การประเมินพื้นที่ผิวรากฟันของฟันแท้บนในผู้ป่วยไทยที่มีภาวะปากแหว่งเพดานโหว่ข้างเดียวแบบสมบูรณ์โดยใช้ภาพรังสีโคนบีมคอมพิวเตดโทโมกราฟฟี

Assessment of Root Surface Areas of Maxillary Permanent Teeth in Thai Patients with Complete Unilateral Cleft Lip and Palate Using Cone Beam Computed Tomography

เนาวรัตน์ แสนจันดี[1], มารศรี ชัยวรวิทย์กุล[2], ธีระวัฒน์ โชติกเสถียร[2], อภิรุม จันทร์หอม[3], ปฏิยุทธ ศรีวิลาศ[4]
[1]นักศึกษาระดับบัณฑิตศึกษา สาขาวิชาทันตกรรมจัดฟัน คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่
[2]ภาควิชาทันตกรรมจัดฟันและทันตกรรมสำหรับเด็ก คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่
[3]ภาควิชาชีววิทยาช่องปากและวิทยาการวินิจฉัยโรคช่องปาก คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่
[4]ภาควิชารังสีวิทยา คณะแพทยศาสตร์ศิริราชพยาบาล มหาวิทยาลัยมหิดล
Naowarat Saenjandee[1], Marasri Chaiworawitkul[2], Dhirawat Jotikasthira[2], Apirum Janhom[3], Patiyut Sriwilas[4]
[1]Graduate student, Division of Orthodontics Dentistry, Faculty of Dentistry, Chiang Mai University
[2]Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University
[3]Department of Oral Biology and Diagnostic Sciences, Faculty of Dentistry, Chiang Mai University
[4]Department of Radiology, Faculty of Medicine, Siriraj Hospital, Mahidol University

ชม. ทันตสาร 2563; 41(3) : 31-41
CM Dent J 2020; 41(3) : 31-41

Received: 15 November, 2019
Revised: 14 February, 2020
Accepted: 10 April, 2020

บทคัดย่อ

วัตถุประสงค์: การศึกษานี้มีวัตถุประสงค์เพื่อประเมินและเปรียบเทียบพื้นที่ผิวรากฟันของฟันแท้บนในผู้ป่วยไทยที่มีภาวะปากแหว่งเพดานโหว่ข้างเดียวแบบสมบูรณ์โดยใช้ภาพรังสีโคนบีมคอมพิวเตดโทโมกราฟฟี

วัสดุและวิธีการ: ภาพรังสีโคนบีมคอมพิวเตดโทโม

Abstract

Objective: To assess and compare the root surface areas of the maxillary permanent teeth between the cleft and the non-cleft sides in Thai patients with complete unilateral cleft lip and palate, using cone beam computed tomography.

Corresponding Author:

มารศรี ชัยวรวิทย์กุล
รองศาสตราจารย์ ภาควิชาทันตกรรมจัดฟันและทันตกรรมสำหรับเด็ก
คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่ 50200

Marasri Chaiworawitkul
Associate Professor, Department of Orthodontics and Pediatric Dentistry, Faculty of Dentistry, Chiang Mai University, Chiang Mai 50200, Thailand
E-mail: ***dr.marasri@gmail.com***

กราฟฟีของฟันแท้บนจำนวน 216 ภาพ จากผู้ป่วยไทยที่มีภาวะปากแหว่งเพดานโหว่ข้างเดียวแบบสมบูรณ์จำนวน 20 ราย (อายุเฉลี่ย 10.50 ± 2.24 ปี) ถูกนำมาใช้ในการสร้างแบบจำลองฟันสามมิติด้วยโปรแกรมมิมิค รีเสิร์ช เวอร์ชั่น 15.01 รอยต่อระหว่างเคลือบฟันและเคลือบรากฟันถูกกำหนดขึ้นและพื้นที่ผิวรากฟันแต่ละซี่ถูกคำนวณแบบอัตโนมัติด้วยโปรแกรมทรีเมติก รีเสิร์ช เวอร์ชั่น 7.01 ค่ามัธยฐานของพื้นที่ผิวรากฟันของฟันแท้บนในฟันแต่ละประเภทจากด้านที่มีภาวะปากแหว่งเพดานโหว่และด้านที่ไม่มีภาวะปากแหว่งเพดานโหว่ถูกนำมาเปรียบเทียบโดยใช้สถิติไม่อิงพารามิเตอร์วิลคอกซัน ($p < 0.05$)

ผลการศึกษา: พื้นที่ผิวรากฟันของฟันตัดบนซี่กลาง ฟันเขี้ยว ฟันกรามน้อยซี่ที่หนึ่ง ฟันกรามน้อยซี่ที่สองและฟันกรามแท้ซี่ที่หนึ่งในด้านที่มีภาวะปากแหว่งเพดานโหว่มีค่ามัธยฐานน้อยกว่าด้านที่ไม่มีภาวะปากแหว่งเพดานโหว่อย่างมีนัยสำคัญทางสถิติ พื้นที่ผิวรากฟันของฟันตัดบนซี่ข้างสี่ซี่ที่เหลือในด้านที่มีภาวะปากแหว่งเพดานโหว่มีค่ามัธยฐานของน้อยกว่าด้านที่ไม่มีภาวะปากแหว่งเพดานโหว่อย่างไม่มีนัยสำคัญทางสถิติ

บทสรุป: พื้นที่ผิวรากฟันของฟันแท้บนด้านที่มีภาวะปากแหว่งเพดานโหว่มีค่าน้อยกว่าด้านที่ไม่มีภาวะปากแหว่งเพดานโหว่ในผู้ป่วยไทยที่มีภาวะปากแหว่งเพดานโหว่ข้างเดียวแบบสมบูรณ์

