พื้นที่ผิวรากฟันแท้ในขากรรไกรบนของผู้ป่วยไทยกลุ่มหนึ่งที่มีฟันหน้าสบเปิดโดยใช้โคนบีมคอมพิวเตดโทโมกราฟฟี

Root Surface Areas of Maxillary Permanent Teeth in a Group of Thai Patients Exhibiting Anterior Open Bite Using Cone-Beam Computed Tomography

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บทคัดย่อ

วัตถุประสงค์: เพื่อประเมินพื้นที่ผิวรากฟันแท้ในขากรรไกรบนของผู้ป่วยไทยกลุ่มหนึ่งที่มีฟันหน้าสบเปิดร่วมกับโครงสร้างขากรรไกรแนวดิ่งแบบเปิดโดยใช้โคนบีมคอมพิวเตดโทโมกราฟฟี

วัสดุอุปกรณ์และวิธีการ: ภาพรังสีโคนบีมคอมพิวเตดโทโมกราฟฟีของฟันแท้ในขากรรไกรบนซึ่งถูกจัดกลุ่มตามชนิดของฟัน จากผู้ป่วยไทย (อายุ 15-30 ปี) จำนวน 18 ราย ถูกคัดเลือก แบบจำลองฟันสามมิติถูกสร้างขึ้นโดยใช้โปรแกรมมิมิค รีเสิร์ช เวอร์ชั่น 17.0 รอยต่อระหว่างเคลือบฟันและเคลือบรากฟันถูกกำหนดขึ้น พื้นที่ผิว

Abstract

Objective: To assess the root surface areas of maxillary permanent teeth in a group of Thai patients exhibiting anterior open bite with open vertical configuration using cone-beam computed tomography (CBCT)

Materials and Methods: CBCT images of maxillary permanent teeth, categorized by tooth type (maxillary third molars were excluded) from 18 patients (age ranged from 15.0 to 30.0 years) were selected. Three-dimensional tooth models were

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รากฟันถูกคำนวณแบบอัตโนมัติโดยใช้โปรแกรม 3-เมติก รีเสิร์จ เวอร์ชั่น 9.0 ค่าเฉลี่ยของพื้นที่ผิวรากฟันระหว่างชนิดของฟันถูกเปรียบเทียบโดยใช้การวิเคราะห์ความแปรปรวนแบบทางเดียวร่วมกับการเปรียบเทียบเชิงพหุคูณ (**p**<0.05)

ผลการศึกษา: ค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของพื้นที่ผิวรากฟันแท้ในขากรรไกรบนถูกจัดเรียงจากมากไปน้อยดังนี้ ฟันกรามบนซี่ที่หนึ่ง (452.40±65.75 มม) ฟันกรามบนซี่ที่สอง (379.85±79.71 มม) ฟันกรามน้อยบนซี่ที่สอง (245.52±44.03 มม) ฟันเขี้ยวบน (244.80±54.11 มม^2) ฟันกรามน้อยบนซี่ที่หนึ่ง (232.22±39.95มม^2) ฟันตัดบนซี่กลาง (182.70±27.80 มม^2) และฟันตัดบนซี่ข้าง (163.29±24.42 มม^2) ตามลำดับ โดยพบความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างชนิดของฟัน

บทสรุป: การวัดพื้นที่ผิวรากฟันแท้ในขากรรไกรบนโดยใช้โคนบีมคอมพิวเตดโทโมกราฟฟี พบว่าฟันกรามบนซี่ที่หนึ่งมีพื้นที่ผิวรากฟันมากที่สุด และฟันตัดบนซี่ข้างมีพื้นที่ผิวรากฟันน้อยที่สุด

คำสำคัญ: พื้นที่ผิวรากฟัน สบฟันเปิด โคนบีมคอมพิวเตดโทโมกราฟฟี

constructed using Mimics Research 17.0 software. The cemento-enamel junction (CEJ) was marked. The root surface area was calculated automatically by 3-Matic Research 9.0 software. The means of root surface areas among tooth types were compared using the one-way analysis of variance (ANOVA) with multiple comparisons (**p**< 0.05).

