The Effectiveness of the Uprighting Spring to Support an Anchorage of Posterior Teeth during Canine Retraction

Chatchalit Poolsak

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 The Effectiveness of the Uprighting Spring to Support an Anchorage of Posterior Teeth During Canine Retraction

Author Mr. Chatchalit Poolsak

Major Program Oral Health Sciences

Major Advisor :

....

(Assoc. Prof. Dr. Chidchanok Leethanakul)

Co-advisors :

....

(Assoc. Prof. Dr. Chairat Charoemratrote)

Examining Committee :

....Chairperson

(Prof. Smorntree Viteporn)

....

(Assoc. Prof. Dr. Chidchanok Leethanakul)

....

(Assoc. Prof. Dr. Chairat Charoemratrote)

....

(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 ประสิทธิภาพของสปริงตั้งฟันในการเสริมหลักยึดฟันหลังขณะทำการเคลื่อนฟันเขี้ยว

ผู้เขียน นายชัชชลิต พูลศักดิ์

สาขาวิชา วิทยาศาสตร์สุขภาพช่องปาก

ปีการศึกษา 2552

บทคัดย่อ

การควบคุมหลักยึดในงานทันตกรรมจัดฟันเป็นสิ่งสำคัญเพื่อให้การเคลื่อนฟันเป็นไปตามแผนการรักษา โดยเฉพาะในผู้ป่วยรายที่ต้องการใช้ช่องว่างที่ได้จากการถอนฟันส่วนใหญ่ในการแก้ไขฟันซ้อนเก หรือการลดฟันหน้ายื่น วิธีการควบคุมหลักยึดมีหลากหลายวิธี และมีข้อดีข้อเสียแตกต่างกันไป การศึกษาในครั้งนี้จึงทำการศึกษาความเป็นไปได้ของการใช้สปริงตั้งฟันซึ่งประยุกต์มาจากหลักการของ Begg technique ในการเสริมหลักยึดฟันหลังขณะทำการดึงฟันเขี้ยว **<u>วัตถุประสงค์</u>** เพื่อศึกษาประสิทธิภาพของสปริงตั้งฟันในการเสริมหลักยึดของฟันหลังบนในขณะทำการเคลื่อนฟันเขี้ยว **<u>วิธีการวิจัย</u>** ประกอบด้วยกลุ่มตัวอย่างจำนวน 15 คน (ชาย 2 คน, หญิง 13 คน อายุเฉลี่ย 21.6 ปี) ซึ่งจำเป็นต้องถอนฟันกรามน้อยซี่ที่ 1 บนทั้งซ้ายและขวาเพื่อการเคลื่อนฟันเขี้ยวไปด้านไกลกลาง การเตรียมหลักยึดฟันหลังบนจะทำการมัดฟันหลังซึ่งรวมถึงฟันกรามซี่ที่ 2 ไว้ด้วยกัน ทำการใส่สปริงตั้งฟันที่ฟันกรามน้อยซี่ที่ 2 เพียงข้างเดียวอย่างสุ่ม ทำการเคลื่อนฟันเขี้ยวบนทั้ง 2 ข้าง ด้วยแรง 150 กรัม เป็นระยะเวลา 4 เดือน ทำการวัดปริมาณการสูญเสียหลักยึดของฟันกรามแท้บนซี่ที่ 1 และการเคลื่อนที่ของฟันเขี้ยวโดยการวัดโดยตรงจากแบบจำลองฟัน นอกจากนี้ยังทำการศึกษาผลของสปริงตั้งฟันที่มีต่อการเปลี่ยนแปลงแนวแกนฟัน และการบิดหมุนของฟันกรามบนซี่ที่ 1 ขณะทำการเคลื่อนฟันเขี้ยว **<u>ผลการศึกษา</u>** พบการสูญเสียหลักยึดเฉลี่ยของทั้ง 2 กลุ่ม โดยปริมาณการสูญเสียหลักยึดของกลุ่ม URS และกลุ่ม NURS มีค่าเท่ากับ 0.31 มิลลิเมตร และ 0.78 มิลลิเมตร ตามลำดับ โดยพบว่ากลุ่มทดลองมีการสูญเสียหลักยึดน้อยกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ปริมาณการเคลื่อนที่ของฟันเขี้ยวในกลุ่ม URS มีค่ามากกว่าอย่างมีนัยสำคัญทางสถิติ พบการหมุนของฟันกรามซี่ที่ 1 ในทั้ง 2 กลุ่ม แต่ไม่พบความแตกต่างของปริมาณการหมุนระหว่างทั้ง 2 กลุ่ม ขณะที่ปริมาณการล้มเอียงของฟันกรามซี่ที่ 1 ในกลุ่ม NURS มีค่ามากกว่ากลุ่ม URS อย่างมีนัยสำคัญทางสถิติที่ระดับความเชื่อมั่น 95% **<u>สรุปผลการศึกษา</u>** สปริงตั้งฟันสามารถเสริมหลักยึดฟันหลังและป้องกันการล้มเอียงของฟันกรามบนซี่ที่ 1 ในขณะทำการเคลื่อนฟันเขี้ยวได้อย่างมีประสิทธิภาพ

Thesis Title The Effectiveness of the Uprighting Spring to Support an Anchorage of Posterior Teeth during Canine Retraction

Author Mr. Chatchalit Poolsak

Major Program Oral Health Sciences

Academic Year 2009

ABSTRACT

Anchorage control in orthodontic treatment is the important factor to achieve treatment plan, especially in patients which need almost all of the extraction spaces for crowding correction or profile reduction. There are many ways to enhance anchorage and each way has different advantage and disadvantage. **Objective** To study the effectiveness of the uprighting spring to enhance anchorage of posterior teeth during canine retraction. **Materials & Methods** Twelve subjects (2 males and 10 females, mean age 23 years 9 months) which the upper 1^{st} premolars had to be extracted for canine distalization were participated. The anchorage control of upper posterior teeth was done by ligating the posterior teeth together. The upper second molars were also included in the posterior segments. The uprighting spring will be placed at the second premolar on one side randomly. Canines were distalized with the force of 150 gram for 4 months. The Amounts of anchorage loss and canine movement were measured directly on study models. Moreover, this study investigated the effect of the uprighting spring on angulation and rotation of the upper first molars during canine retraction. **Results** Mean anchorage loss in URS and NURS groups was 0.31±0.18 mm. and 0.78±0.35 mm, respectively. Anchorage loss of URS group was significantly lesser than NURS group ($P<0.05$), whereas the amount of canine retraction in URS group was greater than NURS group significantly. There were molar rotation in both groups but did not significantly different. The amount of mesial molar tipping was greater in NURS group than URS group significantly. **Conclusion** The uprighting spring can enhance anchorage of posterior teeth and prevent molar tipping effectively during canine retraction.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION AND SYMBOLS

deg	= degree
g	= gram
NiTi	= Nickel Titanium
NSAIDs	= Nonsteroidal anti-inflammatory agents
NURS	= non uprighting spring group
mm	= Millimeter
PP	= palatal plane
ss	= Stainless steel wire
T0	= start canine retraction
T1	= 4 months after canine retraction
URS	= uprighting spring group (or side)
/	= per

CHAPTER 1

INTRODUCTION

Background and rationale

Maximum anchorage conditions are indicated when almost all or all of the extraction spaces are needed for crowding correction or profile reduction.[1] During orthodontic treatment the teeth are exposed to forces and moments, and these acting forces always generate reciprocal forces of the same magnitude but opposite in the direction (The 3rd law of Newton). To avoid unwanted tooth movements and maintain treatment success, these reciprocal forces must be diverted. Orthodontic anchorage, defined as the ability to resist these unwanted reactive tooth movements, can be provided into 2 groups as tooth anchorage and auxiliary anchorage. Angle stated "the resistance of the anchorage must be greater than that the offered by the teeth to be moved".[2]

Auxiliary anchorage or appliances obtain adjunctive resistance by incorporating adjacent hard and soft tissue. In the maxilla, the extraoral appliances such as head gear can be applied to support the upper molars; however, patients' compliances are limited and considered as a critical factor for treatment success.[3] Intra-maxillary appliances as Nance appliances can be applied using the palatal shelf to support the molars but the effectiveness is questionable, particularly when the palatal shelf is relatively flat.[4] Transpalatal arch can prevent only for rotation but not for tipping of the molars.[5] Moreover, both Nance appliance and transpalatal arch need more chair time and more visits for appliance fabrication and delivering.

Tooth anchorage may be defined as resistance to movement by using teeth as anchorage. The first way to enhance tooth anchorage is adding more teeth which increase more root surface area to resist the reactive tooth movement.[2] The more teeth are added into an anchorage unit, the lesser amount of force received per unit area along the periodontal membrane. In extraction cases, many prefer to include the second molars for additional anchorage and control proposes during canine retraction. However, there is no study directly evaluated about the effectiveness of bonding the second molars for anchorage enhancement during canine retraction.

In the first premolar extraction case, the other way to enhance anchorage of posterior segments is tipping the anchorage teeth back by off-center wire bending to change tooth inclination against reaction forces during canine retraction. Because of the off-center bend results in mesial root torque, mesial displacement of the molar would require bodily movement of that tooth, resulting in increased anchorage. This concept is called “the differential moment (torque concept)” from Begg technique.[6] The further studies had been proposed that, by using this concept, maximum anchorage can be achieved without adjunctive appliances.[7, 8]

Begg technique has been introduced since 1954. Begg brackets were modified from Angle’s Ribbon arch appliance which maintains only one point contact with the arch wire, thus facilitating tipping movement of anterior teeth. With the use of his light wire technique, Begg regularly used tip back bends to help maintain the anteroposterior position of the anchorage teeth to effect preferential tooth movement. Additionally, he proposed tipping the anterior teeth during initial retraction and then followed by an uprighting phase. In an uprighting phase, Begg used the uprighting spring which made of Australian wire for uprigthing root after crown tipping.[6]

Gianelly *et al*. modified the uprighting spring from Begg technique to support the anchorage in the lower anterior teeth during molar protraction in the bidimensional technique. This technique use preadjusted edgewise brackets which have vertical slots.[9] The principle of the uprighting spring is creating the moment to tip the tooth forward in wire/slot space. That is the anchorage preparation against the reaction force during molar protraction like the differential moment concept. This same approach is possible to apply to the posterior teeth to enhance the posterior anchorage during canine retraction. Moreover, the uprighting spring can be made easily and immediately apply in the same visit. Up to now, there is no study that directly evaluated the effectiveness of using of uprighting springs in supporting anchorage of posterior teeth for canine retraction.

Review of literatures

Orthodontic anchorage

Anchorage as defined by Graber[10] is “the nature and degree of resistance to displacement offered by an anatomic unit for the purpose of effecting tooth movement”. The resistance of the anchorage must be greater than that offered by the teeth to be moved; otherwise, there will be a displacement of the anchorage.[2]

One of the major concerns of Orthodontics is to provide adequate anchorage for selective movement of individual tooth or a group of teeth.[11-13] Attaining maximum or absolute anchorage has always been an arduous goal for the practicing orthodontist often resulting in a condition, dreaded by most, called ‘anchorage loss’. A number of methods/ appliances have been used in orthodontics to conserve anchorage. There are two generalized types of anchorage used in orthodontics: (1) tooth anchorage and (2) auxiliary anchorage.