คำสำคัญ: ปากแหว่งเพดานโหว่ โคนบีมคอมพิวเตดโทโมกราฟฟี พื้นที่ผิวรากฟัน สามมิติ

Materials and Methods: Two hundred and sixteen cone beam computed tomographic images of maxillary permanent teeth from 20 Thai patients with unilateral cleft lip and palate (mean age: 10.50 ± 2.24 years) were used to construct three-dimensional tooth models with the Mimics Research 15.01 software. The cemento-enamel junction was identified, and the root surface areas of each tooth type was calculated automatically by the 3-Matic Research version 7.01 software. The median root surface areas of each tooth type from the cleft and non-cleft sides were compared using the non-parametric Wilcoxon matched pairs signed rank test ($p < 0.05$).

Results: The median root surface areas of maxillary central incisors, maxillary canines, first premolars, second premolars and first molars on the cleft side in Thai patients with complete unilateral cleft lip and palate were significantly less than those on the non-cleft side. The median root surface area of the four remaining maxillary lateral incisors on the cleft side was less than on the non-cleft side but the difference was not statistically significant.

Conclusions: The root surface areas of the maxillary permanent teeth were less on the cleft side than those on the non-cleft side in Thai patients with complete unilateral cleft lip and palate.

Keywords: cleft lip and palate, cone-beam computed tomography, root surface area, three-dimensional

Introduction

Orofacial cleft is a common congenital craniofacial malformation of the craniofacial region.[1-3] The etiology of cleft lip and palate (CLP) is multifactorial, involving environmental and genetic factors.[1-3] CLP affects not only craniofacial growth, but also the dentition. Previous studies have revealed a higher prevalence of dental anomalies, such as anomalies in number, shape, size, developing time, eruption, and root formation in children with cleft lip (CL), cleft palate (CP), or both, than in other children.[4-7] A common dental anomaly in patients with CLP is tooth agenesis, particularly congenital absence of the maxillary lateral incisors.[4-7] Delayed tooth development in patients with CLP has also been reported.[8-10] Studies on root development have focused on root length and volume; however, few studies have focused on the root surface area (RSA).[8,11-15] Root surface area reflects the root morphology, including root length, root size and root shape. It has an impact on the management of anchorage and on optimal force magnitude.[16,17] The assessment of RSA has been conducted using various methods, e.g., the membrane method, weighting conversion, division planimetry and computerized image analysis of two-dimensional (2-D) radiographs.[18,19]

Nowadays, cone beam computed tomography (CBCT) has become widely used in dentistry, because it provides numerous advantages in comparison with conventional CT images. Also, the CBCT images are obtained at a faster rate and require less radiation dose, because this technology allows customized settings.[20,21] Moreover, it enables the construction of accurate three-dimensional (3-D) images, and can be applied with other software to create 3-D mathematical models of teeth. As a result, CBCT has been used to determine the RSA of vital teeth.[22,23] The objective of this study was to assess the effect of the CLP anomaly on root development and to compare the RSA of the maxillary permanent teeth between the cleft and the non-cleft sides in patients with complete unilateral cleft lip and palate (UCLP).

Materials and Methods

Subjects and image acquisition

This study was approved by the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University, Thailand (No. 46/2018). Informed consent was obtained from all patients and their parents before CBCT images were recorded. The sample consisted of 216 images of maxillary permanent teeth from 20 CBCT images of Thai patients with complete UCLP (12 male and 8 female: age range, eight - 15 years: mean age: 10.50 ± 2.24 years), categorized by tooth type: central incisor, lateral incisor, canine, first premolar, second premolar, and first molar. The second and third molars were excluded because of their root variation. The pre-treatment CBCT images were recorded using a Sirona XG 3-D CBCT unit (ORTHOPHOS® XG 3D, Bensheim, Germany) at 90 kV, 12 mA, a 12.5x12.5-cm field of view, and a voxel size of 0.1 mm. All patients required CBCT imaging before bone grafting and had met the following inclusion criteria: 1) Thai patients with complete ULCP aged from eight to 15 years; 2) mixed or permanent dentition; 3) history of previous lip repair and palatal closure treatment and exclusion criteria 1) history of trauma, systemic disease or previous orthodontic treatment; 2) no root restoration, marked caries, severe attrition or periapical lesions

