement was the cemento-enamel junction and the alveolar bone crest. Then, vertical linear distances from cemento-enamel junction to alveolar bone crest was record as data for alveolar bone height measurement. These distances were obtained in four sides for each tooth. (Figure 7.)
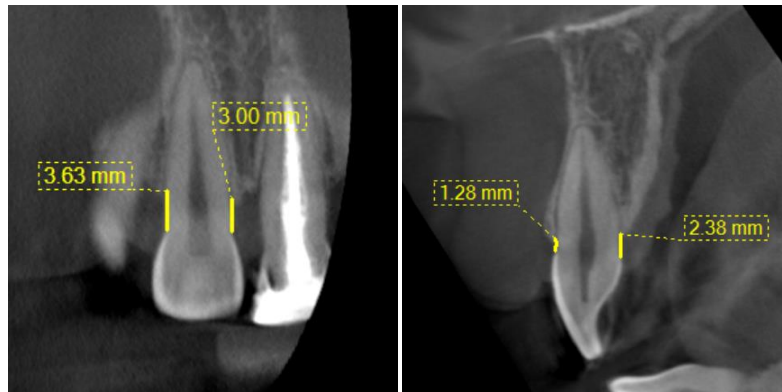
Figure 7. Alveolar bone height measurment

Root length

The same position set in three dimensional. Three planes were set through and perpendicular to the long axis of the tooth allow root length measurement. The landmarks for root length measurement were the cemento-enamel junction and the apex of root. Create the midpoint of the line connecting these two points, the cementoenamel junction at labial side and the cementoenamel junction at lingual side, the distance between the midpoint to apex of roots is measured as root length. (Figure 8.)
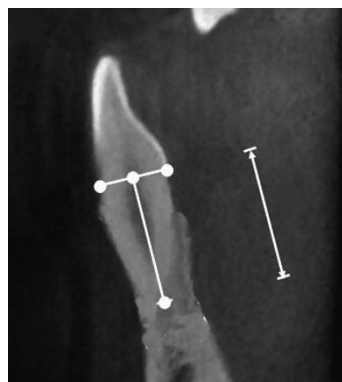
Figure 8. Root length measurement

Statistical Analysis

Measurement errors

Total measurements error (ME) will be calculated with the Dahlberg's formula.

$$ME = \sqrt{\frac{\sum d^2}{2n}}$$

(d= different between two measurement, n= number of evaluations)

The linear measurements should not exceed 0.5 mm. To reduce method error associated with the measurement of cone beam computed tomography analysis.

Intra-examiner reliability

The measurement of cone beam computed tomography analysis repeated 1 month later and the mean of these measurements compared to the mean of the initial measurements The Shapiro-Wilk test was used to test normality. The statistically significant between these two results should not difference.

Data analysis

The data obtained from cone-beam computed tomography as mean and standard deviations will be analyze with the SPSS computer program. Shapiro-Wilk test was used to test normality. Comparisons made between pretreatment and postretention. If found that mean was normally distributed, pair t-test was used to compare the difference of parameters. If found that mean was not normally distributed, Wilcoxon Signed Rank test was used to compare the difference of parameters.

CHAPTER 3

RESULTS

The sample were 14 subjects, 12 females and 2 males. Their mean age at the start of treatment was 22.73 years (SD = 4.92), range from 18-31 years. Treatment time was 3.31 years (SD = 1.38), range from 1.25-5.75 years. And post retention phase was 3.18 years (SD = 1.31), range from 1.42-6.5 years. (Table 1.)

Table 1. Age, the total treatment time and post retention phase in subjects who were treated with decortication-facilitated en-masse retraction.

Subjects	Age at initial (years)	Treatment time (years)	Post retention (years)
1	31.67	1.25	6.50
2	18.08	3.00	4.08
3	18.91	3.42	3.25
4	18.00	3.50	3.00
5	21.50	4.17	2.33
6	19.00	3.58	2.58
7	27.80	3.66	2.42
8	27.73	2.42	3.66
9	26.66	2.25	2.33
10	20.83	5.75	1.42
11	19.16	5.66	1.66
12	17.91	3.00	3.33
13	22.75	3.33	3.17
14	28.33	1.33	4.75
Mean	22.73	3.31	3.18
SD	4.92	1.38	1.31

Cone beam computed tomography analysis

Measurement error analysis

All measurements were repeated 1month apart and calculated to determine the intraobserver reliability. Cone beam computed tomography analysis were measured by same investigator. Systematic error was not significant. The random measurement error (ME) was calculated according to Dalberg's formula. The linear measurement error was found to be less than 0.2 mm. No statistically significant differences were found between the 2 measurements at 2 different times for purpose of error testing.

Alveolar bone thickness

The results for changes in alveolar bone thickness as measured on the cone beam computed tomography from T0 to T1 are listed in Table 2-7.

Maxillary labial alveolar bone width

The average increase in maxillary labial bone thickness was 0.58 mm. All levels found that the maxillary labial bone thickness was increased except crestal level of maxillary canines. The changes were not significant except apical level of maxillary right lateral incisor, mid root level of maxillary central incisors and apical level of maxillary left central incisor. (Table 2.)

Mandibular labial alveolar bone width

The average increase in mandibular labial bone thickness was 0.65 mm. All levels found that the mandibular labial bone thickness was increased except crestal level of mandibular canines. The changes were not significant except mid root level of mandibular left lateral incisor, mid root level of mandibular central incisors and apical level of mandibular left central incisor. (Table 3.)