Results: Means and standard deviations of root surface areas of maxillary permanent teeth were arranged in descending order as maxillary first molar (452.40±65.75 mm), maxillary second molar (379.85±79.71 mm), maxillary second premolar (245.52±44.03 mm), maxillary canine (244.80±54.11 mm^2), maxillary first premolar (232.22±39.95 mm^2), maxillary central incisor (182.70±27.80 mm^2) and maxillary lateral incisor (163.29±24.42 mm^2), respectively. Statistically significant differences among tooth types were found.

Conclusions: The root surface area measurement of maxillary permanent teeth, using CBCT measuring method, showed that the maxillary first molar had the greatest root surface area and the maxillary lateral incisor had the least.

Keywords: root surface area, open bite, cone-beam computed tomography

Introduction

Root surface area (RSA), or the contact area of dental root with the surrounding bone, plays an important role in orthodontic treatment, as well as in prosthodontic treatment and periodontal therapy. The RSA of a tooth to be move is vital in determining proper force magnitude and in justifying the biological response during orthodontic tooth movement, especially during orthodontic intrusion. If the heavy force is applied, the heavy pressure to periodontal ligament (PDL) is produced. This might lead to hyalinization of PDL, delayed tooth movement and root resorption. Moreover, RSA has also been associated with the anchorage value of teeth.

Previous root surface area measuring methods have been categorized as follows: (1) the membrane method, (2) the weighting conversion method and (3) the division planimetry method. The above-mentioned methods show some disadvantages such as inaccuracy, non-precision, complicated measuring procedure and need for tooth extraction prior to root surface area measurement.[1] Hence, three-dimensional (3-D) radiographs were applied to determine the RSA. Gu *et al*.[2] applied 3D radiographs from a micro-computed tomography (Micro-CT) to measure RSA of extracted permanent teeth with root variations. Nevertheless, the RSA of vital teeth which is important for orthodontic treatment cannot be measured using any of these methods.

Recently, Cone Beam Computed Tomography (CBCT) has been applied to investigate 3-D tooth morphology because of its sub-millimeter resolution and non-destructive nature. CBCT reduced acquisition time and required lower irradiation doses.[3,4] The 3-D human tooth models could be constructed and might be applied to determine the RSA of the human vital or non-extracted teeth. Tasanapanont *et al*.[5] presented a novel CBCT approach for measuring RSA, and suggested that this technique could be used to assess the RSA of non-extracted teeth.

The anterior open bite might be classified into dental open bite and skeletal open bite. Orthodontic tooth movement including maxillary anterior tooth extrusion, maxillary posterior tooth intrusion or the combination of the two might be suitable for the correction of the dental open bite or mild skeletal open bite. Some studies[6,7] reported that long-faced patients were associated with low bite force. The low bite force might affect tooth form such as crown size, enamel thickness and microstructure, occlusal topography, and dental root size and shape.[8] The RSA of these patients is vital in determining proper force magnitude during orthodontic treatment. However, there was no report concerning RSA of maxillary permanent teeth using CBCT measuring method, especially in Thai patients. The aim of this study was to assess the RSA of maxillary permanent teeth in a group of Thai patients exhibiting anterior open bite with open vertical skeletal configuration using CBCT.