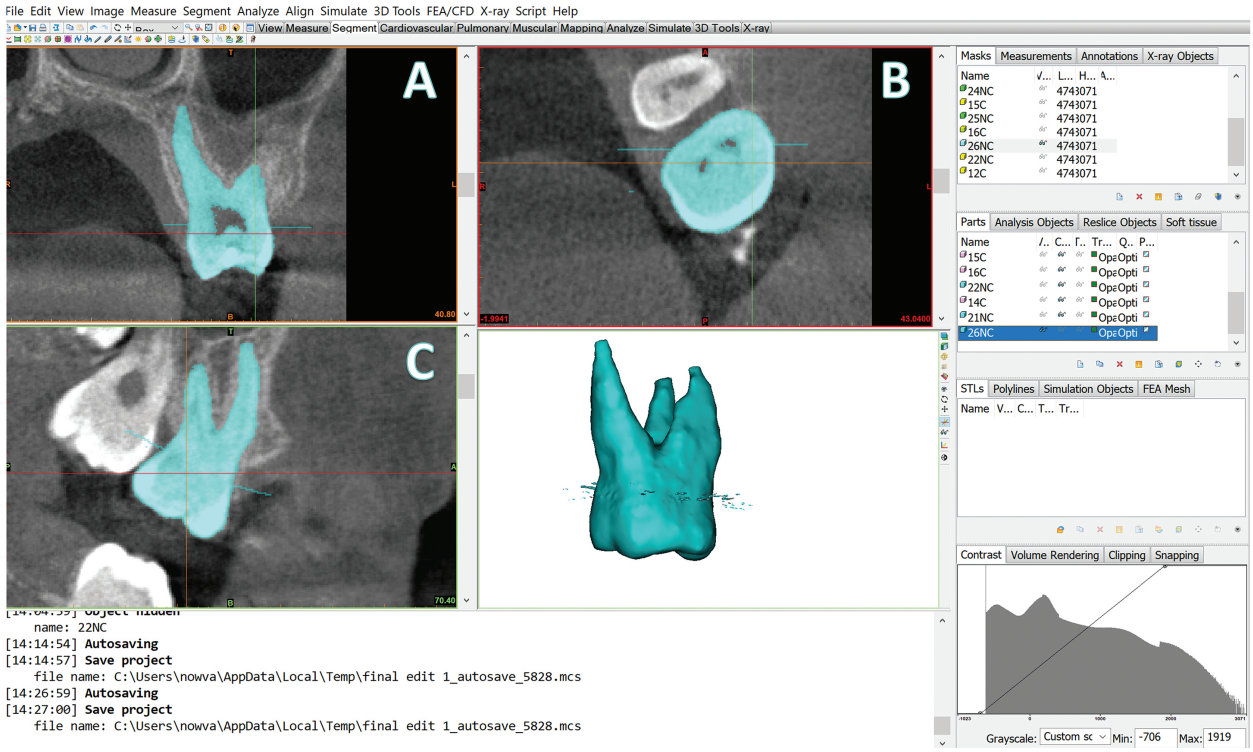
Measurements of the root surface areas

Following the method of Tasanapanont, *et al.*[23] the digital imaging and communications in medicine (DICOM) files of all subjects obtained from CBCT were imported and converted to the stereolithography (STL) format, using Mimics Research 15.01 software (Materialise, Leuven, Belgium). The thresh-

old values for the tooth regions were predefined to reconstruct only the areas of interest. A new mask was created and cropped in all three planes. Details of tooth morphology in the 3-D images were manually defined, slice by slice, for segmentation to separate the tooth from the surrounding structures (Figure 1). Intentional extension spine markings were constructed at the cemento-enamel junction (CEJ) on each slide to facilitate the visualization of the CEJ location on the 3-D dental models (Figure 2). The 3-D dental model was created when the "Calculate 3-D" icon (Figure 3) was selected. The 3-D dental model was then imported into the 3-matic Research 7.01 software (Materialise). The CEJ of each tooth was identified, and the RSA of each tooth was calculated automatically. (Figure 4).

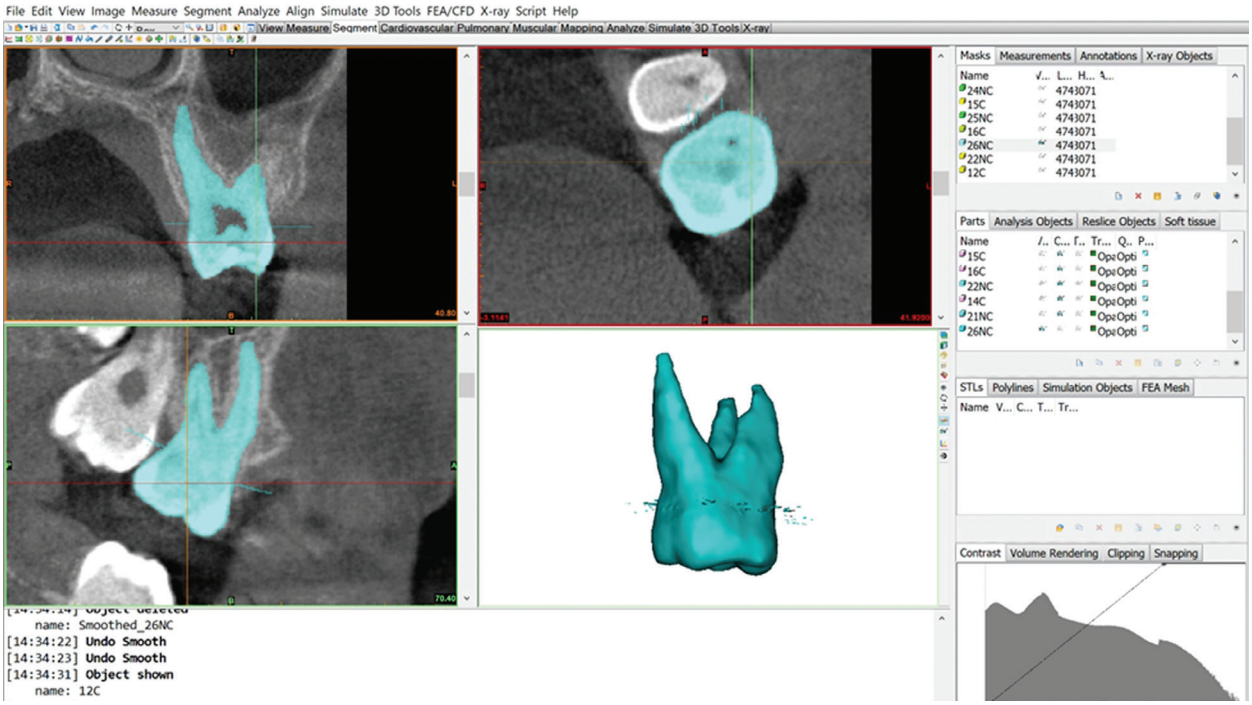
Statistical analysis

The Statistical Package for Social Sciences (SPSS) version 22.0 for Windows (SPSS Inc., Chicago, Illinois, USA) was used to calculate the results. Method reliability was tested by randomly selecting CBCT images of six maxillary permanent teeth of each tooth type (except second and third molars) and re-measuring by the same examiner (General dentist has much experience for assess CBCT) after a four-week interval. The intra-examiner reliability was assessed using the intra-class correlation coefficient (ICC). The Shapiro-Wilk test was used to test the normality of all data. The differences in RSA of maxillary permanent teeth between the cleft side and the non-cleft side were compared using the non-parametric Wilcoxon matched pairs signed ranks test. The results were considered statistically significant at $p<0.05$.



