Effect of Interseptal Bone Reduction on the Rate of Maxillary Canine Retraction

Surat Kanokkulchai

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Oral Health Sciences

Prince of Songkla University

2010

Thesis Title Effect of Interseptal Bone Reduction on the Rate of Maxillary Canine Retraction

Author Mr. Surat Kanokkulchai

Major Program Oral Health Sciences

Major Advisor :

………………………………………………

(Assoc. Prof. Dr. Chairat Charoemratrote)

Co-advisors :

………………………………………………

(Assoc. Prof. Dr. Chidchanok Leethanakul)

………………………………………………

(Asst. Prof. Settakorn Pongpanich)

Examining Committee :

…………………………………Chairperson

(Prof. Smorntree Viteporn)

………………………………………………

(Assoc. Prof. Dr. Chairat Charoemratrote)

………………………………………………

(Asst. Prof. Settakorn Pongpanich)

………………………………………………

(Dr. Bancha Samruajbenjakun)

The Graduate School, Prince of Songkla University, has approved this thesis as partial fulfillment of the requirements for the Master of Science Degree in Oral Health Sciences

……………………………………

(Assoc. Prof. Dr. Krerkchai Thongnoo)

Dean of Graduate School

ชื่อวิทยานิพนธ์ ผลของการกรอกระดูกเบ้าฟันต่ออัตราการดึงฟันเขี้ยวบน

ผู้เขียน นายสุรัฐ กนกกุลชัย

สาขาวิชา วิทยาศาสตร์สุขภาพช่องปาก

ปีการศึกษา 2552

บทคัดย่อ

วิธีการศัลยกรรมกระดูกเบ้าฟันหลายวิธีถูกนำเสนอและรายงานว่าสามารถเร่งอัตราการเคลื่อนฟันในทางทันตกร รมจัดฟันได้ซึ่งทำให้ลดระยะเวลาในการรักษาลง หากแต่วิธีเหล่านั้นก่อให้เกิดความเสี่ยงและภาวะแทรกซ้อนต่างๆ อันเนื่องมาจากกระบวนการทางศัลยกรรมและการใช้แรงปริมาณมากในการเคลื่อนฟัน **วัตถุประสงค์** เพื่อนำเสนอและประเมินแนวทางการรักษารูปแบบใหม่ที่ใช้การศัลยกรรมกระดูกเบ้าฟันซึ่งไม่รุนแรงไปกว่าการถอนฟันธรรมดา ร่วมกับเครื่องมือจัดฟันที่ใช้กันโดยทั่วไปเพื่อเร่งอัตราการดึงฟันเขี้ยว **วัสดุและวิธีการ** กลุ่มตัวอย่างประกอบด้วยผู้ป่วยทางทันตกรรมจัดฟันจำนวน 12 ราย อายุเฉลี่ย 21.92 ปี ฟันข้างหนึ่งถูกจัดเป็นกลุ่มทดลองและอีกข้างหนึ่งเป็นกลุ่มควบคุม หลังจากถอนฟันกรามน้อยซี่ที่หนึ่งเพื่อการจัดฟัน เบ้ากระดูกที่ฟันถูกถอนออกไปในด้านทดลองถูกกรอให้ลึกลงและกระดูกเบ้าฟันทางด้านไกลกลางของฟันเขี้ยวบนถูกกรอให้บางลงโดยไม่มีการกรีดเปิดเหงือก ส่วนด้านควบคุมถอนฟันตามปกติ ฟันเขี้ยวถูกเคลื่อนไปทางด้านไก ลกลางแบบอิสระโดยไม่มีลวด ใช้ยางดึงฟันทั้งทางด้านใกล้ริมฝีปากและด้านเพดานซึ่งให้แรงสุทธิ 150 กรัม วิเคราะห์การเคลื่อนฟันเขี้ยวจากแบบจำลองฟัน **ผลการศึกษา** อัตราการเคลื่อนที่ของฟันเขี้ยวและลักษณะของกระดูกเบ้าฟันที่เหลืออยู่ในด้านทดลองมีความแตกต่างกันในแต่ละราย ดังนั้นกลุ่มตัวอย่างจึงถูกแบ่งออกเป็น 3 กลุ่มย่อย ได้แก่ กลุ่มทดลองที่กรอกระดูกได้ตามเกณฑ์ กลุ่มทดลองที่กรอกระดูกได้ไม่ตามเกณฑ์ (ซึ่งพิจารณาจากภาพถ่ายรังสีรอบปลายรากหลังการศัลยกรรม) และกลุ่มควบคุม จากการวิเคราะห์ทางสถิติพบว่ากลุ่มทดลองที่กรอกระดูกได้ตามเกณฑ์นั้นมีระยะทางการเคลื่อนที่ของฟันเขี้ยวในระยะเวลา 3 เดือนมากกว่าอีก 2 กลุ่มอย่างมีนัยสำคัญทางสถิติ แต่ไม่พบความแตกต่างของระยะทางการเคลื่อนที่ระหว่างกลุ่มทดลองที่กรอไม่ได้ตามเกณฑ์และกลุ่มควบคุม (6.74, 3.19 และ 3.86 มิลลิเมตรตามลำดับ) **สรุป** การกรอกระดูกเบ้าฟั นสามารถเร่งอัตราการดึงฟันเขี้ยวได้อย่างมีประสิทธิภาพในกรณีที่สามารถกรอกระดูกได้บางและลึกเพียงพอตามเกณฑ์ที่กำหนดไว้

Thesis Title Effect of Interseptal Bone Reduction on the Rate of Maxillary Canine Retraction

Author Mr.Surat Kanokkulchai

Major Program Oral Health Sciences

Academic year 2009

ABSTRACT

Many dentoalveolar surgical techniques have been presented and reported to be able to accelerate the rate of tooth movement effectively, contributing to decreased overall orthodontic treatment time. However, risks and complications have been found because of the invasive surgical procedure and heavy force application. **Objectives**: The aim of this study was to propose and evaluate a new surgical approach with minimal trauma, called interseptal bone reduction, combined with the use of conventional orthodontic fixed appliance to accelerate canine retraction. **Materials and methods:** 12 patients with the mean age of 21.92 years were included in this study. After extraction of the first premolar, the extraction socket on experimental side was deepened and interseptal bone distal to the maxillary canine was reduced in thickness using surgical bur without flap operation, while conventional extraction was performed on the control side. The canines were then distalized as free bodies using elastomeric chains on both labial and palatal sides with the net force of 150 g. The rate of canine movement was analyzed from the study models. **Results**: The rate of canine movement on the experimental side itself was varied, also was the features of remaining interseptal bone from the post-operative periapical radiographs. The samples were then allocated into 3 subgroups, those were, *criteria-met*, *criteria-not-met* experimental groups, following the surgical criteria, and the control group. Statistical analysis demonstrated that the total amount of canine movement in 3 month of *criteria-met* group was significantly greater than that of the *criteria-not-met* and control groups (6.74, 3.19 and 3.86 mm, respectively), while no difference was found between the *criteria-not-met* and the control group. **Conclusion:** This experiment showed that interseptal bone reduction could enhance the rate of canine movement when the interseptal bone was sufficiently reduced in both thickeness and depth following the surgical criteria with the use of conventional orthodontic appliance.

ACKNOWLEDGEMENT

This thesis would not have been possible unless I had got supported, guided and helped. I'm heartily thankful to my supervisor, Assoc. Prof. Dr. Chairat Charoemratrote, whose encouragement, supervision and support from the preliminary to the concluding level enabled me to develop an understanding of the subject.

I would like to sincere thank to Assist. Prof. Settakorn Pongpanich and Dr. Narit Leepong who devoted their worth time for the surgical operation and also give the precious guidance for this study. Without them, this thesis could not be completed.

I would like to take the opportunity to thank those people who spent their time and shared their knowledge for helping me to complete my thesis with the best possible result: Assoc. Prof. Dr. Chidchanok Leethanakul, Assoc. Prof. Supanee Suntornlohanakul, Assoc. Prof. Wipapun Ritthagol, Dr. Bancha Samraujbenchakul, and Dr. Udom Thongudomporn.

I also give gratitude to all of my patients who participated in this study, especially Miss Jutha, my first pilot study case. They're not only my patients, but also the great teachers. I would like to extend my thanks to my colleagues: Norachai, Sudarat, Sajjaporn, and Chatchalit for supporting and taking care of the cases in this study.

Not forgetting also the support of the entire staff of the Orthodontic clinic, Department of Preventive Dentistry, Oral Radiology, and Oral and Maxillofacial Surgery at Faculty of Dentistry, Prince of Songkla University for their help and support through the thesis.

Lastly, my deepest gratitude goes to my dad and mom for unconditioned love and tireless support. You are the only reason I was born and live my life for.

Surat Kanokkulchai

CONTENTS

LISTS OF TABLES

LISTS OF DIAGRAMS/ FIGURES

LISTS OF ABBREVIATIONS AND SYMBOLS

mm	=	millimeter
et al.	=	and others
g	=	gram
CT	=	computed tomography
RAP	=	regional acceleratory phenomenon
13	=	Right maxillary permanent canine
23	=	Left maxillary permanent canine
NiTi	=	nickel titanium
Fig.	=	figure
PP	=	palatal plane
Con	=	control
Exp	=	experimental
T0	=	time at the start of canine retraction
T1	=	time after canine retraction for 1 month
T2	=	time after canine retraction for 2 months
T3	=	time after canine retraction for 3 months
%	=	percent
”	=	inch(es)
/	=	per

CHAPTER 1

INTRODUCTION

Background and rationale

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.[1, 2] Classically, the rate of orthodontic tooth movement depends on the magnitude and duration of the force,[1] the number and shape of the roots,[3] the quality of the bony trabeculae,[4-7] the patient's response, and the patient's compliance. The rate of biologic tooth movement with optimum mechanical force is approximately 1 to 1.5 mm in 4 to 5 weeks.[8] Therefore, in maximum anchorage premolar extraction cases, canine distalization usually takes 6 to 9 months, contributing to an overall treatment time of 1.5 to 2 years

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.[9] An association between the duration of the applied force and increased root resorption has been reported.[10] It is generally accepted that the best way to minimize root resorption is to complete the tooth movement in a short time. Root resorption begins 2 to 3 weeks after the orthodontic force is applied and can continue for the duration of force application.[10-12] Moreover, any technique that takes longer than 3 weeks to retract a canine will result in loss of anchorage.[13] And the duration of orthodontic treatment is one of the things that orthodontic patients complain about most—especially adult patients.[14]

Many attempts have been made to shorten orthodontic treatment duration. Mechanical, chemical and physical manipulations applied to periodontal tissues have been reported to have an effect on the rate of tooth movement. One of the mechanical manipulations is dentoalveolar surgery, including distraction of periodontal ligament, dentoalveolar distraction osteogenesis, periodontally accelerated osteogenic orthodontics, speedy orthodontics, and other modified surgical techniques. With these techniques, the active orthodontic treatment can be completed within only one year. However, most of these techniques include flap operation to perform invasive corticotomy or osteotomy, and use of heavy orthodontic force to move teeth rapidly which may increase the risk of periodontal problems and pulpal vitality loss in long-term period. Also, custom-made orthodontic appliances used in some techniques are bulky and unavailable on the market. The less invasive dentoalveolar surgical approach combined with the use of conventional orthodontic appliance with optimum force to accelerate tooth movement is of interest to study.

