A Comparison of Impacted Maxillary Canine Localization by Panoramic Radiograph Interpretation

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ABSTRACT

The aim of this study was to compare the 3 panoramic interpretation methods in predicting the position of a displaced maxillary canine and to determine the new appropriate cut-off point for buccal and palatal canine impaction. We performed a retrospective study of 37 patients with 47 maxillary impacted canines. Patients underwent both panoramic radiograph and cone beam computed tomography (CBCT). Panoramic radiograph methods—including magnification method or canine incisor index (CII), angulation and sector methods—were evaluated using CBCT as the gold standard. The McNemar χ^2 and Stuart-Maxwell tests were calculated to compare the panoramic methods and CBCT. Diagnostic testing (i.e., sensitivity, specificity, accuracy) and Receiver Operating Characteristic curve (ROC) were evaluated for new appropriate cut-off points (significance level 0.05). Of the 37 patients, 23 were female. Age ranged between 12 and 41 years (mean, 20.27±8.03). The 47 impacted canines included 11 (23.40%) buccal, 20 (42.55%) palatal canine and 16 (34.05%) mid alveolus. The sensitivity of the 3 methods for buccal and palatal canine impaction were between 37.5-77.42 %. There were no statistically significant difference among the magnification and angulation method and CBCT (p = 0.80 and 0.07, respectively). However, there was a significant difference between the sector and the CBCT (p = 0.04). In conclusion, magnification and angulation methods were interchangeable and not different from CBCT in determining the position of impacted maxillary canines.

Keywords: Panoramic radiograph/ Impacted canine/ Magnification/ Angulation/ Sector

Introduction

The maxillary canine takes the role of esthetics and continuity of the dental arch.[1] It can become impacted and indeed is the second most commonly impacted tooth after the third molar. The prevalence of maxillary canine impaction ranges between 1-3 %[2,3] and varies by ethnicity. Palatal canines are mostly found among Caucasians,[3,4] whereas buccal canines are commonly found in the Asian population.[5] Several complications occur following maxillary canine impaction; including esthetic and phonetic compromises, arch length loss and referred pain.[2,6] Management options require an appropriate radiographic examination for localization before diagnostic determination and treatment planning.

Several different radiographic techniques including 3D imaging have been recommended for determining the position and spatial context of the displaced canines.[7] Cone beam computed tomography (CBCT), however, is unavailable in rural area. Panoramic radiography is a widespread diagnostic aid and commonly used in dental practice. It was proposed for determining the position of impacted canines because of its simplicity, availability and accuracy.[8-10] In comparing with cone beam CT, panoramic radiograph provided the similar surgical treatment plan of impacted maxillary canine.[11] Many studies promote a single panoramic radiograph for impacted canine localization. Chaushu et al.[8] introduced the panoramic interpretation using the *canine incisor index [CII]*, which proved valid for differentiating buccal from palatal displacement. This magnification method was restricted by the vertical position and limited by tooth rotation and crowding. Katnelson et al.[9] recommended that *angular* measurement in a single panoramic radiograph is a reliable method for determining

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the impacted maxillary canine position when the angulation associated with buccal impaction is >65º. Jung et al.[10] classified the canine position according to the *sector* location and suggested that sector location on panoramic radiography might predict the labio-palatal position of impacted canines. An et al.[12] performed the similar study in China and found the method of magnification and angulation invalid for use in ethnic Chinese. It is interesting that these three radiographic interpretation methods did not provide the same results in different race. Whether the distribution of impacted canine, either in buccal or palatal, affects the prediction of impacted maxillary canine position from single panoramic radiograph has not been clarified.

Our aim, therefore, was to compare the three panoramic methods for maxillary impacted canine localization using CBCT as gold standard and to determine a new appropriate cut-off point for determining the position of maxillary impacted canines in buccal and palatal group. The outcome would have implications for any populations, who present different distribution of maxillary canine impaction.