Materials and Methods

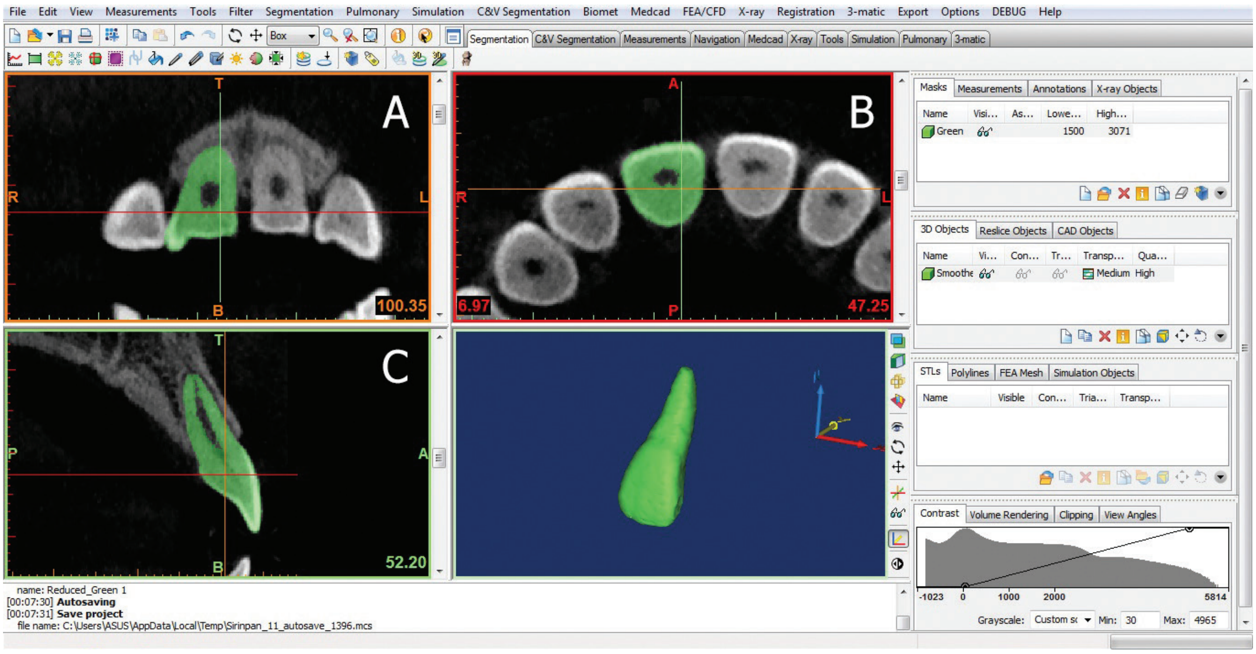
Subjects and image acquisition

This study was approved by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University (NO.53/2016). In this retrospective study, the subjects were Thai orthodontic patients, who required pretreatment CBCT images and had met the following inclusion criteria: 1) age from 15.0 to 30.0 years; 2) a Class I malocclusion with anterior open bite (overbite < 0 mm); 3) Class I sagittal skeletal relationship (ANB angle = $2° \pm 2°$); 4) an open vertical skeletal configuration; 5) complete root formation of permanent teeth (except for third molars); 6) no root resorption; 7) absence of radiographic signs of severe periodontitis or periapical lesions; 8) no history of previous orthodontic treatment; 9) no evidence of craniofacial malformations.

The subjects were categorized into open vertical skeletal configuration according to the following six cephalometric measurements: 1) SN-GoGn angle; 2) SN-PP angle; 3) PP-GoGn angle; 4) Gonial angle; 5) Facial index; 6) ratio of posterior to anterior face height. The open vertical skeletal configuration was chosen when the configuration was confirmed by three or more of those cephalometric measurements. CBCT images of maxillary permanent teeth, categorized by tooth type (maxillary third molars were excluded) from 18 patients (mean age 19.0 ± 3.1 years) were produced using a ProMax 3D (Planmeca OY, Helsinki, Finland) machine at 84 kVp, 10 mA, an 8 cm×8 cm field of view and a voxel size of 0.16 mm.