Auxiliary anchorage

Auxiliary anchorage or auxiliary holding appliances are those adjunctive procedures and appliances that enhance anchorage by incorporating adjacent soft and hard tissue components, i.e., headgear, transpalatal bar, Nance’s holding arch, lip bumper, lingual bar. But from previous studies found that the effectiveness of this anchorage type is questionable.

Headgear and class II elastic need the patient’s compliance for the success. [1] Headgear also has a risk of injury for the patients.[14] In addition, the elastic cervical strap puts an unphysiologic strain on the cervical spine and on the neck muscles and in some patients it causes irritation of the skin.[15, 16]

Bobak *et al*.[5] in 1997 found that Transpalatal arch (TPA) can prevent only rotation of teeth, but the teeth still can loss of anchorage by tipping movement. Zablocki *et al*.[17] studied the effectiveness of TPA to enhance orthodontic anchorage during extraction treatment. This study compared the group treated with TPA and the other that treated without TPA. The results shown no statistically significant differences between groups in any of the variable examined. TPA does not provide a significant effect on either the anteroposterior or the vertical position of the maxillary first molar during extraction treatment.

Nance appliance has an acrylic button that contact the anterior hard palate. It is commonly used to stabilize molars during canine retraction phase in the premolar extraction case and also in non-extraction cases that molars have been moved distally with a pendulum appliance. Chang et al.[4] stated that a Nance appliance is not a very effective anchorage, particularly when the palate is relatively flat.

Shpack *et al.*[18] in 2008 found that there was anchorage loss 17-20% after canine retraction with Nance appliance as anchorage. They concluded that maximum anchorage can not be provided by the Nance appliance. Moreover, TPA and Nance's appliance need more chair time and more visits for appliance fabrication and delivering.

Tooth anchorage

Tooth anchorage may be defined as resistance to movement by using teeth as anchorage that will be gained from[19];

1. Well calcified of surrounding bone.
2. Amount of root surface.
3. Erupting tooth which the direction of eruption opposite to the direction of orthodontic force.
4. Force from muscular pressure.
5. Teeth with interlocking cusps
6. Healthy periodontal status.

By 1907, Angle advocated 5 types of anchorage control. The 3 of 5 methods were dental anchorage techniques. Angle described simple, reciprocal, and stationary methods for dental anchorage. Both simple and reciprocal anchorage methods relied on competing support of the dentition to effect tooth displacement. In contrast, Angle's stationary anchorage methods were based on his view that firm support of the anchorage units, through banding multiple teeth, act to resist tipping and thus promote anchorage.[2]

The clinical practice of combining second molars to increase anchorage is based on the theory that three teeth (considering total root area) will better resist anterior movement while retracting an opposing tooth.[2]

Moreover, tooth anchorage can be increased by changing the mesioaxial inclination of buccal teeth to distoaxial inclination, thus increasing resistance to mesial pull. This concept is called "the differential moment (torque concept)" from Begg technique which uses no supporting appliances but enhances anchorage by a careful application of forces and moments (torque).[6]

The differential moment

The differential moment (torque concept) does not involve the banding /bonding of the second bicuspids and second molars. This technique nullifies the concept of multiple teeth on the anchorage side to form large reactive unit, with the belief that it is possible to control anchorage solely with intraarch bends without adjunctive appliances. It is a "partial strap up" where the only teeth that are banded/bonded are the anchor tooth and the tooth to be moved (the canine) and, in most cases, those teeth anterior to the canine tooth.[6]

In this situation, we take advantage of the long interbracket distance between the canine bracket and the molar tube (at least 14 mm initially), using moments as a means of controlling the anchor unit instead of force distribution.

Anchorage is instituted by using tip-back bends in such a manner as to produce differential torque. The tip-back bend is an off-center bend. The bend is located in the embrasure between the first molar and second premolar. The moments that are produced are unequal. The larger moment lies at the tube containing the short segment. The smaller moment lies at the bracket containing the long segment. This smaller moment may be upward and forward, downward and backward, or absent depending on the angle at which the wire crosses the bracket and the location of the tip-back bend. Regardless of the direction of the smaller moment, the two moments are unequal, and therefore the larger moments will dominate.[6]

Because the off-center bend results in mesial root torque, mesial displacement of the molar would require bodily movement of that tooth and therefore results in increased anchorage. The canine, because of its smaller moment, would have the tendency to tip distally within the limits of the wire/bracket relationship. The molar becomes the source of anchorage. The anterior teeth are not considered a part of the anchor unit and may or may not be ligated to the arch wire.[8]

Rajcick and Sadowsky[8] used the 45^{o} tip-back bend to control maximum anchorage without bonding the upper second molars. The results showed that the upper first molars demonstrated a mean mesial movement of 0.7 mm cephalometrically. From the study casts, a mean of 0.5 mm of mesial movement occurred at the upper first molars. They concluded that maxillary canines can be retracted into extraction sites with minimal (clinically insignificant) horizontal anchorage loss of the molars by controlling forces and moments. These results suggest that cervical headgear, Nance holding arches, and other adjunctive appliances are not necessary for horizontal molar anchorage control in the maxillary arch.

However, the differential moment which uses the tip-back bend to produce mesial root torque to change tooth inclination against the reaction force still has the side effect. This technique provide the effective anchorage control in horizontal plane, but in vertical plane, the first molars are extruded which is the contraindication in openbite and/or long-faced patients.[8]

The uprighting spring

In Begg technique[6], a modified version of Angle's "ribbon arch" appliance, maintains only a point contact with the arch wire, thus facilitating tipping mechanic of dental crown into the space. To upright root of canine, Begg used a preformed uprighting spring which made of a 0.020" Australian wire inserted into the vertical slot of the bracket and activated by hooking onto the arch wire.

With the same concept to the differential moment, Gianelly *et al.*[9] modified the uprighting springs to use in edgewise brackets with vertical slots. The spring will rotate slot of bracket within the limit of the wire/bracket relationship and tooth inclination will be changed. They used the uprighting spring to support the anchorage in the lower anterior teeth during molar protraction by tipping the root of canine into the space and therefore result in increased anchorage of anterior teeth.

Moreover, Gianelly *et al.*[9] applied the uprighting springs for anchorage support in the lower dentition when class II elastic was introduced. Sometimes, the uprighting spring is used in the finishing phase by slightly moving the crown to sock in the occlusion together with intermaxillary elastic.

From Begg technique, the uprighting spring was also made of 0.020 inch Australian wire. Before activation, the arm extended passively to the sulcus, forming a 60^{o} to 70^{o} angle to the base of the arch wire. When activated, the spring exerted a force of 200-250 g.[9]

Canine retraction & Anchorage loss

Smith and Storey[20] and Streed[21] reported that during canine retraction 5%–55% of the extraction space can be taken up by mesial movement of the anchorage unit (i.e., the first molar and second premolar). Johnston and Lin[22] found that there will be mesial movement of lower molar about 3.4 mm in extraction case of orthodontic treatment after the space closure without anchorage preparation.

Thiruvenkatachari *et al.*[23] made a study to compare and measure the amount of anchorage loss with titanium microimplants and conventional molar anchorage (no anchorage preservation) during canine retraction. On the molar anchorage side, they used Nickel Titanium closed coil springs with a force of 100 gm from canine to molar. The period of the study was 4 to 6 months. Wire jigs were inserted in both sides of molar tubes to differentiate the right and left molars on lateral cephalogram. 2 sets of lateral cephalometric radiographs were used to compare the molar position. There were anchorage loss less than 20% (1.60 mm maxilla and 1.70 mm in the mandible) on the molar anchorage side, but no anchorage loss occurred on the implant side

Lotzof *et al.*[24] designed the study to compare the time required to retract canine teeth by using two different preadjusted bracket systems (Tip-Edge vs. Straight wire bracket) in a human sample. Anchorage loss as a result of this movement was also evaluated. Canines were retracted with 200 grams of elastomeric chain which extended to the upper first molars for 4 months. Measurements were performed by direct-technique from study models obtained before and at the completion of retraction of each canine. From the results, they found that the mean of anchorage loss was 2.33 mm. Canine was retracted 5.69 mm (1.88 mm/ interval) for the straight wire bracket and also did without anchorage preparation.

Hart *et al.*[7] investigated maximum and minimum anchorage control in four first premolar extracted class I and class II division 1 patients, using the differential moment (torque) concept. They found that: In maximum anchorage group of class I malocclusion, there were a mean difference of 0.60 mm of mesial movement for the maxillary molars and 0.90 mm for the mandibular molars. In the Class II malocclusion group, the maximum anchorage group experienced a mean maxillary molar movement of 0.28 mm. They concluded that both of these amounts is virtually undetectable in at the clinical level and does not affect the treatment goals. The major finding of this study is the clinical effectiveness of differential moments as a means of controlling intraoral anchorage.

Rajcick and Sadowsky[8] made a prospective survey to test the hypothesis that maximum anchorage can be achieved in the maxillary arch by differential moment concept. Without bonding the upper second molars, they retracted upper canines with the force of 150-200 grams from Nickel-Titanium closed coil springs for 7 months. The main arch wire was a 0.016” stainless steel which was inserted in 0.018”x0.025” slot brackets. Cephalometrically, combining the right and left sides, the first molars demonstrated a mean mesial movement of 0.7 mm. From the study casts, a mean of 0.5 mm of mesial movement of upper molars occurred. The upper first molars displayed mean mesiopalatal rotation 8.4 mm. The mean canine retraction was 5.7 mm. They concluded that maxillary canines can be retracted into extraction sites with minimal (clinically insignificant) horizontal anchorage loss of the molars by controlling forces and moments. These results suggest that cervical headgear, Nance holding arches, and other adjunctive appliances are not necessary for horizontal molar anchorage control in the maxillary arch.

Shpack *et al.*[18] compared the canine retraction undertaken with a Tip-Edge bracket (tipping mechanic) and an Edgewise bracket (bodily mechanic). The upper canine in an Edgewise bracket group were retracted with Nickel Titanium closed coil spring with the force of 0.75 N (75 gF) attached posteriorly to a Nance anchorage appliance through the first molars. The main arch wire sizes were 0.018” stainless steel wires and bracket size was 0.022”x0.028” slot. Anchorage loss, as assessed by mesial molar movement, was measured directly in study models. The results had shown that the mean anchorage loss was 1.4$\pm$0.5 mm. This amount was about 17 – 20% of the extraction space in an Edgewise bracket group. In this group, the duration of canine retraction was 4.5 months. They concluded that maximum anchorage could not be provided by the Nance appliance.

Geron *et al.*[13] found that anchorage loss is seemingly dependent on more than one factor, which has been investigated separately. Thus they made a study to examine the contribution of five such factors: extraction site (first vs second premolars), mechanics (lingual vs labial techniques) age (growing vs nongrowing patients), sex (male vs female), crowding, and overjet and to determine their relative contributions to anchorage loss (primary vs secondary anchorage loss factors). The results had shown that sex was excluded as an anchorage factor because no dimorphism was found. Anchorage loss is a multifactorial response and that the five examined factors can be divided into primary (crowding, mechanics) and secondary factors (age, extraction site, overjet), in declining order of importance.

However, Feldmann and Bondemark[25] made the systematic review to exam what kind of orthodontic anchorage systems/applications are evaluated and their effectiveness. A literature survey databases covering the period from January 1966 to December 2004, found that most of studies had serious problems with small sample size, confounding factors, lack of method error analysis, and no blinding in measurements.