Review of literatures

Many methods of mechanical manipulations to accelerate tooth movement have been reported, the simplest one is to retract canine immediately after first premolar extraction. Hasler *et al*. (1997)[15] studied the rate of movement of the maxillary canines into the healed and recent extraction alveolus of the first premolar in human using Gjessing canine retraction spring. It was found that the canine on the recent extraction site moved faster than that on the healed site, but also tipped somewhat more. The reason for faster movement might be less bone resistance on recent extraction site than the healed site. This study is in agreement with the finding of Yuan X *et al.*[16] (2003) which was performed in mice. However, some studies had been shown to be in contrast. A histologic study of Murphey[17] (1970) performed in monkeys revealed that the osteoblastic and osteoclastic responses were more pronounced at healed extraction site and the extent of tooth movement into the healed site was greater. While the studies of Diedrich and Wehrbein[18] (1997) performed in foxhounds had shown that the rate of tooth movement into the healed site was greater than the recent extraction site, however, they suggested orthodontic retraction should be initiated into the recent extraction site because of tendencies towards progressive atrophy of alveolar bone and gingival duplicature formation in the healed site.

A more invasive mechanical manipulation that has been reported to accelerate tooth movement is corticotomy surgery combined with orthodontics. This technique was first reported by Kole[19] in 1959. The vertical corticotomy cuts were performed between the roots of the teeth beyond apices and connected with a horizontal cut creating blocks of bone in which one or more teeth were embedded. These cuts were made through the entire thickness of the cortical layer, just barely penetrating into the medullary bone. Using the crowns of the teeth as handles, Kole 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. The active orthodontic treatment in adult could be completed within 6 to 12 weeks. He found no incidence of root resorption, no loss of tooth vitality, and no pocket formation.

In 1998, Liou and Huang[20] proposed a new approach so called "dental distraction" which is based on principle of distraction osteogenesis. At the time of first premolar extraction, the interseptal bone distal to the canine was undermined with a bone bur, grooving vertically inside the extraction socket along the buccal and lingual sides and extending obliquely toward the socket base. Then, a custom-made intraoral distraction device was placed to distract the canine distally into the extraction space and activated 0.5 to 1.0 mm/day immediately after the extraction. It was found that canines were distracted bodily 6.5 mm into the extraction space within 3 weeks with minimal anchorage loss (less than 0.5 mm) and root resorption. The main reasons for rapid canine retraction were bending and fracture, not bone remodeling, of interseptal bone and carrying it with tooth movement using heavy force. The explanation of minimal anchorage loss and root resorption was that within 3 weeks of canine retraction, the posterior teeth were in a lag period, the period of elimination of hyalinized tissues, which tooth movement was minimal and root resorption was just initiating. No periodontal defect or endodontic lesion was observed throughout and after distraction. However, it was found that after distraction 17 of 26 canines reacted negatively to the electrical vitality test. They suggested that this technique is best used on those cases whose anterior teeth are severely crowded or protruded. The canines can be distracted rapidly, and almost all of the extraction space can be used for anterior dental alignment or retraction. After distraction, the anterior tooth retraction can be rapid as well, while the new bone tissues distal to the lateral incisors are still fibrous. However, the authors altered the technique in their next study.[21] Anterior teeth were bonded and a segment of 0.016"x0.022" NiTi archwire was placed for activation of periodontal ligament of the canine. .After first premolar extraction, the socket was deepened to the exact length of canine and the interseptal bone distal to the canine was reduced to 1 to 1.5 mm in thickness with a cylindrical carbide bur. Two vertical grooves, at mesiobuccal and mesiolingual corners of the interseptal bone, were made extending obliquely toward the socket base and became a V-shaped groove. Then, the dental distracter was inserted and activated 0.60 mm/day. They reported the 1 to 1.5 years follow up that 28.5% of maxillary and 23% mandibular distracted canines reacted negatively to the electrical vitality test.

In 2004, Sayin *et al.*[22] performed the same technique that Liou and Huang described to evaluate its effects on dentoalveolar tissues. It was found that the maxillary canines were distalized an average of 5.76 mm within 3 weeks with 11.47° distal tipping while the maxillary first molars moved mesially 0.56 mm and extruded 0.64 mm. No significant root resorption was observed in the canine teeth. However, the attached gingival distal to the canine showed invagination in some patients. Fractures were observed in the interseptal bone adjacent to the apex of the canine in some of the periapical radiographs, indicating a considerable resistance to the applied force. It was considered that this might increase the potential tipping movement and the extrusive effect of the mechanism by causing the canine center of resistance to move closer to the apex. They concluded that reducing the entire thickness of the interseptal bone between the canine and first premolar would be more useful in minimizing the undesired tipping and extrusion movements of the canine teeth. However, no long-term follow up regarding pulpal vitality and periodontal status was presented in this study.

Stretching of the periodontal ligament to retract canine rapidly in dental distraction technique can inevitably cause permanent damage to the periodontal tissue resulting in resorption of Sharpey's fibers and reduction of alveolar bone height and thickness. Kisnisci *et al.* (2002)[23] presented a refined osteotomy technique called "dentoalveolar distraction osteogenesis" to retract canine rapidly which does not rely on stretching and widening of periodontal ligament. In this technique the dentoalveolus of canine is designed as a bone transport segment for posterior movement. A horizontal mucosal incision was made parallel to the gingival margin of the canine and premolar beyond the depth of the vestibule to expose the canine root and the first premolar region. Vertical corticotomies were performed around the root of canine, then the first premolar was extracted and the buccal bone was carefully removed through the extraction socket with preservation of palatal or lingual cortical shelves, followed by splitting the spongy bone around the canine root off of the lingual or palatal cortex and neighboring teeth. A custom-made intra-oral distraction device was placed to the first molar and canine at the end of the surgical procedure and activated at the rate of 0.4 mm twice a day and continued until adequate movement of the canine was achieved. It was found that canines were distracted distally and made contact with the second premolars in 8 to 12 days. Root resorption and dental ankylosis were not detected in any of the patients. No discoloration or radiographic evidence suggestive of loss of tooth vitality was noted. They reported that vitality testing after the removal of orthodontic fixed appliances proved to be in normal ranges but no data was presented.

In 2005, Iseri *et al.*[14] conducted the same technique which Kisnisci et al described previously to examine the effect of this technique on dentofacial structures. A significant amount of tipping of the canines was observed (13.15°) at the end of treatment. The mean sagittal and vertical anchorage losses were 0.19 mm and 0.51 mm, respectively. The mandibular plane angle and anterior face height were increased slightly (0.67° and 0.99 mm, respectively). Clinical and radiographic examination showed no evidence of complications, such as root fracture, root resorption, ankylosis, and soft tissue dehiscence, in any patient. Patients reported minimal to moderate discomfort, especially during the first 2 days after surgery, and edema was observed in some patients. They claimed that no reliable reaction to the pulp test was achieved in the study subjects at the end of the dentoalveolar distraction procedure. No long-term follow up regarding pulpal vitality and periodontal status were performed.

In 2007, Sukurica *et al.*[24] replicated the technique of Kisnisci et al. and Iseri et al. to evaluate long-term effects of the procedure on periodontal status, root resorption and pulpal vitality of the distracted canines. A statistically significant increase in gingival sulcus depth was found, particularly in the midbuccal and distobuccal aspects of the canine (0.80 mm and 0.35 mm increase, respectively). However, they claimed that this change in the gingival sulcus depth can be considered insignificant clinically. The results of the radiographic examination revealed no statistically significant difference in the findings regarding root resorption. 13 of the 20 teeth reacted negatively to the electrical vitality test that was performed 6 months after completion of the distraction procedure, but there was no clinical sign of discoloration or pulpal pain in any tooth.

In 2001, Wilcko and Wilcko[25] developed a method called “accelerated osteogenic orthodontics” or “Wilckodontics” which performed corticotomies on all teeth to be moved orthodontically. Standard braces, archwires and normal orthodontic force levels were used. After making sulcular incisions, full-thickness flaps were reflected on both the buccal and lingual aspects. Vertical corticotomies were made between the roots of the teeth, connected beyond the apices of the teeth with a scalloped horizontal corticotomies. Numerous corticotomy perforations were made in the cortical layer to maximize the marrow penetration and bleeding. The corticotomy cuts and perforations extended just barely into the medullary bone. An augmentation procedure using resorbable materials was then performed over the partially decorticated areas and flaps were sutured. Following the surgery, orthodontic adjustments were made approximately every 2 weeks. From bracketing to debracketing, the patients with severe crowding were completed in approximately 6 months without extraction. Posttreatment evaluation revealed no probing depths greater than 3 mm, good preservation of the interdental papillae, no loss of tooth vitality, no significant reduction in the radiographic height of the crestal bone, and no radiographic evidence of any significant apical root resorption. At approximately 15 months following surgery in one patient, a full-thickness flap was again reflected. Visual examination revealed good maintenance of the height of the alveolar crest and an increased thickness in the buccal bone. The canine and premolars in this area were expanded buccally by more than 3 mm, and yet there had actually been an increase in the buccolingual thickness of the overlying buccal bone. The authors claimed that this method was not only safe, but had made it possible to help maintain and even thicken the layer of pretreatment bone over the prominences of the roots. Fenestrations could be covered, and consequently the likelihood of dehiscence formation could be reduced where there was still a vital root surface. Comparison of pretreatment and posttreatment computed tomographic (CT) scans indicated a demineralization of the alveolar bone over the root prominences of moved teeth. CT scan analysis at 2 years posttreatment indicated varying degrees of remineralization of the alveolar bone.

Besides the aforementioned dentoalveolar surgical techniques, many surgical approaches have been modified and reported to facilitate orthodontic tooth movement. Some performed corticotomy cuts only on buccal side, while others performed on both buccal and lingual sides, with or without perforation of cortical bone. No matter which technique was used, all were reported to be able to increase the rate of tooth movement. In 2005, Germec *et al.*[26] reported a severe crowding case treated with modified corticotomy-facilitated orthodontics to shorten the treatment time during lower incisor retraction. After first premolars extraction, aligning and leveling with pre-adjusted edgewise appliance, a full-thickness flap was reflected labially beyond the apices of the lower incisors. The vertical corticotomies were performed in the cortical bone between the roots of the lower incisors. A chisel was then used for reaching the lingual cortical bone from labial side. In this modified corticotomy technique, no horizontal and lingual vertical cuts were performed. Lower contraction arch was immediately activated after the surgical procedure. It was found that lower incisor retraction could be achieved within 1.5 months. Periodontal examination of lower anterior teeth revealed no marked increase in pocket depths or gingival recession.

Iino *et al.* (2006)[27] reported an adult bimaxillary protrusion case performing corticotomy combined with the placement of titanium miniplates to achieve maximum anchorage. After the placement of titanium miniplate, the premolars were extracted and then the corticotomies were performed on both buccal and lingual sides in anterior region. The corticotomy technique was like Wilcko and Wilcko described except no perforation was made. The pre-adjusted edgewise appliance was initiated and adjusted every 2 weeks with a conventional orthodontic force. The active treatment was completed in 1 year. No significant periodontal problems, such as gingival recession or loss of tooth vitality, and no looseness or deformation of the titanium miniplates were observed. Panoramic radiographs before and after treatment showed no significant reduction in the crest bone height and no marked apical root resorption.

Chung *et al.* (2009)[28] developed the new types of corticotomy-assisted orthodontic treatment called speedy orthodontics for treating anterior protrusion patients. This technique combines corticotomy and orthopedic force application with the use of skeletal anchorage. In the maxilla, a mucoperiosteal incision was made along the palatal mucosa, and the bone was exposed, avoiding the incisal nerve and the artery. A vertical and horizontal bone cut was made at the first premolar sites, and the cortical bone was removed. Two weeks later, to allow reconnection of the palatal soft-tissue blood supply, a buccal corticotomy was executed in the same manner as was done on the palate. After the surgery, the maxillary anterior teeth are fixated into a single unit with the specially designed lingual retractor. A retraction force of 500 to 900 g per side is applied to the lingual retractor and the C-plate. In this cases report, the maxillary anterior retraction was completed in 5 months and the overall treatment took about one year.

