The Factors Related to Alveolar Bone Thickness after Upper Incisor Retraction

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ชื่อวิทยานิพนธ์	ปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟัน ภายหลังจากการดึงฟันหน้าบน
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บทคัดย่อ

บทนำ ทฤษฎีของการเคลื่อนฟัน กล่าวว่า เมื่อให้แรงทางทันตกรรมจัดฟันจะเกิดกระบวนการปรับรูปของกระดูกตามการเคลื่อนที่ของฟัน ส่งผลให้กระดูกมีรูปร่างเหมือนเดิมในตำแหน่งใหม่ ภายหลังการดึงฟันหน้าบน พบว่ามีรายงานการเกิดลักษณะของกระดูกโป่งนูน กระดูกที่โป่งนูนบางครั้งนำมาซึ่งความไม่สวยงาม โดยพบว่ากระดูกโป่งนูนมีรูปร่าง ลักษณะ และตำแหน่งที่แตกต่างกัน ดังนั้นจึงเป็นที่น่าสนใจว่าความผิดปกตินี้เกิดขึ้นได้อย่างไร **วัตถุประสงค์** การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบน และศึกษาปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟัน **วัสดุและวิธีการ** ศึกษาในผู้ป่วยจัดฟันที่มีแผนการรักษาด้วยการดึงฟันหน้าบนจำนวน 24 ราย เก็บข้อมูลการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันก่อนและหลังการดึงฟันหน้าบนจากภาพรังสีโคนบีมคอมพิวเตตโทโมกราฟฟีทั้งทางด้านริมฝีปาก ด้านเพดาน และความหนาของกระดูกเบ้าฟันทั้งหมด โดยวัดความหนาของกระดูกเบ้าฟัน 3 ระดับ ได้แก่ ระดับยอดกระดูกเบ้าฟัน ระดับกลางฟัน และระดับปลายรากฟัน ประเมินการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังการดึงฟันหน้าบน นำข้อมูลที่ได้มาวิเคราะห์ด้วยสถิติการทดสอบผลต่างระหว่างค่าเฉลี่ย 2 ประชากรแบบจับคู่ ที่ระดับนัยสำคัญ .005 และวิเคราะห์ความสัมพันธ์ของ อัตราการเคลื่อนฟัน การเปลี่ยนแปลงแนวเอียงฟัน ความหนาของกระดูกเบ้าฟันเริ่มต้น และปริมาณการกดของฟันหน้าบน กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟัน ด้วยสถิติสัมประสิทธิ์สหสัมพันธ์ของสเปียร์แมน ที่ระดับนัยสำคัญ .05 **ผลการศึกษา** พบว่า ภายหลังการดึงฟันหน้าบน ความหนาของกระดูกเบ้าฟันด้านริมฝีปาก ณ ระดับยอดกระดูกเบ้าฟัน และความหนาของกระดูกเบ้าฟันทั้งหมด ณ ระดับปลายรากฟัน เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($p < .005$) อัตราการเคลื่อนฟัน การเปลี่ยนแปลงแนวเอียงฟัน และปริมาณการกดของฟันหน้าบนมีความสัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบนอย่างมีนัยสำคัญทางสถิติ แต่ไม่พบความสัมพันธ์กับความหนาของกระดูกเบ้าฟันเริ่มต้น **สรุป** ปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึง

ฟันหน้าบน ได้แก่ อัตราการเคลื่อนฟัน การเปลี่ยนแปลงแนวเอียงฟัน และปริมาณการกดของฟันหน้าบน ซึ่งปัจจัยดังกล่าวเป็นปัจจัยที่ควรพึงระวังเพื่อไม่ให้เกิดการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันซึ่งเป็นผลอันไม่พึงประสงค์

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ABSTRACT

Introduction: A basic axiom in orthodontics, "bone traces tooth movement", suggests that whenever orthodontic tooth movement occurs, bone around the alveolar socket will remodel to the same extent. Nevertheless, this rule has not always been followed. Labial bone protuberance may occur after upper incisor retraction and causes esthetic problems. Nowadays, factors affecting the difference in alveolar bone response are unclear. **Objectives**: The aims of this study were to evaluate the changes of the alveolar bone thickness after upper incisor retraction and investigate the factors related to the changes of alveolar bone thickness. **Materials and methods:** Subjects consisted of 24 on-going orthodontic patients (mean age 20.47 ± 2.71 years) whose upper incisors were bound to retract. Changes of alveolar bone thickness in the retracted area were assessed from pre-retraction (T_0) and post-retraction (T_1) cone beam computed tomography images. We assessed the labial bone thickness (LBT), palatal bone thickness (PBT), and total bone thickness (TBT) at crestal, mid-root and apical level of the retracted incisors. Paired t-tests were used to compare the difference of bone thickness between T_0 and T_1. To determine the relation between the changes of alveolar bone thickness, and rate of tooth movement, changes of inclination, initial alveolar bone thickness, amount of intrusion, the Spearman rank correlation analysis was performed. **Results**: As the upper incisors were retracted, the LBT at crestal level and TBT at apical level were statistically significant increased ($p < .005$). The changes in alveolar bone thickness were significantly associated with rate of tooth movement, changes of inclination and amount of intrusion. However, initial alveolar bone thickness showed no significant association ($p > .05$). **Conclusion:** Factors that showed significant related alveolar bone thickness after upper incisor retraction were rate of tooth movement, changes of inclination, and amount of intrusion. These factors must be carefully monitored to avoid undesirably thickness of alveolar bone

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Nuengrutai Yodthong

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LISTS OF ABBREVIATIONS AND SYMBOLS

mm	=	millimeter
et al.	=	and others
g	=	gram
CBCT	=	Cone beam computed tomography
NiTi	=	nickel titanium
Fig.	=	figure
PP	=	palatal plane
T_0	=	time at the start of incisor retraction
T_1	=	time after incisor retraction completed
%	=	percent
”	=	inch (es)
/	=	per

CHAPTER 1

INTRODUCTION

Background and rationale

Orthodontic tooth movement is a process whereby the application of a force to induce bone resorption on the pressure side and bone apposition on the tension side. There is controversy over whether the changes that occur in the anterior alveolar bone always follow the direction and quantity of tooth movement.[1] A basic axiom in orthodontics is "bone traces tooth movement" which suggested that whenever orthodontic tooth movement occurs, bone around the alveolar socket will remodel to the same extent.[2] But sometimes there is no coherence with this rule, unfavorable bone response occurs after incisor retraction. For example in the labial cortical plate, bone increase is usually more than tooth displacement, leading to show bone exostosis, labial bone protuberance, and irregular ridge of bone.[3, 4] In the vertical dimension, bone decrease more than the tooth displacement, leading to show open gingival embrasure. When transverse movement is attempted, dehiscence and fenestration in the buccal and lingual plate have been reported.[5]

Labial bone protuberance usually cause esthetic problems. Alveloplasty will be operated to eliminate the excess alveolar bone. Nowadays, factors causing the difference in alveolar bone response are unclear. It is interesting to determine the factors related to the changes of alveolar bone thickness after incisor retraction.

Review of literatures

Anterior tooth retraction represents a fundamental phase of fixed orthodontic appliance treatment. Three dimensional control of anterior tooth movement and corrected tooth position are important for function, esthetics and stability.[6]

Movement of the maxillary and mandibular incisors within the scope of the maxillary anterior palate and mandibular symphysis is one of several methods utilized by orthodontic practitioners to achieve the “idea arch form”. Throughout the process of treatment, orthodontists move anterior in a variety of sagittal, transverse and vertical directions. The alveolar bone that supports the incisor teeth consists of outer cortical bone and inner trabecular bone. Stability is considered to achieve when the maxillary and mandibular incisors are positioned within the trabecular portion of the alveolar bone and in equilibrium with the surrounding musculature.[6]

Several studies have examined the effect of orthodontic tooth movement on the surrounding alveolar bone.

De Angelis[1] who presented the bending capacity of alveolar bone. The distorted alveolus alters the electric environment, a process that is attributed to the piezoelectricity of bone. As a result, the theory is that highly synchronized coordinated changes are triggered with coordinated apposition and resorption, the alveolar bone retains its structural characteristics and size as it moves.

Saikaya *et al.*[2] reported that after incisor retraction, the labial bone maintained its original thickness in both mandibular and maxillary arch. And there was statistically significant decrease in lingual bone thickness in both arches. This finding of reduced alveolar bone thickness in the direction of tooth movement disagree with the result of Vadimon and Basset[7] who found a 1: 2 bone remodeling tooth movement when studying the maxillary labial alveolus, if the apex of the maxillary central incisor moved posterior 3 mm, A point will retract correspondingly 1.5 mm.

In addition the previous studies has found numerous undesirable effects after incisor retraction such as fenestration, dehiscence, alveolar bone loss and gingival recession, root resorption, open gingival embrasure.[8-13]

Wehrbein *et al.*[10] presented the biological and biomechanical factors related to the potential side effects of orthodontic treatment, such as external root resorption, bony dehiscence and fenestration. This finding agreed with Bimstein *et al*.[15] who suggested this findings could be related to several parameters, such as duration of treatment, force applied and individual response to orthodontic treatment. Rungcharassaeng *et al*.[16] who studies the factors that might affect buccal bone changes of maxillary posterior teeth after rapid maxillary expansion. The results suggested factors showing significant correlation to buccal bone changes and dental tipping on first premolars and molars were age, appliance expansion, initial buccal bone thickness, and differential expansion, but rate of expansion and retention time had no significant association.

Mimura[3] published case report that the maxillary alveolar process failed to remodel as the upper anterior teeth were intruded and retracted, leaving behind a prominent labial ridge of bone. This did not happen in the mandible despite similar rapid movement. Unusual bony changes in the maxillary alveolar process during orthodontic treatment have reported by others. Lin *et al.*[4] found a protuberance of alveolar bone near the gingival margin in the maxillary arch after incisor retraction with miniscrew. They concluded that miniscrew, which provided absolute anchorage, enables the incisors to be retracted and intruded much greater distance than with conventional treatment and whole arch can be intruded with a degree of predictability and suggested that extensive and rapid movement of the upper anterior teeth in adults may be associated with unexpected bony changes.

Abdwani *et al.*[17] reported that the effects of incisal inclination changes, due to orthodontic treatment will result in a change in the position of point A. Each 10 degree change in the maxillary incisor inclination results in a statistically significant average change in point A of 0.4 mm in the horizontal plane. Each 10 degree change in the mandibular incisor inclination results in a borderline statistically significant average change in point B of 0.3 mm in the horizontal plane. There were no significant changes in the vertical position of points A and B. This finding agrees with the result of Nimri *et al.*[18] who reported the position of point A is affected by local bone remodeling associated with proclination of the upper incisor in class II division 2 malocclusion.

Objectives

The aims of this study were to evaluate the changes of the alveolar bone thickness after upper incisor retraction and investigate the factors related to changes of alveolar bone thickness.

Hypothesis

1. There are no significant changes in the alveolar bone thickness after upper incisor retraction.

2. Rate of tooth movement, changes of inclination, initial alveolar bone thickness, and amount of intrusion are not related to alveolar bone changes after upper incisor retraction.

Significance of the study

If the study supports the hypothesis that rate of tooth movement, changes of inclination, initial alveolar bone thickness, amount of intrusion are related to alveolar bone changes after upper incisor retraction. Pre-therapeutic evaluation of bone structure and tooth conditions may be necessary to predict treatment effects and prevent undesirable effects after upper incisor retraction.

The limitations of the study

This study was performed under the limitation of time and sample size, thus the long term response of the alveolar bone could not be investigated. A longitudinal follow up study would be beneficial in explaining. And larger sample size will undoubtedly provide more insightful evidence on the factors that relate to changes of alveolar bone.

CHAPTER 2

RESEARCH METHODOLOGY

Sample

The study was approved by the ethical committee of Faculty of Dentistry, Prince of Songkla University. The population for this study was adult patients who received orthodontic treatment in the Orthodontic clinic, Dental Hospital, Faculty of Dentistry, Prince of Songkla University during the sampling time frame. Subjects representative were selected from the new patient pool based on the following inclusion criteria.

1. Adult patients (18 – 30 year old)
2. Mild to moderate upper incisor crowding or upper anterior protrusion, treatment required extraction of first premolars in the maxillary arch and space at least 4 mm between lateral incisors and canines
3. No significant medical history
4. No use of anti-inflammatory drugs for at least 6 months and during period of the study
5. No evidence of periodontal or gingival problems at the beginning of orthodontic treatment
6. No history of trauma on the upper and lower anterior teeth.

