Original Article

Localization of Impacted Maxillary Canine: Comparative Evaluation of Radiographic Techniques

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ABSTRACT

Background: Maxillary canine is the most frequently impacted tooth next to mandibular molar. It, thus, becomes utmost important to localize its position to carry out a proper treatment plan.
Objectives: The purpose of study was to evaluate various radiographic techniques and to develop a reliable method of determining bucco-palatal position of the impacted maxillary canine by comparing panoramic radiograph (principle of magnification), the occlusal radiograph (millimetre rule) and two intraoral periapical radiographs (parallax method).
Procedure: A total of 23 patients with 30 impacted maxillary canines diagnosed with the help of panoramic radiographs were included in this study. The bucco-palatal position of the impacted maxillary canine was determined using magnification principle, millimetre rule, parallax method and the same were confirmed by surgical exposure.
Results: Kappa statistics revealed that agreement between panoramic radiographs and surgical exposure had a kappa value of 0.88 suggestive of an excellent agreement whereas, with occlusal radiographs, kappa value was 0.70 and with two intraoral periapical radiographs it was 0.69 suggestive of intermediate to good agreement.
Conclusion: The study confirms that single panoramic radiograph may serve as a reliable indicator for determining bucco-palatal position of impacted maxillary canine provided both magnification index and the vertical restriction are used.

Keywords: buccopalatal, canine, impaction, millimetre, panoramic, parallax

INTRODUCTION

A tooth is said to be impacted whose eruption is considerably delayed and for which there is clinical or radiographic evidence that further eruption may not take place.[1] Localization on the other hand means "determination of the site or place of any process or lesion.[2] Maxillary canine being the last anterior teeth to erupt in the oral cavity is the most frequently impacted tooth after the third molar with a prevalence that may range from 0.92% to 2.6% depending on the population studied/examined.[3,4]

There are so many treatment options for this condition that may include observation, extraction, auto transplantation and orthodontic correction.[5] But, to recommend the most appropriate treatment modality for this condition, the exact assessment of the position of the impacted maxillary canine in 3 planes of space is essential. This localization is based on

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the combination of clinical and radiographic findings.

Definitely, the clinical evidence of the localization of impacted maxillary canine may be sparse, the clinicians, therefore, rely more frequently on the radiographic evidences.[6, 7]

A dental panoramic radiograph (OPG) is commonly used in dentistry for assessing the presence, position and morphology of the unerupted teeth. From the panoramic view, the impaction of maxillary canine is an occasional but a significant finding. It, would, therefore, be advantageous if this single film could be reliably used for the localization of impacted maxillary canine.

With this view in mind, the present study was undertaken to develop a reliable method which can improve the accuracy of determining the position of an impacted maxillary canine by comparing the panoramic radiograph, the occlusal radiograph and the two intraoral periapical radiographs.

MATERIALS AND METHODS

A total of 23 patients (11 males and 12 females) with 30 impacted maxillary canines diagnosed with the help of panoramic radiograph were included in the study after getting the clearance from the Ethical Committee. The written consent from the patient was obtained, The bucco-palatal position of the impacted maxillary canine was determined using the Parallax method (two intra oral periapical radiographs with horizontal tube shift), millimetre rule (maxillary occlusal radiograph) and magnification principle (OPG) and the same were confirmed by surgical exposure.

The parallax method was based on the principle of parallax. In radiology terms, parallax is defined as the apparent displacement of the object to be localized, relative to the image of the reference object. It is caused by changing the angulation of the X-ray beam, which in turn is caused by the change in the X-ray tube position. Normally the reference object is the root of the tooth closest to the object to be localized. The image of the tooth that is farther away from the X-ray tube moves in the same direction as the tube and the image of the tooth closer to the X-ray tube moves in the opposite direction to the tube (Fig 1).