Diedrich and Wehrbein[26] in 1997 assessed the advantage of an early or delayed treatment start after tooth extraction on the basis of hard-tissue findings (density, maturity, osteodynamics) and of soft-tissue responses at the extraction site in 3 foxhounds. They found that, in the immediately retraction group, there were characterized by: higher bone density with less maturity (bundle bone) at the extraction site, broader alveolar process, reduced tendency towards gingival invagination. The histologic findings therefore indicate that orthodontic retraction into extraction sites should be initiated at an early stage.

Optimum force

The ideal force magnitude and duration required to move teeth most effectively still remains unresolved. Reitan[27] believed that to obtain fairly rapid tooth movement, hyalinized zone were to be avoided or kept to a minimum, and this was best achieved by using light, continuous force. Previous studies on tooth movement and force magnitude have tended to produce variable results.

Burstone and Groves[28] looking for the lowest possible force value to retract anterior teeth by tipping and observed optimal rate between 50 and 75 gm. Smith and Storey[20], in their study on tooth movement, concluded that optimal lower canine movement occurred in the 150 to 250 gram range. At higher force levels of 400 to 600 gm, the anchor unit of the second premolar and first molar move more than canine. Hixon *et al.*[11], in their study on mandibular canine movement, found no optimal force but did find that tooth movement tended to increase with an increase in force up to approximately 300 gm. Quin and Yoshigawa[29] concluded in their review article on the theories of force magnitude in orthodontics that the relationship of rate of tooth movement and force magnitude (force per unit area, gm/cm2) is linear up to a point, but that after this point an increase in stress causes no appreciable increase in tooth movement. Moreover, they suggested that 100-200 gm is optimal for canine retraction.

For ideal physiologic tooth movement and to conserve anchorage, light continuous force has been suggested. Manhartsberger *et al.*[30] investigated the force delivery of NiTi coil springs and they found that it produced constant force delivery in relation to time of use and activation.

Samuel *et al.*[31, 32] in 1993 and 1997 had investigated the effectiveness of Nickel Titanium closed coil spring with the force of 100, 150, 200 grams compared to elastomeric module. The results shown that NiTi close coil spring found to produce a greater and more consistence space closure than the intermittent force of the elastomeric module. The 150- and 200-gram springs produced a faster rate of space closure than the elastic module or the 100-gram spring. No significant difference was noted between the rates of closure for the 150- and the 200-gram springs.

Dixon *et al.*[33] compared the rate of orthodontic space closure for: Active ligatures, elastomeric chain, and NiTi coil springs. They found that mean rate of space closure were 0.35 mm/month for active ligature, 0.58 mm/month for power chain, and 0.81 mm/month for Nickel Titanium closed coil spring. No statically significant differences in rate of canine movement between elastomeric chain and NiTi close coil springs, but they closed space more rapidly than active ligature. They concluded that NiTi closed coil spring gave the most rapid rate of space closure and may be considered the treatment of choice.

Objectives

To investigate the effectiveness of the uprighting spring on to support anchorage of posterior teeth during canine retraction compared with the other side which does not apply the uprighting spring.

Hypothesis

The uprighting spring can enhance anchorage of posterior teeth during canine retraction.

Significance of the study

This study provides a new option of maximum anchorage preparation for canine retraction with the uprighting spring which has high potential to support anchorage with less cost and time consuming in orthodontic treatment.

CHAPTER 2

RESEARCH METHODOLOGY

Materials and methods

<u>Sample selection</u>

This prospective study comprised of 15 subjects (2 male, 13 females) presenting for orthodontic therapy to the orthodontic clinic, Dental hospital, Faculty of Dentistry, Prince of Songkla university. Ages ranged from 17 years 5 months, to 37 years 4 months, with the mean pretreatment age of 23 years 9 months. These samples will be selected by random sampling from the patient pool who met the following inclusion criteria.

1. Upper first premolars or upper and lower first premolars would be extracted during the treatment as a part of their treatment plan.
2. The spaces obtained from extraction would be closed as a moderate anchorage condition.
3. No to slightly symmetrical arch length discrepancy.
4. No congenital missing (except the third molars).
5. Patients had no significant medical history such as diabetes or metabolic diseases.

The exclusion criteria are as follows;

1. Non cooperative patients, e.g., poor oral hygiene and missing and excessive number of appointments.
2. The patients whose anchorage loss had occurred and the remaining anchorage that allows losing is 1 mm.

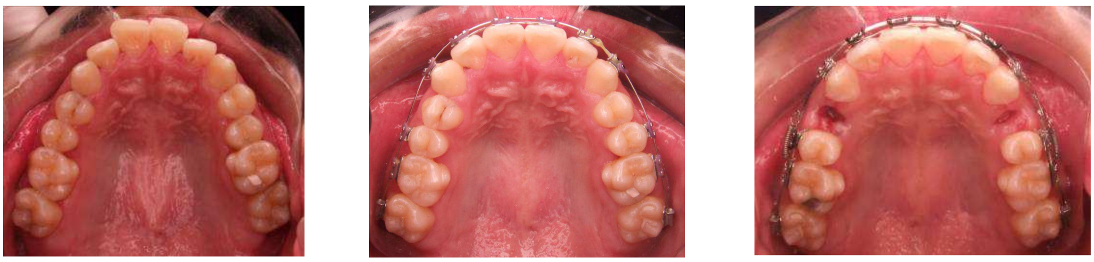
All patients and their parents were informed about the experimental procedure and the consent form was signed prior to the study. The patients had received the repeated oral hygiene instructions for the use of toothbrush dental floss and proxabrush during the study.

The patients will be instructed to avoid non steroidal anti-inflammatory agents in the month before appliance placement and during the study. In case of toothache due to orthodontic procedure, the patients will be instructed to take acetaminophen[34].

The orthodontic appliances and force application

Roth's prescription preadjusted edgewise appliances 0.022" slot were placed from canines to second molars with vertical slot in second premolar brackets. The vertical slots in the second premolar brackets were preserved for placement of the uprighting spring on only one side.

The patients' teeth were aligned and leveled without the first premolar extraction. Arch wires were changed until the size of arch wire was 0.016"x0.022" stainless steel wire and then, this arch wire were maintained for one month to have no force to teeth. After that, the patients were referred for extraction of the first premolars before the canines would be retracted within 2 weeks (Fig. 1).

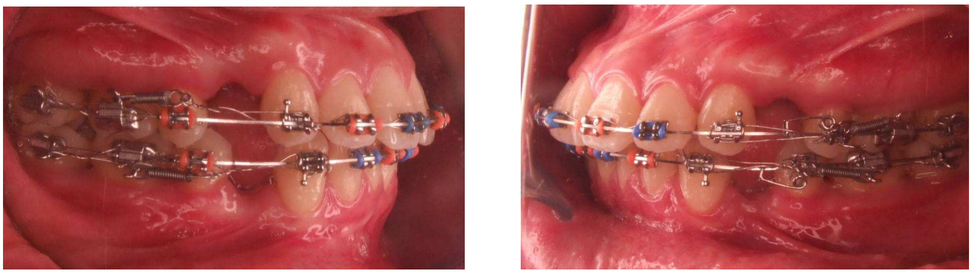


(A) (B) (C)

Fig. 1 (A: Pretreatment, B: Aligning and leveling without extraction, C: canine retracton)

For all patients in this study, split mouth technique was used. That meant one side of the arch would be selected to be the treatment group (With the uprighting spring; URS) and the other side was the control group (Without the uprighting spring; NURS). The uprighting spring were placed in vertical slot of the second premolar bracket of the study side (URS) only.

Before canine retraction, second premolars, first molars and second molars were included to be posterior anchorage units on both sides. On each side, the posterior teeth were ligated with a 0.010" stainless steel wire under the main arch wire to be one unit. The uprighting spring were placed in vertical slot of the second premolar bracket on only one side per arch randomly (Fig. 2).



(A) (B)

Fig. 2 The split mouth technique (A: NURS, B: URS)

On both sides, canines were distalized with Nickel Titanium (NiTi) closed coil springs which had been shown to produce a constant force over varying lengths, with no decay[35]. Thus in this study, canine would be moved along a 0.016”x0.022” stainless steel wire. Distal loop of Nickel Titanium closed coil spring would be hanged to the hook of the upper first molars. Mesial loop would be fastened with 0.010” stainless steel ligature wire and extended to ligate to the canine brackets under main arch wire. The force for canine distalization was 150 grams[20, 29]. The force was applied by the same operator. The main arch wires would be passive without any wire bending through 4 months of study period during canine retraction.

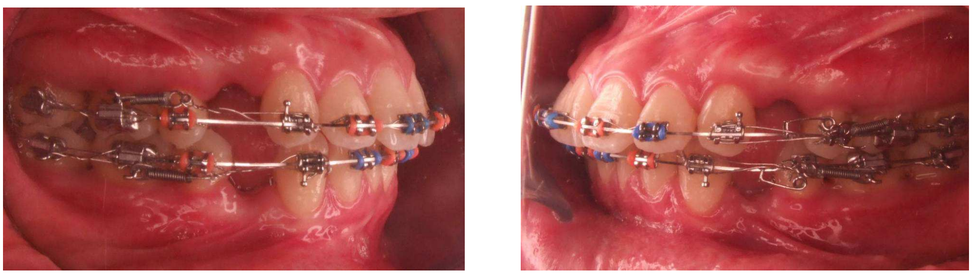
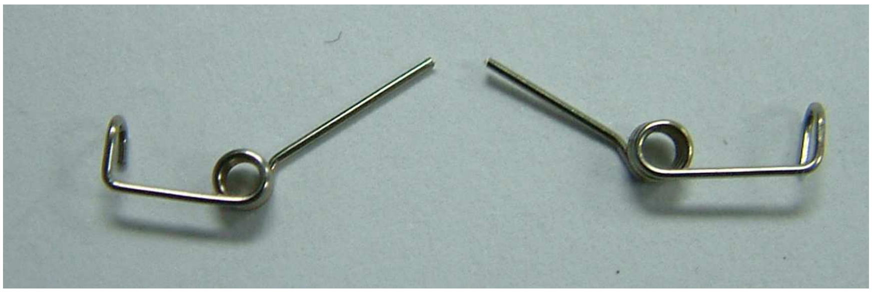


Fig. 3 Canine retraction

The patients would be recalled for routine reviews at regular intervals of 4 weeks for 4 visits (16 weeks). In each visit, the amount of canine retraction force was checked with force gauge to adjust the force of Nickel Titanium closed coil spring to 150 g continuously throughout the experimental period and the uprighting spring would be readjusted to the initial configuration.

The uprighting spring



(A) (B)

Fig. 4 The uprighting spring (A: Clockwise rotation, B: Counterclockwise rotation)

The uprighting springs (URS) in this study were made of a 0.016” stainless steel. From the laboratory investigation, the length of arm of the uprighting spring in this study was 5 mm. All of the uprighting springs used in this study were bended by the investigator. Before activation, the arm of the spring was extended passively to the sulcus, forming a 60 degree angle to the base of the arch wire. To activate the uprighting spring, the arm of the spring was hooked onto the main arch wire during canine retraction. When activated, the spring exerted a force of 300 g. After the uprighting spring application, a ligature tie was placed to the second premolar bracket on the study side to prevent rotation of the second premolar. The springs were adjusted every month by the investigator to maintain the original configuration (Fig. 5).