The exclusion criteria were:

1. Space between upper lateral incisors and upper canines less than 4 mm
2. The patients whose upper incisor had crown fracture during treatment
3. The patients used anti-inflammatory drugs during period of the study

Sample size was calculated from the following equation[19]

$$\text{Sample size (n)} = \frac{(z_{(1-\alpha)} + z_{(1-\beta)})^2 SD^2 \text{ diff}}{(\overline{X}_2 - \overline{X}_1)^2} = 23$$

SD diff: difference standard deviation between pre and post test ^{2} = 0.5

α: significant level 0.05, $Z_{\alpha} = 1.96$

1-ß: power of test = 80%, $Z_{1-ß}= 0.84$

Mean labial bone thickness at alveolar crest level$(\overline{X}_2-\overline{X}_1)^2 = 0.08$

Twenty- four subjects were selected from patients who received orthodontic treatment for prevention subject drop out. Each patient was informed about the study objectives, procedures, and risk-benefit of participation in the study. The consent form was signed prior to the study. The patients received repeated oral hygiene instructions for the use of toothbrush and dental floss during the study.

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

Materials and methods

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. At the beginning of incisor retraction, all had completed retraction of canines for 1 month, and a space at least 4 mm between lateral incisors and canines. Space closure was taken. Reactivations were performed every 4 weeks.

Measurement the changes of alveolar bone and factors

In order to evaluate the changes of alveolar bone and potential influencing factors after upper incisor retraction, CT scan, lateral cephalometric radiographies, and intra-oral photography were taken at the beginning treatment and 6 months after incisor retraction or at the completion of incisor retraction.

Independent variables (Factors):

1. Rate of tooth movement
2. The changes of inclination
3. Initial alveolar bone thickness
4. Amount of intrusion

Dependent variable:

1. Alveolar bone thickness

Records and data analysis

Parameters measured in this study included the rate of tooth movement, changes of inclination, and amount of intrusion, which were measured using lateral cephalograms, while the alveolar bone thickness was measured by the computed tomography.

Cephalometric analysis:

Tooth inclination and distances of upper incisors movement were evaluated from lateral cephalometric radiographs. All subjects were taken in the same cephalostat with the sagittal plane at a right angle to the path of the x-rays, the teeth in centric occlusion, and the lips completely relaxed. The radiographies were traced and the angular parameters were measured by same investigator during the whole period of the study.

Angular used for measurement was as follow;

- UI to palatal plane

Distances of upper incisors movement were used for measurement as follow;

- UI incisal edge (UIE)-OLp
- UI incisal edge (UIE)-palatal plane

The retraction time was registered and the amount of space closure was evaluated by the distance change U1 incisal edge-OLp before and after upper incisor retraction to determine rate of tooth movement.

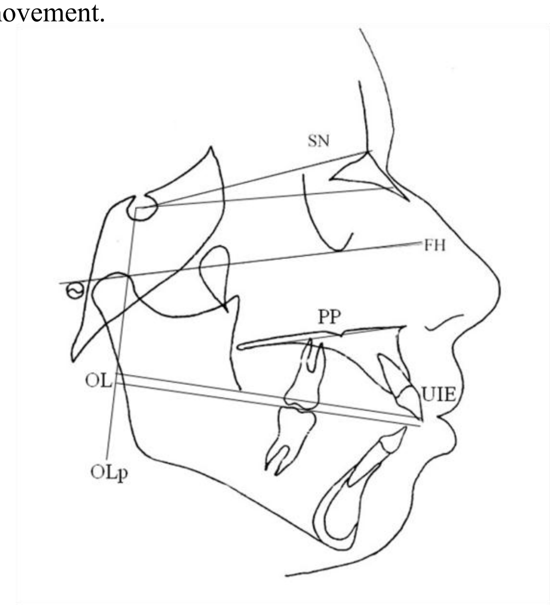


Fig. 1 Reference planes and angular measurements before and after upper incisor retraction[2]

Amount of intrusion was evaluated by distance change UI incisal edge (UIE)-palatal plane before (I_0) and after upper incisor retraction (I_1).

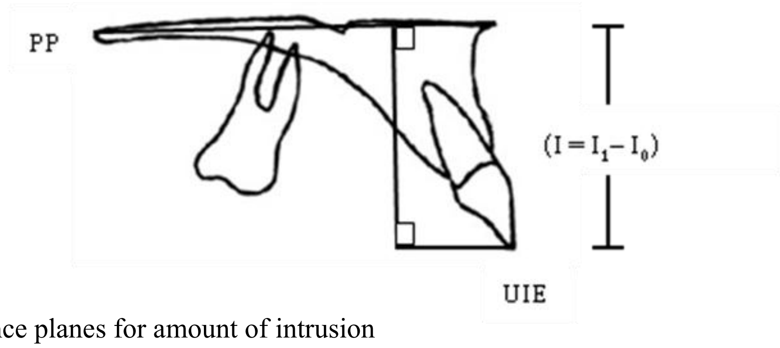


Fig. 2 Reference planes for amount of intrusion

Table 1 Cephalometric landmarks, reference planes, and angular measurements[17]

Landmark, plane or angle	Abbreviation	Definition
Sella	**S**	Center of the pituitary fossa of the sphenoid bone
Nasion	**N**	Junction of the frontonasal suture at the most posterior point on the curve at the bridge of the nose
Anterior nasal spine	**ANS**	Tip of the median, sharp bony process of the maxilla at the lower margin of the anterior nasal opening
Posterior nasal spine	**PNS**	Point of intersection of the line drawn through the hard palate parallel to the nasal floor and perpendicular from the lowest point of the pterygomaxillary fissure
Upper incisor edge	**UIE**	Incisal edge of the most prominent upper central incisor
A point	**A**	Most posterior point on the curve of the maxilla between the anterior nasal spine and superdentale
Palatal plane	**PP**	Plane through ANS and PNS

Table 1 (Continued)

Landmark, plane or angle	Abbreviation	Definition
Upper incisor angle	**UI-PP**	Upper incisor inclination to maxillary plane
Sella- nasion	**SN**	Plane through sella and nasion
Occlusal plane	**OL**	Function occlusal plane
Occlusal plane perpendicular	**OLp**	Vertical reference plane will be drawn as a perpendicular to OL at sella
Nasion-A point	**NA**	Plane through N and A

Computed tomography analysis

The changes of alveolar bone was evaluated using CT scan (Veraviewepocs J Morita MPG (80 kv, 5mA)). CT scanning was perpendicular to the long axis of the central incisors on maxilla. For each tooth, the thickness of the labial and palatal alveolar plates was measured. Measurements were taken at the site adjacent to the widest point of the labiopalatal root in 3 slices separated by 3 mm (S1, S2, and S3). The researcher assessed labial, palatal, and total alveolar thickness at crestal level (S1), mid root level (S2), and apical level (S3) for bone-thickness changes during retraction.

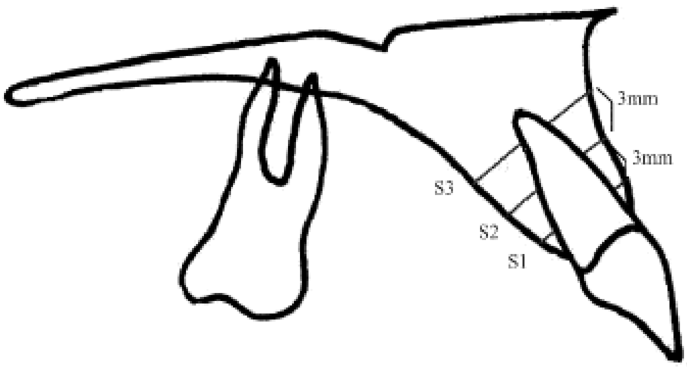


Fig. 3 Location of bone thickness measurement before and after upper incisor retraction[2]

Crestal level (S1): Alveolar bone level from CEJ 3 mm

Mid root level (S2): Alveolar bone level from CEJ 6 mm

Apical level (S3): Alveolar bone level from CEJ 9 mm

At the beginning of treatment (T_0), all radiographs was taken 9 measurements for each tooth: 3 on the labial side, 3 on the palatal side, and 3 for the total thickness. The same measurements were repeated 6 months after incisor retraction or incisor retraction completed (T_1). All measurements on CT scans were traced by same investigator. T_1 measurements took at the same slice levels as those at T_0, using the first slice on the incisor edge of the tooth as a reference point.

Measurements that were used in computed tomography analysis are as follow[21];

Alveolar bone thickness:

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

- L1: labial alveolar bone thickness at crestal level (S1)
- L2: labial alveolar bone thickness at mid root level (S2)
- L3: labial alveolar bone thickness at apical level (S3)

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

- P1: Palatal alveolar bone thickness at crestal level (S1)
- P2: Palatal alveolar bone thickness at mid root level (S2)
- P3: Palatal alveolar bone thickness at apical level (S3)

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

- T1: Total alveolar bone thickness at crestal level (S1)
- T2: Total alveolar bone thickness at mid root level (S2)
- T3: Total alveolar bone thickness at apical level (S3)

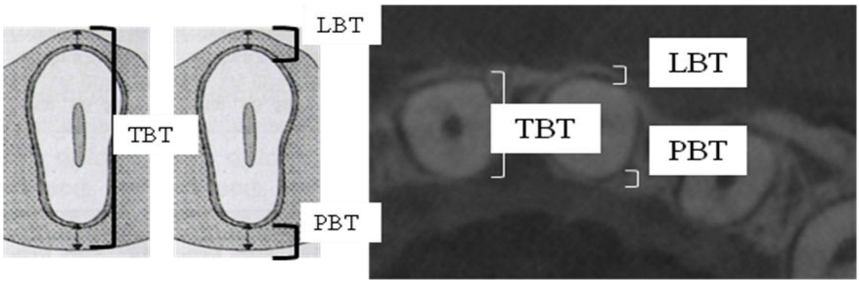


Fig. 4 Measurements of maxillary teeth bone plate thickness[21]

Statistical analysis

Paired *t* tests was used to evaluate the bony changes that occurred as a result of incisor retraction with a significance level of 0.05. This obviously makes it harder to claim a significant result and in so doing decreases the chance of making a Type I error to very acceptable levels. A Bonferroni adjustment[22] was used when there are multiple outcome measures, and there was concern about the possibility that the results might be perceived as being a fishing expedition. The Bonferroni comparison using an adjusted alpha level equal to the original alpha level (usually 0.05) divided by the number of outcome measures.

Spearman rank correlation analysis was applied to identify any correlations between the factors and the changes of alveolar bone.

The reproducibility of bone thickness and bone level measurements was assessed by calculating method error from the difference between two measurements taken at least two weeks apart. The measurement error was calculated from the formula of Dahlberg[23]:

$$\text{Method error} = \sqrt{\Sigma d^2/2n}$$

d: The difference between duplicated measurements

N: The number of double measurements

The reliability of the data was evaluated by calculating the intraclass correlation coefficient (ICC).[24] Based on the clinical importance of measurement errors, the significance might be high (ICC $\geq$0.95), acceptable (0.80 >ICC <0.95), or low (ICC $\leq$ 0.80).

CHAPTER 3

RESULTS

At the beginning of the study there were 24 subjects participating in this study. One subject was excluded because of crown fracture from motorcycle accident. The samples in this study eventually included 21 females and 2 males. Their mean age at the start of the treatment was 20.47 ± 2.71 years, ranging from 18-27 years.

Measurement error analysis

Before for research purposes and in clinical practice, a separate analysis to estimate the identification errors of landmarks with dubious reliability should be a prerequisite. Trpkova *et al*[25] recommend 0.5 mm of total error was acceptable levels of accuracy. In this study, all measurements were repeated 2 weeks apart and calculated to determine the intra observer reliability. Dahlberg's error was 0.29 mm, ranging from 0.00 to 0.38 mm for the distance measurement from computed tomography**,** 0.07 mm, ranging from 0.00 to 0.20 mm for the distance measurement from lateral cephalometric radiographs, and 0.4°, ranging from 0° to 1.0° for the angular measurement. Paired t-test showed no significant difference between two series of measurements. Intraclass correlation coefficients were performed to assess the reliability of the measurements. The reliability of measurements was found to be within 0.90-0.93, and the method was found an acceptable level.

Clinical observations

In this study, the teeth were aligned and leveled until complete on 0.016"x 0.022"stainless steel archwire. At the beginning of incisor retraction, all had completed retraction of canines, and a space at least 4 mm between lateral incisors and canines. Space closure was taken. Reactivations were performed every 4 weeks. The undesirable side effect during upper incisor retraction was noticed. A protuberance of alveolar bone showed at near the gingival margin.