Maxillary lingual alveolar bone width

The average decrease in maxillary lingual bone thickness was 0.18 mm. All levels found that the maxillary labial bone thickness was decreased except crestal and apical level of maxillary right lateral incisor, apical level of maxillary right central incisor, mid root and apical level of maxillary left central incisor and crestal level of maxillary left canine. The changes were not significant. (Table 4.)

Mandibular lingual alveolar bone width

The average increase in mandibular lingual bone thickness was 0.27 mm. All levels found that the mandibular lingual bone thickness was increased except crestal and mid root level of mandibular left canine and lateral incisor, mid root level of mandibular right lateral incisors and crestal level of mandibular right canine. The changes were not significant. (Table 5.)

Maxillary total alveolar bone width

The average increase in maxillary total bone thickness was 0.43 mm. All levels found that the maxillary labial bone thickness was increased except crestal and apical level of maxillary canine, crestal level of maxillary left central incisor and all levels of maxillary left lateral incisor. The changes were not significant except mid root and apical level of maxillary left central incisor. (Table 6.)

Mandibular total alveolar bone width

The average increase in mandibular total bone thickness was 0.91 mm. All levels found that the mandibular lingual bone thickness was increased except mid root level of mandibular left canine. The changes were not significant except all level of mandibular left central incisor, crestal and apical level of mandibular right central incisor, apical level of mandibular right lateral incisor and crestal level of mandibular right canine. (Table 7.)

Alveolar bone height

The results for changes in alveolar bone height as measured on the cone beam computed tomography from T0 to T1 are listed in Table 8-9.

Maxillary alveolar bone hight

The average decrease in maxillary alveolar bone height was 0.19 mm. The changes of all levels in maxillary anterior teeth were not significant. (Table 8.)

Mandibular alveolar bone height

The average decrease in maxillary alveolar bone height was 0.18 mm. The changes of all levels in mandibular anterior teeth were not significant. (Table 9.)

Root length

The results for changes in root length as measured on the cone beam computed tomography from T0 to T1 are listed in Table 10. The root resorption was observed in range 1.06-1.42 mm. Average root resorption in all anterior teeth was 1.01 mm. The lowest root resorption was shown in upper canines and the highest was observed in lower canines. Significant root resorption occurred in all anterior teeth. During the assessment of each anterior teeth with CBCT. No considerable root damage from corticotomy was shown.

Table 2. Comparison of mean values of maxillary labial alveolar bone width measured from CT scans before and after en‑masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
13	Crestal	0.42	0.38	0.19	0.16	-0.23	0.247
	Mid root	0.25	0.27	0.94	0.61	0.69	0.072
	Apical	0.47	0.45	0.67	0.59	0.20	0.423
12	Crestal	0.50	0.36	1.21	0.57	0.71	0.118
	Mid root	0.41	0.11	1.15	0.45	0.74	0.106
	Apical	0.10	0.17	1.00	0.86	0.90	0.061*
11	Crestal	0.61	0.26	1.32	0.35	0.70	0.126
	Mid root	0.53	0.46	1.48	0.83	0.95	0.020*
	Apical	0.38	0.33	1.16	0.75	0.78	0.112
21	Crestal	0.83	0.32	1.48	0.64	0.65	0.075
	Mid root	0.27	0.26	1.25	0.60	0.97	0.042*
	Apical	0.43	0.16	1.52	0.80	1.09	0.044*
22	Crestal	0.62	0.25	0.93	0.37	0.30	0.560
	Mid root	0.61	0.62	1.17	0.53	0.56	0.788
	Apical	0.12	0.13	0.66	0.58	0.54	0.454
23	Crestal	0.53	0.03	0.51	0.10	-0.02	0.578
	Mid root	0.53	0.46	1.11	0.96	0.58	0.424
	Apical	0.31	0.28	0.57	0.49	0.26	0.656

Table 3. Comparison of mean values of mandibular labial alveolar bone width measured from CT scans before and after en-masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
33	Crestal	0.51	0.12	0.30	0.26	-0.21	0.478
	Mid root	0.25	0.23	0.66	0.58	0.41	0.772
	Apical	0.32	0.29	0.45	0.39	0.13	0.423
32	Crestal	0.39	0.35	0.46	0.16	0.07	0.118
	Mid root	0.03	0.06	1.62	0.62	1.58	0.044*
	Apical	0.30	0.26	2.38	1.63	2.08	0.188
31	Crestal	0.05	0.09	0.89	0.46	0.84	0.597
	Mid root	0.04	0.07	1.60	0.93	1.56	0.041*
	Apical	0.57	0.21	1.91	0.97	1.35	0.035*
41	Crestal	0.07	0.12	0.72	0.41	0.65	0.874
	Mid root	0.10	0.17	0.89	0.13	0.79	0.042*
	Apical	0.06	0.10	0.96	0.84	0.90	0.242
42	Crestal	0.30	0.26	0.51	0.45	0.21	0.425
	Mid root	0.08	0.14	0.71	0.16	0.63	0.721
	Apical	0.11	0.19	0.85	0.94	0.74	0.176
43	Crestal	0.47	0.17	0.40	0.36	-0.07	0.658
	Mid root	0.32	0.29	0.38	0.13	0.06	0.542
	Apical	0.18	0.18	0.32	0.29	0.14	0.895