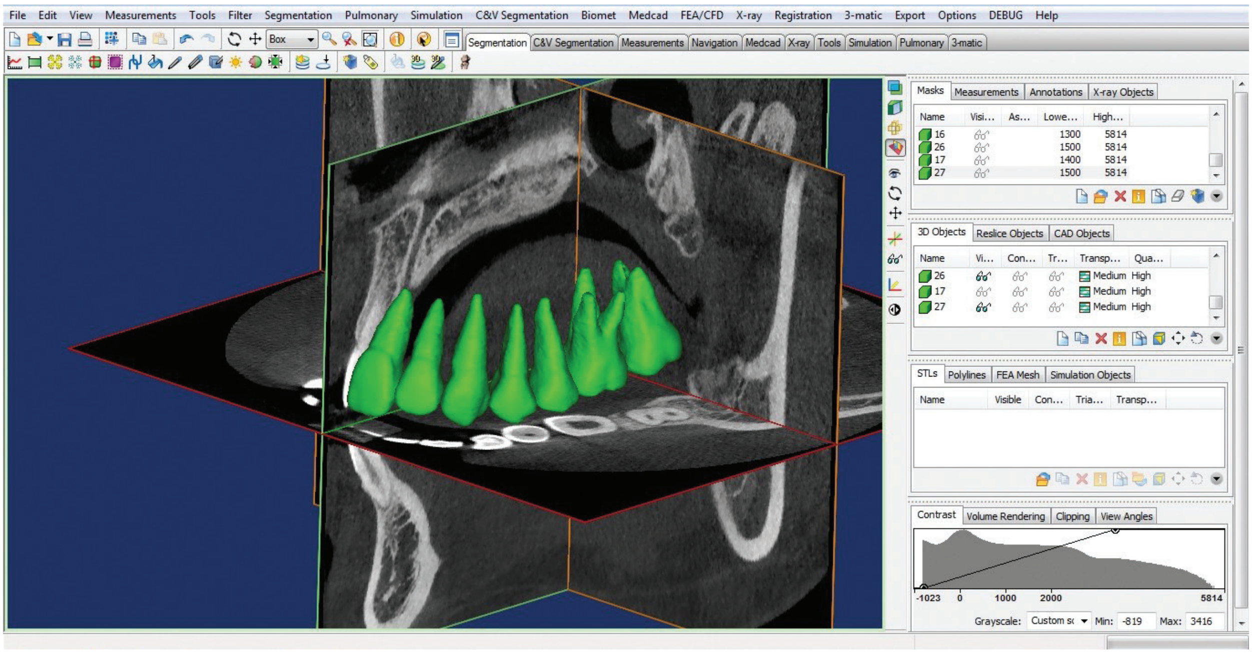
Measurement of the root surface area

The patients' digital imaging and communications in medicine (DICOM) files, obtained by CBCT, was converted to the stereolithography (STL) format using Mimics Research 17.0 software (Materialise, Leuven, Belgium). To reconstruct the areas of interest, we first predefined the threshold value for the tooth region. The outer boundaries of tooth morphology in 2-D images were identified by each slice orientation and section manually (Figure 1). When the "Calculate 3-D" function was selected, the 3-D tooth models were constructed (Figure 2). The cemento-enamel junction (CEJ) was marked, and RSA of each tooth was calculated automatically by 3-Matic Research 9.0 software (Materialise, Leuven, Belgium) (Figure 3). If the CEJ was difficult to identify, the intentional extension spine markings were constructed from 2-D images (Figure 4). The CEJ on each section was marked. Then the CEJ of the 3-D tooth model was easily identified, and used for calculation of the RSA. To test the intra-examiner reliability, all CBCT images were re-measured by the same examiner after a four-week interval.



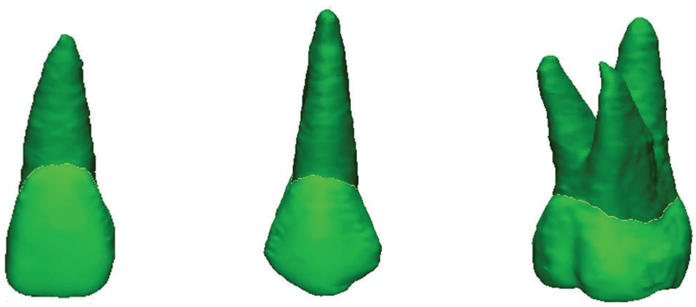
รูปที่ 1 *การกำหนดขอบเขตรูปร่างของฟันในแต่ละภาพจากภาพรังสีสองมิติ (A) ภาพระนาบแบ่งหน้าหลัง (B) ภาพระนาบตามแกน และ (C) ภาพระนาบแบ่งซ้ายขวา*

Figure 1 *Identification of tooth morphology on 2-D images of each slice orientation (A) coronal view; (B) axial view; and (C) sagittal view*