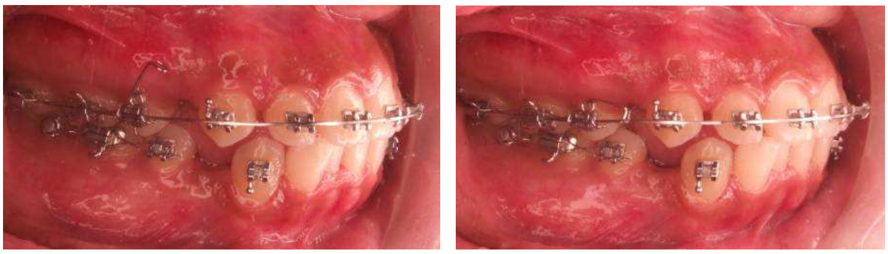


Fig. 5 The uprighting spring activation

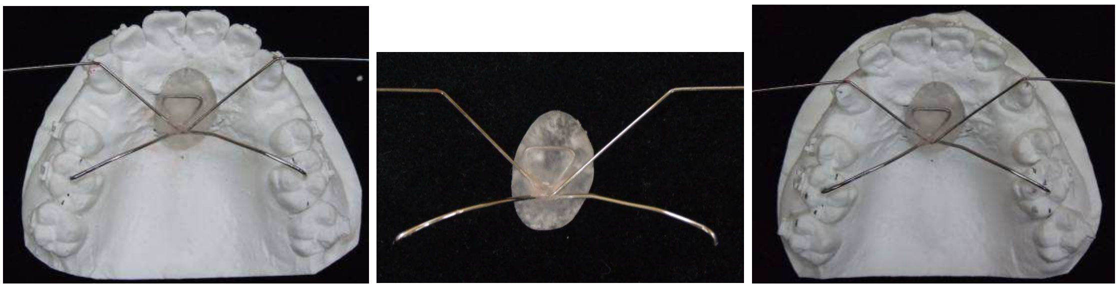
A polyvinyl-siloxane impression of the canines and posterior teeth with their respective brackets was made to act as a matrix should bracket failure occur in order to facilitate rebonding in the original bracket position.

Data measurements

1. Determining distance of canine and molar movement

Measurements were performed by direct-technique from study models with the digital vernier caliper. Direct model measurements were used rather than radiographs. This method was considered to be easier and accurate.

The upper impressions for study model were taken from the patient for 2 times (immediately before canine retraction [T0] and 4 months after canine retraction [T1]). These series of upper study models from each subject were used to measure the changes in the position of each canine and molar. The measurement followed the method used by Lotzof *et al.*[24] in 1996.



A B C

Fig. 6 Study models and acrylic jig (A: [T0], B: Acrylic plug and reference wires, C: [T1])

To measure the movement of each canine and molar in maxillary arch, an acrylic palatal plug was made for each maxillary arch (Figure 6). This plug could thus be transferred from the initial cast [T0] to the postretraction cast [T1] on the same patient. The plugs were fabricated from acrylic and covered the third rugae which can be used as a stable reference point within study models of maxillary arch, whereas the mandibular arch precluded the use of a stable reference point with study models[36]. The reference wires (0.018” stainless steel) were embedded in the acrylic plug. The anterior reference wire extended to the cusp tips of canines and the posterior reference wire extended to the central fossa of the upper first molars. The anterior margin of the plug is next to the 1st rugae and the anterior part must be clear enough to see the 2nd and 3rd rugaes.

Anchorage loss was recorded as the amount of movement in millimeters that was occurred in the direction opposite to the direction of the applied resistance. This superimposition of acrylic plug and the 4-month period after canine retraction cast was allowed for the direct observation of the amount of the upper molar protraction. Anchorage loss was the distances from the ends of the posterior reference wires to central pit of the upper first molars in postretraction cast [T1]. The base of study models would be trimmed to make the occlusal plane of each model parallel to horizontal plane during the measurements. The tooth movements were measured along the line parallel to median palatine raphe[24] (Fig. 7).

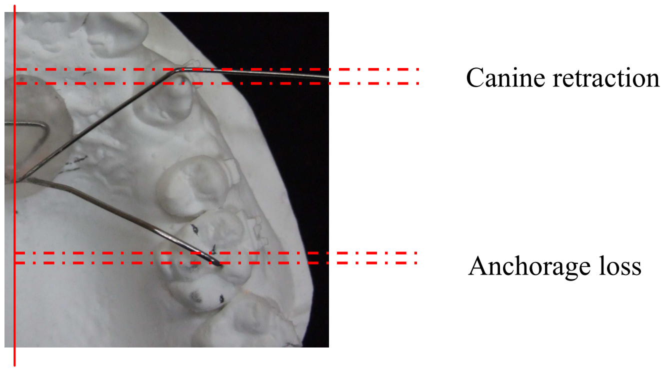


Fig. 7 Measurement of linear tooth movement

In the same way, the distance of canine movement also could be measured from the superimposition of acrylic plug and the 4-month period after canine retraction cast. The distance of canine retraction was the distances from the ends of anterior reference wires to the cusp tips of canines in the 4-month period after canine retraction cast.

The digital vernier caliper was used in these measurements to the nearest 0.01 mm. Measurements of both canine and molar movements were recorded twice on two separate months. The measurements were recorded by the same investigator

2. Determining molar rotation

Rotational changes of the upper first molars were measured from the study models after the method used by Ziegler and Ingervall[37] in 1989. For analysis the upper study models was photocopied to computer by using scanner. Occlusal plane of each study model would parallel to surface of scanner and study models of the same patient would be scanned in the same occlusal plane. Before scanning, cusp tip of canines, the median palatine raphe, and the line connecting between mesial and distal contact points of the upper first molars would be drawn with a pencil.

The angle between the median palatine raphe and the line formed by connecting the mesial and distal contact point of each maxillary first molar would be measured to compare the differences between groups and within group (T0 and T1). The angles (θ) were measured with a protractor to the nearest 0.5 degree. The rotational changes would be derived from the differences of these angles (Fig. 8). Measurements of molar rotation were recorded twice on two separate months. The measurements were recorded by the same investigator.

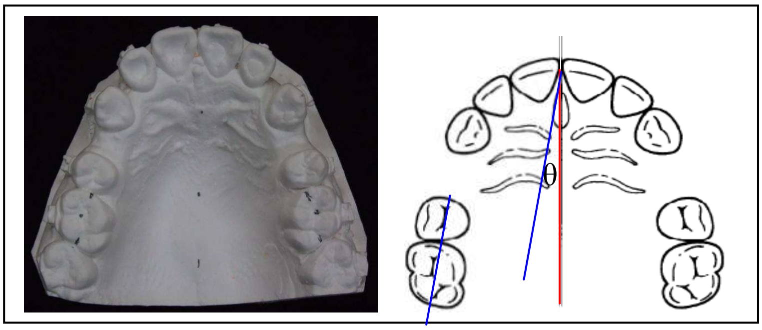


Fig. 8 Molar rotation measurement

3. Determining molar angulation

The series of lateral cephalometric radiograph would be obtained to determine the inclination of the maxillary first molars. Lateral cephalometric radiograph was taken 2 times (immediately before canine retraction [T0] and 4 months after retraction [T1]). All radiographs were taken with the same cephalostat (Orthophos® CD, Siemens, Germany). Tooth positional locating devices (wire jigs) were fabricated from sections of 0.021”x0.025” stainless steel wires (Fig. 9). The horizontal portion was inserted into the slots of maxillary first molars before film exposure at the start [T0] and the end of the experimental periods [T1]. The vertical portion of wire jigs which were bended perpendicularly to the horizontal portion would be a representative of the molar angulation. These devices aided in the precise measurements of angulations of the first molar and in separating the right and left molars.[40]

Fig. 9 Tooth positional locating devices (Wire jigs)

Molar angulations were defined as the angle formed by the intersection of the palatal plane (PP line) and a line extended from the vertical portion of the wire jig of each molar.[40] Theses angle would be traced to the tracing papers and measured with a protractor to the nearest 0.5 degree. Measurements of molar angulation were recorded twice on two separate months. The measurements were recorded by the same investigator. Lines and angle used in cephalometric analysis were as follows (Fig. 10);

PP line: Anterior nasal spine (ANS) to Posterior nasal spine (PNS)

U6 to PP line: The angle between PP line and the line passed through the wire jig of each molar.

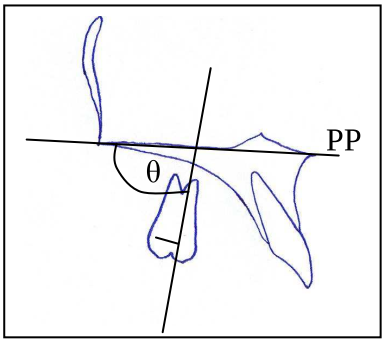


Fig. 10 Molar angulation measurements

Measurement error

Measurement error was tested in determining distance of tooth movement, and degree of rotation and tipping. To reduce method error associated with the measurement of the study models and lateral cephalometric radiographs, the examiner was blind to the study group (URS) and the control group (NURS) in each model. The study models were measured randomly.

Ten study models and ten lateral cephalometric radiographs were remeasured again 2 months later and these measurements were compared to the mean of the initial measurements using Dahlberg formula.

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

Statistical analysis

The data was statistically analyzed by using SPSS software (version 13.0, SPSS, Chicago, III). The means and standard deviations of the changes in all of the measurements were determined. The Normality test was used to examine distribution of the results. We found that the results of this study did not have normal distribution and a Wilcoxon signed-ranks test would be used to analyze the differences *between groups* at [T0] and *within group* and *between groups* at [T1]. Statistical significance was tested at the alpha significant level of 0.05.

CHAPTER 3

RESULTS

A total of 30 extraction sites from 15 patients were compared in this study. There were 2 males and 13 females, ranging in age from 18 to 38 years with the mean pretreatment age of 21.58 years (SD = $\pm$5.68 years) (Table 1). From the selected patients, four had Class II division 1 malocclusion and eleven had Class I malocclusion.

Table 1. Age of patients in this study (years)

	N	Mean	Std. Deviation	Maximum	Minimum
Age (year)	15	21.60	5.262	38	18

To evaluate error from measurement, 2 months after the first measurement, 10 study models and lateral cephalometric radiographs were selected randomly. Measurement errors of linear and angular measurements were calculated from the difference between the 2 measurements followed Dahlberg formula. The results had shown 0.05 mm and 0.03 degree of linear and angular measurement errors respectively.

Due to the data of this study did not have normal distribution, non-parametric test was used for statistically testing using SPSS software. The differences between the 2 dependent measurements would be evaluated with a Wilcoxon signed-ranks test at an alpha significant level of 0.05. Table summarized all measurement findings on casts and cephalograms for 4 months of canine retraction period. All data were shown as mean $\pm$ standard deviations, maximum and minimum values.

During canine retraction, the differences of Molar rotation, molar angulation, and canine angulation at [T0] between groups might affect the results of this study. However, we found that there was no significant difference ($P < 0.05$) between groups of molar rotation, molar angulation, and canine angulation before canine retraction (Table 2).