Table 4. Comparison of mean values of maxillary lingual alveolar bone width measured from CT scans before and after en‑masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
13	Crestal	0.54	0.38	0.21	0.16	-0.33	0.247
	Mid root	1.51	0.27	1.10	0.21	-0.51	0.072
	Apical	1.70	0.45	1.20	0.59	-0.50	0.423
12	Crestal	0.79	0.36	0.9	0.57	0.11	0.118
	Mid root	1.55	0.11	0.9	0.45	-0.70	0.106
	Apical	1.79	0.17	1.80	0.86	0.01	0.478
11	Crestal	1.38	0.26	1.17	0.35	-0.21	0.772
	Mid root	2.38	0.46	2.17	0.83	-0.20	0.188
	Apical	3.01	0.33	3.68	0.75	0.67	0.118
21	Crestal	1.63	0.32	1.18	0.64	-0.45	0.188
	Mid root	2.01	0.26	2.81	0.60	0.80	0.118
	Apical	4.14	0.16	5.21	0.80	1.07	0.242
22	Crestal	0.35	0.25	0.21	0.37	-0.14	0.425
	Mid root	0.91	0.62	0.75	0.53	-0.20	0.478
	Apical	2.53	0.16	1.57	0.80	-0.96	0.772
23	Crestal	0.45	0.03	0.53	0.10	0.08	0.658
	Mid root	0.71	0.46	1.27	0.96	-0.56	0.542
	Apical	2.15	0.13	0.97	0.58	-1.18	0.118

Table 5. Comparison of mean values of mandibular lingual alveolar bone width measured from CT scans before and after en‑masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
33	Crestal	1.35	0.12	1.08	0.26	-0.27	0.718
	Mid root	3.58	0.23	3.40	0.58	-0.20	0.188
	Apical	2.19	0.29	2.98	0.39	0.79	0.118
32	Crestal	0.45	0.35	0.30	0.16	-1.50	0.158
	Mid root	1.35	0.06	0.83	0.62	-0.50	0.106
	Apical	1.31	0.26	1.43	1.63	0.12	0.188
31	Crestal	0.13	0.09	0.60	0.46	0.47	0.247
	Mid root	0.38	0.07	0.53	0.93	0.15	0.072
	Apical	1.01	0.21	2.11	0.97	1.14	0.072
41	Crestal	0.13	0.12	0.60	0.41	0.47	0.423
	Mid root	0.62	0.17	0.69	0.13	0.07	0.118
	Apical	1.02	0.10	2.11	0.84	1.11	0.788
42	Crestal	0.11	0.26	0.78	0.45	0.30	0.454
	Mid root	0.79	0.14	0.69	0.16	-0.10	0.578
	Apical	0.95	0.19	2.17	0.94	1.22	0.424
43	Crestal	1.08	0.17	0.95	0.36	-0.13	0.442
	Mid root	2.3	0.29	2.75	0.13	0.45	0.111
	Apical	2.92	0.18	4.26	0.29	1.34	0.218

Table 6. Comparison of mean values of maxillary total alveolar bone width measured from CT scans before and after en-masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
13	Crestal	7.91	1.38	7.5	1.16	-0.41	0.247
	Mid root	8.46	2.27	8.74	0.61	0.28	0.072
	Apical	8.39	1.45	7.5	0.59	-0.89	0.423
12	Crestal	7.64	1.36	8.73	0.57	1.09	0.118
	Mid root	7.2	1.11	7.62	1.45	0.42	0.106
	Apical	5.86	2.17	7.23	0.86	1.37	0.188
11	Crestal	8.5	1.26	8.67	1.35	0.17	0.772
	Mid root	8.38	1.46	9.01	0.83	0.63	0.423
	Apical	9.38	1.33	10.51	0.75	1.13	0.423
21	Crestal	8.49	1.32	8.41	0.64	-0.08	0.118
	Mid root	7.68	1.26	9.63	0.60	1.95	0.022*
	Apical	8.70	1.16	11.09	0.80	2.39	0.011*
22	Crestal	7.16	1.25	6.85	1.37	-0.31	0.072
	Mid root	7.66	1.62	7.60	1.53	-0.10	0.423
	Apical	7.44	1.13	7.34	1.58	-0.10	0.118
23	Crestal	8.6	1.93	8.34	1.10	-0.26	0.106
	Mid root	8.38	1.46	9.21	0.96	0.83	0.423
	Apical	8.71	1.28	8.24	1.49	-0.47	0.118

Table 7. Comparison of mean values of mandibular total alveolar bone width measured from CT scans before and after en‑masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
33	Crestal	9.97	1.12	10.14	0.16	0.17	0.247
	Mid root	11.49	1.23	11.09	1.61	-0.4	0.072
	Apical	9.12	1.29	9.66	2.59	0.54	0.423
32	Crestal	7.2	1.35	7.49	0.57	0.29	0.118
	Mid root	7.27	1.06	8.24	1.45	0.97	0.106
	Apical	6.8	1.26	8.31	1.86	1.51	0.188
31	Crestal	5.84	0.79	7.28	0.65	1.44	0.022*
	Mid root	5.41	1.07	7.12	1.83	1.71	0.041*
	Apical	5.82	1.21	7.21	1.75	1.39	0.001*
41	Crestal	5.65	0.82	6.92	0.64	1.27	0.011*
	Mid root	5.63	1.17	6.60	1.60	0.97	0.442
	Apical	5.25	1.10	7.31	1.80	1.06	0.010*
42	Crestal	5.32	0.56	6.97	0.37	0.65	0.423
	Mid root	6.29	1.14	6.64	1.53	0.35	0.118
	Apical	5.94	1.19	8.51	2.08	1.57	0.010*
43	Crestal	8.85	0.17	11.05	0.10	1.10	0.022*
	Mid root	9.91	0.59	10.77	1.96	0.86	0.247
	Apical	9.21	1.18	10.18	1.49	0.97	0.072