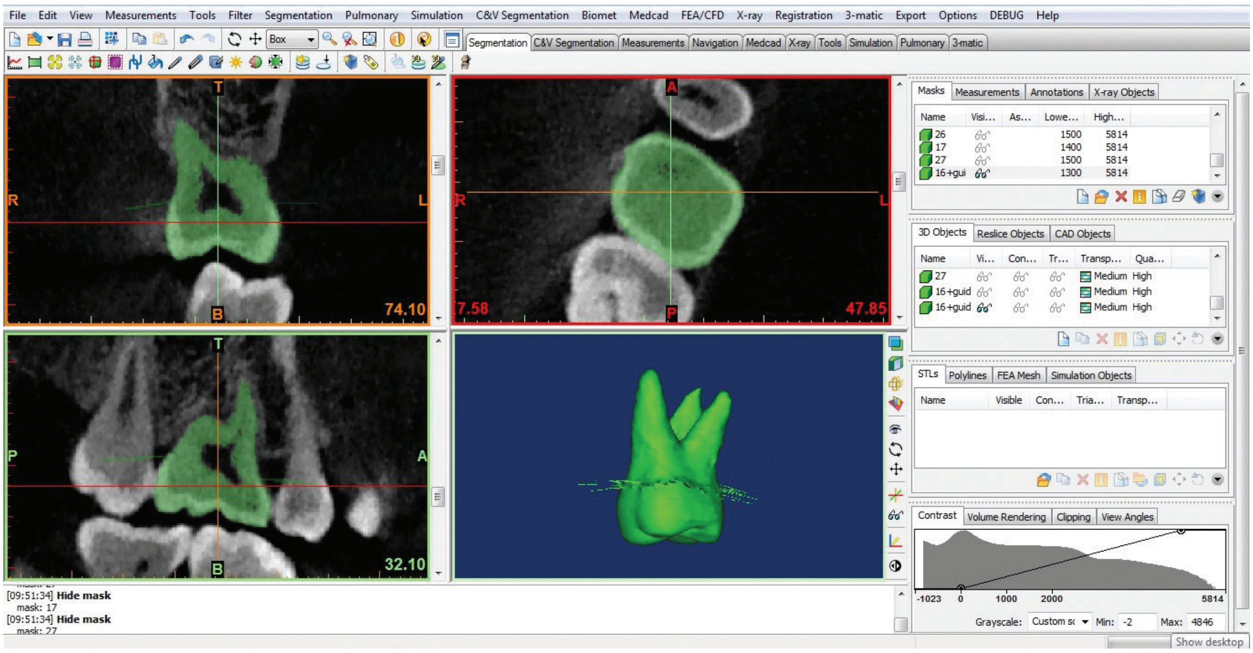
รูปที่ 2 *การสร้างแบบจำลองฟันสามมิติ*

Figure 2 *Construction of the 3-D tooth models*



รูปที่ 3 *การกำหนดแนวรอยต่อระหว่างเคลือบฟันและเคลือบรากฟัน และการคำนวณพื้นที่ผิวรากฟัน*

Figure 3 *Identification of cemento-enamel junction (CEJ) and calculation of root surface area*



รูปที่ 4 *การสร้างส่วนยื่นเพื่อกำหนดแนวรอยต่อระหว่างเคลือบฟันและเคลือบรากฟัน*

Figure 4 *Construction of the intentional extension spine markings for identification of the cemento-enamel junction (CEJ)*