In the clinical observation, the protuberance in 1 of 23 cases was considered clinically significant. In this case upper incisors were retracted with sliding mechanic on 0.016”x 0.022”stainless steel archwire. Upper incisors were retracted and intruded 6 mm and 3 mm, respectively, over the 5 months of treatment with rate of tooth movement 1.2 mm/month. And upper incisors were retracted with tipping 12 degrees. A protuberance of alveolar bone was noted about 3 months after incisor retraction.

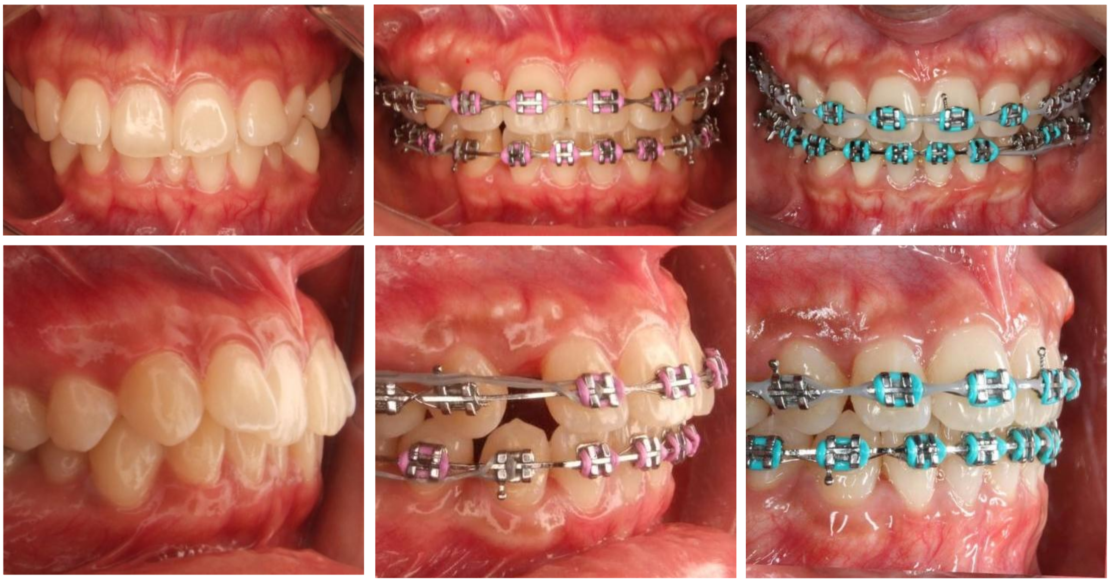


Fig. 5 One case with clinically significant difference in protuberance of alveolar bone near the gingival margin

Lateral cephalometric analysis

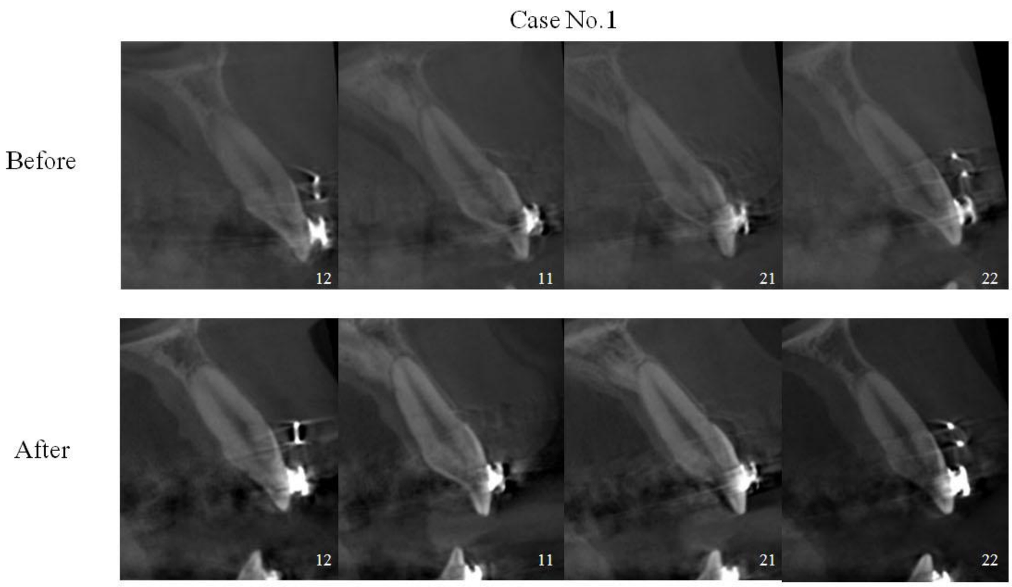
The result of lateral cephalometric measurements are listed in table 2

Table 2 Means, standard deviation, and ranges of, distance, retraction time, rate of tooth movement, amount of intrusion, and changes of inclination

	mean ± SD	range
Distance (mm)	6.21 ± 2.45	4-14
Retraction time (month)	5.82 ± 2.25	3-10
Rate of tooth movement (mm/ month)	1.15 ± 0.22	0.80-1.64
Amount of intrusion (mm)	1.34 ± 1.05	-1-3
Changes of inclination (degree)	10.95 ± 3.92	6-18

Computed tomography analysis

CBCT was performed before and after upper incisor retraction. The CBCT data was saved as DICOM (Digital Imaging and Communications in Medicine) format. CBCT images of 23 subjects are showed in Fig.6



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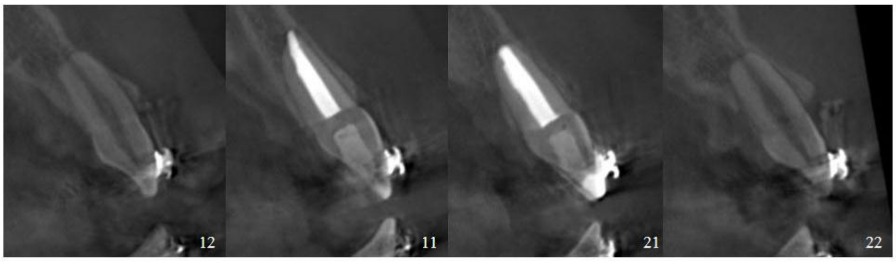
Before

After



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Before

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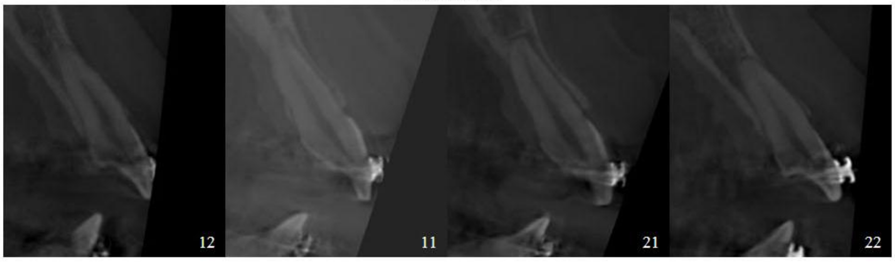
Case No.4

Before



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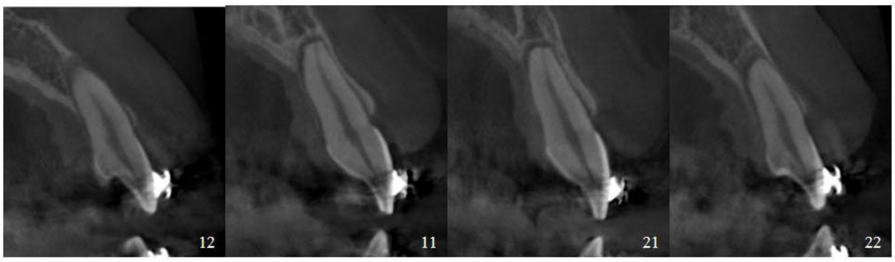

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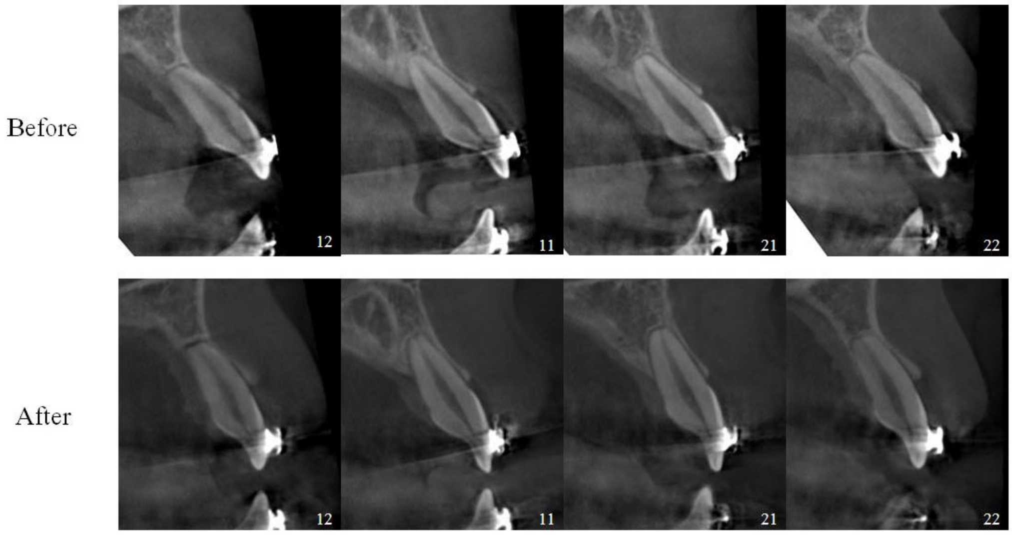

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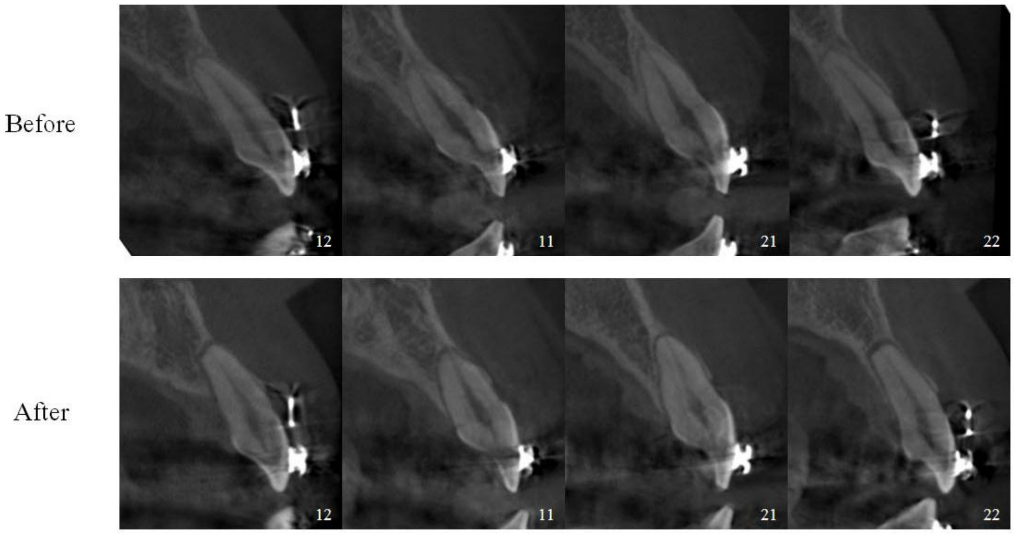

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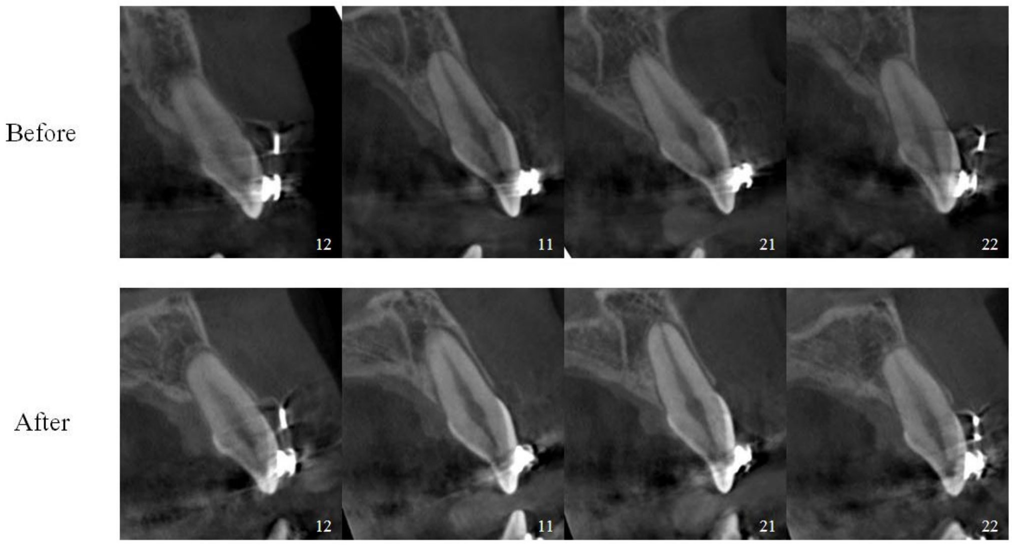