Table 2. Measurement finding of NURS and URS at [T0]

Measurements	Groups	Mean	Standard deviation	Maxaimum	Minimum	Significance
Molar rotation	NURS	12.5	3.7	22.5	7	NS
	URS	11.5	2.8	20	6.5	
Molar angulation	NURS	80.5	3.5	84	71	NS
	URS	81.5	2.1	83	70	
Canine angulation	NURS	95.5	4.5	98	87	NS
	URS	96.0	3.2	100	90	

NS No significant difference

$P < 0.05$

Table 3. Measurements of the differences between [T1] and [T0]

Measurements	Mean	Standard deviation	Maximum	Minimum	Significant (B/W groups)
Anchorage loss (mm.)					
NURS	0.78^{+}	0.35	1.54	0.50	*
URS	0.31^{+}	0.18	0.63	0.00	
Molar rotation (degree)					
NURS	2.25^{+}	1.34	4.50	0.00	NS
URS	2.05^{+}	1.09	3.00	0.00	
Molar tipping (degree)					
NURS	1.50^{+}	0.94	3.00	0.00	*
URS	0.00	0.56	0.50	-1.00	
Canine retraction (mm.)					
NURS	2.93^{+}	0.40	3.59	2.27	*
URS	3.20^{+}	0.32	4.00	2.90	

$^{+}$ Significant difference compared to [T0]

* Significant difference between groups at [T1]

NS No significant difference

$P < 0.05$

Anchorage loss

The amount of anchorage loss of both groups; for URS side, the maximum anchorage loss was 0.63 mm and the minimum anchorage loss was 0.00 mm. The mean of this group was 0.31±0.18 mm. For NURS side, the maximum anchorage loss was 1.54 mm and the minimum anchorage loss was 0.50 mm. The mean of this group was 0.78±0.35 mm (Table 3).

The results were tested with a Wilcoxon signed-ranks test to compare the differences within group [T1-T0] and between groups (URS-NURS). The differences in the amount of forward movement of the upper first molars between the URS and NURS groups were statistically significant ($P < 0.05$) (Table 3).

The differences of the amount of anchorage loss within group, however, were shown the statistically significant difference of mesial movement of the molars compared to the initial tooth position on both sides (Table 3).

Molar rotation

Table 3 described the amount of molar rotation of both sides after after canine retraction for 4 months. We found that the upper first molars rotated mesiolingually during canine retraction. The amount of molar rotation of both groups; for URS side, the maximum molar rotation was 3 degree and the minimum molar rotation was 0 degree. The mean molar rotation of this side was 2.05 $\pm$ 1.09 degree. For NURS side, the maximum molar rotation was 4.50 mm and the minimum molar rotation was 0.00 mm. The mean molar rotation of this group was 2.25±1.34 mm (Table 3).

A wilcoxon signed-rank test shown that, for within group [T1-T0], the differences of the upper fist molar rotation were statistically significant of both sides when compared to the initial tooth rotation ($P < 0.05$). For between groups, however, the result of the test shown that there were no statistically difference of the upper first molar rotation between the URS and NURS sides after 4 months of canine retraction.

Molar tipping

Degree of the upper molar tipping was measured from lateral cephalometric radiograph. The amount of molar tipping for both groups was shown in Table 3. The positive value represented mesial tipping of the upper first molars, whereas the negative value meant distal tipping of the upper first molars. For URS side, the maximum molar tipping was 0.5 degree and the minimum molar tipping was -1 degree. The mean molar tipping of this side was 0.00 $\pm$ 0.56 degree. For NURS side, the maximum molar tipping was 3 degree and the minimum molar tipping was 0 degree. The mean molar tipping of this side was 1.50 $\pm$ 0.94 degree.

A Wilcoxon signed-rank test showed that the change of molar angulation between [T0] and [T1] were no statistically difference in the URS side. For NURS side, angulation of the upper first molars at T1 was significantly difference when compared to the initial molar angulation [T0]. The differences of molar angulation between groups after 4 months of canine retraction were also significantly difference ($P < 0.05$).

Canine retraction

After the upper canines were distalized for 4 months, the amounts of canine retraction for both groups were shown in Table 3. For URS side, the maximum canine retraction was 4.00 mm and the minimum canine retraction was 2.90 mm. The mean canine retraction of this side was 3.2 $\pm$ 0.32 mm. For NURS side, the maximum canine retraction was 3.59 mm and the minimum canine retraction was 2.27 mm. The mean canine retraction of this side was 2.93 $\pm$ 0.40 mm. The results were analyzed with a Wilcoxon signed-rank tests. We found that the distance of canine retraction in URS side was greater than in NURS side significantly ($P < 0.05$) (Table 3.).

Table 4 described the rates of canine retraction and molar movement per month on both sides (URS and NURS) at [T1]. For URS side, the rate of canine retraction was 0.69 mm/ month and the rate of anchorage loss was 0.08 mm/ month. For NURS side, the rate of canine retraction was 0.63 mm/ month and the rate of anchorage loss was 0.20 mm/ month.

Table 5 showed the ratio of 1 mm of canine movement to the amounts of anchorage loss in both groups. In NURS side, we found that there was anchorage loss 0.20 mm when canine was distalized 1 mm. In URS side, there was anchorage loss 0.08 mm when canine was distalized 1 mm.

Table 4. Rate of tooth movements per month

Sides	Rate of tooth movements (mm/month)	
	Canine retraction	Anchorage loss
NURS	0.73	0.20
URS	0.80	0.08

Table 5. The ratio of canine movements to the amounts of anchorage loss

Groups	Ratio of canine movement to anchorage loss	
	Canine retraction (mm)	Anchorage loss (mm)
NURS	1	0.26
URS	1	0.09

CHAPTER 4

DISCUSSIONS

To enhance anchorage during canine retraction, there are many methods to be recommended. Headgear, Class II elastic, Nance appliance, and the differential moment technique are used widely but from the previous studies, these anchorage preparation techniques have their disadvantages, limitations, and even side effects.[3, 4, 7, 8, 14, 15, 18, 38] The main disadvantage of headgear is patient cooperation, which is unpredictable. [3] Nance's appliance enhances anchorage by using the palatal shelf to support the molars, but the effectiveness is decreased when the inclination of the anterior palate is relatively flat. [4] Moreover, Nance appliance has to waste time for appliance fabrication. From the study of the differential moment technique, we find that this technique can support anchorage effectively. Anchorage loss was only 0.5 mm after canines was retracted for 7 months. But from their results, this technique has some side effects such as molar rotation and extrusion[8]. This might be because of a small size of main arch wire.

However, when compared the rate of anchorage loss per month with many methods of anchorage preparation during canine retraction, we found that with the differential moment, the rate of anchorage loss was 0.07 mm per month. That was the least rate of anchorage loss when compared to the studies which used Headgear and Nance's appliance. The rate of anchorage loss with using Headgear as anchorage was 0.11 mm per month[37], whereas the rate of anchorage loss when using Nance's appliance as anchorage was 0.28 mm per month[4]. We could see that the differential moment's concept which tipped the posterior teeth back to create the additional moment against the moment of the reaction force during canine retraction provided the effective anchorage preparation method without patient's cooperation. Anyway, changing inclination of teeth could be done by the uprighting spring.

When the retraction force was applied with any force generator from the posterior teeth to canine to retract canine into the extraction space, the reaction force would act onto the posterior teeth with the same magnitude but in the opposite direction. The reaction force acted on the posterior segment composed of 3 teeth at the bracket level. When force applied away from the center of mass, the object will rotate due to moment of force.

Moment (M) = Force (F) X Distance from center of mass (D)

Similarly, 150 g of the reaction force did not pass through the center of resistance of the 3 posterior teeth which ligated together. The center of resistance of the posterior segment should be at furcation of the first molar which was about 10 mm from the bracket level. Therefore, there should be a moment created with size 1500 gm-mm (150 gm x 10 mm). To support the posterior anchorage, the additional moment with the size 1500 gm-mm should be applied in the opposite direction to the reaction force. The uprighting spring could generate the additional moment to counteract moment of the reaction force

The objective of this investigation is to study the effectiveness of the uprighting spring to enhance anchorage during canine retraction for 4 months. The split mouth technique was used in this study and there were no significantly differences of molar rotation, molar angulation, and canine angulation between NURS and URS groups at [T0]. The 4 measurements such as anchorage loss, molar rotation, molar angulation, and canine retracton were documented at [T0] and [T1] to evaluate the effectiveness of the uprighting spring. From our results, the mean amount of anchorage loss after canine retraction for 4 months in NURS and URS groups were 0.78±0.35 mm and 0.31±0.18 mm, respectively. The mean difference between groups (NURS - URS) was 0.47 mm clinically and there was a statistically significant difference ($P < 0.05$).

The results of molar tipping in NURS and URS groups of this study were 1.50±0.94 degree and 0.00±0.56 degree, respectively. There was a significantly difference between groups at $P < 0.05$. In URS group, moreover, there was no significantly difference when compared tipping at [T1] to [T0] in URS group. The mean amounts of molar rotation were 2.25±1.34 degree and 2.05±1.09 degree in NURS and URS, respectively. There was no significantly difference of molar rotation within group and between groups. The amounts of canine retraction were 2.93±0.40 mm and 3.20±0.32 mm in NURS and URS, respectively.

From these results, we found that the uprighting spring can enhance anchorage of posterior teeth during canine retraction. Moreover, the results had shown the effectiveness of the uprighting in the vertical slot of the second premolar bracket to prevent mesial tipping of the upper first molar which was the point of force application during canine retraction. Even molar rotation in URS group did not significantly difference from NURS group, the mean and standard deviation of URS group was less than NURS group.

When the force applied on the upper first molar for canine retraction did not pass through center of resistance of the posterior teeth, tipping movement is more easily to occur than bodily movement which needs force and couple to control. Begg stated that tipping movement needed lower force than bodily movement[6]. So when the reaction force acted against the posterior unit of NURS group, posterior teeth tended to tip in play of the wire in the slot. Slot size of molar tube was 0.022”x0.028” whereas the main arch wire size was 0.016”x0.022” ss, thus there was play of the wire in the slot and molar could be tipped θ degree in this play as shown in Fig. 11.

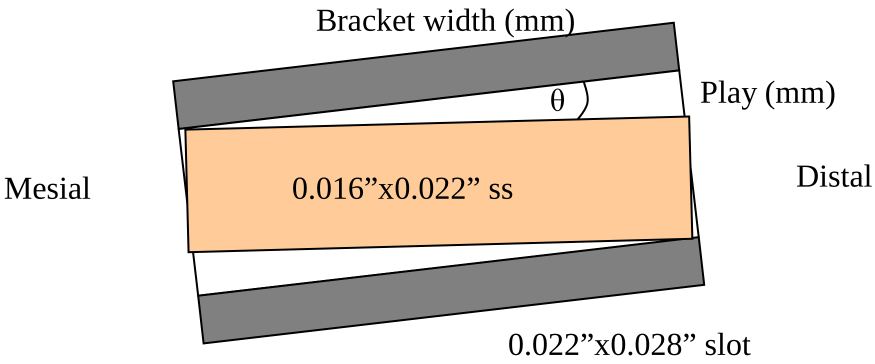


Fig. 11 Play of the wire in the slot

When $\theta = \tan^{-1}(X/Y)$, In this study, the upper first molar could be tipped 2.58 degree in the slot play and if the upper first molar tipped distally at [T0], it could be tipped mesially, for 2 times, 5.16 degree as well. But from the results, the mean of molar tipping in URS side was only 0 ± 0.56 degree. 10 of 15 cases or 66.67% had no angular change. 2 of 15 cases or 13.33% had distal tipping about 0.5 – 1 degree. 3 of 15 cases had mesial tipping only 0.5 degree. 80% of samples had no mesial tipping. It meant that anchorage loss on URS side was almost bodily movement. It was according to the statement of Begg.[6] Due to tipping movement needed lower force than bodily movement, thus anchorage loss as tipping movement on NURS side was more than URS side.