Statistical analysis

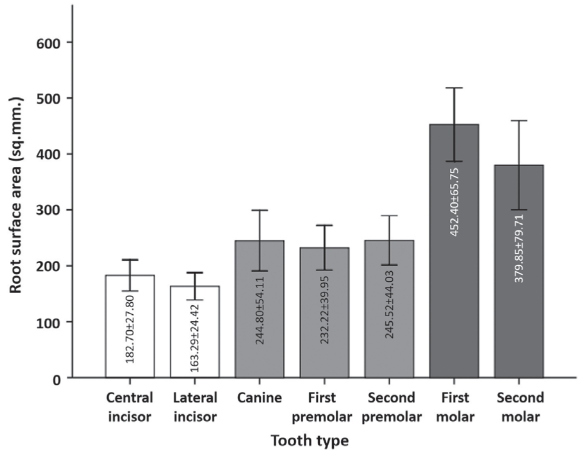
Data were analyzed using SPSS 22.0 (SPSS Inc., Chicago, Ill., USA). The means and standard deviations of the root surface area were measured. The root surface areas between tooth types were compared using the one-way analysis of variance (ANOVA) with multiple comparisons. p values < 0.05 indicated statistical significance. The intra-class correlation coefficient (ICC) was used to assess the intra-examiner reliability.

Results

The intra-examiner reliability test for measurement of the root surface area showed high intra-class correlation (r = 0.999) and suggested high reliability in measurement. The root surface area measurements were normally distributed, and had no statistical difference between the left and right sides. Therefore, the measurements from both sides were pooled for statistical analysis.

The means and standard deviations of the root surface areas of maxillary permanent teeth were arranged in descending order as maxillary first molar (452.40±65.75 mm^2), maxillary second molar (379.85±79.71 mm^2), maxillary second premolar (245.52±44.03 mm^2), maxillary canine (244.80±54.11 mm^2), maxillary first premolar (232.22±39.95 mm^2), maxillary central incisor (182.70±27.80 mm^2) and maxillary lateral incisor (163.29±24.42 mm^2), respectively, as shown in Figure 5.

The comparisons of the root surface areas of maxillary permanent teeth had no significant difference between the central incisor and the lateral incisor (p = 0.787), the canine and the first premolar (p = 1.0), the first premolar and the second premolar (p = 1.0), the canine and the second premolar (p = 1.0) and the first molar and the second molar (p = 0.108), as shown in Figure 5.



รูปที่ 5 *แผนภูมิแท่งแสดงค่าเฉลี่ยและส่วนเบี่ยงเบนมาตรฐานของพื้นที่ผิวรากฟันหน้าบนซี่กลางถึงฟันกรามบนซี่ที่สอง*

Figure 5 *Bar graph demonstrating the means and standard deviations of the root surface areas of the maxillary central incisor to the maxillary second molar*

Discussion

The root surface areas of maxillary permanent teeth, shown in previous studies[9-11], showed pattern in descending order as maxillary first molar, maxillary second molar, maxillary canine, maxillary first premolar, maxillary second premolar, maxillary central incisor and maxillary lateral incisor, respectively. The maxillary first molar had the greatest root surface area and the maxillary lateral incisor had the least. It should be noted that the maxillary second premolar, in our CBCT-based investigation, had the third greatest root surface area (or greater than maxillary canine, maxillary first premolar and maxillary incisors).

Normal occlusal loading and function is responsible for normal development of alveolar bone and dental roots. Occlusal hypofunction decreases alveolar bone mass, accelerates bone resorption and causes deficient root development.[12] In addition, it leads to atrophic changes in the periodontal ligament, such as narrowing of the periodontal space, vascular constriction and deformation of the mechanoreceptors.[13,14] According to experimental findings in rat molars, external root resorption during tooth movement was seen in associated with hypofunction. The hypofunctional periodontium exhibited progressive atrophic changes in all functional structures.[15] Several previous studies[16,17] reported that anterior open bite had a tendency toward developing short dental roots form the incisors to the premolars that can be associated with occlusal hypofunction. The open-bite malocclusion and occlusal hypofunction plays an important role in dental root morphology, leading to the risk of root resorption during tooth movement.[18,19]

The open-bite malocclusion and occlusal hypofunction might affect root surface area. The root surface area of anterior teeth in patients with anterior open bite might be decrease and should be further investigated. For further study, the root surface area of patients exhibiting normal anterior overbite and of those exhibiting anterior open bite should be compared. Furthermore, the root surface area in patients with different sagittal skeletal relationship should be also further investigated.

Conclusions

The root surface area measurement of maxillary permanent teeth, using CBCT measuring method, showed that the maxillary first molar had the greatest root surface area and the maxillary lateral incisor had the least.

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