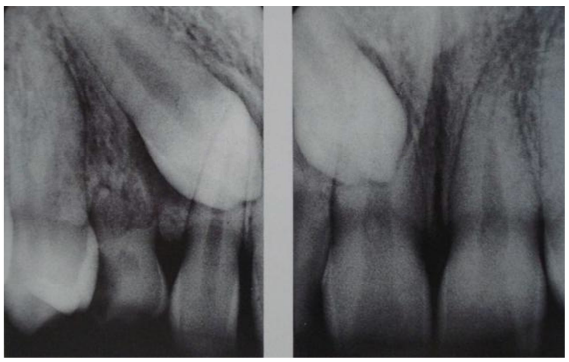

Fig 1: Parallax (Horizontal tube shift) technique (SLOB), Impacted tooth moving towards the tube = Palatal; Impacted tooth moving in opposite direction = Buccal

In millimeter rule by maxillary occlusal radiograph, taken at + 60 to 65 degrees, the buccopalatal position of the impacted maxillary canine was assessed using the line of dental arch as a reference. This line was identified on each occlusal film by drawing a curve through the midpoints of the crowns of adjacent erupted premolars and molars and along the incisal edges of the adjacent erupted incisors (Fig 2).

Measurements were made using a millimeter rule from the midpoint of the impacted canine crown to the line of dental arch along a line passing perpendicular to the arch. When the midpoints were aligned with the “line of dental arch” or were within 1 mm of it, the impacted canine was assessed as being in the arch. Outside this range, the position of the impacted canine was recorded as either buccal or palatal.

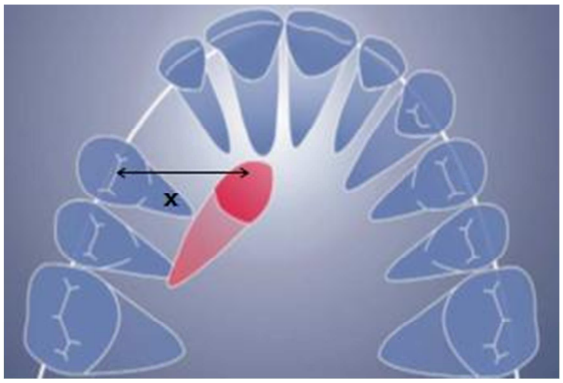

Fig 2: X = Distance of impacted maxillary canine from line of arch in mm

The panoramic localization was based on the principle of magnification (Fig 3). On a panoramic radiograph, the images of teeth situated at the palatal aspect of the dental arch, i.e. closer to the tube and farther from the film, are magnified, whereas those on the labial are diminished when compared with the size of the images of the teeth in the line of the arch. To ensure that the horizontal magnification was equivalent, the widest mesiodistal dimensions of the first molars on both the sides were measured and compared. A difference greater than 5% resulted in exclusion from the study.

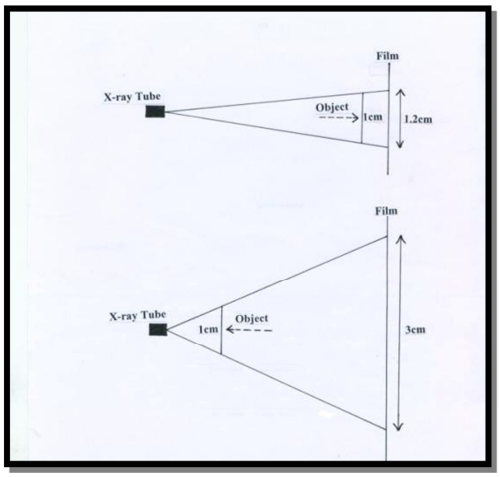

Fig 3: Principle of magnification showing that the objects nearer to the film are less magnified or diminished and the objects away from the film are magnified

Then the widest mesiodistal dimensions of impacted canine, homolateral central incisor and the contra laterally normally erupted canine were measured and following ratios were obtained (Canine - Incisor Index i.e. CII, Canine - Canine Index i.e. CCI and Canine - Incisor Index of the controls i.e. CII-c) (Fig 4).