How can these techniques accelerate tooth movement?

The concept of the rapid tooth movement facilitated with dentoalveolar surgery has been explained in many ways. Liou and Huang stated that the canine could be distracted rapidly in their study because the first premolar extraction socket was less resistant and not refilled by solid bone tissue yet which would occur in 3 weeks. Also, in their technique the interseptal bone distal to the canine, which was undermined surgically to weaken its strength, was bent and fractured by heavy force generated by the distraction device. They cited the studies of

Baumrind[29] and Grimm[30] which observed that flexion of the alveolar bone results in recruitment of osteoclasts and osteoblasts on the tension and pressure sides.

Kisnisci *et al.* described that their dentoalveolar distraction technique could accelerate canine retraction by moving dentoalveolar bone block as a unit distally which based on a principle of distraction osteogenesis. Moreover, neither the buccal bone through the extraction site nor the palatal cortical plate interfered with the movement of the canine-dentoalveolus segment during the distraction procedure because of the surgical procedure and the distal movement vector of the canine along the guidance burs of the dentoalveolar distractor through the extraction cavity.

On the other hand, Wilcko and Wilcko believed that the concept on rapid tooth movement after corticotomy was supported by the "regional acceleratory phenomenon (RAP)". Orthopedist Harold Frost[31] 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.[32] Moreover, it has been demonstrated that the residual soft tissue matrix has the ability to induce remineralization after the cessation of tooth movement.[33] All of these suggest that the dynamics of the physiologic tooth movement after corticotomy 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.[34] 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.*[35] 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. Although tooth extraction seems to be a kind of trauma to the alveolar bone, Cho *et al.*[36] found that tooth extraction site with corticotomy showed higher cellular activity than extraction site without corticotomy. 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.

Objective

The aims of this study were to propose and to evaluate a new approach which combines interseptal bone reduction distal to the canine and the use of conventional orthodontic appliance with optimum force to increase the rate of maxillary canine retraction.

Hypothesis

The interseptal bone reduction combined with the use conventional orthodontic appliance with optimum force can increase the rate of maxillary canine retraction.

Significance of the study

This new approach will be able to accelerate maxillary canine retraction in which the surgical technique is not much more invasive than routine orthodontic extraction and the orthodontic appliances used are available.

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

Sample

The samples were selected from patients who received orthodontic treatment at orthodontic clinic in the Faculty of Dentistry, Prince of Songkla University.

The inclusion criteria were:

1. Class I or II malocclusion with mild or no crowding which the maxillary first premolars on both sides had been planned to be extracted in orthodontic treatment.
2. Canines were needed to be moved distally at least 5 mm (maximum anchorage).
3. Good general health.
4. No sign and symptom of periodontal disease.

Each patient was informed about the experimental procedure and the consent form was signed for participating in this study.

Materials and methods

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. Mini-implants were placed between the roots of second premolars and first molars on both left and right sides before surgical procedure about one month to observe their stability. They were used as anchorage during canine retraction to minimize the risk of anchorage loss.

This study was a split-mouth design which the experimental side was allocated by randomization. Upper impression, lateral cephalograph, and periapical radiographs of canines and first premolars on both sides were taken for pre-operation records (T0). Before the surgical procedure, interseptal bone thickness and root length of the canine were assessed by means of the periapical radiograph and the surgical guide wire. The surgical guide wire was fabricated from a section of 0.021”x0.025” stainless steel wire which would be inserted to the bracket of maxillary canines on experimental side before film exposure. Also, the surgical guide wire was positioned at the contact point and paralleled to the distal aspect of the canine root to direct the bur while grinding (Fig. 1). Traditional extraction of the first premolar was performed on one side as a control, while extraction combined with interseptal bone reduction was performed on another as an experimental side.

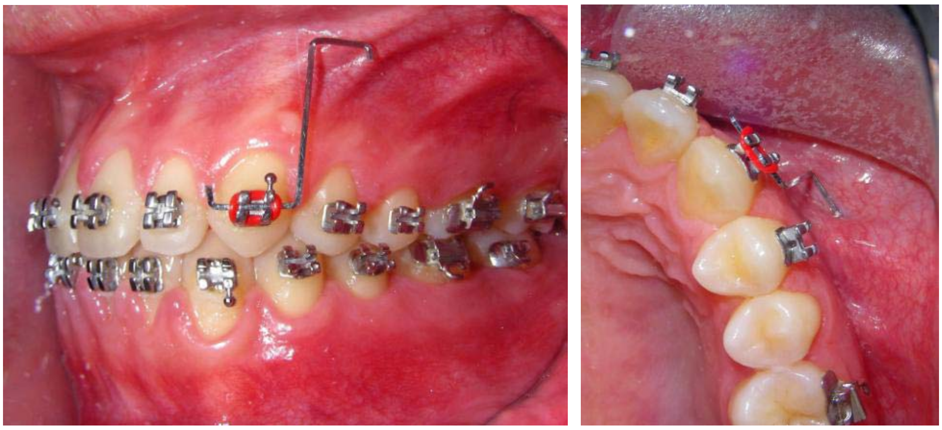


Fig. 1 Position of the surgical guide wire intraorally**.**

Surgical procedure

The surgical procedure was performed inside the extraction socket of the maxillary first premolar without flap operation by 2 surgeons, following these steps:

1. The length of maxillary canine and the thickness of interseptal bone were estimated based on the ratio of the exact length and the radiographic length of surgical guide wire on the periapical radiograph (Fig. 2).
2. The maxillary first premolars were extracted under local anesthesia.

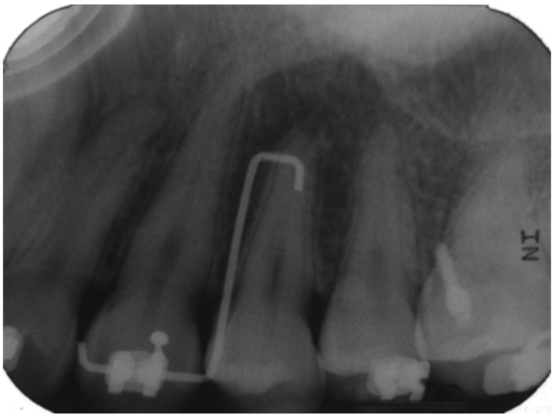


Fig. 2 Surgical guide wire in periapical radiograph.

3. The extraction socket was deepened to the length of the canine apex and interseptal bone distal to the canine was reduced to 1 to 1.5 mm in thickness with round and cylindrical carbide burs. The interradicular septal bone of the socket was also removed if presented. The first premolar extraction socket was surgically widened in buccopalatal dimension along the curvature of the canine's root. The bur was held parallel to the surgical guide wire and moved buccopalatally while the alveolar crest of interseptal bone was left untreated (Fig. 3). Periapical radiograph was taken again after the surgical procedure for the post-operation records.

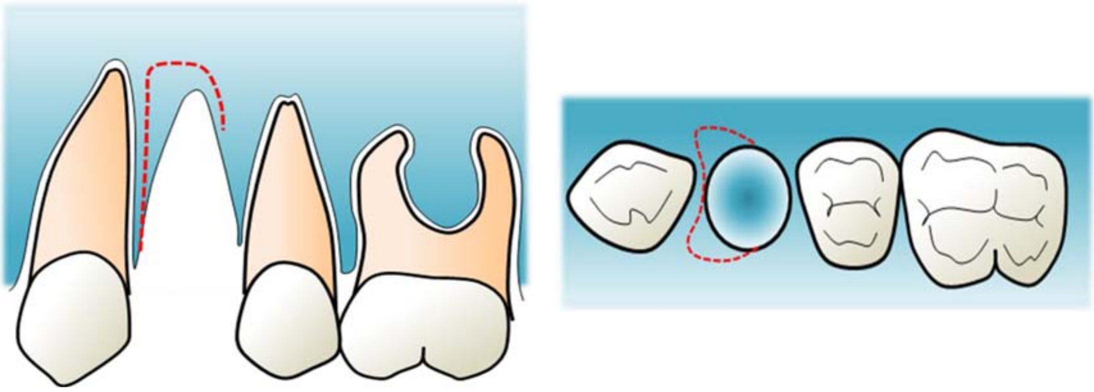


Fig. 3 Interseptal bone reduction technique. Dashed lines indicate interseptal bone that was reduced.

After the surgical procedure, canine distalization was started immediately on both sides. To eliminate the friction between the archwire and the canine bracket, which might be a confounding factor to our surgical intervention, the canine was distalized as a free body without archwire (Fig. 4). Maxillary teeth were divided into three segments, which were incisors segment, right and left posterior segments. Sectional 0.016”x0.022” stainless steel wires were engaged in these segments separately. Power arm was fabricated from 0.021”x0025” stainless steel wire with the height of hook approximate to mini-implant’s vertical position to produce force vector parallel to the occlusal plane, and also aimed to decrease tipping tendency. The power arm was then inserted in canine bracket, and elastomeric chain attached to mini-implant was used to retract canine. To avoid rotation of the canine, a counteractive force was applied on the palatal side by attaching elastomeric chain between the buttons of canine and first molar. Both labial and palatal chains were approximately equal in force magnitude producing a net force of 150 g on the canine.

The patients were followed up within 1 week after the surgery to monitor whether there was any sign or symptom of infection. Elastomeric chains were reactivated every 4 weeks. The experimental period was 3 months.

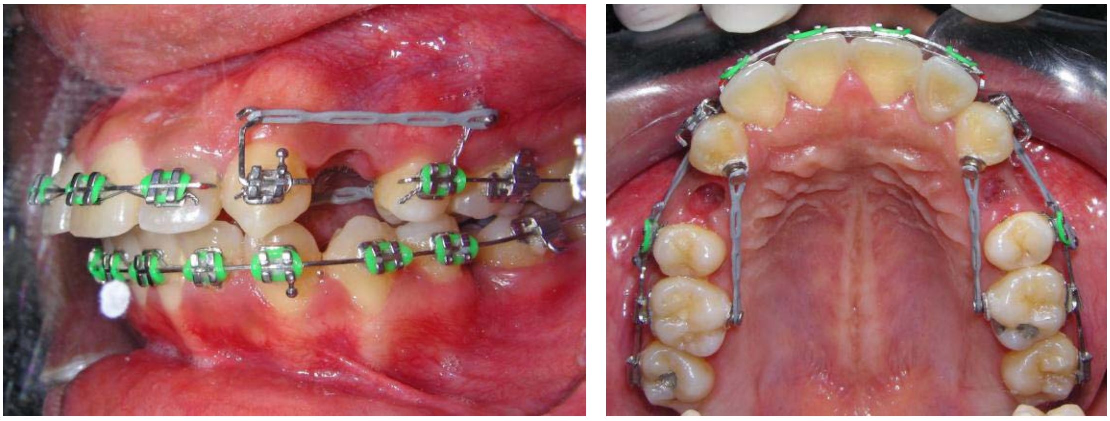


Fig. 4 Mechanics used for canine distalization.

Records and data analysis

Parameters measured in this study included the rate of canine movement, the amount of canine rotation and angulation which were analyzed from lateral cephalograms and study models.