Materials and methods

This was a retrospective review (October, 2005 to June, 2013) of 37 standard panoramic radiographs, retrieved from the Dental Hospital, Khon Kaen University. All patients included in this study must have had cone beam computed tomography taken within 2 months of the panoramic radiographs. Patients were between 12 and 41. Forty-seven impactions were included. The maxilla had to be in the zone of sharpness. We excluded any image with (a) pathologies of the anterior maxilla, (b) crowding, rotational impacted maxillary canine or (c) craniofacial syndrome. All panoramic radiographs were numbered and shown in random order for interpretation.

Panoramic radiographs were produced using an Orthopantomograph® OP100 (Instrumentarium Imaging, Tuusula, Finland). CBCT images were obtained from a Whitefox® (Acteon, Merignac, France) with Whitefox imaging software version 3.0. Before being classified as labial, mid alveolus or palatal, panoramic radiographs were numbered and interpreted vis-à-vis the adjacent teeth by (a) magnification or canine incisor index (CII), (b) angulation and (c) sector.

Image interpretation

The Magnification method was introduced by Chaushu et al.[8] CII stands for the ratio of the widest mesiodistal dimension of impacted canine to ipsilateral central incisor. A cut-off point CII = 1.15 is used: if CII is ≥ 1.15, it indicates a palatal position and if < 1.15, a buccal position (Fig 1).

The Angulation method was proposed by Katnelson et al.[9] It comprises 2 lines; the first from the right mesiobuccal cusp molar to the left side of the same tooth and the second representing the long axis of the impacted canine. The angle from the 2 lines is "ϴ" (Fig 2). If ϴ is ≤ 65°, it indicates buccal canine impaction and if > 65°, a palatal position.

The Sector method was presented by Jung et al.[10] and was modified to make it simply understandable. The ipsilateral central incisor is divided into 3 sectors: Sector 1, is the area behind the distal line of ipsilateral central incisor; Sector 2 the area at the distal half of the ipsilateral central incisor; and, Sector 3 the area at the mesial half of the ipsilateral central incisor (Fig 3). Palatal canine will be located in sector 3 mid alveolus in sector 2 and buccal canine in sector 1.

One of the observers underwent intra-examiner reliability testing, by evaluating magnification, angulation and sector. Ten cases with impacted canines were randomly selected. This observer reviewed the panoramic radiographs twice 2 weeks apart. Kappa statistics were calculated to determine intra-observer reliability for the duplicate measurements. The other observer evaluated CBCT images independently once.

The study conformed to the Helsinki declaration (HE 572093) and the Khon Kaen University Ethics Committee reviewed and approved the study.

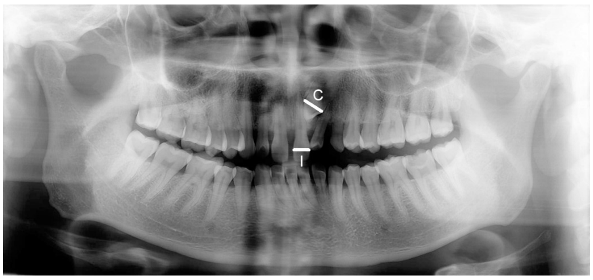

Figure 1 Magnification method: CII the ratio of the widest mesiodistal dimension of impacted canine (C) to ipsilateral central incisor (I).

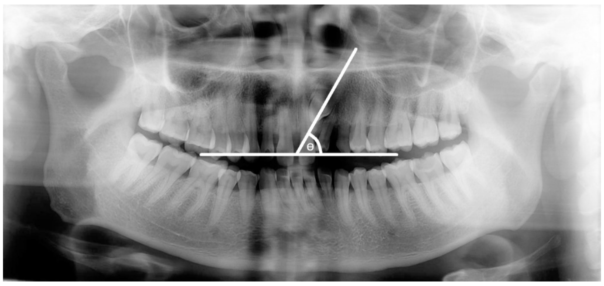

Figure 2 Angulation method: angle (Ө) between horizontal mesiobuccal line of the first molar and long axis of the impacted canine