The results of this study had shown the effectiveness of the uprighting spring to enhance anchorage of posterior teeth during canine retraction. It might be explained based on several reasons. First, the uprighting spring created the additional moment against the moment from reaction force. Second, likewise to the differential moment concept, the uprighting spring tipped the second premolar distally within the wire/slot space and increased the resistance to mesial tipping of the upper first molar from the reaction force. When the upper first molar could not be tipped during canine retraction, anchorage loss would be decreased. Third, from Thurow’s theorizes[39], when bracket of the second premolar tipped against the main arch wire from moment of the uprighting spring, the frictional resistance would be occurred. This frictional resistance might be the additional force to prevent the posterior segment from mesial movement. But with this frictional resistance, we could not use the uprighting spring during incisor retraction with sliding mechanic.

There was no study directly investigated the effective of the uprighting spring before, so we compared the effectiveness of the uprighting spring to other anchorage preparation methods which measured anchorage loss during canine retraction with the comparable force. To compare with the previous studies about anchorage loss during canine retraction, we would compare in the rate of tooth movement per month (Table 6). In this study, the mean amount of anchorage loss for URS and NURS groups were 0.08 mm and 0.20 mm/month, respectively. The result of URS group was approximate to the studies using the differential moment concept (Table 6). Rajcich and Sadowsky[8] used differential moments for anchorage preparation during canine retraction. A 45 degree off-center bend was placed mesial to the second premolar in the main arch wire to tip posterior teeth distally before canine would be retracted. They distalized canines with the retraction force of 150-200 gram from Nickel Titanium closed coil spring along a 0.016" stainless steel arch wire. Size of bracket slots was 0.018"x0.025". The amount of anchorage loss was measured from photocopies which made of dental casts. They found anchorage loss 0.5 mm in 7 months or 0.07 mm/ month in the maxillary arch.

In NURS side, anchorage preparation was acquired from bonding the second molar to increase the root surfaces. The amount of anchorage loss per month was nearby the result of anchorage preparation by Nance appliance (Table 6.). Shpack *et al.* [18] studied anchorage loss during canine retraction between edgewise and Tip-Edge bracket. Nance appliance was used to enhance anchorage. In Edgewise bracket group, they retracted canines with the force of 0.75 N on a 0.018" stainless steel arch wire. The size of bracket slots was 0.022"x0.028". The amount of anchorage loss was measured directly from dental casts followed the method of Lotzof *et al.* [24] in 1996. They found that in edgewise bracket, there was anchorage loss 1.4 mm in 5 months or 0.28 mm/month in the maxillary arch.

Table 6. Comparison of anchorage loss between different anchorage preparation methods

Author (Year)	Anchorage Preparation	Duration	Anchorage Loss	Anchorage Loss (mm/month)
Rajcich and Sadowsky[8] (1997)	Differential Moment	7 months	0.5 mm	0.07
Zeigler and Ingervall.[37] (1989)	Headgear	3.5 months	0.4 mm	0.11
Shpack *et al.*[18] (2008)	Nance appliance (without 7)	5 months	1.4 mm	0.28
Lotzof *et al.*[24] (1996)	No anchorage Preparation	4 intervals	2.33 mm	0.58
Recent study				
• NURS	Bond 7 only	4 months	0.78 mm	0.20
• URS	Bond 7 + URS	4 months	0.31 mm	0.08

The amount of anchorage loss per month in NURS side from this study was less than the results of the studies which retracted canines without anchorage preparation. In these studies, the second molars would not be banded or bonded. Elastomeric chain or Nickel Titanium closed coil spring would be attached from canines to hooks of the upper first molars. Lotzof *et al.* [24] in 1996 compared the results of canine retraction with 2 preadjusted bracket systems (Tip-Edge vs Straight wire bracket). In Straight wire bracket group, canines were retracted with the force of 200 gram from elastomeric chain on a 0.018” stainless steel arch wire. They found that in straight wire bracket, there was anchorage loss 2.33 mm in 4 intervals or 0.58 mm/interval in the maxillary arch.

Thiruvenkatachari *et al.* [23] compared the amount of anchorage loss during canine retraction between one side which retract canine to microimplant and the other side which had no anchorage preparation. On the tooth anchorage side, canines were retracted with the force of 100 gram from Nickel Titanium closed coil spring onto hook of the upper first molar. The amount of anchorage loss was measured from lateral cephalometric radiograph by superimposition. They found that on the side without any anchorage preparation, there was anchorage loss 1.6 mm in 5 months or 0.3 mm/month in the maxillary arch (Table 6).

The results of this study had shown that the amount of molar rotation in URS side was 2.05±1.09 degree. When compared the amount of molar rotation to the study of Rajcich and Sadowsky[8] which uses the differential moment to enhance anchorage, they had shown molar rotation 8.4 degree. We would notice that molar rotation was the problem of this study. It might be due to using the round small wire like a 0.016” stainless steel during canine retraction. When force was applied to teeth, the main arch wire was not rigid enough to control rotation and angulation of moving teeth and teeth could bend the main arch wire. Moreover, the auxiliary wire which used to apply additional moment to the upper first molars to counteract the moment of reaction force was also the small round 0.016” stainless steel wire. When the auxiliary wire was bended and inserted into the auxiliary tubes, this small round wire could flip in the tubes and action of the differential moment would not be maximized.

This clinical study was designed to investigate the anchorage loss during canine retraction with the retraction force 150 gram. The force recommended in this study for optimal canine movement of 150 gram was based on previous studies.[20, 29] Reitan stated that initial force application should be light, because this procedures desire biologic effects.[27] These lighter forces will produce less extensive hyalinized tissue that can be readily replaced by cellular elements. He stated that an appropriate force of 150 to 250 gram for maxillary canines should be used for translator movement. Ricketts et al recommended a force of 115 to 150 gram for canine retraction by a frictionless technique. Smith and Storey[20], using a similar technique, concluded that a force of 150 to 200 gram would move lower canine efficiently.

The patients were referred for extraction after the size of main arch wire reached 0.016”x0.022” stainless steel. The canines were retracted after extraction of the first premolars within 2 weeks to reduce the bone resistance. Diedrich and Wehbein recommended that the orthodontic retraction into extraction sites should be initiated at an early stage due to lesser bone maturity, broader alveolar process, and reduced gingival invagination.[26]

From the results, the amount of canine retraction on URS and NURS side were 3.20 mm and 2.93 mm respectively. The mean difference between groups of canine retraction was significantly difference. Canine on URS side could move distally more than NURS side. It might explain that when anchorage loss occurred, the retraction force was decreased due to the distance between canine and molar was decreased. So the retraction force on NURS side would be less than URS side and the amount of canine retraction would be less than URS side too.

Table 7. Rate of canine movement per month

Studies	Rate of canine movement (mm/month)
This study	
- NURS	0.73
- URS	0.80
Dixon et al. (2002)	0.81
Lotzof et al. (1996)	1.63
Rajcich and Sadosky (1997)	0.81

The rate of canine retraction per month of this study was 0.80 amd 0.73 mm/month in URS and NURS side respectively. These rates were nearby to the results of the previous studies. The previous studies focusing on the rate of canine movement found that the canine with conventional brackets, which had been retracted by Nickel Titanium closed coil spring 150 to 200 gram, could move with rate 0.81 to 1.63 mm per month. Dixon *et al.*[33] in 2002 studied rate of tooth movement using Nickel Titanium closed coil spring 200 gram compared to active ligature and elastomeric chain. They found that with NiTi spring, rate of canine retraction was 0.81 mm. Lotzof *et al.*[24] retracted canine to the first molar without any anchorage preparation and they found that the rate of canine retraction was 1.63 mm per interval but the rate of anchorage loss was 0.58 mm per interval. The rate of canine movement of this study were also nearby to the result of Rajcich and Sadowsky[8] who used the differential moment to enhance anchorage, found that the rate of canine retraction of their study was 0.81 mm per month with the rate of anchorage loss 0.07 mm per month (Table 7).

When we focused on the ratio of canine retraction to anchorage loss, we found that, from this study, when canine was moved distally 1 mm, the upper first molar was moved mesially 0.09 mm in URS group. This result was coincided with the result from the study of Rajcich and Sadowsky[8] who found that, with using the differential moment for anchorage preparation, when canine was moved distally 1 mm, the upper first molar was also moved mesially 0.09 mm. In NURS, when canine moved 1 mm, the the upper first molar would move 0.26 mm. This ratio was better than the study of Lotzof *et al.*[24] which found that, without anchorage preparation, anchorage loss was 0.41 mm when canine was distalized only 1 mm.

Statement of problem of this study was limitation, disadvantage, and side effects of the anchorage preparation methods used generally during canine retraction. The uprighting spring was introduced in Begg technique for root uprighting. It could be made easily, no time consuming, inexpensive, and no need of patient cooperation. Gianelly et al.[9] used the uprighting spring from Begg technique[6] for anchorage preparation during molar protraction. This study evaluated the effectiveness of the uprighting spring which had high potential to support anchorage during canine retraction. From the results, we found that the rate of anchorage loss in URS group was 0.08 mm per month which coincided to the rate of anchorage loss in the differential moment technique. The amount of molar rotation in URS group was 2.05 ± 1.09 degree which was better than 8.4 ± 5.67 degree of molar rotation in the differential moment technique. Moreover, the uprighting spring could prevent molar tipping during canine retraction significantly.

URS group also had anchorage loss after 4 months of canine retraction. The rate of 0.08 mm per month of URS group and 0.20 mm per month of NURS group may be no clinically insignificant difference but it may be considered when the large space are planned to be closed. In clinical application, bonding the second molars and included into the posterior anchorage unit combined with using the uprighting spring could enhance the maximum anchorage during canine retraction. However, if the absolute maximum anchorage was desired, we recommend applying other anchorage preparation methods such as tip back and toe in the main arch wire to maximized anchorage preparation during canine retraction.

The clinical application of the uprighting spring from the results of this study was not the length of the arm of the uprighting spring or the degree which the arm of the spring angled to the main arch wire. The important thing was the calculation of the reaction moment. To counteract the reaction moment which depended on the canine retraction force and the distance from bracket to center of resistance of the posterior teeth in the axial dimension, we needed the additional moment which had a magnitude of moment at least equaled to the moment of retraction force. So we had to calculate the retraction moment and used the appropriate length of the arm of the uprighting which did not interfere during canine retraction and did not irritate soft tissue of the patients. The size of angle of the spring was dependent on the amount of the desired additional moment.

From this study, we found that the force used to activate the uprighting spring was about 360 g. With this amount of force, the main arch wire might be bended if canine retraction was done in the small main arch wire. When the wire was bended, there was the effect of wire bending likewise the differential moment technique. The posterior teeth might be extruded during canine retraction. If molar extrusion was undesirable, we recommended using the main arch wire which had larger or equal size to 0.016”x0.022” ss.

A limitation of this study was that the effectiveness of the uprighting spring had never been evaluated before, so we had to select the sample from the patients which needed to close the extraction spaces as a moderate anchorage. With this criterion, the duration of canine retraction was limited due to canine could be distalized only half of the extraction spaces. But from the results we found that the uprighting spring could enhance the maximum anchorage during canine retraction effectively.