Radiographic analysis

The periapical radiographs were taken every 4 weeks to observe the changes in periodontal space and extraction socket. The lateral cephalographs were taken together with angulation indicating wires before extraction of the first premolars (T0) and once again after canine retraction for 3 months (T3) to evaluate the change in canine angulation (Fig. 5). The angulation indicating wire was fabricated from a section of 0.021”x0.025” stainless steel wire attached to the maxillary canine bracket before film exposure. Then, the radiographs were traced and the angular parameters were measured by one investigator. The reference line and the variables used for measurement as follow:

- PP : Palatal plane
- 13/PP : The angle between the wire on 13 and PP
- 23/PP : The angle between the wire on 23 and PP

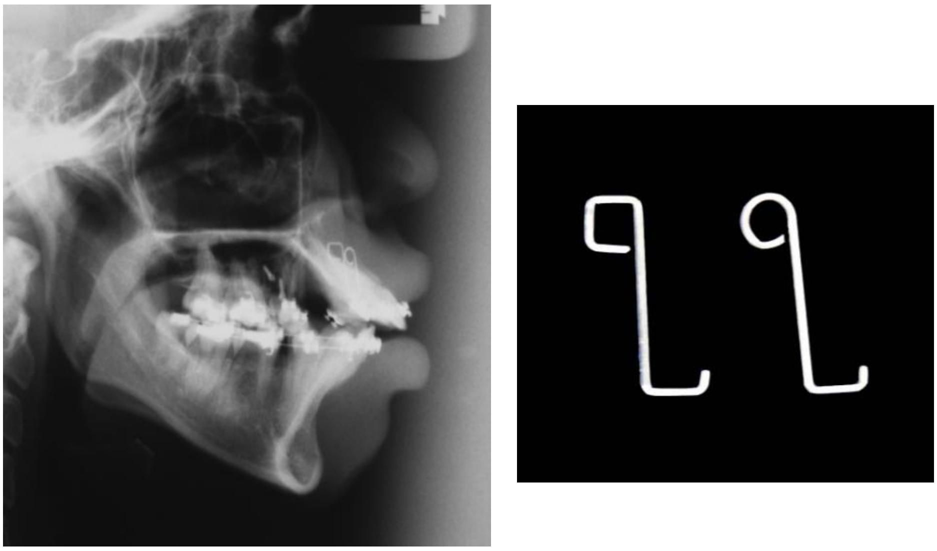


Fig. 5 Angulation indicating wires on the canine brackets.

Model analysis

The upper arch impressions were taken every 4 weeks from the beginning of canine retraction and made into study models. These models were marked at right and left medial end of the second and third palatal rugae which have been determined to be relatively stable landmarks as reference points[37] by using a 0.5-mm graphite pencil. The mesial and distal contact points of the canine were also specified. The models were then scanned into a computer via the scanner (HP scanjet 5530). Pink wax was put on the incisal edges and occlusal surfaces as tripod during scanning to eliminate the instability of the models affected from changes of teeth position during canine retraction. Millimeter ruler was scanned together with the models to assess magnification. The series of scanned images of the models were transferred and superimposed on marked reference points by the use of Adobe Photoshop CS3 software. Distance between mesial and distal contact points of the canine were averaged and plotted representing canine position of each month (Fig. 6). The image with identified canine positions was then printed out from laser printer (HP laserjet 1015), and the distance of canine movement was measured using a digital vernier calipers (Mitutoyo absulute IP67) which was accurate to 0.01 mm.

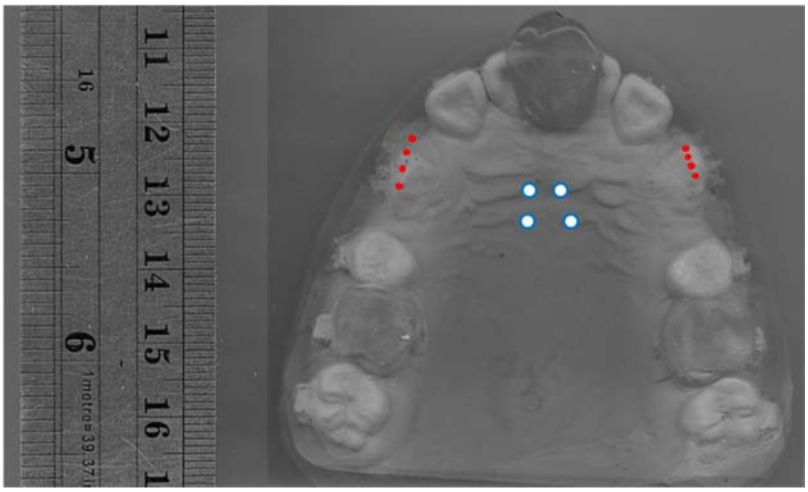


Fig. 6 Measurement of canine movement. White dots are the reference points for model superimposition, whereas red dots represent the canine positions in each month.

Rotation of the canine before (T0) and after retraction (T3) were also measured on the scanned image by the same superimposition technique. The line was drawn connecting mesial and distal contact points of the canine at T0 and T3 (Fig. 7). The change in canine rotation was measured using the protractor which was accurate to 0.5 degree by one investigator.

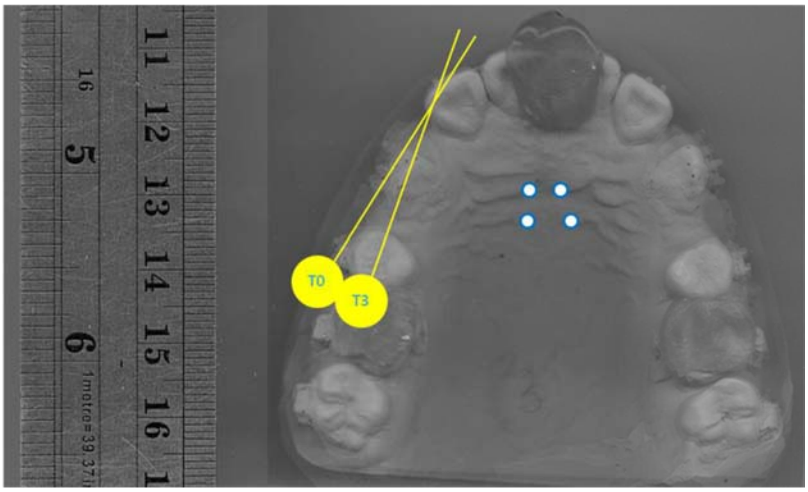


Fig. 7 Measurement of canine rotation.

Statistical analysis

Linear and angular measurements of all samples were repeated twice and averaged. Paired t-test and Dahlberg's formula were used to determine the intraobserver reliability. All variables were presented by the median. Wilcoxon signed rank test was used to compare the distance and the rate of canine movement between experimental and control sides, while Kruskal-Wallis and Mann-Whitney U test were used to compare among subgroups using SPSS (version 14) software. The values of $P < .05$ were evaluated as statistically significant.

CHAPTER 3

RESULTS

At the beginning there were 15 subjects participated in this study. Because of the modification of mechanics used, the first 3 cases were excluded. The samples in this study eventually included 11 females and 1 male. Their mean age at the start of the treatment was 21.92 ∂ 4.76 years, range from 16-31 years. On one week follow-up visit after the surgical procedure, 3 of 12 patients complained more discomfort and pain on the experimental side, while the rest reported no difference between both sides.

Clinical observations

In the pilot study cases, the maxillary canines were distalized along the 0.016”x0.022” stainless steel continuous archwire with the use of NiTi closed coil springs. The problem about the rate of canine movement was noticed. The canines on both control and experimental sides moved slower than normal orthodontic tooth movement rate ever reported, i.e., less than 1 mm per month. Decrease in the overjet was also observed even though the maxillary incisors were not retracted yet. The possible reason might be the friction between the archwire and the canine bracket that bound the canine with the incisors contributing to unexpected en-masse retraction. Hence the method of canine retraction was changed, as mentioned earlier, to eliminate the friction which would affect the result of our surgical intervention. Three cases whose canines were distalized with the sliding mechanics were then excluded.

In the clinical observation, 4 of 12 cases were considered clinically significant. In one case the experimental canine contacted the second premolar in only 2 months and another 3 cases the experimental canines made contact in 3 months, whereas the canines on the control side were still in the middle of extraction space (Fig. 8). Neither periodontal problem nor discoloration of the experimental canine was evident in any case.

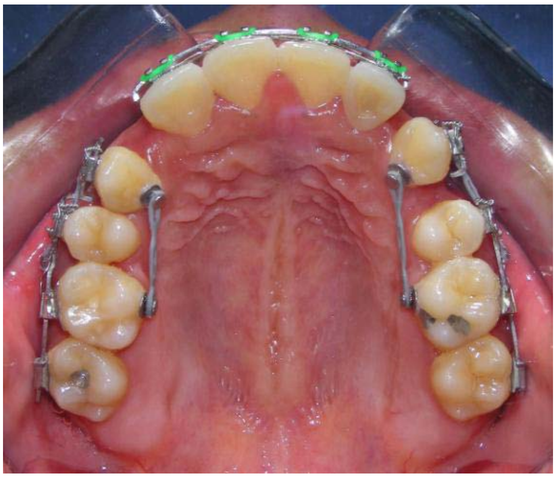


Fig. 8 One of four cases which clinically significant difference was observed. The canine retraction on experimental side was completed in three months.

Magnification and measurement error analysis

The magnification of the scanned model images was -0.70%. All measurements were repeated 2 weeks apart and calculated to determine the intraobserver reliability. Dahlberg's error was 0.07 mm, ranging from 0 to 0.19 mm for the distance measurement, and 0.3∀, ranging from 0∀ to 1.0∀ for the angular measurement. Paired t-test showed no significant difference between two series of measurements.

Periapical radiographic analysis

Regarding the post-operative periapical radiographs, the feature of remaining interseptal bone at surgical site in each patient was different. In some cases the bone was reduced enough in both thickness and depth, while others the bone was sufficiently reduced only either in thickness or depth, or even neither following the surgical procedure's criteria (Fig. 9). Maxillary sinus pneumatization extending through the root apex of the first premolar was found in two cases. This was an anatomical limit in bone reduction. Although this feature from periapical radiograph probably was a superimposition of these two structures, it might be safe not to reduce the bone to this depth. Moreover, there were two surgeons performing the surgery, their techniques and surgical burs used were different. However, all subjects were still included in this study to imitate the real clinical situation.

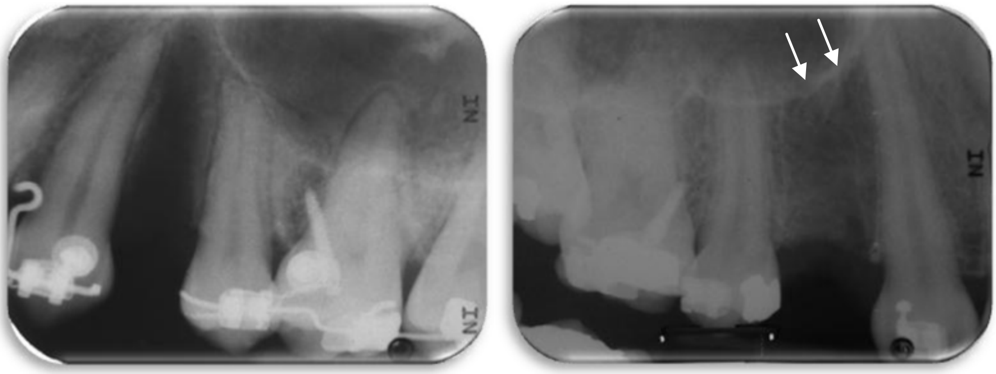


Fig. 9 Post-operative periapical radiographs indicate bone thickness and socket depth after the procedure. Left radiograph shows that the surgical criteria were met, while the right one was not because of maxillary sinus pneumatization (arrow).

During canine retraction the lamina dura on the distal side of the canines could not be traced on both control and experimental sides. On the mesial side, particularly on the cervical half of the root, widening of the periodontal ligament and the striated bone extending from the mesial lamina dura was evident (Fig. 10). This characteristic implied that the canine was moved as controlled tipping. The faster the canine was moved, the wider the periodontal space was noted. These findings were observed throughout 3-month experimental period. In the subjects with clinical significance, bending of interseptal bone distal to the canine into the extraction socket was observed (Fig. 11). The radiopacity of the first premolar extraction sockets increased progressively in each month on both sides. In the third month the radiopacity of the socket content was almost identical to that of the surrounding alveolar process.