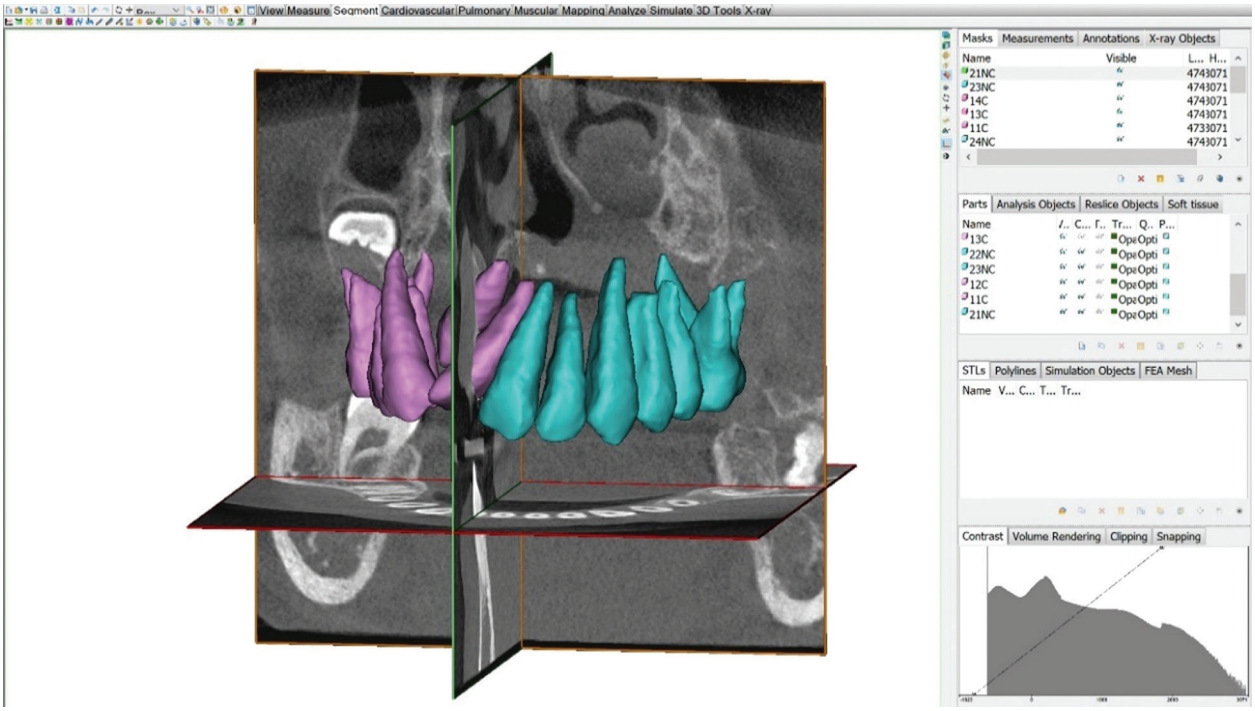
รูปที่ 1 *การกำหนดขอบเขตรูปร่างของฟันจากภาพรังสีสามมิติในแต่ละชั้นด้วยโปรแกรมมิมิค รีเสิร์ช เวอร์ชั่น 15.01 (A) ภาพระนาบแบ่งหน้าหลัง (B) ภาพระนาบตามแกน และ (C) ภาพระนาบแบ่งซ้ายขวา*

Figure 1 *Identification of tooth morphology on 3-D images of each slice orientation using Mimics Research 15.01 software. (A) Coronal view; (B) Axial view, and (C) Sagittal view,*