For the further study, first, we may apply the uprighting spring to enhance anchorage of posterior teeth in the maximum anchorage groups to increase the investigation period of the effectiveness of the uprighting spring during canine retraction. Second, the next study may measure the amount of anchorage loss of the upper second premolar due to anchorage loss always be clinically detected in the second bicuspids earlier than the upper first molars. Moreover, third, the anchorage loss will occur in 3 dimensions, but this study did not measure the changes in vertical dimension which always related to molar tipping and rotation. So the further study may include the measurement of anchorage loss in the vertical dimension into the methods and when we will know the effect of the uprighting spring in the vertical dimension, we can compare the results to other studies which using other anchorage preparation methods.

CHAPTER 5

CONCLUSIONS

The uprighting spring could enhance anchorage of posterior teeth and prevent molar tipping effectively during canine retraction.

REFERENCES

1. Burstone CJ. Rationale of the segmented arch. ***Am J Orthod*** 1962; 48: 805-822.
2. Angle EH. Treatment of malocclusion of teeth, 7th ed. Philadelphia: White dental manufacturing Co; 1907.
3. Egolf RJ, BcGole EA, Upshaw HS. Factors associated with orthodontic patient compliance with intraoral elastic and headgear wear. ***Am J Orthod Dentofac Orthop*** 1990; 97: 336-348.
4. Chang HN, Hsiao H, Tsai C, Robert WE. Bone-screw anchorage for Pendulum appliances and other fixed mechanic application. ***Semin Orthod*** 2006; 12: 284-293.
5. Bobak V, Christiansen RL, Hollister SJ, Kohn DH. Stress-related molar responses to the transpalatal arch: A finite element analysis. ***Am J Orthod Dentofac Orthop*** 1997; 112: 512-518.
6. Begg RP. Light arch wire technique. ***Am J Orthod*** 1961; 47: 30-48.
7. Hart A, Taft L, Greenberg SN. The effectiveness of differential moments in establishing and maintaining anchorage. ***Am J Orthod Dentofac Orthod*** 1992; 102: 434-442.
8. Rajcich MM, Sadowsky C. Efficacy of intra-arch mechanics using differential moments for achieving anchorage control in extracton cases. ***Am J Orthod Dentofac Orthop*** 1997; 112: 441-448.
9. Gianelly AA, Smith JB, Bednar JR, Dietz VS. Asymmetrical space closure. ***Am J Orthod Dentofac Orthop*** 1986; 90: 335-341.
10. Graber TM: Orthodontics: Principles and Practice. WB Saunders; 1998.
11. Hixon EH, Atikan H, Callow GE, McDonald HE, Tacy RJ. Optimum force, differential force and anchorage. ***Am J Orthod*** 1969; 55: 437-456.
12. Thompson WJ. Combination anchorage technique (CAT)-An update of current mechanics. ***Am J Orthod*** 1988; 93: 363-379.
13. Geron S, Shpack N, Kandos S, Davidovitch M, Vardimon AD. Anchorage loss – A multifactirial response. ***Angle Orthod*** 2003; 73: 730-737.
14. Postlethwaite K. The range and effectiveness of safety headgear products. ***Eur J Orthod*** 1989; 11: 228-234.

15. Berg KK. Komplikationen bei anwendung von zervikalem nackenzuug. Informationen aus Orthodontie und Kieferorthopadie 1974; 1: 39-44.
16. Rebholz K, Rakosi T. Extraorale krafte und die Wirbelsaule. ***Forchritte der Kieferorthopadie*** 1977; 38: 324–331.
17. Zablocki HL, McNamara JA, Franchi L, Baccetti T. Effect of the transpalatal arch during extraction treatment. ***Am J Orthod Dentofac Orthop*** 2008; 133: 852-860.
18. Shpack N, Davidovitch M, Sarne O, Panayi N, Vardimon AD. Duration and anchorage management of canine retraction with bodily versus tipping mechanics. ***Angle Orthod*** 2008; 78: 95-100.
19. Salzmann JA. Principles of orthodontics. Philadelphia: Lippincott company; 1943.
20. Smith R, Storey E. Force in orthodontics and its relation to tooth movement. ***Austr J Dent*** 1952; 56: 11–8.
21. Streed S. *A* Method of Measuring Clinical Orthodontic Tooth Displacement [dissertation]. Minneapolis, MN: The university of Minnesota; 1964.
22. Johnston LE, Lin S, Peng SJ. Anchorage Loss: a comparative analysis**. *J Charles H. Tweed Int Found*** 1988; 16: 23-27.
23. Thiruvenkatachari B, Pavithranand A, Rajasigamani K, Kyung HM. Comparison and measurement of the amount of anchorage loss of the molars with and without the use of implant anchorage during canine retraction. ***Am J Orthod Dentofac Orthop*** 2006; 129: 551-554.
24. Lotzof L, Fine H, Cisneros G. Canine retraction. A comparison of two preadjusted bracket systems. ***Am J Orthod Dentofac Orthop*** 1996; 110: 191–196.
25. Feldmann I, Bondemark L. Orthodontic anchorage: a systematic review. ***Angle Orthod*** 2006; 76: 493-501.
26. Diedrich P, Wehrbein H. Orthodontic retraction into recent and healed extraction sites. ***J Orofacial Orthop**,* 1997; 58: 90-99.
27. Reitan K. Clinical and histologic observations on tooth movement during and after orthodontic treatment. ***Am J Orthod*** 1967; 53: 721-45.
28. Burstone CJ, Groves MH. Threshold and optimum force values for maxillary anterior teeth movement. ***J Dent Res*** 1961; 39: 695.

29. Quinn RS, Yoshikawa DK. A reassessment of force magnitude in orthodontics. ***Am J Orthod*** 1985; 88: 252-60.

30. Manhartsberger C, Seidenbusch W. Force delivery of Ni-Ti coil springs. ***Am J Orthod Dentofac Orthop*** 1996; 109: 8-21.

31. Samuels RHA, Rudge SJ. A comparison of the rate of space closure using a Nickel – Titanium spring and an elastic module. ***Am J Orthod Dentofac Orthop*** 1993; 103: 464-467.

32. Samuels RHA, Rudge SJ. A clinical study of space closure with nickel-titanium closed coil springs and an elastic module. ***Am J Orthod Dentofac Orthop*** 1998; 114: 73-79.

33. Dixon V, Read MJ, O'Brien KD, Worthington HV, Mandall NA. A randomized clinical trial to compare three methods of orthodontic space closure. ***J Orthod*** 2002; 29: 31-36.

34. Proffit WR, Fields HW jr. Contemporary orthodontics. 3th ed. St Louis: Mosby; 2000.

35. Sonis AL. Comparison of NiTi coil springs vs. elastic in canine retraction. ***J Clin Orthod*** 1994; 33: 293-295.

36. Lebret L. Growth changes of the palate. ***J Dent Res*** 1962; 36: 39-47.

37. 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.

38. Feldmann I, Bondemark L. Anchorage capacity of osseointegrated and conventional anchorage systems: A randomized controlled trial. ***Am J Orthod Dentofac Orthop*** 2008; 133: 339.e19-339.e28.

39. Thurow RC. Edgewise orthodontics**.** 2nd ed. St. Louis: The C. V. Mosby company; 1966.

40. Erverdi N, Koyuturk O, Kuculleles N. Nickel-titanium coil springs and repelling magnets: a comparison of two different intra-oral molar distalization techniques. ***Bri J Orthod*** 1997; 24: 47-53.

Appendices

ที่ ศธ 0521.1.03/ 749

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

หนังสือฉบับนี้ให้ไว้เพื่อรับรองว่า

โครงการวิจัยเรื่อง "การทดสอบประสิทธิภาพของสปริงตั้งฟัน ในการสนับสนุนหลักยึดสำหรับการดึงฟันเขี้ยว"

หัวหน้าโครงการ ทันตแพทย์ชัชชลิต พูลศักดิ์

สังกัดหน่วยงาน นักศึกษาหลังปริญญา ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

ได้ผ่านการพิจารณาและได้รับความเห็นชอบจากคณะกรรมการจริยธรรมในการวิจัย (Ethics Committee) ซึ่งเป็นคณะกรรมการพิจารณาศึกษาการวิจัยในคนของคณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ แล้ว

ให้ไว้ ณ วันที่ 17 ส.ค. 2551

(รองศาสตราจารย์ ทพ.นพ.ธงชัย นันทนรานนท์)
~~รักษาการใน~~ตำแหน่งรองคณบดีฝ่ายวิจัยและวิเทศสัมพันธ์
ประธานกรรมการ

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

....กรรมการ
(ผู้ช่วยศาสตราจารย์ ทพญ.สรียา ศรีสินทร)

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

ไม่ได้เข้าประชุม.............กรรมการ
(ผู้ช่วยศาสตราจารย์ ทพ.สุทธิพงศ์ เชาวนาดิศัย)

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

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

ใบเชิญชวน

ขอเชิญเข้าร่วมโครงการวิจัยเรื่อง ประสิทธิภาพของสปริงตั้งฟัน ในการเสริมหลักยึดฟันหลังขณะทำการเคลื่อนฟันเขี้ยว

เรียน ท่านผู้อ่านที่นับถือ

ข้าพเจ้า ทพ.ชัชชลิต พูลศักดิ์ กำลังศึกษาระดับปริญญาโท สาขาทันตกรรมจัดฟัน ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ใคร่ขอเล่าถึงโครงการวิจัยที่กำลังทำอยู่ และขอเชิญชวนท่านเข้าร่วมโครงการดังนี้ โดยโครงการวิจัยนี้จะทำการศึกษาผลของการเตรียมหลักยึดฟันหลังชนิดแมกซิมัม (maximum anchorage) ขณะดึงฟันเขี้ยวหลังจากการถอนฟันกรามน้อยซี่แรกเพื่อการรักษาทางทันตกรรมจัดฟัน โดยงานวิจัยนี้ทำการทดสอบประสิทธิภาพการควบคุมหลักยึดฟันหลัง 2 วิธี คือการติดเครื่องมือจัดฟันชนิดติดแน่นถึงฟันกรามแท้ซี่ที่สอง กับการติดเครื่องมือจัดฟันชนิดติดแน่นถึงฟันกรามแท้ซี่ที่สองร่วมกับการใช้สปริงตั้งฟัน (uprighting spring)

หลักยึดฟันหลังชนิดแมกซิมัม (maximum anchorage) หมายถึงการที่ยอมให้หลักยึดฟันหลังเคลื่อนที่เข้ามาไม่เกินหนึ่งในสามของช่องว่างจากการถอนฟันในขณะปิดช่องว่าง

ผู้เข้าร่วมการวิจัยนี้จะได้รับการจัดฟันตามปกติ และถูกต้องตามหลักวิชาการทั้งในส่วนงานวิจัย และหลังเสร็จสิ้นงานวิจัย โดยที่ยังไม่ได้รับการถอนฟัน จนกระทั่งมีการเรียงตัวของฟันเรียบดีแล้วจึงส่งผู้เข้าร่วมงานวิจัยไปถอนฟันกรามน้อยซี่ที่หนึ่งด้านซ้ายและขวา ของขากรรไกรบน หรือทั้งขากรรไกรบนและล่างตามแต่แผนการรักษา หลังจากนั้นจึงเริ่มทำการดึงฟันเขี้ยว