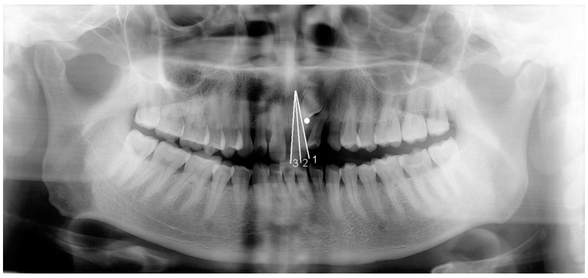

Figure 3 Sector method: Sector 1- the area behind the distal line of ipsilateral central incisor, Sector 2 the area at the distal half of the ipsilateral central incisor; and, Sector 3 the area at the mesial half of the ipsilateral central incisor. Dot= canine's cusp tip.

Statistical analysis

Descriptive statistics were calculated to establish the distribution of sex, side and position of the impacted canine. Tooth position on the panoramic radiographs was correlated with the same tooth in CBCT images. The diagnostic test (sensitivity, specificity, predictive values and likelihood ratio) with 95% confidence intervals and the area of the receiver operating characteristic (ROC) curve were calculated for each method and used for determining the new cut-off point. Differences between magnification and angulation with CBCT were assessed using the McNemar test and between sector and CBCT with the Stuart-Maxwell test. All evaluations were performed at a significance level of 5%. The degree of intra-observer reliability was assessed using the kappa index. Statistical evaluations were performed using SPSS®17.0 (IBM Corporation, Armonk, NY; formerly SPSS Inc., Chicago, IL).

Results

The study was performed in 14 males and 23 females. The average age was 20.27±8.03 years. Thirty-seven patients presented with 27 unilateral impacted canines and 10 with bilateral impactions. The distribution of the maxillary canine on the left side (n=23) was not significantly different to the right side (n=24). The number(percentage) of the maxillary impacted canines—according to the position in cone beam computed CT—is as follows; buccal, palatal and mid alveolus impaction were 11 (23.40), 20 (42.55), and 16 (34.05), respectively.

Among three methods in localizing maxillary canine impaction, sector showed the highest sensitivity (77.42 %) for buccal canine impaction and showed the lowest sensitivity for palatal canine detection(37.50%). Angulation method can detected palatal canine impaction with the highest sensitivity (75.00 %). No statistically significant difference was found between the magnification and angulation methods (p=0.14) and between the magnification and sector methods (p=0.36) (Tables 1 and 2). There was, however, a statistically significant difference between the angulation and sector methods (p=0.01). There were no significant differences between the magnification and angulation methods and the CBCT (p = 0.80, and 0.07, respectively) but there was a significant difference between the sector and the CBCT (p = 0.04) Following the cut-off point suggested by Chaushu[9] (CII=1.15), it was found that this cut-off point provided the highest sensitivity in buccal canine impaction. In case of palatal canine impaction, cut-off point 1.08 show the highest sensitivity. The highest sensitivity in the angulation method for buccal and palatal canine localization was 70.97% (ϴ=53°) and 81.25%, (ϴ=67°), respectively. Area under the curve (ROC) of the magnification and angulation methods were 0.608 (95% Confidence interval = 0.608-0.771) and 0.697 (95% confidence interval = 0.533-0.860), respectively (Fig 4 and 5).

The new selected cut-off points for the magnification method were 1.15 and 1.08. The appropriated angles of angulation method were at 53° and 67° (Tables 3, 4, 5 and 6).

The respective intra-observer reliability kappa value for magnification, angulation and sector method was 0.8, 0.9 and 1.00.