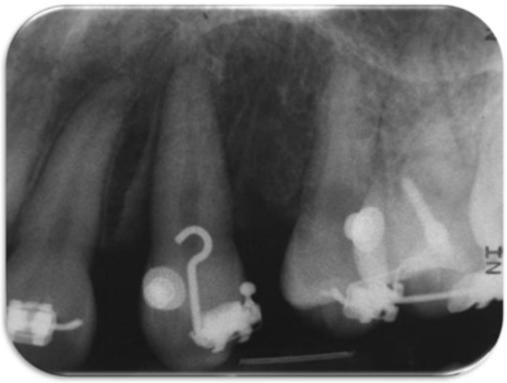


Fig. 10 Periapical radiograph in the third month of canine retraction.

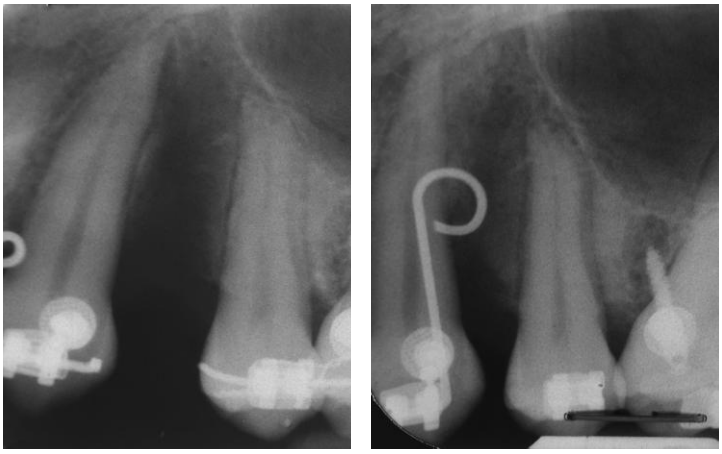
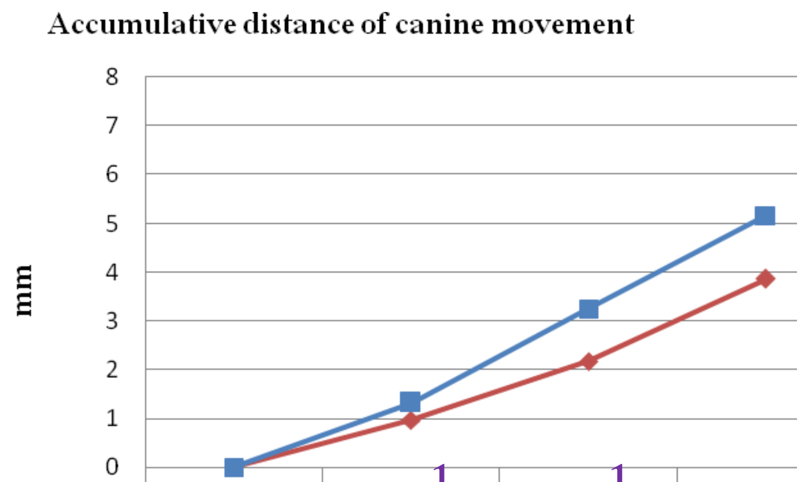


Fig. 11 Periapical radiographs indicate bending of interseptal bone distal to the canine.

Model analysis

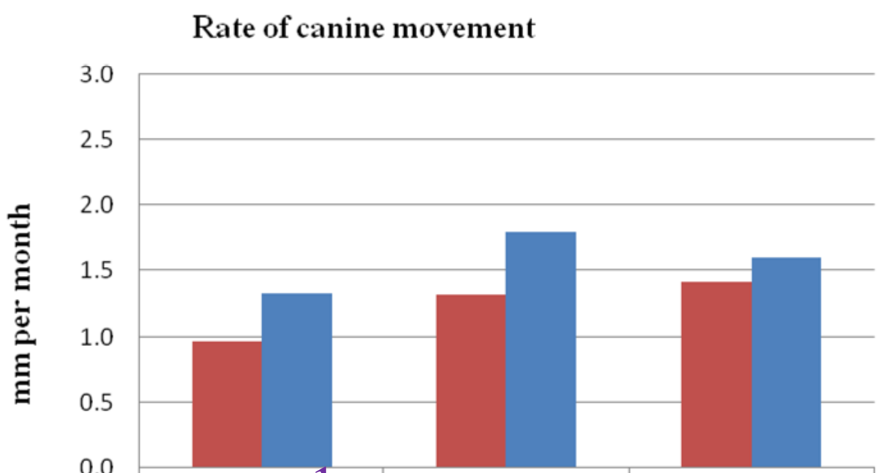
The accumulative distance and the rate of canine movement

Medians of the accumulative distance and the rate of canine movement in each month measured from the models were shown in Fig. 12 and 13. It demonstrated that the accumulative distance of canine movement on the experimental side were greater than that on the control side throughout the experimental period, however, the significant difference was found only in 1 and 2 months. When the rate of canine movement was regarded monthly, it was significantly higher in the experimental side than the control side only in the first month.



	T0	T1	T2	T3
Control side	0.00	0.97	2.17	3.86
Experimental side	0.00	1.32	3.25	5.17

Fig. 12 The accumulative distance of canine movement (mm) on the experimental side compared with the control side. (* P < .05)



	T0-T1	T1-T2	T2-T3
Control side	0.97	1.32	1.41
Experimental side	1.32	1.79	1.60

Fig. 13 The rate of canine movement (mm) in each month on the experimental side compared with the control side. (* P < .05)

The total amount of canine movement in 3-month period in each subject was quite varied, ranging from 2.21 to 4.84 mm on the control side, and 2.51 to 7.45 mm on the experimental side (Fig. 14).

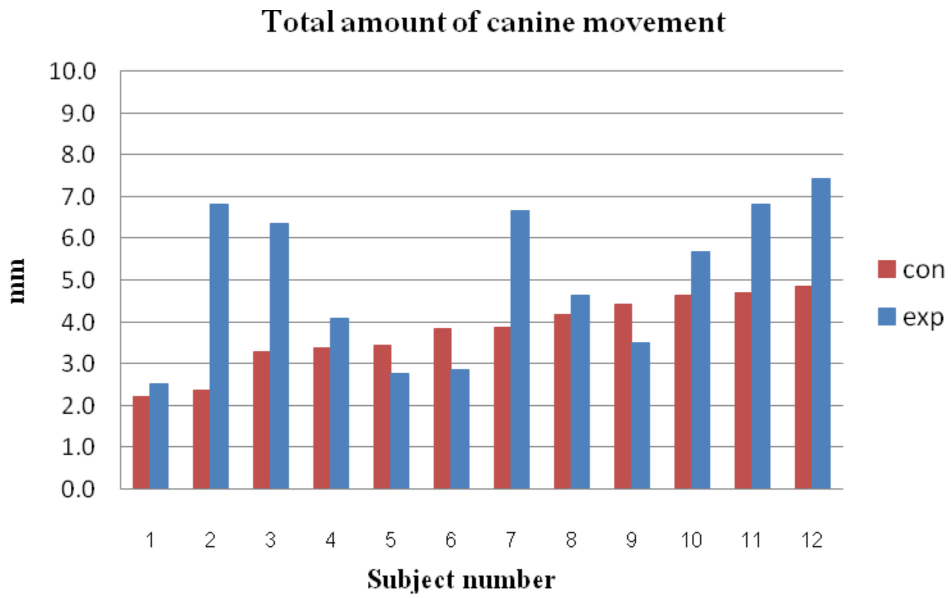


Fig. 14 Total amount of canine movement on the control and experimental sides in each subject.

Because of the wide range in the rate of tooth movement and the difference of remaining bone among samples in the experimental group itself as aforementioned, they were then allocated into two subgroups depending on whether the remaining interseptal bone met the surgical criteria or not, determined from post-operative periapical radiographs. Six of 12 samples were defined as *criteria-met*, i.e., the interseptal bone was surgically reduced to 1.0 to 1.5 mm in thickness and deepened to the canine apex in depth. The other 6 samples were defined as *criteria-not-met*, i.e., the bone was sufficiently reduced only either thickness or depth, or even neither according to the surgical criteria.

When these 2 experimental subgroups were analyzed to investigate the correlation, the point-biserial correlation analysis demonstrated that the total amount of canine movement on the experimental side was strongly correlate to the feature of remaining interseptal bone (*criteria-met* and *criteria-not-met*). On the other hand, when the surgical site (left or right) and the surgeons (S.P. and N.L.) were considered, no correlation was found (Table 1).

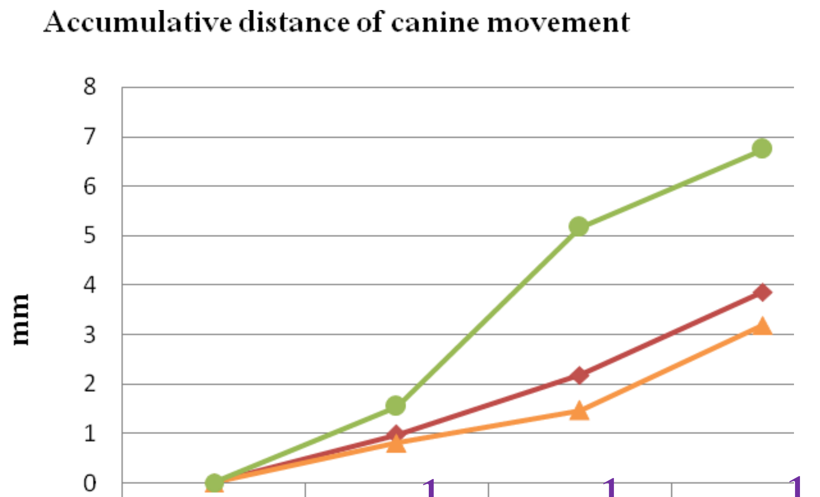
Table 1 Correlation between total amount of canine movement and other factors

	Total amount of canine movement	
	R value	P value
Remaining interseptal bone	.926	***
Surgeon	-.367	NS
Surgical site	-.001	NS

*** P < .001; NS, no significant

Regarding the remaining interseptal bone in each subject, they eventually could be categorized into three subgroups, those were, the control group, the *criteria-met* experimental group, and the *criteria-not-met* experimental group. The difference in the rate of tooth movement between the *criteria-met* **experimental** and *criteria-not-met* **experimental** groups probably was affected by individual response to orthodontic loading. However, no significant difference was found in the rate of canine movement between the *criteria-met* **control** and the *criteria-not-met* **control** groups. This could imply that there was no difference among subjects of this study in the sense of individual response. The accumulative distance and the rate of canine movement of the control, *criteria-met* experimental, and *criteria-not-met* experimental groups were then analyzed and shown in Fig. 15 and 16, respectively. The Kruskal-Wallis Test demonstrated that the significant differences among these three subgroups were found in accumulative distance of canine movement throughout the experimental period. Also, the rate of canine movement was significantly different in the first and second month.