Table 8. Comparison of mean values of maxillary alveolar bone height measured from CT scans before and after en‑masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
13	Labial	1.13	0.38	2.02	0.16	0.89	0.423
	Lingual	1.51	0.27	1.01	0.61	-0.50	0.118
	Mesial	1.51	0.45	1.27	0.59	-0.24	0.106
	Distal	1.13	0.16	1.77	0.15	0.64	0.188
12	Labial	1.38	0.36	1.52	0.57	0.14	0.247
	Lingual	1.40	0.11	0.75	0.45	-0.65	0.072
	Mesial	1.01	0.17	1.50	0.86	0.49	0.423
	Distal	1.13	0.15	0.10	0.15	-1.13	0.118
11	Labial	0.76	0.26	2.02	0.35	1.26	0.106
	Lingual	2.12	0.46	2.05	0.83	-0.12	0.188
	Mesial	1.51	0.33	2.02	0.75	0.51	0.423
	Distal	1.26	0.16	2.30	0.58	1.04	0.118
21	Labial	1.13	0.32	2.02	0.64	0.89	0.106
	Lingual	1.51	0.26	1.02	0.60	-0.51	0.188
	Mesial	1.51	0.16	1.27	0.80	-0.24	0.247
	Distal	1.13	0.32	1.77	0.61	0.64	0.072
22	Labial	1.38	0.25	1.52	0.37	0.14	0.423
	Lingual	1.40	0.62	0.75	0.53	-0.65	0.118
	Mesial	1.03	0.13	1.5	0.58	0.47	0.247
	Distal	1.13	0.11	0.10	0.13	-1.13	0.072
23	Labial	0.76	0.03	1.98	0.10	1.22	0.423
	Lingual	2.12	0.46	2.05	0.96	-0.07	0.118
	Mesial	1.51	0.28	2.02	0.49	0.51	0.423
	Distal	1.26	0.51	2.30	0.48	1.04	0.118

Table 9. Comparison of mean values of mandibular alveolar bone height measured from CT scans before and after en-masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	Level	T0	SD	T1	SD	T1-T0	P-value
33	Labial	1.38	0.36	1.52	0.57	0.14	0.247
	Lingual	1.40	0.11	0.75	0.45	-0.65	0.072
	Mesial	1.20	0.17	1.50	0.86	0.30	0.423
	Distal	1.13	0.15	0.10	0.15	-1.13	0.118
32	Labial	0.76	0.26	1.98	0.35	1.24	0.106
	Lingual	2.12	0.46	2.02	0.83	-0.10	0.188
	Mesial	1.51	0.33	2.02	0.75	0.51	0.423
	Distal	1.26	0.16	2.30	0.58	1.04	0.118
31	Labial	1.13	0.32	2.02	0.64	0.89	0.106
	Lingual	1.51	0.26	1.02	0.60	-0.49	0.188
	Mesial	1.51	0.16	1.27	0.80	-0.24	0.247
	Distal	1.13	0.32	1.77	0.61	0.64	0.072
41	Labial	1.38	0.25	1.52	0.37	0.14	0.423
	Lingual	1.40	0.62	0.75	0.53	-0.65	0.118
	Mesial	1.05	0.13	1.50	0.58	0.45	0.247
	Distal	1.13	0.11	0.1	0.13	-1.13	0.072
42	Labial	0.76	0.03	1.82	0.10	1.06	0.423
	Lingual	2.12	0.46	1.78	0.96	-0.34	0.118
	Mesial	1.51	0.28	2.02	0.49	0.51	0.423
	Distal	1.26	0.51	2.30	0.48	1.04	0.118
43	Labial	1.02	0.17	1.50	0.86	0.48	0.423
	Lingual	1.13	0.15	1.10	0.15	-0.03	0.118
	Mesial	0.76	0.26	1.55	0.35	0.79	0.106
	Distal	2.12	0.46	2.02	0.83	-0.10	0.188

Table 10. Comparison of mean values of root length measured from CT scans before and after en-masse retraction with corticotomy assisted orthodontic treatment

Tooth No.	T0	SD	T1	SD	T1-T0	P-value
13	16.99	1.36	16.29	1.35	0.70	0.011*
12	13.53	1.31	12.56	1.12	0.97	0.021*
11	13.82	1.53	12.95	1.42	0.87	0.041*
21	13.95	1.67	13.04	1.35	0.91	0.013*
22	13.24	1.26	12.21	1.32	1.03	0.010*
23	17.02	1.53	16.39	1.45	0.63	0.021*
33	16.87	1.11	15.30	1.19	1.57	0.001*
32	13.47	1.43	12.72	1.06	0.75	0.022*
31	13.13	1.12	11.90	1.21	1.23	0.001*
41	13.27	1.63	12.11	1.24	1.16	0.001*
42	13.35	1.37	12.63	1.17	0.72	0.032*
43	16.57	1.53	15.27	1.25	1.30	0.001*