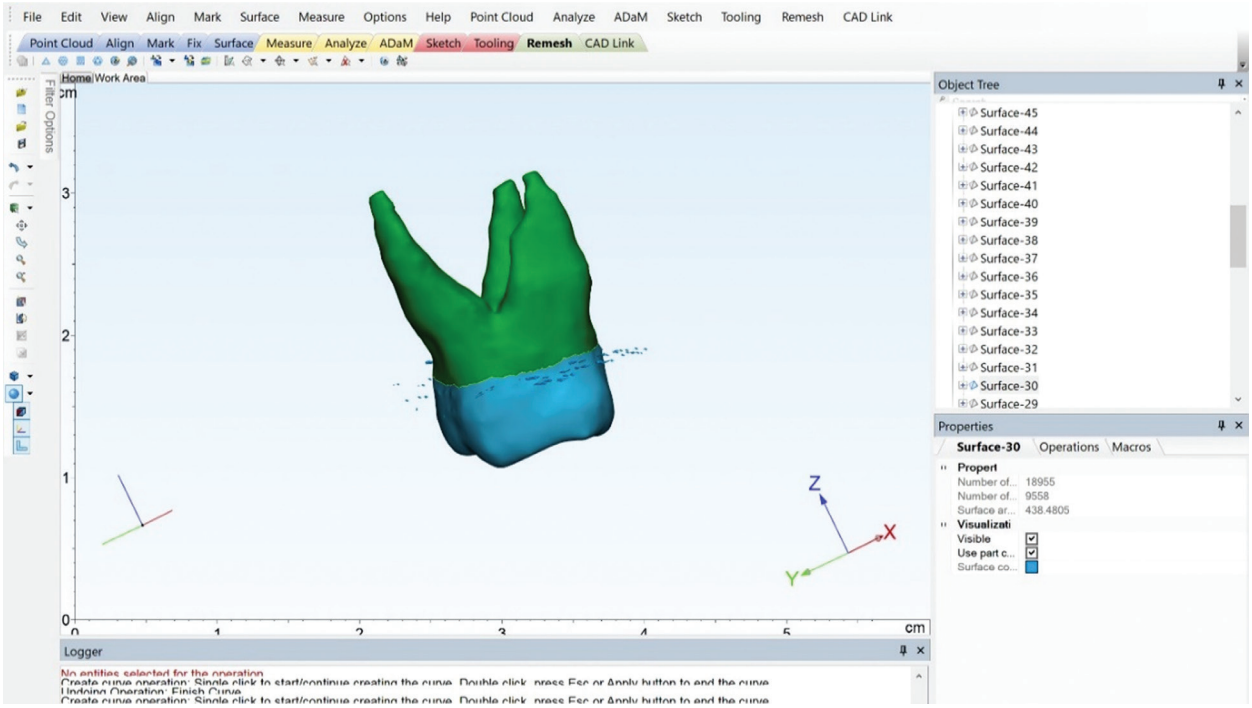
รูปที่ 2 *ส่วนยื่นถูกสร้างขึ้นเพื่อการกำหนดเส้นตามแนวรอยต่อระหว่างเคลือบฟันและเคลือบรากฟัน*

Figure 2 *Intentional extension spine markings were constructed by marking the CEJ in the 3-D images on each section.*



รูปที่ 3 *การสร้างแบบจำลองฟันสามมิติ*

Figure 3 *Construction of a 3-D dental model.*



รูปที่ 4 *กำหนดแนวรอยต่อระหว่างเคลือบฟันและเคลือบรากฟันบนแบบจำลองฟันสามมิติและการคำนวณพื้นที่ผิวรากฟันแต่ละซี่ด้วยโปรแกรมทรีเมติก รีเสิร์ช เวอร์ชั่น 7.01*

Figure 4 *The CEJ was identified on the 3-D dental model and the RSA of each tooth was calculated, using the 3-matic Research 7.01 software.*

Results

An intra-examiner reliability test for measurement of the RSA showed a high intra-class correlation (r = 0.998), indicating a high level of reproducibility in the RSA measurement.

The prevalence of the maxillary lateral incisor with congenital absence, bilateral congenital absence, and unilateral congenital absence were 80.0%, 40.0%, and 40.0% respectively. as shown in Table 1

The medians of the RSA of the maxillary central incisor, canine, first premolars, second premolar, and first molars on the cleft side were significantly less than those on the non-cleft side, as shown in table 2. The median RSA of the four remaining maxillary lateral incisors on the cleft side was also less than on the non-cleft side but the difference was not statistically significant. (p = 0.068), (n=4)

Discussion

The most common dental anomaly in patients with CLP reported in numerous previous studies is tooth agenesis, particularly the congenital absence of the maxillary lateral incisors on both cleft side and non-cleft sides.[4-7,10,13,24-27] In this study, the prevalence of congenitally absent maxillary lateral incisors was 80.0%, a finding which agrees with the findings of other studies.[7,24,26]

The results demonstrate that the RSAs of maxillary permanent teeth of each tooth type on the cleft side were less than those of their counterparts on the non-cleft side in patients with UCLP. The asymmetrical root development was also previously mentioned by other authors who used different comparative methods, such as the predefined root development rating systems[2,12,28-30], measured root length from 2-D radiographs[31], measured crown height, root length and full length from CBCT[15] and measured

ตารางที่ 1 *จำนวน (N) และความชุก (กลุ่มตัวอย่างทั้งหมด) ของการหายไปแต่กำเนิดของฟันตัดซี่ข้างตามด้านที่เป็น*

Table 1 *Number (N) and prevalence (total the subjects) of congenital absence of the maxillary lateral incisor located by region*

Cleft region		Prevalence	
		N	Percentage
Bilateral congenital absence		8	40.0%
Unilateral congenital absence	Cleft side	8	
	Non-cleft side	0	40.0%
Total		16	80.0%

ตารางที่ 2 *ค่ามัธยฐานและการเปรียบเทียบพื้นที่ผิวรากฟันของฟันแท้บนระหว่างด้านที่มีภาวะปากแหว่งเพดานโหว่และพื้นที่ผิวรากฟันของฟันแท้ที่อยู่ตรงข้ามในด้านที่ไม่มีภาวะปากแหว่งเพดานโหว่*

Table 2 *The comparisons of the RSA of the maxillary permanent teeth on the cleft side and those of its counterpart on the non-cleft side in Thai patients with complete UCLP.*

Group	Cleft side	Non-cleft side	*p* value [a]
	Median (IQR)	Median (IQR)	
Central incisor	**181.48** (29.77)	**192.28** (34.76)	**<0.001***
Lateral incisor	**123.50** (119.61)	**168.42** (49.84)	**0.068**
Canine	**198.29** (59.85)	**201.71** (83.07)	**0.007***
First premolar	**176.67** (83.77)	**202.76** (82.44)	**0.005***
Second premolar	**146.05** (65.44)	**165.12** (98.21)	**0.040***
First molar	**369.56** (79.73)	**392.79** (67.23)	**<0.001***

Differences between groups was derived from the root surface area of Non-cleft side group minus that of the cleft side group.