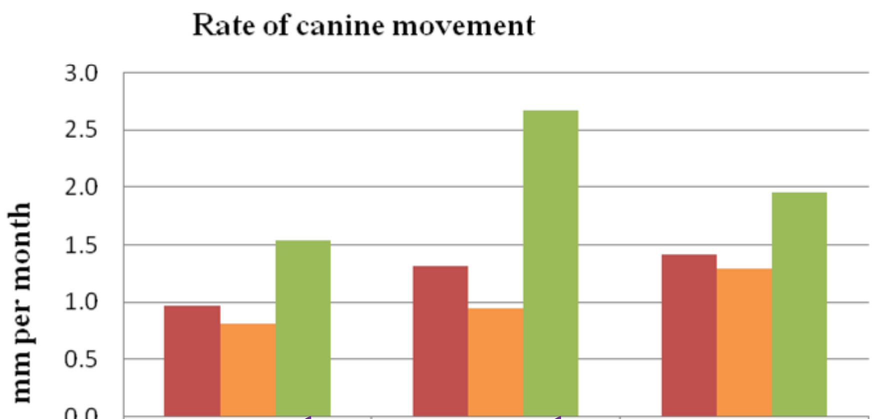
Mann-Whitney U Test was then used following the Kruskal-Wallis Test to compare the difference between each paired subgroups in case of significance. It was found that the accumulative distance of canine movement in the *criteria-met* experimental group was significantly greater than that in the control and the *criteria-not-met* experimental groups. Whereas the accumulative distance of canine movement between the control and *criteria-not-met* experimental groups was not different. These findings were also the same in the rate of canine movement in the first and second month.



	T0	T1	T2	T3
Control side	0.00	0.97 [a]	2.17 [c]	3.86 [e]
Criteria-not-met	0.00	0.81 [b]	1.47 [d]	3.19 [f]
Criteria-met	0.00	1.54 [a, b]	5.16 [c, d]	6.74 [e, f]

Fig. 15 The accumulative distance of canine movement (mm) in the control, *criteria-met* experimental, and *criteria-not*-met experimental groups.

* P < .05 with Kruskal-Wallis Test; a, b, c, d, e, f, P < .05 with Mann-Whitney U Test



	T0-T1	T1-T2	T2-T3
Control side	0.97 [a]	1.32 [c]	1.41
Criteria-not-met	0.81 [b]	0.94 [d]	1.29
Criteria-met	1.54 [a, b]	2.67 [c, d]	1.95

Fig. 16 The rate of canine movement (mm) in the control, *criteria-met* experimental, and *criteria-not*-met experimental groups.

Determining the rate of canine movement in each month within subgroup itself, the rate in the control and *criteria-not-met* experimental groups gradually increased monthly but no significant difference was found (Fig. 15). While in the *criteria-met* experimental group, the rate of canine movement increased in the second month and then decreased in the third month. However, the statistical analysis showed no different either.

When the accumulative distances and the rates of canine movement on the experimental sides were considered according to the surgical operators, there was no significant difference between them. Also, no statistically significant difference was found regarding the right or left side of the surgical procedure.

The canine rotation

Even though the elastomeric chains were used on both labial and palatal aspects of the canine with equal force magnitude during retraction, the mesiolabial rotation was still observed. Rotational changes of the canine on the experimental and control sides were shown in Table 2. The statistical analysis demonstrated that the canine on the *criteria-met* experimental group was more rotated significantly than that on the control. However, when the rotation was calculated in each millimeter of movement, there was no significant difference between these two groups.

Table 2 The amount of total rotation and rotation per millimeter movement of the canine (degree) on the *criteria-met* experimental group compared with the control group

	Control	*Criteria-met* Exp	Wilcoxon signed-rank
Total rotation	14.00∀	23.50∀	*
Rotation per mm	4.26∀	4.18∀	NS

* $P < .05$; NS, no significant

Lateral cephalometric analysis

The canine angulation change

Although the power arm was fabricated approximate to the height of the mini-implant, the line of force application remained incisally to the center of resistance of the canine, resulting in tipping tendency. It was found that the *criteria-met* experimental canine tipped distally more than the control, however, the statistical analysis showed no significant difference between them (Table 3).

Table 3 The amount of total tipping and tipping per millimeter movement of the canine (degree) on the *criteria-met* experimental group compared with the control group

	Control	*Criteria-met* Exp	Wilcoxon signed-rank
Total tipping	4.50∀	7.50∀	NS
Tipping per mm	1.06∀	2.75∀	NS

NS, no significant

CHAPTER 4

DISCUSSION

Many dentoalveolar surgical techniques have been reported to accelerate the rate of tooth movement and reduce overall orthodontic treatment time.[20-28] With these techniques, the active orthodontic treatment can be completed within only one year. The mechanism of rapid tooth movement facilitated with dentoalveolar surgery has been explained in many different ways including bending of interseptal bone and less bone resistance (distraction of periodontal ligament),[20-22] dentoalveolar block movement (dentoalveolar distraction osteogenesis),[23-24] and regional acceleratory phenomenon (RAP) after bone injury (periodontally accelerated osteogenic orthodontics)[25] which can increase bone turnover rate.

In this study we would like to propose a new approach to accelerate the rate of maxillary canine movement. We performed the less invasive surgical procedure without flap operation which was not much more invasive and complicated than simple extraction for orthodontic treatment. We also used conventional orthodontic appliance instead of the custom-made distraction device, as in other studies, to simplify clinical practice. Elastomeric chain was used with optimal force application to move teeth within biologic limit.

Our surgical intervention resembles distraction of periodontal ligament presented by Liou and Huang,[20] except no buccal and lingual vertical grooving of interseptal bone was performed. The vertical groove was conducted in periodontal ligament distraction technique to weaken the interseptal bone, contributing to fracture of the bone that would be moved along with the canine during distraction with the use of distractor. In our study, what we expected from the surgical procedure was to reduce the bone resistance and promote alveolar bone bending during canine retraction, not to break the interseptal bone. Also, we expected that RAP would be initiated from the alveolar surgery which would produce transient osteoporosis. With these mechanisms we thought the experimental canine should be moved faster than the control one.

When RAP was anticipated following the alveolar surgery, we then use the mini-implants as an anchorage during canine retraction to minimize the risk of anchorage loss. In this study 24 mini-implants were placed between the roots of maxillary second premolars and first molars in 12 subjects. The mini-implants were observed 1 month to ensure their stability before orthodontic loading. Three mini-implants in 2 patients failed after placement without loading within 1 month although post-placement periapical radiographs demonstrated no root contact and no sign of infection was noted. This probably was a result of trauma-induced changes in the bone that occurred during insertion.[38] However, the failed mini-implants were replaced 2 months later in the same position and these 2 subjects were still included in the study. All mini-implants, including the replaced ones, were stable throughout the experimental period.

Before the surgical procedure, we used the surgical guide wire engaged in the canine bracket with periapical radiograph as an indicator for how much the interseptal bone would be removed. No other more accurate tool, such as surgical stent or computed tomogram, was used because we proposed this technique based on practical approaching in routine orthodontic treatment. Thus, the technique sensitivity might be one of limitations which depended on skill of the surgeon.

Our result demonstrated that the rate of tooth movement on the control side (3.86 mm in 3 months) was similar to biologic tooth movement rate with optimum force ever reported, which is approximately 1 to 1.5 mm in 4 to 5 weeks,[8] while the canine in the experimental side was moved distally 5.17 mm in 3 months. Despite the greater rate of canine retraction on the experimental side, the total distances of canine movement in 3 month were not significantly different between these two groups. We did not expect such rapid canine movement rate as in the distraction periodontal ligament, or dentoalveolar distraction osteogenesis technique, which are 0.5 to 1.0 mm per day. Nevertheless, the average total result of all subjects was inferior to what we initially expected.

In the clinical observation, the rate of canine retraction in 4 of 12 cases was obviously greater in the experimental side than control side. When the post-operative periapical radiographs were considered, it was found that the characteristics of remaining interseptal bone at surgical site of each patient were different according to the surgical criteria. Some were sufficiently reduced in both thickness and depth, while others reached only either thickness or depth, or even neither. One of the obvious obstacles in the surgical procedure was the maxillary sinus pneumatization which was an anatomical limitation of bone reduction in depth. This situation was found in 2 cases. Therefore, we categorized the experimental subjects into 2 groups, those were *criteria-met* and *criteria-not-met* groups.

In the *criteria-met* experimental group, the accumulative distance of canine movement in 3 months was significantly greater than that of the criteria-not-met group (6.74 mm and 3.19 mm, respectively). From these findings, we could imply that RAP was probably not produced by this kind of surgery. If RAP was initiated by any kind of dentoalveolar surgery, it could be expected that the rate of tooth movement in both *criteria-met* and *criteria-not-met* experimental groups should not be different because the bone was injured in both groups no matter how much it was. Also the rate of canine retraction in the *criteria-not-met* experimental group should be greater than that of the non-surgical control group. However, the statistical analysis demonstrated that there was no significant difference between the rate of canine retraction in the *criteria-not-met* experimental group and the control group. Moreover, RAP is believed to peak at 1 to 2 months and last about 6 months,[35] thus the rate of canine movement on the experimental side should be greater than physiologic tooth movement throughout the 3-month experimental period. From the study of Lee *et al.* [39] and Wang *et al.*[40] which compared the alveolar bone response following corticotomy and osteotomy using microCTs and histologic analysis, it was found that alveolar bone responded differently to the type of bony cut used. The corticotomy produced transient bone resorption around dental roots, i.e., RAP, while this phenomenon was not observed in osteotomy. Furthermore, in many histologic studies of the distraction of periodontal ligament technique performed in animals, RAP had not been mentioned at all. However, the more extensive studies are needed to investigate this assumption.

Although the interseptal bone was reduced sufficiently in both thickness and depth in 6 subjects defined as *criteria-met*, the rate of canine movement in only 4 subjects of this subgroup were considered as clinically significant, i.e., the canine were moved to contact the second premolar within 2 to 3 months. It could imply that there probably were the other factors affecting canine retraction in another 2 subjects besides the mesiodistal thickness of the interseptal bone. When the root anatomy is regarded, it is known that the root of canine in buccolingual dimension is greater than that of the first premolar. Hence, the first premolar extraction socket should be surgically widened to the width of the canine’s root in buccolingual dimension. Unfortunately, this could not be considered from the periapical radiograph. Furthermore, the rate of canine retraction might be limited due to the resistance from the cortical bone. If the labiolingual width of the canine root is greater than that of alveolar ridge between the canine and the first premolar, the canine can be distalized only when the cortical plate is resorbed.

From all of above reasons, it could imply that our surgical technique is quite sensitive, similar to those reported by the distraction of periodontal ligament technique.[41, 42]

Like the periodontal ligament distraction technique, the possible explanation for the increased rate of canine movement of our intervention, in the case which the interseptal bone was surgically reduced enough, might be less bone resistance and alveolar bone bending. In this study, if the rate of canine retraction was considered in each month, it was found that the rate in *criteria-met* experimental group was significantly greater than in the control group only in the first (1.54 mm and 0.97 mm, respectively) and second month (2.67 mm and 1.32 mm, respectively). No significant difference was observed in the third month. It can be explained that in the early period after the surgical procedure, the remaining interseptal bone on the pressure side was being resorbed. If the interseptal bone was surgically reduced enough, the whole bone might be completely resorbed within one month. Then the canine was retracted into the extraction socket which was not refilled by solid bone yet,[43] while in the control and *criteria-not-met* experimental group the interseptal bone was still being resorbed. In the study of Ren *et al.*[44] which undermined the interseptal bone, as in the distraction of periodontal ligament technique, together with the use of 150-g NiTi coil spring to accelerate the rate of tooth movement in dog, the histoligic results showed that during the third and fourth weeks the undermined interseptal bone became discrete because of bone resorption, and the periodontium joined with the extraction socket. In our human study the mechanism of rapid tooth movement in the *criteria-met* experimental group might be similar. Moreover, the bending of alveolar bone might be one of the mechanisms which accelerated canine retraction in our study. Picton[45] demonstrated that the bending of the alveolar bone could constitute as much as 25% of the initial tooth movement.

In the third month no significant difference was found, this might be because the remaining first premolar extraction space in the *criteria-met* experimental group was only 2 to 3 mm until the canine would contact the second premolar (the average accumulative distance in 2 month was 5.16 mm). No matter how fast the canine could be moved, the rate would be limited under the remaining space. Hence, the rate of canine movement of the *criteria-met* experimental group in the third month might not indicate the real rate.