ผู้เข้าร่วมการวิจัยจะได้รับการเก็บข้อมูลเพิ่มเติม 2 ครั้ง (ก่อนการดึงฟันเขี้ยวและหลังจากให้แรงเคลื่อนฟันเขี้ยวเป็นเวลา 4 เดือน) เพื่อศึกษาผลของงานวิจัย ได้แก่ การพิมพ์ฟันบนและล่างเพื่อทำแบบจำลองฟัน ถ่ายภาพภายในและนอกช่องปาก ถ่ายภาพรังสีกระโหลกศรีษะด้านข้าง (lateral cephalometric) ซึ่งผู้เข้าร่วมงานวิจัยไม่ต้องรับผิดชอบค่าใช้จ่ายเพิ่มเติมในส่วนนี้ หลังจากสิ้นสุดการวิจัยแล้วผู้เข้าร่วมการวิจัยจะได้รับการรักษาทางทันตกรรมจัดฟันต่อจนเสร็จสิ้นตามแผนการรักษา

ความเสี่ยงที่มีโอกาสเกิดขึ้นเมื่อเข้าร่วมการวิจัย

- ความเสี่ยงจากการจัดฟันตามปกติ เช่น การสูญเสียการมีชีวิตของฟัน โรคปริทันต์ ฟันผุ ฝ้าขาวที่เกิดจากการสูญเสียแร่ธาตุของผิวเคลือบฟัน การละลายของรากฟัน และความผิดปกติของข้อต่อขากรรไกร ซึ่งความเสี่ยงที่กล่าวมานี้เป็นความเสี่ยงที่มีโอกาสเกิดขึ้นได้ในผู้ป่วยที่มารับการรักษาทางทันตกรรมจัดฟันด้วยวิธีทั่วไป โดยไม่จำเพาะกับวิธีการศึกษาในครั้งนี้ เนื่องจากมีหลายปัจจัยเข้ามาเกี่ยวข้องรวมถึงความร่วมมือของตัวผู้ป่วยเองและการตอบสนองทางชีวภาพของแต่ละบุคคลซึ่งไม่สามารถพยากรณ์ได้

- ความเสี่ยงในขั้นตอนของการเก็บข้อมูลนั้น ผู้เข้าร่วมวิจัยจำเป็นที่จะต้องถ่ายภาพรังสีร่วมด้วย ได้แก่ ภาพถ่ายรังสีกะโหลกศีรษะด้านข้าง เพิ่มมากกว่าปกติ 2 ครั้ง ดังที่กล่าวมาแล้ว ซึ่งการถ่ายภาพรังสีแต่ละครั้งนั้น มีความเสี่ยงที่จะเกิดอันตรายต่อผู้เข้าร่วมวิจัยน้อยมาก เนื่องจากปริมาณรังสีที่ได้รับในแต่ละครั้งของการถ่ายนั้นน้อยมาก และมีการสวมเสื้อตะกั่วและไทรอยด์ชีลเพื่อป้องกันรังสีให้แก่ผู้เข้าร่วมวิจัยทุกราย และพยายามให้มีความผิดพลาดในการถ่ายภาพรังสีน้อยที่สุด เพื่อลดปริมาณรังสีที่ผู้เข้าร่วมวิจัยจะได้รับโดยไม่จำเป็น
- วัสดุที่ใช้ในการทำสปริงตั้งฟัน มาจาก 0.016” Stainless steel หรือ Australian wire ที่ใช้เป็นปกติในการจัดฟัน ดังนั้นวัสดุชนิดนี้จึงไม่ก่อให้เกิดอันตรายแก่ผู้วิจัย
- ความเสี่ยงในส่วนของการเตรียมหลักยึดฟันหลังโดยการติดเครื่องมือจัดฟันชนิดติดแน่นถึงฟันกรามซี่ที่สองเพียงอย่างเดียว และการติดเครื่องมือจัดฟันชนิดติดแน่นถึงฟันกรามซี่ที่สองร่วมกับการใช้สปริงตั้งฟัน (uprighting spring) ในการเสริมหลักยึดชนิดแมกซิมัม (Maximum anchorage) ของฟันหลังในขั้นตอนการดึงฟันเขี้ยวนั้น มีโอกาสเกิดขึ้นในกรณีที่เกิดการสูญเสียสภาพหลักยึดฟันหลังชนิดแมกซิมัม (Maximum anchorage) ส่งผลทำให้ไม่สามารถดึงฟันเขี้ยวและฟันหน้าถอยหลังเพื่อแก้ฟันยื่นได้มากอย่างที่ควรจะเป็น เพื่อเป็นการป้องกันความเสียหายที่อาจเกิดขึ้นได้ ผู้วิจัยมีมาตรการเพื่อป้องกันความเสี่ยงที่อาจเกิดขึ้นได้โดยจะกระทำการวิจัยในกลุ่มตัวอย่างที่ต้องการหลักยึดฟันหลังชนิดโมเดอเรท (Moderate anchorage) ซึ่งผู้ป่วยกลุ่มนี้ต้องการให้หลักยึดฟันหลังเคลื่อนที่ไปข้างหน้าในช่องว่างที่ได้จากการถอนฟัน มากกว่าหนึ่งในสาม แต่ไม่เกินสองในสามของพื้นที่ที่ได้จากการถอนฟัน ตามปกติการเคลื่อนที่ของฟันจะมีอัตราเฉลี่ย 1 มิลลิเมตร/เดือน ซึ่งโดยทั่วไปผู้ป่วยจะได้รับการนัดหมายเดือนละ 1 ครั้ง การสูญเสียหลักยึดของผู้ป่วยที่เข้าร่วมงานวิจัยจะได้รับการตรวจอย่างต่อเนื่องทุกเดือน เพื่อป้องกันความเสียหายที่อาจเกิดขึ้นต่อผู้ป่วยได้อย่างทันท่วงที

การสูญเสียกลักยึดจนเกิดความเสียหายต่อผู้ป่วย หมายถึงการสูญเสียหลักยึดมากจนเกินกว่าแผนการรักษาที่วางไว้ เพื่อป้องกันความเสียหายที่อาจเกิดขึ้น ผู้วิจัยจะทำการตรวจสอบสภาวะหลักยึดทุกครั้งที่นัดผู้ป่วยมาเพิ่มแรงการดึงฟันเขี้ยว (เดือนละ 1 ครั้ง) โดยหากพบว่ามีการสูญเสียหลักยึดจนเหลืออีกเพียง 1 มิลลิเมตร จะเกิดความเสียหายต่อผู้ป่วย จะหยุดการให้แรงดึงฟันเขี้ยวทันที และตัดผู้ป่วยออกจากงานวิจัย หลังจากนั้นจะทำการเตรียมหลักยึดเพิ่มเติมตามความเหมาะสม เพื่อป้องกันการสูญเสียหลักยึดเพิ่มเติม และทำการรักษาตามแผนการรักษาต่อไป

ถ้าท่านตัดสินใจเข้าร่วมโครงการนี้จะมีขั้นตอนของการวิจัยที่เกี่ยวข้องกับท่านคือ การพิมพ์ฟันบนและล่าง การถ่ายรูปภายในช่องปาก การถ่ายภาพรังสีภายนอกช่องปากด้านข้าง และการ

เตรียมหลักยึดฟันหลังด้วยวิธีดังที่กล่าวมาซึ่งจะไม่ก่อให้เกิดความเจ็บปวดและอันตรายต่อผู้ป่วยมากขึ้น และไม่มีค่าใช้จ่ายเพิ่มเติมอย่างใด

ทั้งนี้ ท่านยังคงต้องรับผิดชอบค่าใช้จ่ายในส่วนของการรักษาทางทันตกรรมจัดฟันตามปกติรวมถึงค่าใช้จ่ายในการเดินทางตลอดระยะเวลาการวิจัยและการรักษา

ไม่ว่าท่านจะเข้าร่วมในโครงการวิจัยนี้หรือไม่ ท่านจะยังคงได้รับการรักษาที่ถูกต้องตามหลักวิชาการ เช่นเดียวกับผู้ป่วยคนอื่นๆ และถ้าท่านต้องการที่จะถอนตัวออกจากการศึกษานี้เมื่อใด ท่านก็สามารถกระทำได้อย่างอิสระ

ถ้าท่านมีคำถามใดๆ ก่อนที่จะตัดสินใจก่อนเข้าร่วมโครงการนี้ โปรดซักถามคณะผู้วิจัยได้อย่างเต็มที่

ขอขอบคุณเป็นอย่างสูง
ทพ.ชัชชลิต พูลศักดิ์

หมายเหตุ: กรุณาอ่านข้อความให้เข้าใจก่อนเซ็นชื่อยินยอมเข้าร่วมโครงการ

แบบยินยอมเข้าร่วมการศึกษา

โครงการวิจัยเรื่อง ประสิทธิภาพของสปริงตั้งฟัน ในการเสริมหลักยึดฟันหลังขณะทำการเคลื่อนฟันเขี้ยว

วันที่_______เดือน__________________พ.ศ._______

ข้าพเจ้า____________________________________อายุ________ปี อาศัยอยู่บ้านเลขที่_________หมู่_______ ถนน___________________ตำบล__________________ อำเภอ___________________จังหวัด______________________ ได้รับการอธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

หากข้าพเจ้ามีข้อสงสัยประการใด หรือเกิดผลข้างเคียงจากการวิจัยจะสามารถติดต่อกับผู้รับผิดชอบโครงการวิจัยคือ ทพ.ชัชชลิต พูลศักดิ์ ได้ที่ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ หมายเลขโทรศัพท์ 074-429876 (ในเวลาราชการ) หรือหมายเลข 081-5665881 (นอกเวลาราชการ) หรือเมื่อมีปัญหาใดๆ เกิดขึ้นเนื่องจากการทำวิจัยในเรื่องนี้ ข้าพเจ้าสามารถร้องเรียนได้ที่คณบดี คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287510

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่มีปิดบัง

ข้าพเจ้ามีสิทธิ์ที่จะของดการเข้าร่วมโครงการวิจัย โดยจะแจ้งให้ทราบล่วงหน้า โดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการได้รับบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่อย่างใด

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ จะไม่เปิดเผยข้อมูลหรือผลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชน จะเปิดเผยได้ในรูปแบบที่เป็นการสรุปผลการวิจัย หรือการเปิดเผยข้อมูลต่อผู้มีหน้าที่ที่เกี่ยวข้องกับการสนับสนุนและกำกับดูแลการวิจัย

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ จึงได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ โดยผู้วิจัยได้ให้สำเนาแบบยินยอมที่ลงนามแล้วกับข้าพเจ้าเพื่อเก็บไว้เป็นหลักฐานจำนวน 1 ชุด

ลงชื่อ…………….……………………….....ผู้ยินยอม

( )

ลงชื่อ…………………..……………ผู้ปกครองหรือผู้แทนโดยชอบ

( )

ลงชื่อ…………………………..……...ผู้รับผิดชอบโครงการวิจัย

(ทันตแพทย์ชัชชลิต พูลศักดิ์)

ลงชื่อ…………………………...………..………….พยาน

( )

ลงชื่อ…………………………….....……………….พยาน

( )

VITAE

Name Mr. Chatchalit Poolsak

Student ID 5010820010

Educational Attainment

Degree	Name of Institution	Year of Graduation
Doctor of Dental Surgery	Chulalongkorn University	2547

List of Publication and Proceeding

The 4th Conference on graduate school, Surindra Rajabhat University, February 20-22, 2010.