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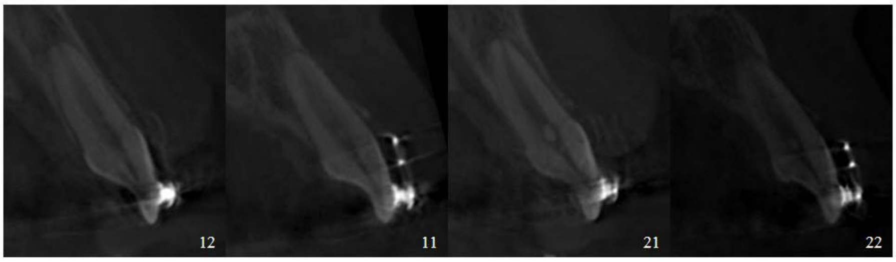

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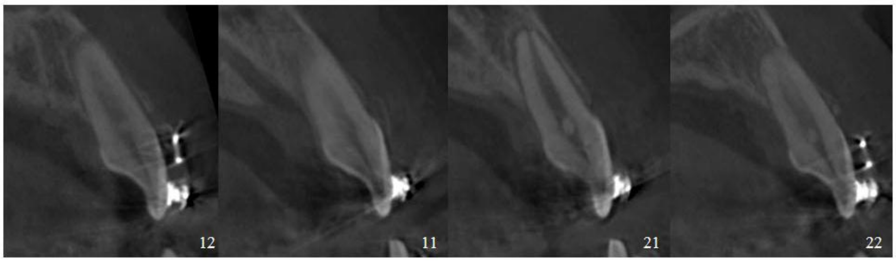

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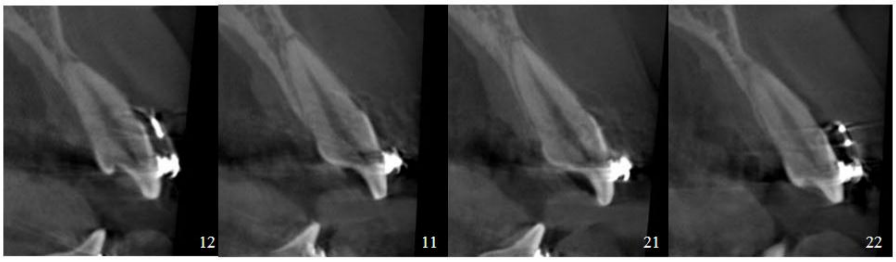

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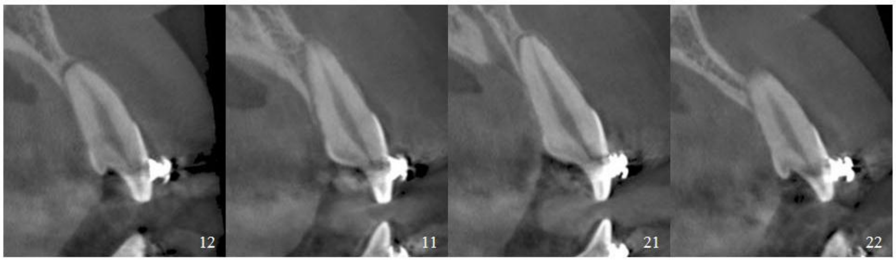

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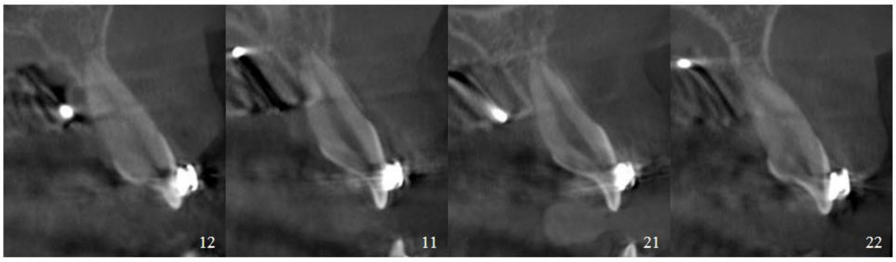

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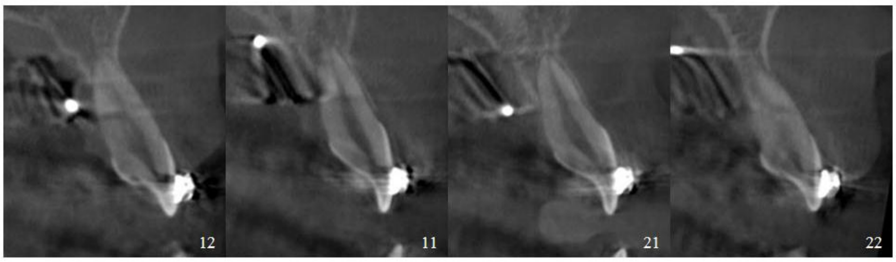

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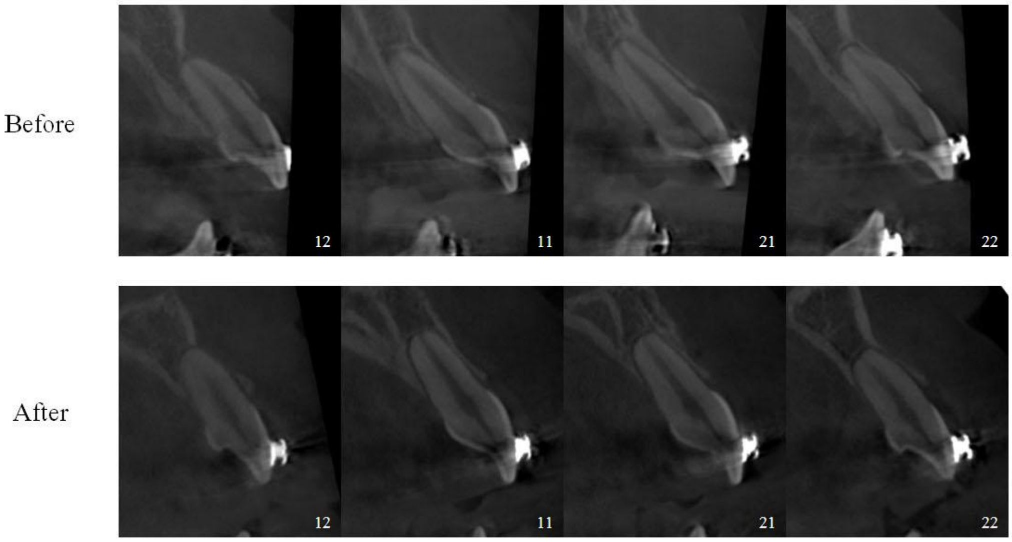

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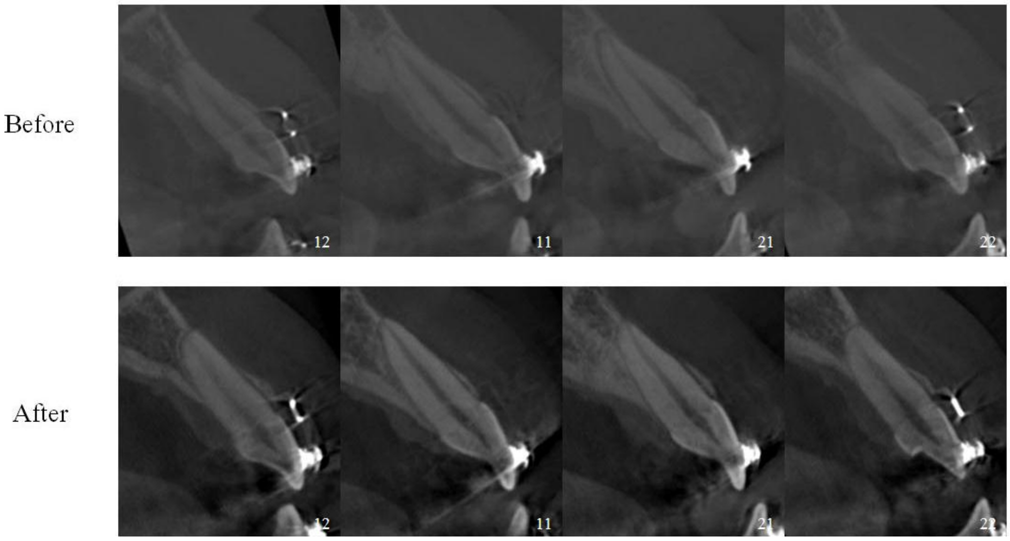

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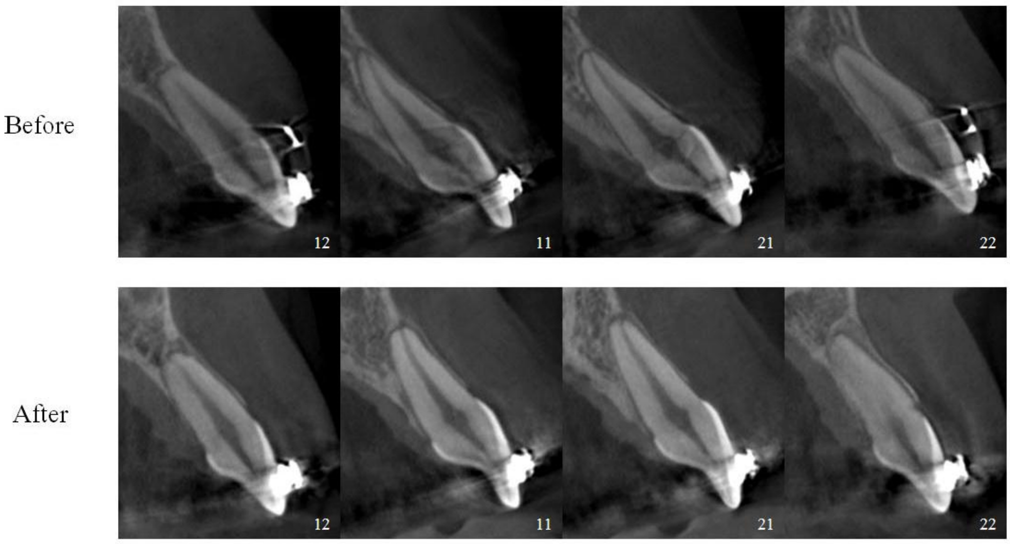

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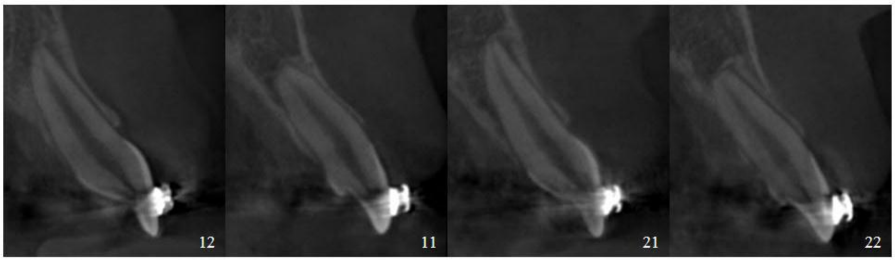

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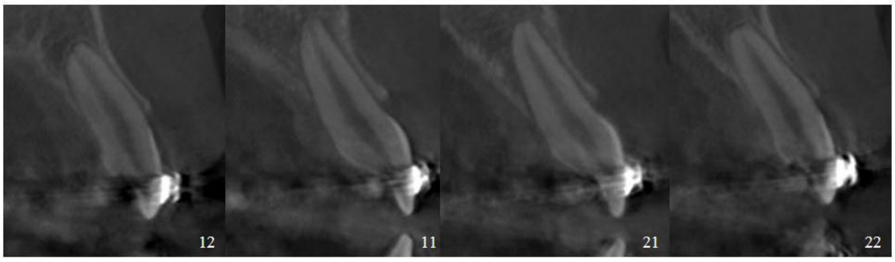