CHAPTER 4

DISCUSSION

Orthodontic walls is the anatomical limits that set by the cortical bone.[70] Orthodontic tooth movement are limited due to a dense cortical bone plate on the both labial and lingual sides around the roots of the anterior teeth. Moreover, patients with dentoalveolar protrusion usually have thin and bony defect before treatment,[77,95] pushing the tooth against the thin cortical plate may cause alveolar bone defect and root resorption. So, retraction of the anterior teeth combined with corticotomy of the alveolar bone can offer an effective alternative with which to minimize the risk of movements of the anterior teeth.[30]

Lateral cephalograms presented only in midsagittal plane, the cortical plates and the symphysis are shown only in 2 dimensions and the orthodontic tooth movement effect cannot clearly be seen. So the limitation of the alveolar bone housing and the symphysis at the midline may be narrower than lateral cephalograms presented. For this reason, 3 dimensional evaluation is required to provide 3 dimensional displacement of alveolar bone changes. Cone beam computed tomography (CBCT) is now used to evaluated alveolar bone and CBCT scan have proven that statistically similar to histologic finding.[96]

In many study, the reduced alveolar bone thickness was found in the direction of tooth movement.[97,98] Recently in CBCT study found that the maxillary and mandibular alveolar bone thickness decreased during orthodontic tooth movement in bimaxillary protrusion with 4 bicuspids extraction.[22,77,99,100] Alveolar bone loss was shown more at the crestal region especially on the lingual side. Ten Hoeve and Mulie[101] said that the cortical bone would be repaired within 6 months, no matter how much the tooth has been moved. In contrast to many studies[77,102] when perforation was developed, newly thin cortical plate do not form in that patients. And complete repair may be seen if relapse occurs.[97]

There are many methods to measure alveolar bone before and after orthodontic treatment. It is difficult to accurately measure, since the teeth have been moved orthodontically. It is possible that they have been moved into a region with thicker alveolar housing or grafting area. The method of alveolar bone changes measurement perpendicular to the tooth axis cannot detect

at the same point because as the tooth axis changes. However, the advantage of this method is that it observes alveolar bone changes relative to the root, which it is clinical concern.

Due to the orthodontic tooth movement was controlled tipping in this study. (Figure 9.) Alveolar bone loss should be found more at the crestal level than at the apical level. The retraction forces applied to the incisors were pressured in great amount at the alveolar crest. Therefore, the entire alveolar housing should be considered when a clinician tries to know the limitation for orthodontic tooth movement. Compare to other CBCT studies in alveolar bone thickness following orthodontic tooth movement in bimaxillary protrusion with 4 bicuspids extraction without corticotomy[77,99,100], it was found that the alveolar bone thickness in this study had mostly improved. An overall increase in alveolar bone thickness both at the apical and mid root level of the teeth, even though increased bone thickness in some levels are not statically significant. Alveolar bone height in all sides of anterior teeth are not different between pretreatment and postretention. (Table 11.) Whether the increase in measurement is due to the graft material, the orthodontic tooth movement, or a combination of both is difficult to determine without histologic sampling from these patients.
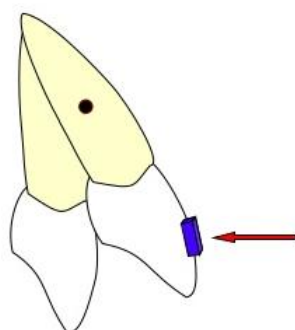

Figure 9. Controlled tipping orthodontic tooth movement

Table 11. Comparing the alveolar bone height changes

Author	Maxillary alveolar bone height loss	Mechanics
GUO et al[91]	1.58 mm.	Miniscrew
This study	0.19 mm.	

The effect of corticotomy on orthodontically induced inflammatory root resorption has been stated briefly in previous studies.[28,34] The conclusion from the limited data

indicated that corticotomy did not result in more root resorption than conventional orthodontic treatment. And there was less root resorption in the other studies.[103] However, the accuracy of these studies could be questioned, they examined from periapical radiographs. Traditional 2D imaging has several limitations when root resorption was assessed. For example, magnification, superimposition of structures and lack of reproducibility and sensitivity of technique. These limitations of 2D imaging result in detecting only advanced root. CBCT allow better detection of root resorption than do 2D imaging. CBCT study found that corticotomy facilitated orthodontics resulted in an average of 0.6 mm of apical root loss, less than this study, whereas conventional orthodontics resulted in 1.5 mm.

Significant root resorption occurred in all anterior teeth in this study. However, an average of apical root loss is 1.01 mm still less than 1.5 mm. found in conventional orthodontic treatment.[104] There were individual variations in root resorption values among subjects and this was expected because of the impact of individual susceptibility on the root resorption process. The biologic mechanisms behind the acceleration of tooth movement in corticotomy and their effects on root resorption are complex and unclear. RAP increases the turnover rate of alveolar bone and the periodontal ligament by increasing the activity of associated cells. An increased bone turnover rate leads to a reduction in the resistance of teeth moving through alveolar bone. By reducing the resistance and the hyalinization, corticotomy could reduce the amount of root resorption, but the relationship between alveolar bone density and the root resorption process is not clear.[105] Some studies found that increased bone turnover and reduced bone density favor remodeling of bone over root surface.[106] Another study shown that root resorption increased due to increased bone turnover.[107] The treatment duration is positively correlated with root resorption, although some recent studies do not agree.[108,109] Corticotomy accelerated tooth movement, so this should reduce in root resorption. Future research still required to provide information how the various biologic mechanisms of corticotomy facilitated tooth movement interact and influence the overall root resorption process.