Our study has shown that if the interseptal bone was sufficiently reduced in both thickness and depth according to the surgical criteria, the canine movement can be significantly accelerated. However, the canine in this study was distalized as a free body which was frictionless mechanics. Also, the line of force application was positioned insically to the center of resistance, contributing to tipping tendency. It can be argued that the frictionless mechanics and tipping movement has a higher rate than the friction mechanics and bodily movement. When the rates of maxillary canine movement in other human clinical studies performing the frictionless mechanics are compared, our results still show a higher rate (Table 4).

Table 4 Human clinical studies on the rate of maxillary canine retraction with frictionless mechanics

Author	Rate (mm/month)	Measurement
Boester & Johnston[46]	0.98	Oblique radiograph
Ziegler & Ingervall[47]	1.91	Clinical
Dincer & Iscan[48]	0.85	Lateral radiograph
Daskalogianakis & McLachlan[49]	0.63	Model
Darendeliler *et al.*[50]	1.43	Lateral radiograph
Hasler *et al.*[15]	0.91	Model
Hayashi *et al.*[51]	1.95	Model
Martins *et al.*[52]	1.60	Oblique radiograph
This study - Control	1.29	Model
- *Criteria-met* exp	2.58	

In this study it was found that the tipping of the experimental canine was greater than that of the control one although no significant difference was noted (7.50∀ and 4.50∀, respectively). This could be explained that the increased tipping on the experimental side might be the effect of the increased movement. On the other hand, if the interseptal bone was reduced in only thickness while the bone around the canine apex remained intact, the center of resistance of the canine might be located further apically resulting in the increased tipping of the experimental canine.[15] However, another important factor to be regarded is that the line of force application and center of resistance of tooth in each case were different. The height of the power arm was determined by the vertical position of mini-implant, and the center of resistance of the canine depends on many factors.

Mesiolabial rotation of the canine was still observed on both experimental and control sides although the counteractive force with equal magnitude was applied on the palatal aspect, This might be because the moments of force produced on the labial and palatal sides were not identical due to the different distances. The force on the labial aspect of the canine was applied on the power arm, which was further from the center of resistance of the canine than that applied on the lingual button bonded to the cingulum. Moreover, the inclination of the canine might influence on the moment in transverse plane. The more labially inclined of the canine, the more moment is produced. Nevertheless, the rotation per millimeter movement of the canine between the experimental and control sides were not significantly different.

Table 5 Human clinical studies on tipping and rotation of maxillary canine retraction with frictionless mechanics

Author	Rate (mm/month)	Tipping / mm	Rotation / mm
Ziegler& Ingervall[47]	1.79	0.77∀	5.07∀
Darendeliler *et al.*[50]	1.43	1.75∀	7.08∀
Hayashi *et al.*[51]	1.95	2.00∀	5.58∀
This study - Control	1.29	1.06∀	4.26∀
- Experiment	2.58	2.75∀	4.18∀

Clinical implication

With our technique, the maxillary canine can be distalized faster than conventional canine movement when the interseptal bone is surgically reduced sufficiently according to the criteria. However, this approach is sensitive as mentioned earlier. Case selection should be conducted appropriately regarding the surrounding anatomical limitations, such as maxillary sinus pneumatization or narrowed alveolar ridge. Also, the case with any systemic condition which is prone to the risk of surgery is not a proper candidate. Mechanical trauma to the root of tooth during the surgical procedure must be cautious.

The biomechanics of orthodontic treatment to contract anterior teeth should be two-step retraction rather than en-masse retraction. If en-masse anterior teeth retraction is performed, more accurate tool is needed before and during the surgical procedure for the most identical result on both sides, or else the midline deviation may occur during contraction. In addition, the rate of en masse retraction may not be enhanced by this technique, because the palatal cortical bone is a main resistance of anterior teeth retraction. Canine distalization can be performed with either sliding or frictionless mechanics. Nevertheless, the friction issue should be regarded if the sliding mechanics will be used.

Mini-implants might not be needed in this technique because the RAP initiation was still suspected. However, the anchorage preparation is necessary in those cases that need maximum anchorage, that is, bimaxilary dentoalveolar protrusion.

Despite the increased rate of canine movement, it must be kept in mind that the long term effects of this technique on pulpal vitality, root resorption, and periodontal tissue have not been investigated in this study yet because of time limit.

CHAPTER 5

CONCLUSION

Interseptal bone reduction combined with the use of conventional orthodontic appliance with optimum force can accelerate maxillary canine retraction effectively when the bone is sufficiently reduced in both thickness and depth following the surgical criteria. Anatomical structures, such as maxillary sinus or narrowed alveolar ridge, may be limiting factors in the surgical procedure and tooth movement. Thus case selection must be done appropriately.

REFERENCES

1. Reitan K. Clinical and histological observations on tooth movement during and after orthodontic treatment. ***Am J Orthod*** 1967; 53: 721-45.
2. Rygh P. Elimination of hyalinized periodontal tissues associated with orthodontic tooth movement. ***Scand J Dent Res*** 1974; 80: 57-73.
3. Macapanpan L, Weinmann JP, Brodie AG. Early tissue changes following tooth movement in rat. ***Angle Orthod*** 1954; 24: 79.
4. Midgett RJ, Shaye R, Fruge JF. The effect of altered bone metabolism on orthodontic tooth movement. ***Am J Orthod*** 1981; 80: 256-62.
5. Goldie RS, King GJ. Root resorption and tooth movement in orthodontically treated calcium deficient and lactating rats. ***Am J Orthod*** 1984; 85: 424-30.
6. Collins MK, Sinclair PM. The local use of vitamin D to increase the rate of orthodontic tooth movement. ***Am J Orthod Dentofac Orthop*** 1988; 94: 278-84.
7. Ashcraft MB, Southard KA, Tolley EA. The effect of corticosteroid-induced osteoporosis on orthodontic tooth movement. ***Am J Orthod Dentofac Orthop*** 1992; 102: 310-9.
8. Pilon JJGM, Kuijpersa-Jagtman AM, Maltha JC. Magnitude of orthodontic forces and rate of bodily tooth movement, an experimental study in beagle dogs. ***Am J Orthod Dentofac Orthop*** 1996; 110: 16-23.
9. Travess H, Roberts-Harry D, Sandy J. Orthodontics. Part 6: Risks in orthodontic treatment. ***Br Dent J*** 2004; 196: 71-7
10. Reitan K. Tissue behavior during orthodontic tooth movement. ***Am J Orthod*** 1960; 46: 881-900.
11. Williams S. A histomorphometric study of orthodontically induced root resorption. ***Eur J Orthod*** 1984; 6: 35-47.
12. Kurol J, Owman-Moll P, Lundgren D. Time-related root resorption after application of a controlled continuous orthodontic force. ***Am J Orthod Dentofac Orthop*** 1996; 110: 303-10.
13. Liou EJW, Figueroa AA, Polley JW. Rapid orthodontic tooth movement into newly distracted bone after mandibular distraction osteogenesis in a canine model. ***Am J Orthod Dentofac Orthop*** 2000; 117: 391-8.

14. Iseri H, Kisnisci R, Bzizi N, Tuz H. Rapid canine retraction and orthodontic treatment with dentoalveolar distraction osteogenesis. ***Am J Orthod Dentofac Orthop*** 2005; 127: 533-41.
15. Hasler R *et al*. A clinical comparison of the rate of maxillary canine retraction into healed and recent extraction sites--a pilot study. ***Eur J Orthod*** 1997; 19: 711-9.
16. Yuan X, Luo S, Shen G. Experimental study on selecting optimal time of orthodontic tooth movement into extraction sites. ***Hua Xi Kou Qiang Yi Xue Za Zhi*** 2003; 21: 311-3. [Abstract]
17. Murphey WH. Oxytetracycline microfluorescent comparison of orthodontic retraction into recent and healed extraction sites. ***Am J Orthod*** 1970; 58: 215-39.
18. Diedrich P, Wehrbein H. Orthodontic retraction into recent and healed extraction sites. ***J Orofac Orthop*** 1997; 58: 90-9.
19. Köle H. Surgical operations of the alveolar ridge to correct occlusal abnormalities. ***Oral Surg Oral Med Oral Pathol*** 1959; 12: 515–29.
20. Liou EJ, Huang CS: Rapid canine retraction through distraction of the periodontal ligament. ***Am J Orthod Dentofac Orthop*** 1998; 114: 372-81.
21. Liou EJ. Accelerated orthodontic treatment by rapid canine retraction in various malocclusions. In: Mauchamp OP, Miolti FA, eds. 6th International Orthodontic Congress: papers and abstracts. Paris, France; 2005 September; 70-1.
22. Sayin S, Bengi O, Gurton U, Ortakoglu K. Rapid canine distalization using distraction of the periodontal ligament: A preliminary clinical validation of the original technique. ***Angle Orthod*** 2004; 74: 304-15.
23. Kisnisci R, Iseri H, Tuz H, Altug A. Dentoalveolar distraction osteogenesis for rapid orthodontic canine retraction. ***J Oral Maxillofac Surg*** 2002; 60: 389-94.
24. Sukurica Y, Karaman A, Gurel H, Dolanmaz D. Rapid canine distalization through segmental alveolar distraction osteogenesis. ***Angle Orthod*** 2007; 77: 226-36.
25. Wilcko WM, Wilcko MT, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. ***Int J Periodont Restor Dent*** 2001; 21: 9-19.
26. Germec D, Giray B, Kocadereli I, Enacart A. Lower incisor retraction with a modified corticotomy. ***Angle Orthod*** 2006; 76: 882-90.

27. Iino S, Sakoda S, Miyawaki S. An adult bimaxillary protrusion treated with corticotomy-faciliated orthodontics and titanium miniplates. ***Angle Orthod*** 2006; 76: 1074-82.

28. Chung KR, Kim SH, Lee BS. Speedy surgical-orthodontic treatment with temporary anchorage devices as an alternative to orthognathic surgery. ***Am J Orthod Dentofac Orthop*** 2009; 135: 787-98.

29. Baumrind S. A reconsideration of the propriety of the pressure-tension hypothesis. ***Am J Orthod*** 1969; 55: 12-22.

30. Grimm FM. Bone bending, a feature of orthodontic tooth movement. ***Am J Orthod*** 1972; 62: 384-93.

31. Frost HM. The biology of fracture healing. An overview for clinicians. Part I. ***Clin Orthop Related Res*** 1989; 248: 283-93.

32. Goldie RS, King GJ. Root resorption and tooth movement in orthodontically treated, calcium-deficient, and lactating rats. ***Am J Orthod*** 1984; 85: 424–30.

33. Nyman S, Karring T, Bergenholtz G. Bone regeneration in alveolar bone dehiscences produced by jiggling forces. ***J Periodont Res*** 1982; 17: 316–22.

34. Nevins M, Kirker-Head C, Nevins M, Wozney JA, Palmer R, Graham D. Bone formation in the goat maxillary sinus induced by absorbable collagen sponge implants impregnated with recombinant human bone morphogenetic protein-2. ***Int J Periodont Restor Dent*** 1996; 16: 8–19.

35. Yaffe A, Fine N, Binderman I. Regional accelerated phenomenon in the mandible following mucoperiosteal flap surgery. ***J Periodontol*** 1994; 65: 79–83.

36. Cho KW, Cho SW, Oh CO, Ryu YK, Ohshima H, Jung HS. The effect of cortical activation on orthodontic tooth movement. ***Oral Dis*** 2007; 13: 314-9.

37. Almeida MA, Philips C, Kula C, Tulloch C. Stability of the palatal rugae as landmarks for analysis of dental casts. ***Angle Orthod*** 1996; 65: 43-8.