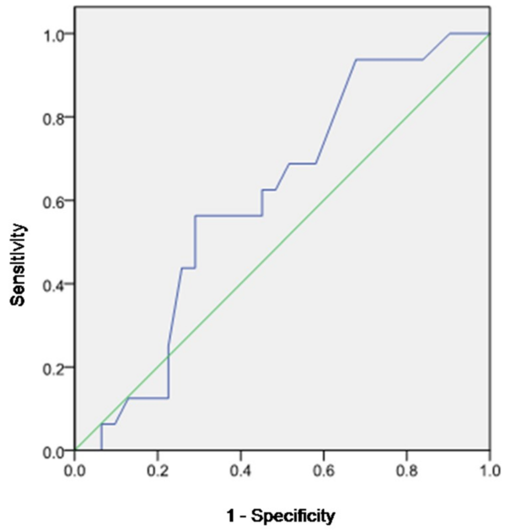

Figure 4 ROC curve of magnification method: Canine incisor index (CII)

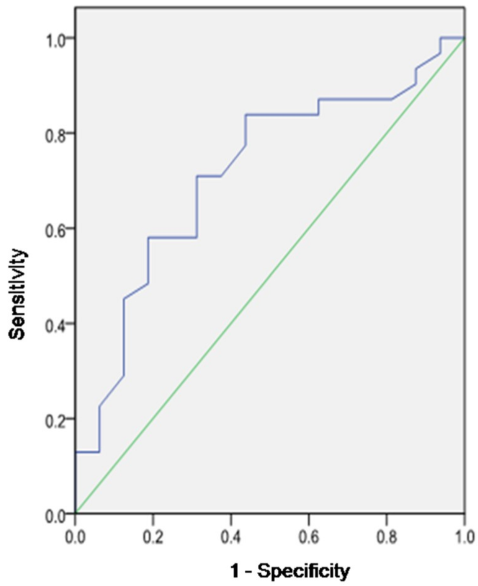

Figure 5 ROC curve of angulation method

Table 1 Diagnostic values according to panoramic interpretation method in buccal canine impaction

Method	Buccal canine impaction						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
Magnification	70.97	56.25	65.95	0.75	0.50	1.62	0.52
Angulation	61.29	75.00	65.95	0.82	0.50	2.45	0.52
Sector	77.42	37.50	63.82	0.70	0.46	1.24	0.60

Table 2 Diagnostic values according to panoramic interpretation method in palatal canine impaction

OPG Methods	Palatal canine impaction						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
Magnification	56.25	70.97	65.95	0.50	0.75	1.94	0.62
Angulation	75.00	61.29	65.95	0.50	0.82	1.94	0.41
Sector	37.50	77.42	63.82	0.46	0.70	1.66	0.81

Table 3 Diagnostic values according to magnification method in buccal canine impaction

CII	Buccal impacted canines						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
1.08	54.84	62.50	57.44	0.73	0.41	1.46	0.72
1.15	70.97	56.25	65.95	0.75	0.50	1.62	0.52

Table 4 Diagnostic values according to magnification method in palatal canine impaction

CII	Palatal impacted canine						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
1.08	62.50	54.84	57.44	0.41	0.73	1.38	0.68
1.15	56.25	70.97	65.95	0.50	0.75	1.94	0.62

Table 5 Diagnostic values according to angulation method in buccal canine impaction

Angle	Buccal impacted canine						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
53	70.97	68.75	70.21	0.81	0.55	2.27	0.42
67	58.06	81.25	65.95	0.85	0.50	3.10	0.52

Table 6 Diagnostic values according to angulation method in palatal canine impaction

Angle	Palatal impacted canine						
	Sensitivity	Specificity	Accuracy	Predictive value		Likelihood ratio	
				Positive	Negative	Positive	Negative
53	68.75	70.97	70.21	0.55	0.81	2.37	0.44
67	81.25	58.06	65.95	0.50	0.85	1.94	0.32

Discussion

Since the panoramic radiographs are often taken in patients undergoing orthodontic treatment and also using as screening film, many studies use the single panoramic interpretation for identifying the position of impacted maxillary canines due to less radiation exposure, availability, and inexpensive procedure. The purpose of the present study was to compare 3 methods of panoramic interpretation whether we can find the best methods for impacted canine localization. We found that magnification method substituted for angulation methods and both methods were not different from CBCT in determining the position of impacted maxillary canines.