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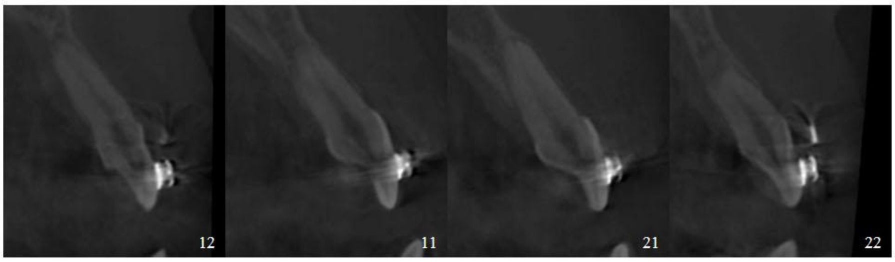

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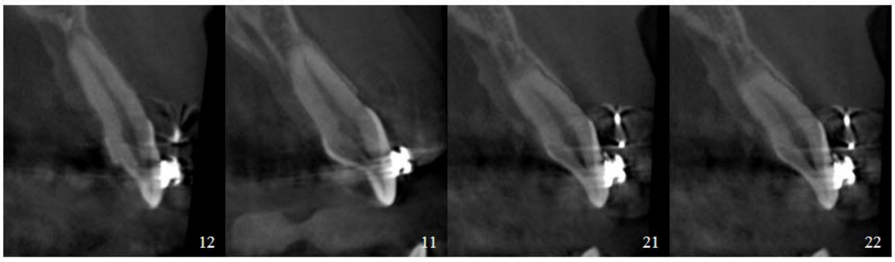

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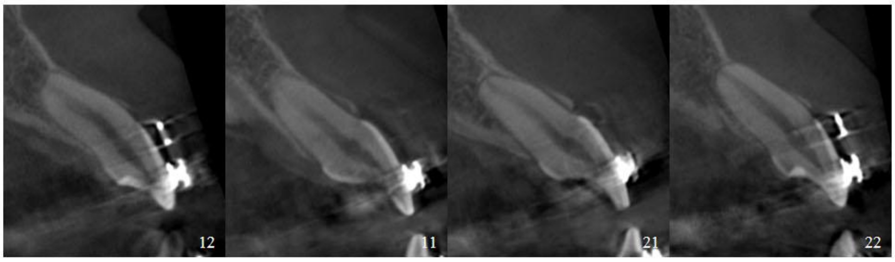

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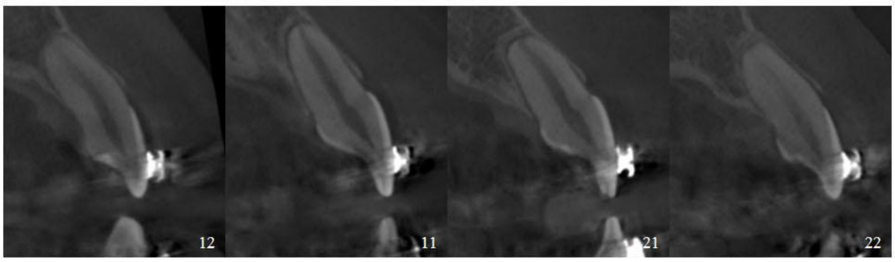

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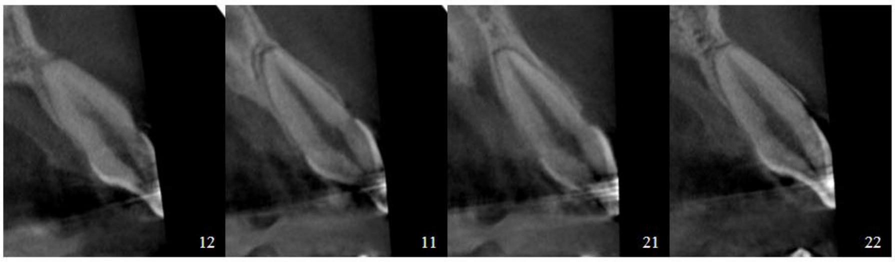

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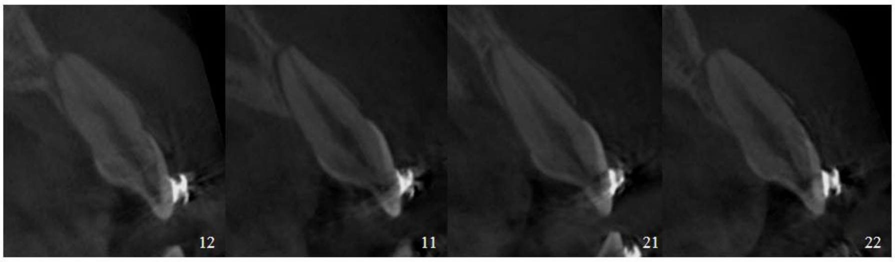

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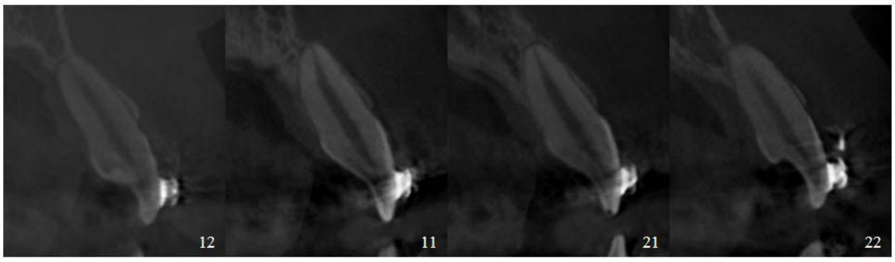

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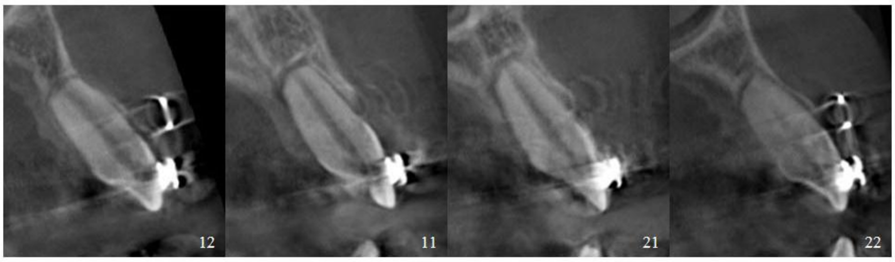

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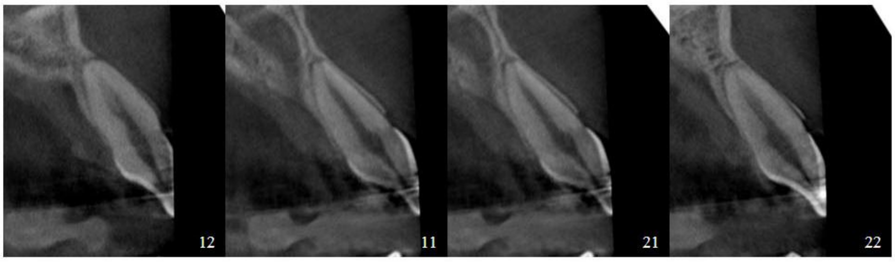

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Before

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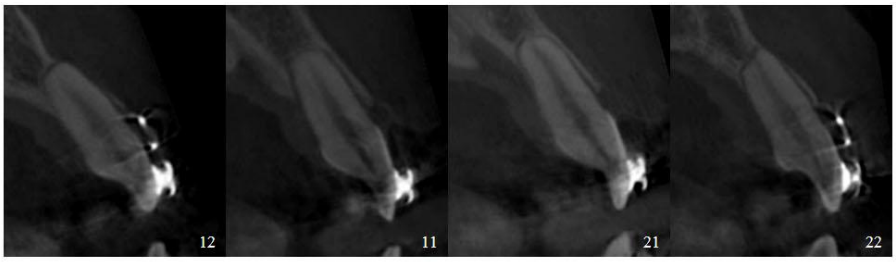

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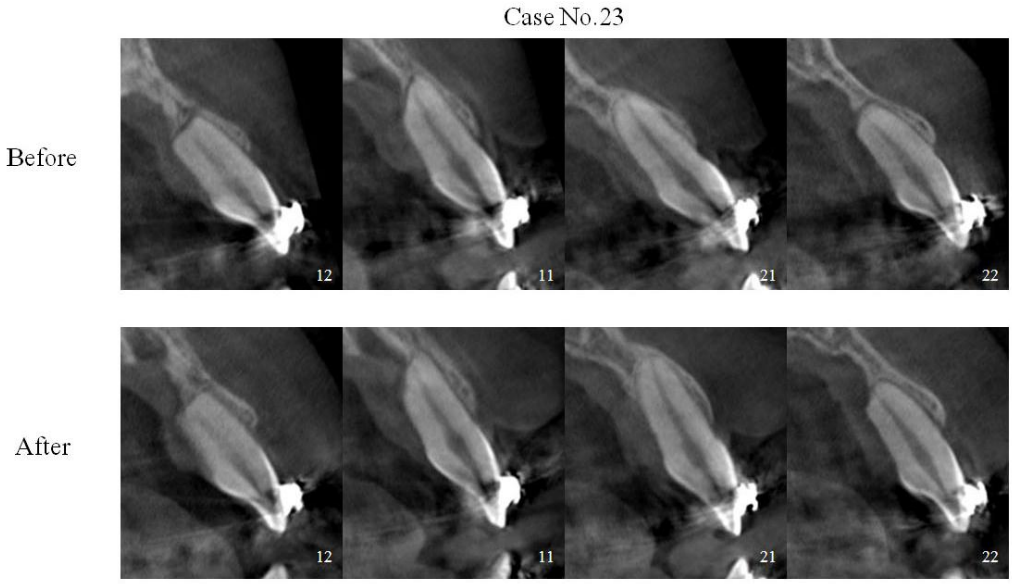

Fig. 6 CBCT images of 23 subjects before and after incisor retraction

Shapiro-Wilk test was used to test of normality, and found that mean alveolar bone thickness was normally distributed. Paired t-test was used following to compare the difference mean alveolar bone thickness before incisor retraction (T_0) and after incisor retraction (T_1). Bonferroni adjustment was used by adjusted alpha level (p = .05) divided by the number of outcome measures (9 level of alveolar bone thickness). So, the significant level was p = .005.

The result for changes in mean alveolar bone thickness of four upper incisors as measures on the CT scans from T_0 to T_1 are listed in table 3.

Table 3 Comparison of mean alveolar bone thickness of four upper incisors at T_0 and T_1 measurements with Paired t-test

Level	T_0 (mean ± SD)	T_1 (mean ± SD)	*p* value
L1	0.65 ± 0.32	0.98 ± 0.39	<.001*
L2	0.49 ± 0.34	0.60 ± 0.31	.135
L3	0.63 ± 0.36	0.63 ± 0.38	.971
P1	0.62 ± 0.48	0.38 ± 0.35	.011
P2	1.08 ± 0.77	1.12 ± 0.35	.719
P3	3.19 ± 1.12	3.89 ± 1.62	.010
T1	7.48 ± 0.85	7.41 ± 0.71	.545
T2	6.97 ± 0.95	7.07 ± 0.97	.468
T3	6.81 ± 1.34	7.43 ± 1.49	<.001*

*$p < .005$

Alveolar bone thickness significantly increased at L1 and T3. These findings were consistent to the results from the analysis of the difference in alveolar bone thickness in maxillary right lateral incisor, maxillary right incisor, maxillary left incisor, and maxillary left lateral incisor, respectively (Table 4, 5, 6, and 7).