[a] Significance levels: * $p<0.05$

(Wilcoxon matched pairs signed ranks test)

root volume from CBCT.[11] Many previous studies revealed that the root development of permanent maxillary anterior teeth next to the cleft area was more delayed than on the non-cleft side, especially the lateral incisor, followed by the central incisor and canine respectively.[12,15,32] However, this study has limitation in the calculation of the validity of the RSA measurement for the maxillary lateral incisors due to congenital missing of this tooth which was detected in 80 per cent of the total subjects lead to not statistically insignificant and the maxillary central incisor on the cleft side was the most delayed. This finding might not imply that the CLP anomaly did not affect the RSA of the maxillary lateral incisors, because the CLP anomaly was so affected that this tooth missed. Besides, asymmetric root development was likewise involved with maxillary posterior teeth that were far from the cleft region. Delayed root development of premolars and molars on the cleft side has also been demonstrated in other studies.[12,32] Nevertheless, the small size of the subjects was limitation which had an impact on being unable to divide the age range to find the relation of RSA in each tooth of maxillary teeth on both sides. The patients with CLP especially who had the permanent dentition and were qualified by the inclusion and exclusion criteria without orthodontic treatment history were a rare case. As a result, for explicit result in this patient group, further study should be performed.

Etiological factors in the agenesis of the lateral incisor and in delayed dental development are not well understood but such factors could be associated with the same etiological factors in the development of the cleft.[32,33] Genetics is such an etiological

factor[29,30,32], as are prenatal damage, maternal factors associated with a defective genotype[10,34], postnatal environmental factors such as postnatal surgery[29,30], nutritional factors[32], and lack of bone support.[33]

In many theories, the agenesis of the lateral incisor on the cleft side may be caused by several factors, especially adjacency to the cleft fissure and the effect of post-surgical palatal cleft closure.[35,36] Lack of alveolar bone in the cleft area may cause the absence of the lateral incisor and the division of its bud in the cleft area. The cleft appears before formation of the dental lamina. The cleft may include the precanine section of the oral epithelium and the extension of the dental lamina. Therefore, the cleft may damage the dental lamina, which, normally, should develop into tooth germs. Severe deficiency of mesenchymal mass and blood supply at the cleft site may lead to insufficient mesenchymal support to the tooth bud.[37,38] In term of, surgical treatment for palatal cleft closure seems to be have impact on the agenesis of the lateral incisor on the cleft side than does lack of alveolar bone in the cleft because the procedure is performed at one year of age in patients with CLP, which is during the period of dental hard tissue formation in the permanent teeth, including the maxillary lateral incisor.[39-41]

Ribeiro, *et al*.[2] confirmed that lack of maxillary anterior alveolar bone support on the cleft side as well as scar formation and blood supply deficiency likely to be affected by the postnatal surgery may cause deficient root development of the maxillary anterior teeth adjacent to the cleft. Zhou, *et al.*[31] revealed that a deficient blood supply might decrease cell differentiation and proliferation in the developing root, which could affect root dentine organization during tooth development.

Vastadis, *et al.*[42] however, revealed that agenesis in patients with CLP seems to be controlled by homeobox Msx-1 genes, which are expressed approximately four times more frequently in patients with CLP and tooth agenesis than in patients without clefts. This finding agrees with the findings of previous studies in which both maxillary and mandibular teeth also demonstrated delayed root development, possibly implying that some genetic factors seem to be more important in delayed and asymmetric root development in patients with CLP than are postnatal environmental factors, such as postnatal surgery.[12,15] Thus, further investigations are essential.

This study found decreased RSA in maxillary permanent teeth on the cleft side. Root surface area is an important factor in determining anchorage during tooth movement and is related to optimal orthodontic force magnitudes. Moreover, decreased RSA is related to short root, leading to an increased incidence of root resorption during orthodontic treatment.[43] Decreased RSA also influences the mobility and center of resistance of teeth.[22] Therefore, the findings imply that application of low force magnitudes during tooth movement should be considered, in particular, in patients with CLP, to avoid further feasible complications.

Conclusions

The RSA of maxillary permanent teeth on the cleft side in Thai patients with complete UCLP was less than on the non-cleft side.

Acknowledgements

The authors would like to thank Dr. Thanapat Sastraruji, Faculty of Dentistry, Chiang Mai University for statistical consultation, the Department of Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, for simulation software support and Dr. M. Kevin O Carroll, Professor Emeritus of the University of Mississippi School of Dentistry, U.S.A., and Faculty Consultant at Chiang Mai University Faculty of Dentistry, Thailand, for his assistance in the preparation of the manuscript.