The magnification method provided the low accuracy in identifying either buccal or palatal canines among Asians (68.00% and 69.57%, respectively),[12] of which the percentage was similar to our study buccal canine (70.97%), palatal canine (56.25%). In Caucasian, Wolf and Matilla[13] reported the accuracy of magnification method in labio-palatal impacted canine detection was high up to 80.00-90.00%. A similar figure (87.50%) was found in the study of Chaushu et al.[8] In the study by Fox et al.,[14] the sensitivity in detection of palatal canine with magnification method was high (82.00%), while that for buccal canine was low (65.00%). According to different results, the new appropriate cut-off point was determined. If the prevalence of impacted canine is primarily buccal, then CII was 1.15. Whereas if palatal impaction is prevalent, then CII was 1.08.

As the limitation of crowding and rotating canine from magnification method, Katsnelson[9] introduced another simple method - angulation method, of which an angulation between the long axis of the maxillary impacted canines and the occlusal plane was measured. It was recommended a cut-off of 65º — provided an accuracy of 86.00% for palatal canine identification. The study by An et al.[12] could achieve the similar result (82.61%). However, the current study used the same cut-off point with lower accuracy (75.60%) for palatal canine impaction. After considering the angulation data, we found the sensitivity of palatal canine impaction (81.25%) was higher with angulations >65º. The appropriate cut-off for the buccal impaction was 53º. Whereas the palatal impaction was 67º. Alqerban A et al.[15] introduced a combination of angles and distances which may be predict early canine impaction in young patients. This study, however, could only explain the incidence of the impaction, not predict the position of canine.

The sector method was claimed to predict the labio-palatal position of impacted canines comparing with CBCT.[10] In our study, sector method by Jung et al.[10] was modified. Buccal canine impaction was detected with sensitivity of 77.42%, which is higher than that of palatal canine detection (sensitivity 37.50%). In addition, sector revealed the significant difference from CBCT in localize impacted canine position. An S et al.[12] proposed another method superimposition, this method was similar to sector method; the criteria for diagnosis was the impacted maxillary canines that were superimposed on the central incisor would be palatal impaction. This superimposition method provided the moderate accuracy (59.26%) and was recommended to be an adjunctive tool for localizing maxillary impacted canines.

The difference in each result, even though they used the same methods in various studies, implies firstly, the position of the impacted canine, either buccal or palatal, influences the prediction of panoramic interpretation methods. It was reported the prevalence and distribution of maxillary impacted canine depends on races and age;[10,12] Chinese patients present labially impacted canine more than palatal canine.[12] On the contrary, based on our pilot study, we could see the impacted maxillary canines tend to be palatal impaction (42.55%) over buccal impaction (23.40%) as same as the previous report[16]. It is interesting that the number of mid alveolus impaction in this study seems to be almost one-third of impacted canine (34.05%). It might be owing to the small sample size and the patient was limited only the person who came to the dental hospital. This study was not aimed to detect the impacted canine in this position. Factors involved this prevalence should be further studied. In addition, the radiographic detection method of this position should be further taken into consideration. Labially impacted canines were most found in <15 years old group,[10] etc. A study reported palatal canine impaction could be detected more easily than buccal canine impaction.[17] Secondly, panoramic radiograph has limitation in identifying the impact canine, which lined in 3 directions and could show only some parts in two dimensional image.

The exact cut-off point in magnification and angulation method can apply in clinical practice if we know the distribution of canine impaction in each population. Because of the short term of research fund, and small amount of cases we could collect, further study was suggested to increase the sample size, in order to understand the influence of canine position to the interpretation methods.