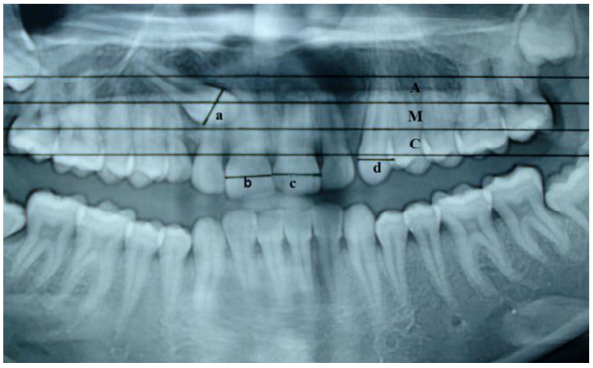

Fig 4: Maximum mesio-distal dimensions of impacted maxillary canine (a), central incisors (b & c) and contralateral normally erupted canine (d) with vertical zones as Apical zone (A), Middle zone (M) and Coronal zone (C)

On the panoramic view, the height of the crown of each impacted canine was assessed in the vertical plane relative to its erupted central incisor, which were divided into three zones as Apical zone, including the apical 3rd of the root, Middle zone including the middle 3rd of the root and Coronal zone including the remainder of the root (Fig 4).

On the basis of the principle of magnification and Canine-Incisor Index of the controls (CII-c) (Table 1), the bucco-palatal position of the impacted maxillary canines was determined. Through the use of above mentioned radiographic techniques, the bucco-palatal position of the impacted maxillary canines was predicted and further correlated with the true position that was obtained after surgical exposure of the impacted maxillary canines (Table 2).

Statistical analysis was carried out using kappa statistics, which correlates the degree of co-efficient of agreement between the surgical exposure and various radiographic techniques being used. With kappa value < 0.4 were considered as poor agreement, between 0.4 – 0.75 as intermediate to good and the values > 0.75 as excellent.

Table 1: Localization of bucco-palatal position of the impacted Maxillary Canines on the basis of principle of magnification and CII of the controls in relation to various vertical zones

Zones	Buccal			Palatal		
Vertical	Predicted	True	%	Predicted	True	%
Coronal	00	00	------	05	05	100%
Middle	03	03	100%	14	12	85.71%
Apical	00	00	-------	08	04	50.00%
Coronal+ Middle	03	03	100%	19	17	89.47%
Total	03	03	100%	27	21	77.77%
Overall buccopalatal localization		Buccopalatal prediction = 03+27 = 30		True buccoplatal position = 03 +21 = 24		80.00%

Table 2: Prediction of impacted maxillary canines using panoramic, occlusal and two intraoral periapical radiographs and their true positions after surgical exposure/extraction
(A = Apical Zone, M = Middle Zone, C = Coronal Zone, P = Palatal, B = Buccal)

S.No.	Age/Sex	Panoramic vertical zone	Panoramic localization	Localization by millimeter rule	Localization by parallax method	True position
1.	25/F	A	P	B	B	P
2.	25/F	M	P	B	B	P
3.	14/M	C	P	P	P	P
4.	18/F	A	P	P	P	P
5.	30/F	M	P	P	P	P
6.	14/M	M	P	B	B	P
7.	23/F	A	P	P	P	P
8.	25/F	M	B	B	B	B
9.	25/M	M	B	B	P	B
10.	25/M	M	B	B	B	B
11.	16/M	M	P	P	P	P
12.	16/F	M	P	B	B	P
13.	18/M	M	P	P	P	P
14.	17/F	A	P	P	B	B
15.	17/F	A	P	P	P	B
16.	28/M	A	P	P	P	B
17.	18/F	A	P	P	B	P
18.	20/F	M	P	P	P	B
19.	20/F	M	P	P	B	B
20.	36/F	M	P	P	P	P
21.	14/M	M	P	P	B	P
22.	20/M	M	P	P	P	P
23.	35/F	M	P	P	B	P
24.	35/F	C	P	P	P	P
25.	23/M	C	P	P	P	P
26.	23/M	M	P	B	P	P
27.	25/M	M	P	B	P	P
28.	20/F	C	P	P	B	P
29.	20/F	C	P	P	P	P
30.	32/M	A	P	B	B	B

RESULTS

Out of 23 patients, 16 patients (69.57%) exhibited unilateral impaction and 07 patients (30.43%) exhibited bilateral impactions. Of bilaterally impacted patients, 04 (57.14%) showed bilateral palatal impactions and 03

patients (42.86%) bilateral buccal impaction. Of the total 30 impacted canines, 21 canines (70.00%) were located palatally and 09 canines (30.00%) were located buccally after surgical exposure/extraction. The distribution of the various categories of impacted canines after surgical exposure is shown in the Table 3.