Table 4 Comparison of alveolar bone thickness of upper right lateral incisor at T_0 and T_1 measurements with Paired t-test

Level	T_0 (mean ± SD)	T_1 (mean ± SD)	*p* value
L1	0.52 ± 0.47	0.96 ± 0.56	<.001*
L2	0.32 ± 0.43	0.44 ± 0.32	.223
L3	0.31 ± 0.33	0.41 ± 0.39	.266
P1	0.52 ± 0.51	0.21 ± 0.38	.001
P2	0.93 ± 0.90	0.82 ± 0.97	.468
P3	6.36 ± 1.52	7.04 ± 1.88	.026
T1	7.22 ± 0.93	7.21 ± 0.80	.923
T2	6.78 ± 1.03	6.72 ± 1.03	.702
T3	6.37 ± 1.52	7.76 ± 1.83	<.001*

*$p < .005$

Table 5 Comparison of alveolar bone thickness of upper right central incisor at T_0 and T_1 measurements with Paired t-test

Level	T_0 (mean ± SD)	T_1 (mean ± SD)	*p* value
L1	0.83 ± 0.31	1.01 ± 0.35	<.001*
L2	0.64 ± 0.41	0.66 ± 0.36	.743
L3	0.74 ± 0.47	0.74 ± 0.62	.968
P1	0.76 ± 0.62	0.49 ± 0.49	.016
P2	1.20 ± 1.06	1.32 ± 1.08	.474
P3	2.36 ± 1.38	3.04 ± 1.63	.011
T1	7.73 ± 0.98	7.88 ± 0.71	.054
T2	6.07 ± 1.07	7.09 ± 0.98	.101
T3	7.04 ± 1.30	7.92 ± 1.49	<.001*

*$p < .005$

Table 6 Comparison of alveolar bone thickness of upper left central incisor at T_0 and T_1 measurements with Paired t-test

Level	T_0 (mean ± SD)	T_1 (mean ± SD)	*p* value
L1	0.80 ± 0.39	1.03 ± 0.38	.002*
L2	0.73 ± 0.44	0.87 ± 0.35	.087
L3	1.01 ± 0.61	0.84 ± 0.54	.120
P1	0.78 ± 0.74	0.39 ± 0.71	.025
P2	1.51 ± 1.15	1.53 ± 1.34	.892
P3	2.53 ± 1.48	3.22 ± 1.79	.013
T1	7.81 ± 1.05	7.74 ± 0.81	.714
T2	7.60 ± 1.29	7.61 ± 1.31	.962
T3	7.54 ± 1.65	8.17 ± 1.85	<.001*

*$p < .005$

Table 7 Comparison of alveolar bone thickness of upper left lateral incisor at T_0 and T_1 measurements with Paired t-test

Level	T_0 (mean ± SD)	T_1 (mean ± SD)	*p* value
L1	0.46 ± 0.42	0.92 ± 0.51	<.001*
L2	0.29 ± 0.48	0.42 ± 0.49	.241
L3	0.47 ± 0.51	0.54 ± 0.44	.480
P1	0.41 ± 0.45	0.21 ± 0.29	.042
P2	0.69 ± 0.76	0.78 ± 0.79	.558
P3	1.52 ± 1.24	2.08 ± 1.85	.044
T1	7.14 ± 0.90	7.28 ± 0.97	.393
T2	6.56 ± 1.03	6.73 ± 1.28	.309
T3	6.29 ± 1.49	6.88 ± 1.94	.004*

*$p < .005$

Spearman rank correlation analysis was applied to identify any correlations between the factors and the mean changes of alveolar bone of four upper incisors (Table 8).

Table 8 Correlation between mean changes of alveolar bone thickness and factors

	Changes of alveolar bone; r value (*p* value)	
	L1	T3
Rate of tooth movement	.451 (.031)*	-.045 (.837)
Changes of inclination	-.191 (.084)	.433 (.039)*
Amount of intrusion	.185 (.399)	.526 (.010)*
Initial bone thickness	-.379 (.074)	-.077 (.728)

*$p < .05$

For alveolar bone thickness changes at L1 showed a strong correlation with rate of tooth movement (r = .451; p = .031). Alveolar bone thickness changes at T3 showed a strong correlation with changes of inclination and amount of intrusion (r = .433 and .526; p = .039 and

.010 respectively). Initial alveolar bone thickness had no significant correlation with alveolar bone thickness changes (p >.05).

Regarding the type of root movement in each subject could be categorized into two subgroup, those were retraction of upper incisors with tipping group 11 subjects and retraction of upper incisor with torque group 12 subjects. Paired t-test was used following to compare the difference mean alveolar bone thickness before incisor retraction (T_0) and after incisor retraction (T_1). Bonferroni adjustment was used by significant level p = .005. The result for changes in mean alveolar bone thickness of four upper incisors as measured by on the CT scans from T_0 to T_1 are listed in table 9.

Table 9 Comparison of mean alveolar bone thickness of fours upper incisors at T_0 and T_1 measurements with Paired t-test in subgroup

Level	Retraction with tipping group			Retraction with torque group		
	T_0 (mean ± SD)	T_1 (mean ± SD)	p value	T_0 (mean ± SD)	T_1 (mean ± SD)	p value
L1	0.68 ± 0.28	1.04 ± 0.37	.001*	0.58 ± 0.32	0.73 ± 0.33	.004*
L2	0.46 ± 0.36	0.51 ± 0.37	.511	0.48 ± 0.28	0.67 ± 0.22	.037
L3	0.45 ± 0.24	0.48 ± 0.33	.975	0.75 ± 0.36	0.78 ± 0.39	.611
P1	0.65 ± 0.37	0.43 ± 0.34	.011	0.42 ± 0.32	0.33 ± 0.37	.186
P2	1.13 ± 0.77	1.14 ± 0.93	.771	1.06 ± 0.78	1.00 ± 0.84	.586
P3	3.19 ± 1.28	3.80 ± 1.73	.094	3.14 ± 1.02	3.86 ± 1.54	.064
T1	7.47 ± 0.82	7.23 ± 0.61	.441	7.56 ± 1.00	7.47 ± 0.79	.668
T2	7.11 ± 0.88	7.04 ± 0.91	.867	6.94 ± 1.10	6.99 ± 1.08	.820
T3	6.67 ± 1.43	7.34 ± 1.45	<.001 *	6.90 ± 1.31	7.54 ± 1.59	.004*

*p < .005

The results demonstrated that both the retraction of upper incisors with tipping group and retraction of upper incisors with torque group showed a significant increase of bone thickness at L1 and T3 (Fig. 7 and 8).

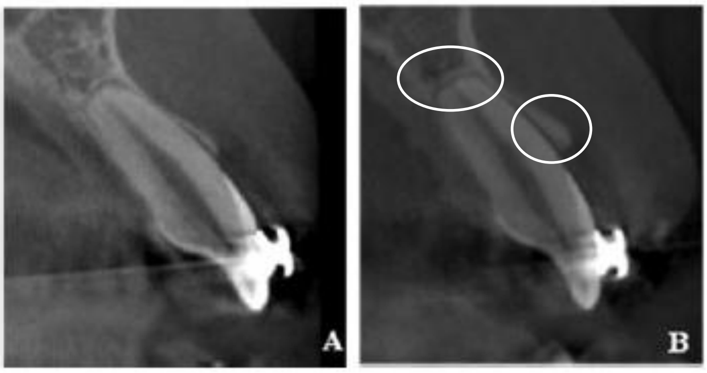

Fig. 7 Changes of alveolar bone thickness at L1 and T3 in upper incisors retraction with tipping

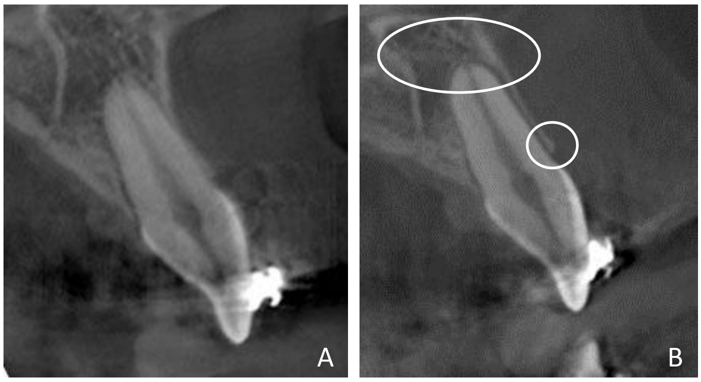

Fig. 8 Changes of alveolar bone thickness at L1 and T3 in upper incisors retraction with torque

When these 2 subgroups were taken into account when analyzing the correlation between retraction with tipping group and retraction with torque group, Spearman rank correlation analysis demonstrated that alveolar bone thickness changes at L1 was strongly and positively correlated to retraction with tipping group (r = .558; p = .006). On the other hand, alveolar bone thickness change at L1 was strongly and negatively correlated to retraction with torque group (r = -.358; p = .031). But 2 subgroups had no significant correlation with alveolar bone thickness changes at T3 (p >.05).

CHAPTER 4

DISCUSSION

Bone remodeling in orthodontic treatment has been one of the most concerned issues. It is generally accepted that tooth movement can occur either with the bone or through the bone. The question that is of significant interest to the orthodontists is whether "bone traces tooth movement" or, specifically, whether the bone around the alveolar socket can remodel to the same extent when orthodontic tooth movement occurs.[1]

In order to assess dentoalveolar morphology in both sagittal and vertical dimensions, orthodontists often use cephalometric tracings. However, this fails to assess bone thickness. CBCT is now used to qualitatively and quantitatively assess potential implant sites. Fuhrmann *et al.*[21] recently showed that quantitative evaluation of alveolar bone plates is accurate to a minimum bone thickness of 0.25 mm. Lascala *et al.*[26] found that, although the CBCT image underestimated the real distances between skull sites, the differences were significant only for the skull base; therefore, it was reliable for linear evaluation measurements of other structures more closely associated with dental and maxillofacial imaging. Lagravere *et al.*[27] evaluated the accuracy of measurements made on CBCT images compared with measurements made on a coordinate measuring machine; they found no significant statistical differences between the linear and angular measurements from the coordinate measuring machine and the NewTom 3G (Aperio Services, Verona, Italy) images. Hence, they concluded that the NewTom 3G produces a 1-to-1 image-to-reality ratio. CBCT findings have proven to be statistically similar to histologic measurements. Moreover accuracy and reliability of CBCT measurements are not affected by changing the skull orientation.[28-29] Therefore, this study was designed to use CT measurements to more accurately evaluate bone thickness changes.

The purpose of this study was to characterize the changes in bone thickness on both labial and palatal aspects of the anterior teeth during incisor retraction. Several studies have indicated a lag of bone remodeling in response to tooth movement. These studies have shown that as the upper incisors were retracted, labial bone thickness at crestal level and total alveolar bone thickness at apical level significant increased (L1 and T3 respectively; Fig. 9).

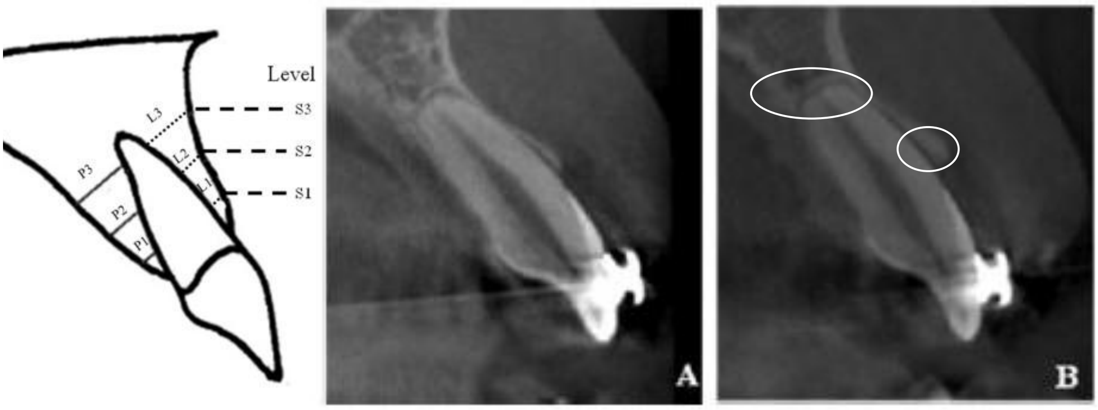

Fig. 9 Changes in alveolar bone thickness on both labial and palatal aspects of the anterior teeth during incisor retraction.

This findings disputes that of De Angelis[1], who presented the bending capacity of alveolar bone. According to De Angelis, mechanotherapy induces alveolar distortion, and the distorted alveolus alters the electric environment, a process that is attributed to the piezoelectricity of bone. As a result, the theory is that highly synchronized coordinated changes are triggered, and, with coordinated apposition and resorption, the alveolar bone retains its structural characteristics and size as it moves.