The drawback of this study is that it was a retrospective study to look at only those patients who had corticotomy combined with orthodontic treatment. There were no matched controls who had similar alveolar bone and orthodontic treatment done without the use of the corticotomy and bone grafting procedure.

Overall, corticotomy seems to be a safe procedure that can shorten treatment time and potentially provide for better post‑operative stability by slightly increasing the width of the alveolar housing. So in patients with thin buccal or lingual alveolar bone, corticotomy may be alternative procedure to reduce treatment time and possible periodontal complications such as dehiscence, fenestration and recession. However, the disadvantages such as cost and complications of an additional surgical procedure must be considered and discussed with the patient.

CHAPTER 5

CONCLUSION

Corticotomy not only accelerates the orthodontic treatment but also provides the advantage of increased alveolar width. This study showed an average increase in alveolar bone width following corticotomy. However, there were also sites, maxillary lingual bone thickness, in which there was a decrease in alveolar width. No significant alveolar bone height changes were found. But significant root resorption occurred in all anterior teeth.

1. The average increase in maxillary and mandibular labial bone thickness was 0.58 mm. 0.65 mm. respectively. The average decrease in maxillary lingual bone thickness was 0.18 mm. but found average increase 0.27 mm. in mandibular lingual bone thickness.

2. No significant alveolar bone height changes were found in all anterior teeth. The average decrease in maxillary and mandibular alveolar bone height was 0.19 mm., 0.18 mm. respectively.

3. Significant root resorption occurred in all anterior teeth. Average root resorption in all anterior teeth was 1.01 mm.

Thesis title	Alveolar Bone and Root Length Changes Following En-masse Retraction with Corticotomy assisted Orthodontic Treatment
Author	Miss Satinee Narupakorn
Major Program	Oral Health Sciences
Academic Year	2017

ABSTRACT

Introduction: Corticotomy is an effective method of accelerating the orthodontic treatment. Corticotomy also has been proposed to increase the volume of the alveolar process and decrease root resorption. **Objectives:** To compare alveolar bone and root length before and after en-masse retraction with corticotomy in bimaxillary protrusion patient. **Materials and methods:** Fourteen subjects were selected from patients who required the removal of first premolars in upper and lower arches, en masse retraction and corticotomy as a part of their orthodontic treatment. Cone beam computed tomography analysis was used to compare alveolar bone width at crestal, mid-root and apical level, alveolar bone height at mesial, distal, labial and lingual sides and root length changes between pretreatment and postretention in all anterior teeth **Results:** The average increase in maxillary and mandibular labial bone thickness was 0.58 mm. 0.65 mm. respectively. The average decrease in maxillary lingual bone thickness was 0.18 mm. but found average increase 0.27 mm. in mandibular lingual bone thickness. No significant alveolar bone height changes were found in all anterior teeth. The average decrease in maxillary and mandibular alveolar bone height was 0.19 mm., 0.18 mm. respectively. Significant root resorption occurred in all anterior teeth. Average root resorption in all anterior teeth was 1.01 mm. **Conclusions:** Corticotomy not only accelerates the orthodontic treatment but also provides the advantage of increased alveolar width. This study showed an average increase in alveolar bone width following corticotomy. However, there were also sites, maxillary lingual bone thickness, in which there was a decrease in alveolar width. No significant alveolar bone height changes were found. But significant root resorption occurred in all anterior teeth.

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APPENDICES

ที่ ศธ 0521.1.03/ **755**

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

<div align="center">หนังสือฉบับนี้ให้ไว้เพื่อรับรองว่า</div>

โครงการวิจัยเรื่อง "การเปลี่ยนแปลงกระดูกเบ้าฟันและรากฟัน ภายหลังจากการผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟันในผู้ป่วยที่มีลักษณะฟันยื่นในขากรรไกรบนและล่าง"

รหัสโครงการ EC5906-23-P-LR

หัวหน้าโครงการ ผู้ช่วยศาสตราจารย์ ดร. ทพ.บัญชา สำรวจเบญจกุล

ผู้ร่วมโครงการวิจัย ทันตแพทย์หญิงสาธินี นฤปกร

สังกัดหน่วยงาน ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

      ได้ผ่านการพิจารณาและได้รับความเห็นชอบจากคณะกรรมการจริยธรรมในการวิจัย (Research Ethics Committee) ซึ่งเป็นคณะกรรมการพิจารณาศึกษาการวิจัยในคนของคณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ดำเนินการให้การรับรองโครงการวิจัยตามแนวทางหลักจริยธรรมการวิจัยในคนที่เป็นสากล ได้แก่ Declaration of Helsinki, the Belmont Report, CIOMS Guidelines และ the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

ในคราวประชุมครั้งที่ 6/2559 **เมื่อวันที่** 16 มีนาคม 2559

ให้ไว้ ณ วันที่ 5 กรกฎาคม 2559

<div align="center">
(รองศาสตราจารย์ ดร.ทพญ.ศรีสุรางค์ สุทธปรียาศรี)
ประธานคณะกรรมการจริยธรรมในการวิจัย
</div>

...................................กรรมการ   ....กรรมการ
(ผู้ช่วยศาสตราจารย์ ทพ.นพ.สุรพงษ์ วงศ์วัชรานนท์)   (ผู้ช่วยศาสตราจารย์วศิน สุวรรณรัตน์)

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(ผู้ช่วยศาสตราจารย์ ดร. ทพญ.สุพัชรินทร์ พิวัฒน์)   (นายเขมรัฐ เขมวงศ์)

Documentary Proof of Ethical Clearance
Research Ethics Committee (REC)
Faculty of Dentistry, Prince of Songkla University

The Project Entitled	Alveolar Bone and Root Length Changes Following En-masse Retraction with Corticotomy Assisted Orthodontic Treatment
REC Project No.	: EC5906-23-P-LR
Principal Investigator	: Asst. Prof. Dr. Bancha Samruajbenjakun
Co-Principal Investigator	: Miss Satinee Narupakorn

Approved by Research Ethics Committee (REC), Faculty of Dentistry, Prince of Songkla University.