38. Schatkzer J, Sanderson R, Murnaghan JP. The holding power of orthopedic screws *in vivo*. ***Clin Orthop and Related Res*** 1975; 108: 115-26

39. Lee W, Karapetyan G, Moats R, Yamashita DD, Moon HB, Furguson DJ, Yen S. Corticotomy-/osteotomy-assisted tooth movement microCTs differ. ***J Dent Res*** 2008; 87: 861-5.

40. Wang L, Lee W, Lei D, Liu Y, Yamashita DD, Yen SL. Tissue responses in corticotomy- and osteotomy-assisted tooth movements in rats: Histology and immunostaining. ***Am J Orthod Dentofac Orthop*** 2009; 136: 770.e1-e11.

41. Chang YI, Kim TW, Choi HY. Histological periodontal tissue reaction to rapid tooth movement by periodontal distraction in dogs. ***Korea J Orthod*** 2002; 32: 455-66.

42. Kumar PS, Saxena R, Patil S, Nagaraj K, Kotrashetti SM. Clinical investigation of periodontal ligament distraction osteogenesis for rapid orthodontic canine retraction. ***Aust Orthod J*** 2009; 25: 147-52.

43. Amler MH, Johnson PL, Salman I. Histological and histochemical investigation of human alveolar socket healing in undisturbed extraction wounds. ***J Am Dent Assoc*** 1960; 61: 33–44.

44. Ren A, Lv T, Zhao B, Chen Y, Bai D. Rapid orthodontic tooth movement aided by alveolar surgery in beagles. ***Am J Orthod Dentofac Orthop*** 2007; 131: 160.e1-e10.

45. Picton DCA. On the part played by the socket in toot support. ***Arch Oral Biol*** 1965; 10: 945-55.

46. Boester CH, Johnston LE. A clinical investigation of the concepts of differential and optimal force in canine retraction. ***Angle Orthod*** 1974; 44: 113-9.

47. Ziegler P, Ingervall B. A clinical study of maxillary canine retraction with a retraction spring and with sliding mechanics. ***Am J Orthod Dentofac Orthop*** 1989; 95: 99-106.

48. Dincer M, Iscan HN. The effects of different sectional arches in canine retraction. ***Eur J Orthod*** 1994; 16: 317-23.

49. Daskalogiannakis J, McLachlan KR. Canine retraction with rare earth magnets: an investigation into the validity of the constant force hypothesis. ***Am J Orthod Dentofac Orthop*** 1996; 109: 489-95.

50. Darendeliler MA, Darendeliler H, Uner O. The drum spring (DS) retractor: constant and continuous force for canine retraction. ***Eur J Orthod*** 1997; 19: 115-30.

51. Hayashi K, Uechi J, Murata M, Mizoguchi I. Comparison of maxillary canine retraction with sliding mechanics and a retraction spring: a three-dimensional analysis based on a midpalatal orthodontic implant. ***Eur J Orthod*** 2004; 26: 585-9.

52. Martins RP, Buschang PH, Gandini LG, Rossouw PE. Changes over time in canine retraction: An implant study. ***Am J Orthod Dentofac Orthop*** 2009; 136: 87-93.

APPENDICES

ใบเชิญชวน

ขอเชิญเข้าร่วมโครงการวิจัยเรื่อง ผลของการกรอกระดูกเบ้าฟันต่ออัตราการดึงฟันเขี้ยวบน

เรียน ท่านผู้อ่านที่นับถือ

ข้าพเจ้า ทพ.สุรัฐ กนกกุลชัย กำลังศึกษาระดับปริญญาโท สาขาทันตกรรมจัดฟัน ภาควิชาทันตกรรมป้องกัน ค ณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ใคร่ขอเล่าถึงโครงการวิจัยที่กำลังทำอยู่ และขอเชิญชวนท่านเข้าร่วมโครงการดังนี้ โครงการวิจัยนี้จะทำการศึกษาอัตราการเคลื่อนของฟันเขี้ยวหลังจากการถอนฟันกรามน้อยซี่แรกร่วมกับการกรอกระดูกเบ้าฟัน เปรียบเทียบกับการถอนฟันด้ วยวิธีการตามปกติ หลังจากสิ้นสุดการวิจัยแล้ว ผู้เข้าร่วมการวิจัยจะได้รับการรักษาทางทันตกรรมจัดฟันด้วยวิธีการตามปกติต่อไป

ผู้เข้าร่วมการวิจัยจะได้รับการเก็บข้อมูลเบื้องต้นตามปกติ ได้แก่ การพิมพ์ฟันเพื่อทำแบบจำลองฟัน ถ่ายภาพภายในช่องปาก ถ่ายภาพรังสีกะโหลกศีรษ ะเพื่อวางแผนการรักษา หลังจากนั้นจะได้รับการติดเครื่องมือจัดฟันชนิดติดแน่นและปรับเครื่องมือทุก 1 เดือนจนกระทั่งฟันอยู่ในตำแหน่งที่เหมาะสม จากนั้นผู้เข้าร่วมการวิจัยจะได้รับการถอนฟันกรามน้อยซี่แรก โดยที่ข้างหนึ่งถอนฟันตามปกติ ส่วนอีกข้างหนึ่งถอนฟันร่วมกับการ กรอกระดูก และให้แรงเคลื่อนฟันเขี้ยว จนกระทั่งฟันเขี้ยวอยู่ในตำแหน่งที่ต้องการตามแผนการรักษาทางทันตกรรมจัดฟันจึงสิ้นสุดการวิจัย

ถ้าท่านตัดสินใจเข้าร่วมโครงการนี้จะมีขั้นตอนของการวิจัยที่เพิ่มเติมขึ้นมาจากการจัดฟันตามปกติดังนี้

1. พิมพ์ฟันเพิ่มเติม ได้แก่ ก่ อนถอนฟัน ระหว่างการดึงฟันเขี้ยวเดือนละ 1 ครั้ง จนกระทั่งสิ้นสุดการดึงฟันเขี้ยว

2. ถ่ายภาพรังสีรอบปลายรากฟันเพิ่มเติม ได้แก่ ก่อนถอนฟัน หลังถอนฟันและระหว่างการดึงฟันเขี้ยวเดือนละ 1 ครั้งจนกระทั่งสิ้นสุดการดึงฟันเขี้ยว

3. ถ่ายภาพรังสีกะโหลกศีรษะด้านข้างเพิ่ม เติม ได้แก่ ก่อนถอนฟันและเมื่อสิ้นสุดการดึงฟันเขี้ยว

4. การถอนฟันกรามน้อยซี่แรกร่วมกับการกรอกระดูกในด้านใดด้านหนึ่ง โดยจะมีการคำนวณปริมาณกระดูกที่จะกรอเพื่อป้องกันการเกิดอันตรายต่อฟันเขี้ยว

นอกจากนี้ผู้เข้าร่วมงานวิจัยต้องมารับการติดตามผลทุก 2 สัปดาห์ในช่วง 2 เดือนแรกหลังจากถอนฟันและกรอกระดูก หลังจากนั้นจึงมารับการติดตามผลและปรับเครื่องมือจัดฟัน

ทุก 1 เดือนตามปกติจนกระทั่งสิ้นสุดการวิจัย ทั้งนี้ผู้เข้าร่วมการวิจัยไม่ต้องเสียค่าใช้จ่ายใดๆ เพิ่มเติม

การกรอกระดูกเบ้าฟันอาจมีความเสี่ยงเกิดขึ้นในลักษณะเดียวกับการผ่าฟันคุดซึ่งมีการกรอกระดูกเช่นกัน ได้แก่ ความเสี่ยงต่อการเกิดการอักเสบของแผล (ปวด บวม) การติดเชื้อ และอันตรายต่อรากฟันข้างเคียง อย่างไรก็ตามในงานวิจัยนี้มีมาตรการป้องกันโดยกระทำภายใต้หลักวิชาการและมาตรฐานของโรงพยาบาลเพื่อป้องกันความเสี่ยงต่างๆ ที่อาจเกิดขึ้ นและมีการติดตามผลเป็นระยะ หากพบว่าโพรงประสาทฟันหรือรากฟันข้างเคียงได้รับอันตรายจากการกรอกระดูก ผู้วิจัยจะหยุดทำการวิจัยทันที และหากมีการสูญเสียความมีชีวิตของฟันเขี้ยวเกิดขึ้น ผู้เข้าร่วมงานวิจัยจะได้รับการส่งต่อไปยังผู้เชี่ยวชาญเพื่อทำการรักษาคลองรากฟัน โ ดยผู้วิจัยจะเป็นผู้รับผิดชอบค่าใช้จ่ายในการรักษาทั้งหมด

ไม่ว่าท่านจะเข้าร่วมในโครงการวิจัยนี้หรือไม่ ท่านจะยังคงได้รับการรักษาที่ดีเช่นเดียวกับผู้ป่วยคนอื่นๆ และถ้าท่านต้องการที่จะถอนตัวออกจากการศึกษานี้เมื่อใด ท่านก็สามารถกระทำได้อย่างอิสระ

ถ้าท่านมีคำถ ามใดๆ ก่อนที่จะตัดสินใจก่อนเข้าร่วมโครงการนี้ โปรดซักถามคณะผู้วิจัยได้อย่างเต็มที่

ขอขอบคุณเป็นอย่างสูง
ทพ.สุรัฐ กนกกุลชัย

หมายเหตุ: กรุณาอ่านข้อความให้เข้าใจก่อนเซ็นชื่อยินยอมเข้าร่วมโครงการ

แบบยินยอมเข้าร่วมการศึกษา

โครงการวิจัยเรื่อง ผลของการกรอกระดูกเบ้าฟันต่ออัตราการดึงฟันเขี้ยวบน

วันที่______เดือน_________________พ.ศ.______

ข้าพเจ้า____________________________________อายุ____________ปี อาศัยอยู่บ้านเลขที่________หมู่______ ถนน________________ตำบล________________ อำเภอ_________________จังหวัด___________________ ได้รับการอธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

หากข้าพเจ้ามีข้อสงสัยป ระการใด หรือเกิดผลข้างเคียงจากการวิจัยจะสามารถติดต่อกับ ทพ .สุรัฐ กนกกุลชัย ได้ที่ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ หมายเลขโทรศัพท์ 074-429876 หรือเมื่อมีปัญหาใดๆ เกิดขึ้นเนื่องจากการทำวิจัยในเรื่องนี้ ข้าพเจ้าสามารถร้องเรีย นได้ที่คณบดี คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287510

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่มีปิดบัง

ข้าพเจ้ามี สิทธิ์ที่จะของดการเข้าร่วมโครงการวิจัย โดยจะแจ้งให้ทราบล่วงหน้า โดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการได้รับบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่อย่างใด

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ จะไม่เปิดเผยข้อมูลหรือผ ลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชน จะเปิดเผยได้ในรูปที่เป็นสรุปผลการวิจัย หรือการเปิดเผยข้อมูลต่อผู้มีหน้าที่ที่เกี่ยวข้องกับการสนับสนุนและกำกับดูแลการวิจัย

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ จึงได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ โดยผู้วิจัยได้ให้สำเนาแบบยินยอมที่ลงนามแล้วกับข้าพเจ้าเพื่อเก็บไว้เป็นหลักฐานจำนวน 1 ชุด

ลงชื่อ…………………………………..……………………....ผู้ยินยอม

( )

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

(ทันตแพทย์สุรัฐ กนกกุลชัย)

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

( )

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

( )

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

( )

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

( )

VITAE

Name Mr. Surat Kanokkulchai

Student ID 5010820018

Educational Attainment

Degree	Name of Institution	Year of Graduation
Doctor of Dental Surgery	Chulalongkorn University	2004

List of Publication and Proceeding

The 4th Conference on Graduate Research, Surindra Rajabhat University, February 20-22, 2010.