The results demonstrated significant increase in the labial bone thickness at crestal level which was similar to the study of Bimstein *et al.*[15], which reported that an increase in the amount of buccal alveolar bone may take place as a result of orthodontic treatment that involves lingual positioning of procumbent mandibular permanent central incisors. Palatal bone thickness did not remain the same; rather, it decreased. But there was no statistically significant. This finding disagreed with the results of Sarikaya *et al.*[2], Vardimon *et al.*[7], Wehrbein *et al.*[14], Wainwright[30], and Ten Hoeve and Mulie.[31]

The hypothesis of this study was that changes of inclination, rate of tooth movement, initial alveolar bone thickness, and amount of intrusion are related to alveolar bone thickness changes after upper incisor retraction. Spearman rank correlation analysis was applied to identify any correlations between factors and the mean changes of alveolar bone of four upper incisors.

The result demonstrated significant correlations between changes of inclination, rate of tooth movement, amount of intrusion and changes of alveolar bone thickness after upper incisor retraction. Furthermore, no significant correlation was found between initial alveolar bone thickness and changes of alveolar bone thickness.

Rate of tooth movement showed a strong correlation with changes at labial bone thickness at crestal level; L1 (r = .451; *p* = .031). The result indicated rate of tooth movement was related to alveolar bone thickness changes at L1. Similar finding was observed in clinical examination in one subject, a protuberance of alveolar bone showed near the gingival margin at upper incisors after incisor retraction (Fig.10). The result is similar to reports of Mimura[3] and Lin *et al.*[4] (Fig.11).

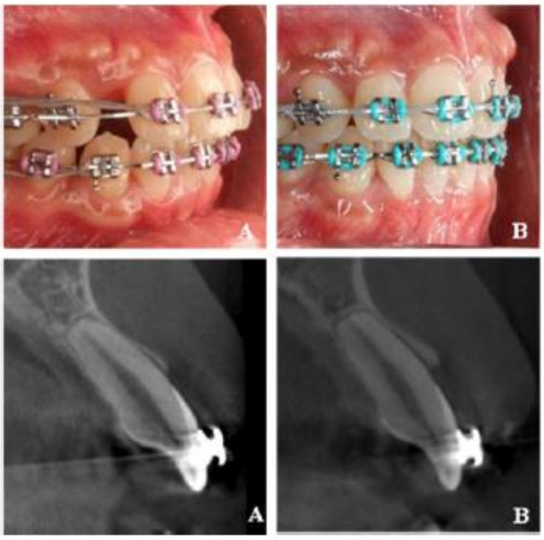

Fig. 10 A protuberance of alveolar bone showed near the gingival margin at upper incisors after incisor retraction

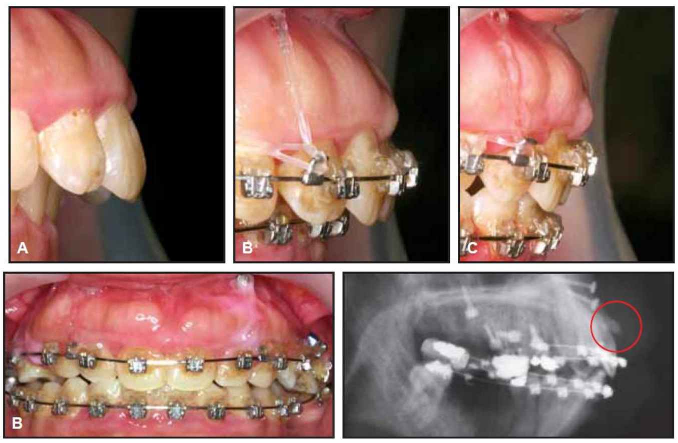

Fig. 11 Labial bone protuberance reports of Mimura[3]

In our study, it was demonstrated that the faster rate of incisor retraction, the more bone thickness at labial crestal level increased. Bone remodeling process may not be able to catch up with too rapid tooth movement. The result showed total alveolar bone thickness was maintained. It can be interpreted that the rate of resorption on the labial aspect is relatively slower than the rate of apposition on the lingual aspect (secondary bone remodeling) followed by bone prominent (Fig. 12). A longitudinal follow up study would be beneficial to explain the long term response of the alveolar bone to various tooth movement rates.

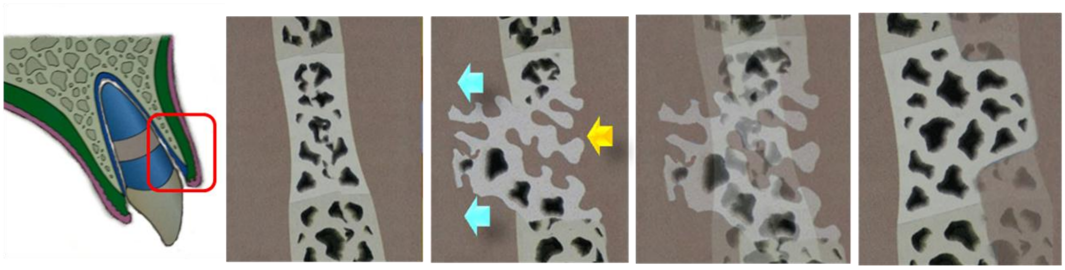

Fig. 12 Illustration of second bone remodeling process may not be able to catch up with too rapid tooth movement.

Changes of inclination showed strong correlations with changes of total bone thickness at apical level; T3 (r =.433; *p* = 039)**.** This finding agreed with the result of Abdwani *et al.*[17]and Nimri *et al.*[18]*,* who reported that the effects of incisal inclination changes, due to orthodontic treatment will result in a change in the position of point A.

Amount of intrusion showed strong correlations with changes of total bone thickness at apical level; T3 (r = .526; *p* = .010). It could be explained that with increased amount of intrusion, more alveolar bone at apical level change can be expected during upper incisor retraction. Moreover Mimura[3] reported case report that the maxillary alveolar process failed to remodel as the upper anterior teeth were intruded and retracted, leaving behind a prominent labial ridge of bone.

Changes of total alveolar bone thickness at apical level related to the changes of inclination and amount of intrusion of the upper incisors. This is the same as the result of Bimstein *et al.*[15] that suggested change in the alveolar bone height of protruded mandibular permanent incisors may be influenced not only by the change in angulation between the mandibular plane and the axis of the mandibular central incisors but also by the orthodontic intrusion of the teeth. When considering association between changes of inclination and amount of intrusion, it found that changes of inclination and amount of intrusion show a positive correlation (r = .526; P = .010).

Regarding the type of root movement, both the retraction of upper incisors with tipping and torque group showed a significant increase in the labial bone thickness at crestal level and total bone thickness at apical level. Spearman rank correlation analysis demonstrated that the labial bone thickness at alveolar crestal level was strongly positive correlated to upper incisors with tipping group. On the other hand, the labial bone thickness at alveolar crestal level was strongly negative correlated to upper incisors with torque group. This could imply that there was difference in the alveolar bone thickness changes among types of root movement when upper incisors were retracted. The possible explanation is the retraction forces applied to the alveolar bone at crestal level were different at the labial and palatal bone. Moreover, in the case which retraction with tipping, result of orthodontic treatment involved lingual positioning of incisor edge that increased in the amount of labial bone thickness at alveolar crestal level. However, it is different from guideline of Vardimon *et al.*[7] who recommended to used the 1:2 bone remodeling/tooth movement ratio as to determine the biocompatible range of orthodontic tooth movements during maxillary incisor retraction with tip or torque movements.

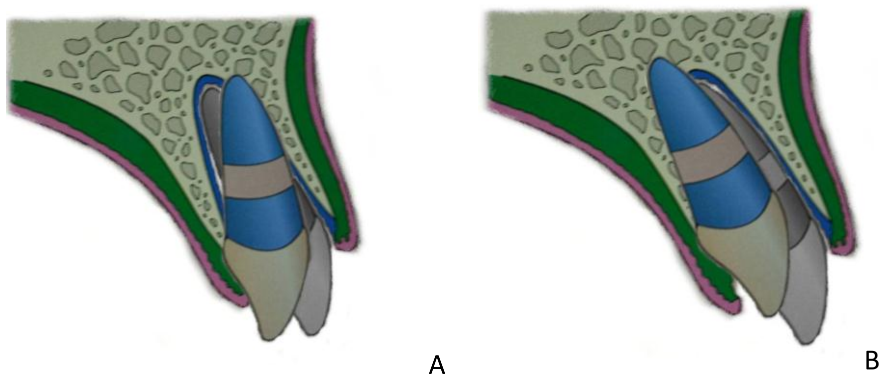

Fig. 13 Illustration of changes of alveolar bone thickness when upper incisor retraction with tipping (A) or upper incisor retraction with torque (B)

In addition, both upper incisor retraction with tipping and torque group (6 of 23 cases) showed that palatal bone dehiscence and the loss of alveolar bone height at crestal level. It may be the retraction forces applied to the incisors were concentrated at the alveolar crest, leading to greater accumulation of pressure in the marginal region (Fig. 14).

Fig. 14 6 of 23 cases showed that palatal bone dehiscence and the loss of alveolar bone height at crestal level. (A: Before incisor retraction B: After incisor retraction)

Meanwhile, some patients (3 of 11 cases) who upper incisor retraction with tipping exhibited root perforation, labial bone fenestration and dehiscence at apical level (Fig. 15). However, on the basis of their laminagraphic evidence Ten Hoeve and Mulie[31], suggested that the cortex would be reestablished within 6 months, no matter how extensive the tooth movement was.

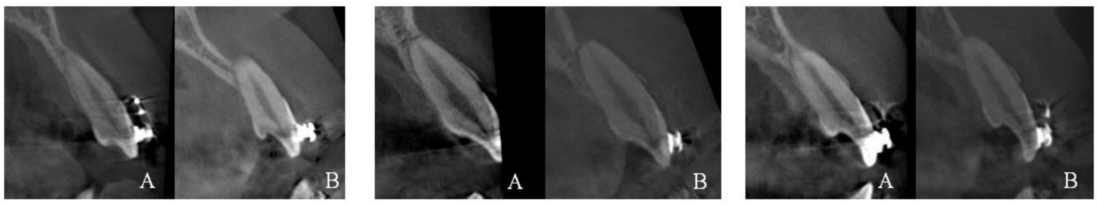

Fig. 15 3 of 11 cases exhibited root perforation, labial bone fenestration and dehiscence at apical level. (A: Before incisor retraction B: After incisor retraction)

Although the mean values in our study did not indicate the presence of fenestration or dehiscence, individual findings are also important when focusing on iatrogenic sequelae. The anatomical limits set by the cortical plates of the alveolus may be regarded as orthodontic walls.[12] Since the cortical plates of the palate are represented only in 2 dimensions on lateral cephalograms, the examiner cannot rule out iatrogenic sequelae during or after tooth movement based on these films. Therefore, unlimited tooth movement is not possible during retraction of the incisors.

Furthermore, no significant correlation was found initial alveolar bone thickness and changes of alveolar bone thickness. The results disagreed with Rungcharassaeng *et al.*[16], who studies the factors that might affect buccal bone changes of maxillary posterior teeth after rapid maxillary expansion. The results suggested factors that showed significant correlation to buccal bone changes and dental tipping on first premolars and molars were age, appliance expansion, initial buccal bone thickness, and differential expansion. It may be explained that difference of direction of tooth movement.

The mechanics of orthodontic treatment to retract anterior teeth in this study were loop and sliding mechanics. The result had no significant association with changes of alveolar bone thickness. Moreover, no significant correlation was found between changes of alveolar bone thickness and type of wire, retraction time, distance of tooth movement and sex.

In the clinical observation, 1 of 23 cases experienced an obviously changes in alveolar bone thickness, a protuberance of alveolar bone near the gingival margin was noted. It seems that the maxillary alveolar process failed to remodel as the upper anterior teeth were retracted. Unintentional side effects of changes of alveolar bone thickness in the maxillary alveolar process during orthodontic treatment have been reported. The results similar to reported of Mimura[3] and Lin *et al.*[4]

In this case were retracted upper incisors with sliding mechanic on 0.016”x 0.022” stainless steel archwire. Upper incisors were retracted and intruded 6 mm and 3 mm, respectively, over the 5 months of treatment with rate of tooth movement 1.2 mm/month. Upper incisors were retracted with tipping 12 degrees. Our result showed correlation between changes of alveolar bone thickness and rate of tooth movement, amount of upper incisor intrusion, and changes of inclination. These factors may be related to a protuberance of alveolar bone in this case. However, another case showed alveolar bone changes at L1 more than this case and did not show a protuberance of alveolar bone (Fig. 16). Therefore, each case should be carefully evaluated to determine soft tissue thickness.