This is to certify that REC is in full Compliance with International Guidelines for Human Research Protection such as the Declaration of Helsinki, the Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP).

Date of Approval   : 5 JULY   2016   No. of Approval   :   MOE 0521.1.03/ 755

(Assoc. Prof. Dr. Srisurang Suttapreyasri)
Chairman of Research Ethics Committee

(Asst. Prof. Surapong Vongvatchranon)

(Asst. Prof. Wasin Suwannarat)

(Assoc. Prof. Pornchai Sathirapanya)

(Mr. Kamolphan Nuangsri)

(Asst. Prof. Dr. Angkana Thearmontree)

(Dr. Supitcha Talungchit)

(Asst. Prof. Dr. Suwanna Jitpakdeebodintra)

(Mr. Boonsit Buaban)

(Asst. Prof. Dr. Supatcharin Piwat)

(Mr. Kemarajt Kemavongse)

ใบเชิญชวน

เรื่อง   ขอเชิญเข้าร่วมโครงการวิจัยเรื่อง การเปลี่ยนแปลงกระดูกเบ้าฟันและรากฟัน ภายหลังจาก
การผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟันในผู้ป่วยที่มีลักษณะฟันยื่นใน
ขากรรไกรบนและล่าง

เรียน   ผู้สนใจเข้าร่วมโครงการวิจัยฯทุกท่าน

ข้าพเจ้า ทพญ.สาธินี นฤปกร นักศึกษาระดับปริญญาโท สาขาทันตกรรมจัดฟัน ภาควิชา
ทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ขอแจ้งรายละเอียด
เกี่ยวกับโครงการวิจัยและขอเชิญชวนท่านผู้สนใจเข้าร่วม โครงการฯ ดังนี้

โครงการวิจัยนี้จัดทำขึ้นเพื่อศึกษา การเปลี่ยนแปลงกระดูกเบ้าฟันและรากฟัน ภายหลังจาก
การผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟันในผู้ป่วยที่มีลักษณะฟันยื่นในขากรรไกร
บนและล่าง และมีกระดูกทางด้านใกล้เพดานและใกล้ลิ้นบาง ซึ่งเป็นลักษณะทางกายวิภาคที่จำกัด
การเคลื่อนฟัน ซึ่งเดิมหากรักษาทางทันตกรรมจัดฟันทั่วไปเพียงอย่างเดียว จะก่อให้เกิด
ภาวะแทรกซ้อน ได้แก่ การละลายของรากฟัน การละลายของกระดูกเบ้าฟันและเหงือกร่นได้ อีกทั้ง
ยังใช้เวลาในการรักษานาน ซึ่งจากการศึกษาที่ผ่านมาพบว่า วิธีการรักษาที่ใช้ในการศึกษานี้สามารถ
ลดภาวะแทรกซ้อนดังกล่าวได้ และใช้เวลาในการรักษาน้อยกว่าการรักษาทางทันตกรรมจัดฟัน
ทั่วไปเพียงอย่างเดียว

ผู้เข้าร่วมโครงการวิจัยฯ   จะเข้ารับบริการที่คณะทันตแพทยศาสตร์
มหาวิทยาลัยสงขลานครินทร์ โดยเป็นผู้ป่วยที่ได้รับการรักษาทางทันตกรรมจัดฟันร่วมกับการถอน
ฟันกรามน้อยซี่ที่ 1 ในขากรรไกรบนและล่าง มีการดึงฟันหน้าบนเข้าในปริมาณที่มากกว่าความ
หนาของกระดูกด้านลิ้นที่ระดับปลายรากฟัน   โดยการรักษาทางทันตกรรมจัดฟันเสร็จสิ้นแล้วเป็น
ระยะเวลาอย่างน้อย 6 เดือน ผู้ป่วยจะได้รับการถ่ายภาพรังสีคอมพิวเตอร์ จำนวน 1 ครั้ง เพื่อ
ประเมินการเปลี่ยนแปลงกระดูกเบ้าฟันและรากฟัน   ภายหลังจากการผ่าตัดกระดูกทึบร่วมกับการ
รักษาทางทันตกรรมจัดฟัน ซึ่งผู้เข้าร่วมวิจัยไม่ต้องรับผิดชอบค่าใช้จ่ายในส่วนนี้

ทั้งนี้   ในขั้นตอนของการเก็บข้อมูล   ผู้เข้าร่วมวิจัยจำเป็นต้องได้รับการถ่ายภาพรังสี
คอมพิวเตอร์เพิ่มเติมนอกเหนือไปจากการเก็บข้อมูลพื้นฐานตามปกติ ซึ่งการถ่ายภาพรังสีแต่ละครั้ง
นั้นมีความเสี่ยงที่จะเกิดอันตรายต่อผู้เข้าร่วมวิจัยน้อยมาก เนื่องจากปริมาณรังสีที่ได้รับในแต่ละครั้ง
ของการถ่ายนั้นน้อยมาก   โดยให้สวมเสื้อตะกั่วเพื่อป้องกันรังสีให้แก่ผู้เข้าร่วมวิจัยทุกรายและทุก