Conclusion

In conclusion, panoramic radiograph is a useful radiograph in remote area, where CBCT is unaccessible. Based on our results, panoramic radiography could provide a guide for locating the position of the maxillary impacted canines; however, in cases of severely displaced canines, and for those with suspected incisor resorption or any pathology, the use of CBCT for localization of impacted canines is recommended. Magnification and angulation methods were interchangeable and not different from CBCT in determining the position of impacted maxillary canines. These 2 methods can be used as the early prediction tools.

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การเปรียบเทียบวิธีการระบุตำแหน่งฟันเขี้ยวบนคุด ด้วยวิธีอ่านภาพรังสีแพโนรามา

สุวดี โฆษิตบวรชัย ปฐมพงศ์ รุ่งเรืองศิลป์** ณัฐนันท์ วัฒนอเนก*** สุบิน พัวศิริ*****

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อเปรียบเทียบวิธีการอ่านภาพรังสีแพโนรามา 3 วิธี ในการทำนายตำแหน่งของฟันเขี้ยวบนคุด และเพื่อกำหนดค่าที่เหมาะสมในการระบุตำแหน่งของฟันเขี้ยวบนคุดด้านแก้มและด้านเพดานปาก โดยศึกษาย้อนหลังในผู้ป่วย 37 คน ที่มีฟันเขี้ยวบนคุด จำนวน 47 ซี่ ผู้ป่วยได้รับการถ่ายภาพรังสีทั้งภาพรังสีแพโนรามาและภาพรังสีโคนบีมซีที วิธีการอ่านภาพรังสีในภาพรังสีแพโนรามา 3 วิธี ประกอบด้วย 1. วิธีกำลังขยาย หรือ วิธีดัชนีฟันเขี้ยวฟันตัดบน 2. วิธีการวัดมุม และ 3. วิธีการแบ่งส่วน โดยมีภาพรังสีโคนบีมซีทีเป็นภาพมาตรฐานในการประเมินตำแหน่งที่แท้จริงของฟันเขี้ยวบนคุด การคำนวณความถูกต้องของการวิธีการอ่านภาพรังสีแพโนรามาทั้งสามวิธีเปรียบเทียบกับภาพรังสีโคนบีมซีที ใช้การทดสอบแม็คนีมาร์ และสจ็วตแม็กซ์เวลล์ การกำหนดค่าที่เหมาะสมในการระบุว่าเป็นฟันเขี้ยวบนด้านแก้มหรือด้านเพดานปาก ใช้ไดแอ็คโนสติกเทส หาค่าความไว ความจำเพาะ ความถูกต้องและค่าพื้นที่ใต้กราฟอาร์โอซี ผลการศึกษา พบว่า ผู้ป่วย 37 คน เป็นผู้หญิง 23 คน อายุระหว่าง 41-12 ปี (ค่าเฉลี่ย 20.27±8.03) ในจำนวนฟันเขี้ยวบนคุดทั้งหมด 47ซี่ อยู่ด้านแก้ม 11 ซี่ (23.40%) อยู่ด้านเพดานปาก 20 ซี่ (42.55%) และอยู่กึ่งกลางกระดูกขากรรไกร 16 ซี่ (34.05%) ความไวของทั้ง 3 วิธีในการระบุตำแหน่งฟันเขี้ยวบนคุด อยู่ระหว่าง 37.5-77.42% ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติระหว่างวิธีกำลังขยายและวิธีวัดมุม (P = 0.80 และ 0.07 ตามลำดับ) อย่างไรก็ตามมีความแตกต่างอย่างมีนัยสำคัญ ระหว่างวิธีการแบ่งส่วนและโคนบีมซีที (P = 0.04) สรุปได้ว่า วิธีกำลังขยายและวิธีวัดมุมสามารถใช้แทนกันได้ และไม่แตกต่างจากภาพรังสีโคนบีมซีทีในการระบุตำแหน่งฟันเขี้ยวบนคุด

คำไขรหัส: *ภาพรังสีแพโนรามา/ ฟันเขี้ยวคุด/ กำลังขยาย/มุม/ การแบ่งส่วน*

ผู้รับผิดชอบบทความ

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