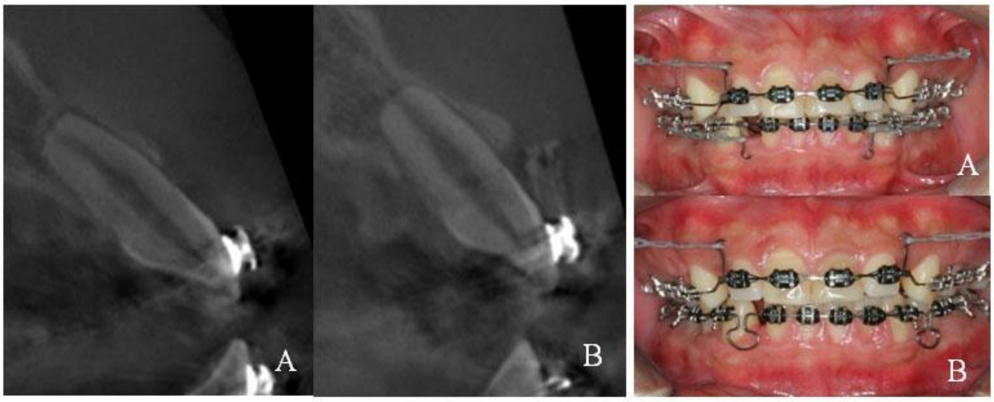

Fig.16 One case show alveolar bone changes at L1 but did not show a protuberance of bone.

Clinical implication

Our result showed that the factors related to alveolar bone thickness changes after upper incisor retraction were rate of tooth movement, amount of intrusion, and changes of inclination.

In cases with orthodontic treatment plan with retraction of the anterior teeth, case selection should be assessed appropriately regarding the amount of intrusion, and changes of inclination, such as gummy smile case or camouflage cases. In the case prone to the risk of undesirable side effect of changes of alveolar bone thickness, surgery is a proper choice of treatment.

In addition, if upper incisors are retracted with the faster the rate of tooth movement, labial alveolar bone thickness was more increased. Proper rate of tooth movement must be carefully monitored to avoid undesirably thickness of alveolar bone. Moreover, risk of alveolar bone loss should be considered during incisor retraction and the anatomical limitation of labial and palatal bone should be greatly emphasized on the tooth movement.

CHAPTER 5

CONCLUSION

With the limits of this study, the following concluded that

1. As the upper incisors are retracted, labial bone thickness at crestal level (L1) and total alveolar bone thickness at apical level (T3) significantly increases.

2. Rate of tooth movement, changes of inclination, and amount of intrusion were related to alveolar bone thickness changes after upper incisor retraction.

3. No significant correlation was found between initial alveolar bone thickness, mechanic, type of wire, retraction time, distance of tooth movement, sex and changes of alveolar bone thickness after upper incisor retraction.

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APPENDICES

ใบเชิญชวน

ขอเชิญเข้าร่วม โครงการวิจัยเรื่อง ปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟัน ภายหลังจากการดึงฟันหน้าบน

เรียน ท่านผู้อ่านที่นับถือ

ข้าพเจ้า ทพญ.หนึ่งฤทัย ยอดทอง นักศึกษาระดับปริญญาโทสาขาทันตกรรมจัดฟัน ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ใคร่ขอเล่าถึงโครงการวิจัยที่กำลังทำอยู่ และขอเชิญชวนท่านเข้าร่วมโครงการนี้โครงการวิจัยนี้จัดทำขึ้นเพื่อศึกษาปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบนโดย ประโยชน์ที่จะได้รับภายหลังจากการวิจัยคือ นำข้อมูลที่ได้มาประกอบการตรวจทางคลินิก การประเมินภาพถ่ายรังสี และวางแผนการรักษา เพื่อทำนายผลการรักษา และผลที่อาจจะเกิดขึ้นภายหลังจากการดึงฟันหน้าบน

ขั้นตอนของการวิจัยคือ จะเก็บ และ บันทึกข้อมูลก่อนและหลังการดึงฟันหน้าบน ผู้เข้าร่วมวิจัยจะได้รับการรักษาตามขั้นตอนและแผนการรักษาของผู้ป่วยตามปกติ โดยจะเก็บข้อมูลเพิ่มเติมจากการถ่าย CT scan (Cone beam computed tomogram) หลังจากนั้นนำข้อมูลที่ได้มาประเมินการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันและ วิเคราะห์หาปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบน

<u>สำหรับความเสี่ยงที่อาจจะเกิดอันตรายขึ้นจากการถ่ายภาพรังสีมีน้อยมาก ซึ่งอยู่ในระดับที่ปลอดภัยและค่าใช้จ่ายที่ผู้เข้า ร่วมวิจัยจะต้องรับผิดชอบนั้นประกอบด้วย ค่าทำประวัติ ค่ารักษาทางทันตกรรมจัดฟันในอัตราปกติ และค่า X-ray ซึ่งโดยปกติ จะถ่าย X-ray ก่อนการรักษา ระหว่างการรักษา และหลังการรักษา สำหรับค่า CT scan ที่เพิ่มเติมจากการรักษาปกติ ทางคณะผู้วิจัยจะเป็นผู้รับผิดชอบ มีรายละเอียดโดยประมาณดังนี้</u>

ค่าใช้จ่าย	จำนวน (บาท)	ผู้รับผิดชอบ	หมายเหตุ
ค่าทำประวัติ	600	ผู้เข้าร่วมวิจัย	ข้อมูลที่เก็บเพื่อใช้ในการรักษาตามขั้นตอนปกติ
ค่ารักษาทางทันตกรรมจัดฟัน	24,000		
ค่า X-ray ประมาณ 3 ครั้ง ■ Lateral cephalometry ครั้งละ 120 บาท ■ OPG ครั้งละ 200บาท	360 600		
ค่า CT scan	3,500	คณะผู้วิจัย	ข้อมูลที่เก็บเพิ่มเติมเพื่อใช้ในงานวิจัย

ถ้าท่านตัดสินใจเข้าร่วมโครงการวิจัยฯนี้ จะมีขั้นตอนของการวิจัยที่จำเป็นต้องขอความร่วมมือของท่านตามที่กล่าวมาข้างต้น ซึ่งจะไม่ก่อให้เกิดความเจ็บปวดและอันตรายต่อเนื้อเยื่อใดๆ โดยผู้เข้าร่วมโครงการฯ ต้องมารับการรักษาและติดตามผล ณ คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ ตามระยะเวลาที่กำหนดอย่างเคร่งครัด

ไม่ว่าท่านจะเข้าร่วมในโครงการวิจัยนี้หรือไม่ ท่านจะยังคงได้รับการรักษาที่ดีเช่นเดียวกับผู้ป่วยคนอื่นๆ และถ้าท่านต้องการที่จะถอนตัวออกจากการศึกษานี้เมื่อใดท่านก็สามารถกระทำได้อย่างอิสระ ถ้าท่านมีคำถามใดๆ ก่อนที่จะตัดสินใจเข้าร่วมโครงการนี้ โปรดซักถามจากคณะผู้วิจัยได้อย่างเต็มที่

ขอขอบคุณเป็นอย่างสูง
ทพญ. หนึ่งฤทัย ยอดทอง

หมายเหตุ: - กรุณาอ่านข้อความให้เข้าใจก่อนเซ็นชื่อยินยอมเข้าร่วมโครงการ

แบบยินยอมเข้าร่วมการศึกษา

โครงการวิจัยเรื่อง ปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบน

วันที่_______เดือน__________________พ.ศ._______

ข้าพเจ้า____________________________________อายุ________ปี อาศัยอยู่บ้านเลขที่_________หมู่_______ถนน___________________ตำบล________________________ อำเภอ___________________จังหวัด________________ ได้รับการอธิบายถึงวัตถุประสงค์ของการวิจัย วิธีการวิจัย อันตรายที่อาจเกิดขึ้นจากการวิจัย รวมทั้งประโยชน์ที่จะเกิดขึ้นจากการวิจัยอย่างละเอียด และมีความเข้าใจดีแล้ว

หากข้าพเจ้ามีข้อสงสัยประการใดหรือเกิดผลข้างเคียงจากการวิจัยสามารถติดต่อกับ ทพญ.หนึ่งฤทัย ยอดทอง ได้ที่ ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์ หมายเลขโทรศัพท์ 074-287601 หรือ เมื่อมีปัญหาใดๆ เกิดขึ้นเนื่องจากการทำวิจัยในเรื่องนี้ ข้าพเจ้าสามารถร้องเรียนได้ที่คณบดี คณะทันตแพทยศาสตร์ มหาวิทยาลัย สงขลานครินทร์ อ.หาดใหญ่ จ.สงขลา 90112 หมายเลขโทรศัพท์ 074-287510

หากผู้วิจัยมีข้อมูลเพิ่มเติมทั้งทางด้านประโยชน์และโทษที่เกี่ยวข้องกับการวิจัยนี้ ผู้วิจัยจะแจ้งให้ข้าพเจ้าทราบอย่างรวดเร็วโดยไม่มีปิดบัง

ข้าพเจ้ามีสิทธิ์ที่จะของดการเข้าร่วมโครงการวิจัย โดยจะแจ้งให้ทราบล่วงหน้าโดยการงดการเข้าร่วมการวิจัยนี้จะไม่มีผลต่อการได้รับบริการหรือการรักษาที่ข้าพเจ้าจะได้รับแต่อย่างใด

ผู้วิจัยรับรองว่าจะเก็บข้อมูลเฉพาะที่เกี่ยวกับตัวข้าพเจ้าเป็นความลับ จะไม่เปิดเผยข้อมูลหรือผลการวิจัยของข้าพเจ้าเป็นรายบุคคลต่อสาธารณชนจะเปิดเผยได้ในรูปแบบที่เป็นสรุปผลการวิจัย หรือการเปิดเผยข้อมูลต่อผู้มีหน้าที่ที่เกี่ยวข้องกับการสนับสนุนและกำกับดูแลการวิจัย

ข้าพเจ้าได้อ่านข้อความข้างต้นแล้ว และมีความเข้าใจดีทุกประการ จึงได้ลงนามในใบยินยอมนี้ด้วยความเต็มใจ โดย ผู้วิจัยได้ให้สำเนาแบบยินยอมที่ลงนามแล้วกับข้าพเจ้าเพื่อเก็บไว้เป็นหลักฐานจำนวน 1 ชุด

ลงชื่อ…………………………………….…...ผู้ยินยอม

( )

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

(ทันตแพทย์หนึ่งฤทัย ยอดทอง)

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

( )

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

( )

ลงชื่อ……………………….……………พยาน

( )

ลงชื่อ……………………...……....……พยาน

( )

ที่ ศธ 0521.1.03/ 138

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

หนังสือฉบับนี้ให้ไว้เพื่อรับรองว่า

โครงการวิจัยเรื่อง "ปัจจัยที่สัมพันธ์กับการเปลี่ยนแปลงความหนาของกระดูกเบ้าฟันภายหลังจากการดึงฟันหน้าบน "

หัวหน้าโครงการ ทันตแพทย์หญิงหนึ่งฤทัย ยอดทอง

สังกัดหน่วยงาน นักศึกษาหลังปริญญา ภาควิชาทันตกรรมป้องกัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยสงขลานครินทร์

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

ให้ไว้ ณ วันที่ 19 กุมภาพันธ์ 2553

(รองศาสตราจารย์ ทพ.นพ.ธงชัย นันทนรานนท์)
รองคณบดีฝ่ายวิจัย
ประธานกรรมการ

....กรรมการ	......ไม่ได้เข้าประชุม......กรรมการ
(ผู้ช่วยศาสตราจารย์ ดร.ทพญ.สุวรรณา จิตภักดีบดินทร์)	(ผู้ช่วยศาสตราจารย์ ทพญ.สรียา ศรีสินทร)
....กรรมการ	....กรรมการ
(ผู้ช่วยศาสตราจารย์ ทพ.นพ.สุรพงษ์ วงค์วัชรานนท์)	(ผู้ช่วยศาสตราจารย์ นพ.พรชัย สถิรปัญญา)
....กรรมการ	......ไม่ได้เข้าประชุม......กรรมการ
(ผู้ช่วยศาสตราจารย์ ดร.ทพญ.อังคณา เธียรมนตรี)	(อาจารย์วศิน สุวรรณรัตน์)

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Doctor of Dental Surgery	Prince of Songkla University	2005

List of Publication and Proceeding

Yodthong N, Leethanakul C, Charoemratrote C. Association between Amount of Upper Incisor Intrusion and Alveolar Bone Thickness Changes during Orthodontic Retraction. Proceedings of the 23rd National Graduate Research Conference; 2011 December 23-24; Nakhon Ratchasima, Thailand. Faculty of Sciences and Liberal Arts, Rajamangala University of Technology Isan; 2011.