ครั้งที่ต้องถ่ายภาพรังสี และพยายามให้มีความผิดพลาดในการถ่ายภาพรังสีน้อยที่สุด เพื่อลดปริมาณ
รังสีที่ผู้เข้าร่วมวิจัยจะได้รับโดยไม่จำเป็น

   ถ้าท่านตัดสินใจเข้าร่วมโครงการวิจัยฯนี้ จะมีขั้นตอนของการวิจัยที่จำเป็นต้องขอความ
ร่วมมือของท่าน คือ การถ่ายภาพรังสีคอมพิวเตอร์ ภายหลังจากการผ่าตัดกระดูกทึบร่วมกับการ
รักษาทางทันตกรรมจัดฟัน โดยผู้เข้าร่วมโครงการฯต้องมารับการถ่ายภาพรังสีคอมพิวเตอร์ ณ คณะ
ทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ โดยไม่เสียค่าใช้จ่าย

   หากท่านมีข้อสงสัยประการใดหรือเกิดผลข้างเคียงจากการวิจัยจะสามารถติดต่อกับ ทพญ.
สาธินี   นฤปกร   ได้ที่ภาควิชาทันตกรรมป้องกัน   คณะทันตแพทยศาสตร์
มหาวิทยาลัยสงขลานครินทร์ หมายเลขโทรศัพท์ 081-7022077 หรือ เมื่อมีปัญหาใดๆ เกิดขึ้น
เนื่องจากการทำวิจัยในเรื่องนี้   ข้าพเจ้าสามารถร้องเรียนได้ที่คณบดี   คณะทันตแพทยศาสตร์
มหาวิทยาลัยสงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287500

   ไม่ว่าท่านจะเข้าร่วมในโครงการวิจัยนี้หรือไม่ ท่านจะยังคงได้รับการรักษาที่ดีเช่นเดียวกับ
ผู้ป่วยคนอื่นๆ และถ้าท่านต้องการที่จะถอนตัวออกจากการศึกษานี้เมื่อใด ท่านก็สามารถกระทำได้
อย่างอิสระ ถ้าท่านมีคำถามใดๆ ก่อนที่จะตัดสินใจก่อนเข้าร่วมโครงการนี้ โปรดซักถามคณะผู้วิจัย
ได้อย่างเต็มที่

                     ขอแสดงความนับถือ
                     ทพญ.สาธินี นฤปกร

แบบยินยอมเข้าร่วมการศึกษา

โครงการวิจัยเรื่อง   การเปลี่ยนแปลงกระดูกเบ้าฟันและรากฟัน   ภายหลังจากการผ่าตัดกระดูกทึบร่วมกับการรักษาทางทันตกรรมจัดฟัน ในผู้ป่วยที่มีลักษณะฟันยื่นในขากรรไกรบน และล่าง

วันที่_____เดือน_____พ.ศ._____

ข้าพเจ้า_____อายุ_____ปี
อาศัยอยู่บ้านเลขที่_____หมู่_____ถนน_____
ตำบล_____อำเภอ_____จังหวัด_____
ได้รับการอธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียดและมีความเข้าใจดีแล้ว

หากข้าพเจ้ามีข้อสงสัยประการใด   หรือเกิดผลข้างเคียงจากการวิจัยจะสามารถติดต่อกับ ทพญ.สาธินี   นฤปกร   ได้ที่   ภาควิชาทันตกรรมป้องกัน   คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์   หมายเลขโทรศัพท์ 074-429876   หรือ   เมื่อมีปัญหาใดๆ เกิดขึ้น เนื่องจากการทำวิจัยในเรื่องนี้   ข้าพเจ้าสามารถร้องเรียนได้ที่คณบดี   คณะทันตแพทยศาสตร์ มหาวิทยาลัย สงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287500

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่มีปิดบัง

ข้าพเจ้ามีสิทธิ์ที่จะของดการเข้าร่วมโครงการวิจัย โดยจะแจ้งให้ทราบล่วงหน้าโดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการได้รับบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่อย่างใด

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ จะไม่เปิดเผยข้อมูลหรือผลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชน จะเปิดเผยได้ในรูปที่เป็นสรุปผลการวิจัยหรือการเปิดเผยข้อมูลต่อผู้มีหน้าที่ที่เกี่ยวข้องกับการสนับสนุนและกำกับดูแลการวิจัย

      ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ จึงได้ลงนามในใบ
ยินยอมนี้ด้วยความเต็มใจ โดยผู้วิจัยได้ให้สำเนาแบบยินยอมที่ลงนามแล้วกับข้าพเจ้าเพื่อเก็บไว้เป็น
หลักฐานจำนวน 1 ชุด

            ลงชื่อ...ผู้ยินยอม
                (   )
            ลงชื่อ...หัวหน้าโครงการ
                 (ทพญ. สาธินี นฤปกร   )
            ลงชื่อ...พยาน
                (   )
            ลงชื่อ...พยาน
                (   )

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List of Publication and Proceeding

Narupakorn S., Samruajbenjakun B. Root Length Changes following En masse-Retraction with Corticotomy-assisted Orthodontic Treatment using Cone-beam Computed Tomography Analysis. Proceedings of The 7th Conference on the topic CREATIVE SCHOOLS; 2017 February 24; Nakhon Si Thammarat, Thailand. Southern College of Technology; 2017.