References

1. Dixon MJ, Marazita ML, Beaty TH, Murray JC. Cleft lip and palate: understanding genetic and environmental influences. *Nat Rev Genet* 2011; 12(3): 167-178.
2. Ribeiro LL, Neves LTD, Costa B, Gomide MR. Dental development of permanent lateral incisor in complete unilateral cleft lip and palate. *Cleft Palate Craniofac J* 2002; 39(2): 193-196.
3. Tortora C, Meazzini MC, Garattini G, Brusati R. Prevalence of abnormalities in dental structure, position, and eruption pattern in a population of unilateral and bilateral cleft lip and palate patients. *Cleft Palate Craniofac J* 2008; 45(2): 154-162.
4. Celikoglu M, Buyuk S, Sekerci A, Cantekin K, Candirli C. Maxillary dental anomalies in patients with cleft lip and palate: a cone beam computed tomography study. *J Clin Pediatr Dent* 2015; 39(2): 183-186.
5. Haque S, Alam MK. Common dental anomalies in cleft lip and palate patients. *Malays J Med Sci* 2015; 22(2): 55-60.
6. Lehtonen V, Anttonen V, Ylikontiola L, Koskinen S, Pesonen P, Sándor G. Dental anomalies associated with cleft lip and palate in Northern Finland. *Eur J Paediatr Dent* 2015; 16(4): 327-332.
7. Rullo R, Festa V, Rullo R, et al. Prevalence of dental anomalies in children with cleft lip and unilateral and bilateral cleft lip and palate. *Eur J Paediatr Dent* 2015; 16(3): 229-232.
8. Amarlal D, Muthu M, Kumar NS. Root development of permanent lateral incisor in cleft lip and palate children: a radiographic study. *Indian J Dent Res* 2007; 18(2): 82-86.
9. Brouwers HJ, Kuijpers AM. Development of permanent tooth length in patients with unilateral cleft lip and palate. *Am J Orthod Dentofacial Orthop* 1991; 99(6): 543-549.
10. Ranta R. A review of tooth formation in children with cleft lip/palate. *Am J Orthod Dentofacial Orthop* 1986; 90(1) :11-18.
11. Celebi AA, Ucar FI, Sekerci AE, Caglaroglu M, Tan E. Effects of cleft lip and palate on the development of permanent upper central incisors: a cone-beam computed tomography study. *Eur J Orthod* 2015; 37(5): 544-549.
12. Lai MC, King NM, Wong HM. Dental development of Chinese children with cleft lip and palate. *Cleft Palate Craniofac J* 2008; 45(3): 289-296.
13. Suzuki A, Nakano M, Yoshizaki K, Yasunaga A, Haruyama N, Takahashi I. A longitudinal study of the presence of dental anomalies in the primary and permanent dentitions of cleft lip and/or palate patients. *Cleft Palate Craniofac J* 2017; 54(3): 309-320.
14. Topolski F, Souza RBd, Franco A, Cuoghi OA, Assuncao LRdS, Fernandes A. Dental development of children and adolescents with cleft lip and palate. *Braz J Oral Sci* 2014; 13(4) :319-324.
15. Zhang X, Zhang Y, Yang La, Shen G, Chen Z. Asymmetric dental development investigated by cone-beam computed tomography in patients with unilateral cleft lip and alveolus. *Cleft Palate Craniofac J* 2016; 53(4): 413-420.
16. Oppenheim A. Tissue changes, particularly of the bone, incident to tooth movement. *Eur J Orthod* 2007; 29(suppl 1): 2-15.
17. Schwarz AM. Tissue changes incidental to orthodontic tooth movement. *Int J Orthod* 1932; 18(4): 331-352.

18. Chen SK, Chen CM, Jeng JY. Calculation of simplified single-root surface area from simulated X-ray projection. *J Periodontol* 2002; 73(8): 906-910.
19. Mowry JK, Ching MG, Orjansen MD, et al. Root surface area of the mandibular cuspid and bicuspids. *J Periodontol* 2002; 73(10): 1095-1100.
20. Gibbs SJ. Effective dose equivalent and effective dose: comparison for common projections in oral and maxillofacial radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000; 90(4): 538-545.
21. Ngan D, Kharbanda OP, Geenty JP, Darendeliler M. Comparison of radiation levels from computed tomography and conventional dental radiographs. *Aust Orthod J* 2003; 19(2): 67-75.
22. Suteerapongpun P, Sirabanchongkran S, Wattanachai T, Sriwilas P, Jotikasthira D. Root surface areas of maxillary permanent teeth in anterior normal overbite and anterior open bite assessed using cone-beam computed tomography. *Imaging Sci Dent* 2017; 47(4): 241-246.
23. Tasanapanont J, Apisariyakul J, Wattanachai T, Sriwilas P, Midtbo M, Jotikasthira D. Comparison of 2 root surface area measurement methods: 3-dimensional laser scanning and cone-beam computed tomography. *Imaging Sci Dent* 2017; 47(2): 117-122.
24. Mangione F, Nguyen L, Foumou N, Bocquet E, Dursun E. Cleft palate with/without cleft lip in French children: radiographic evaluation of prevalence, location and coexistence of dental anomalies inside and outside cleft region. *Clin Oral Investig* 2017; 22(2): 689-695.
25. Menezes R, Vieira AR. Dental anomalies as part of the cleft spectrum. *Cleft Palate Craniofac J* 2008; 45(4): 414-419.
26. Nicholls W. Dental anomalies in children with cleft lip and palate in Western Australia. *Eur J Dent* 2016; 10(2): 254-258.
27. Paradowska A, Dubowik M, Szelag J, Kawala B. Dental anomalies in the incisor-canine region in patients with cleft lip and palate-literature review. *Dev Period Med* 2014; 18(1): 66-69.
28. Pioto NR, Costa B, Gomide MR. Dental development of the permanent lateral incisor in patients with incomplete and complete unilateral cleft lip. *Cleft Palate Craniofac J* 2005; 42(5): 517-520.
29. Ranta R. A comparative study of tooth formation in the permanent dentition of Finnish children with cleft lip and palate. An orthopantomographic study. *Proc Finn Dent Soc* 1972; 68(2): 58-66.
30. Ranta R. Asymmetric tooth formation in the permanent dentition of cleft-affected children. an orthopantomographic study. *Scand J Plast Reconstr Surg* 1973; 7(1): 59-63.
31. Zhou W, Li W, Lin J, Liu D, Xie X, Zhang Z. Tooth lengths of the permanent upper incisors in patients with cleft lip and palate determined with cone beam computed tomography. *Cleft Palate Craniofac J* 2013; 50(1): 88-95.
32. Solis A, Figueroa AA, Cohen M, Polley JW, Evans CA. Maxillary dental development in complete unilateral alveolar clefts. *Cleft Palate Craniofac J* 1998; 35(4): 320-328.
33. Peterka M, Tvrdek M, Müllerová Z. Tooth eruption in patients with cleft lip and palate. *Acta Chir Plast* 1993; 35(3-4): 154-158.
34. Bailit HL, Niswander JD, MacLean CJ. The relationship among several prenatal factors and variation in the permanent dentition in Japanese children. *Growth* 1968; 32(4): 331-345.
35. Akcam MO, Evirgen S, Uslu O, Memikoğlu UT. Dental anomalies in individuals with cleft lip and/or palate. *Eur J Orthod* 2010; 32(2): 207-213.

36. Lekkas C, Latief B, Ter Rahe S, Kuijpers-Jagtman A. The adult unoperated cleft patient: absence of maxillary teeth outside the cleft area. *Cleft Palate Craniofac J* 2000; 37(1): 17-20.
37. Cosman B, Crikelair GF. The minimal cleft lip. *Plast Reconstr Surg* 1966; 37(4): 334-340.
38. Dixon DA, Newton I. Minimal forms of the celft syndrome demonstrated by stereophotogram-metric surveys of the face. *Br Dent J* 1972; 132(5): 183-189.
39. Dixon DA. Defects of structure and formation of the teeth in persons with cleft palate and the effect of reparative surgery on the dental tissues. *Oral Surg Oral Med Oral Pathol* 1968; 25(3): 435-446.
40. Hellquist R, Linder-Aronson S, Norling M, Ponten B, Stenberg T. Dental abnormalities in patients with alveolar clefts, operated upon with or without primary periosteoplasty. *Eur J Orthod* 1979; 1(3): 169-180.
41. Kraus BS, Jordan RE, Pruzansky S. Dental abnormalities in the deciduous and permanent dentitions of individuals with cleft lip and palate. *J Dent Res* 1966; 45(6): 1736-1746.
42. Vastardis H, Karimbux N, Guthua SW, Seidman JG, Seidman CE. A human MSX1 homeodomain missense mutation causes selective tooth agene-sis. *Nat Genet* 1996; 13(4): 417-421.
43. Lopatiene K, Dumbravaite A. Risk factors of root resorption after orthodontic treatment. *Stomatologija* 2008; 10(3): 89-95.

เปิดบริการ

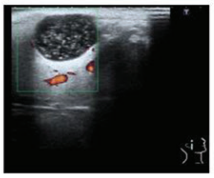
ศูนย์เอกซเรย์ทางทันตกรรม

โรงพยาบาลทันตกรรม คณะทันตแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

ให้บริการถ่ายภาพรังสี ทางทันตกรรม (เอกซเรย์) แก่ผู้ป่วยทั้งใน-นอกเวลาราชการ

Panoramic

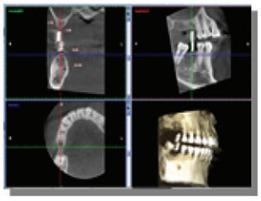
▶ บริการถ่ายภาพรังสีทางทันตกรรมทั่วไป (ชนิดภาพรังสีนอกช่องปาก) ด้วยระบบดิจิตอล (Digital Radiograph)



Ultrasound

Cephalometric

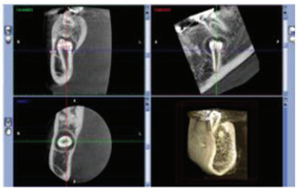
▶ การตรวจด้วยอัลตราซาวด์ (บริเวณขากรรไกร-ใบหน้า)



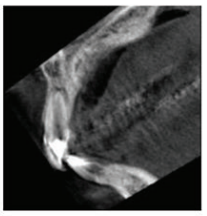
การวางแผนเพื่อฝังรากเทียม

▶ ภาพถ่ายรังสีโคนบีมซีที (Cone beam CT : CBCT) ด้วยเครื่องถ่ายภาพซึ่งเป็นเทคโนโลยีอันทันสมัย สามารถแสดงภาพของฟัน กระดูกขากรรไกรและใบหน้า ได้ในหลายระนาบและสร้างเป็นภาพสามมิติ พร้อมรายงานผลอ่านภาพโดยทันตแพทย์เฉพาะทาง

PA



ระบุตำแหน่งของฟันฝังคุด

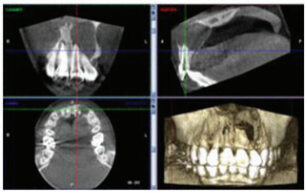


การตรวจการแตกหักของรากฟัน

เปิดให้บริการ

จันทร์-ศุกร์ : เวลา 09.00 - 20.00 น.

เสาร์-อาทิตย์ : เวลา 09.00 - 16.00 น.



การตรวจรอยโรคของฟันและกระดูก

ศูนย์เอกซเรย์ทางทันตกรรม โรงพยาบาลทันตกรรม คณะทันตแพทยศาสตร์ ม.ช. ตั้งอยู่ชั้น 1 อาคาร 6 (ติดห้องเอกซเรย์เบอร์ 2)

โทรศัพท์ : 053-941-605 E-Mail address : dentxraycenter@gmail.com

ศูนย์เอกซเรย์ทางทันตกรรมเป็นสถานพยาบาลของทางราชการ สามารถเบิกค่ารักษาพยาบาลจากทางราชการได้ตามระเบียบกระทรวงการคลัง