In the vertical plane, 05 (23.82%) of the palatal canines were located in the coronal zone, 12 (57.14%) in the middle zone and 04 (19.04%) in the apical zone of their adjacent teeth (Table 3).The buccal canines with respect to their vertical position were located as follows: 00 (00.00%) in the coronal zone, 05 (55.56%) in the middle zone and 04 (44.44%) in the apical zone (Table 3).

The panoramic radiograph under magnification criteria revealed an accuracy of 80.00% (24 out of 30). It could be appreciated that the impacted canines that were placed in coronal and middle zones were localized more accurately than the canines that were placed in the apical zones (Table 1).

With parallax method using two intraoral periapical radiographs with horizontal tube shift, an accuracy of 60% (18 out of 30) was obtained in the bucco-palatal localization of the impacted maxillary canines (Table 4) whereas with occlusal radiographs using the millimeter rule, the accuracy was found to be 63.33% (19 out of 30) (Table 5).

Use of kappa statistics revealed that the agreement between the panoramic radiographs and surgical exposure had a kappa value of 0.88 suggestive of an excellent agreement as far as the bucco-palatal localization is concerned whereas with occlusal radiographs, the kappa value was 0.70 and for parallax method it was 0.69 suggestive of intermediate to good agreement.

Table 3: Distribution of location of impacted Maxillary Canines after surgical exposure

Bucco Palatal Position	**Buccal canines**			**Palatal canines**			**Total sample**	
Vertical position	N	Buccal %	Total %	N	Palatal %	Total%	N	Total%
Coronal	00	00%	00%	05	23.82%	16.67%	05	16.67%
Middle	05	55.56%	16.67%	12	57.14%	40.00%	17	56.67%
Apical	04	44.44%	13.33%	04	19.04%	13.33%	08	26.66%
Total	09	100%	30.00%	21	100%	70.00%	30	100.00%

Table 4: Localization of the impacted maxillary canines by parallax method using intraoral periapical radiographs

Buccal			**Palatal**		
Predicted position	True position	%age	Predicted position	True position	%age
13	05	38.46%	17	13	76.47%
Overall buccopalatal prediction 13 + 17 = 30		Overall true buccopalatal localization 05 +13 = 18		60.00%	

Table 5: Localization of the impacted maxillary canines by millimeter rule using occlusal radiographs

Buccal			**Palatal**		
Predicted position	True position	%age	Predicted position	True position	%age
10	04	40%	20	15	75%
Overall buccopalatal prediction 10 + 20 = 30		Overall true buccopalatal localization 04 + 15 = 19		63.33%	

DISCUSSION

Maxillary canine is the most frequently impacted tooth next to the mandibular third molar. Proper localization of the impacted canine is thus important in determining the feasibility of the surgical approach as well as the application of the orthodontic forces in a proper direction. This is possible only by having an accurate knowledge of the impacted maxillary canine that is based on the combination of clinical and radiographic findings. Clinical findings may provide a useful clue but radiographs are required for precise localization.[6, 7]

Various radiographic techniques have been used for localization of the impacted canine either single or in combination. These include the parallax method (image/tube shift/Buccal object rule/Clark's rule) introduced by Clark in 1909, vertical tube shift by Richards and Keur,vertex occlusal radiograph, the right angle technique using two radiographs taken at right angles to each other, stereoscopy, panoramic radiographs (OPG), multiple exposure method, image superimposition, computed tomography.[8-15]

The parallax method is still the radiographic technique of choice of many practitioners to localize the impacted maxillary canine.In radiology terms, parallax (image / tube shift) is the apparent displacement of an image, relative to the image of a reference object, caused by an actual change in the angulation of the x-ray beam. The reference object is normally the root of an adjacent tooth. The image of the tooth that is farther away from the x-ray tube moves in the same direction as the tube, and the image of the tooth closer to the x-ray tube moves in the opposite direction to the tube.

A tube shift may be carried out in either the horizontal or the vertical plane. For a horizontal tube shift, usually the periapical radiographs (Pas) are used, but occlusal radiographs (ORs) are superior because they cover a larger area. Therefore, the tube can be moved much more between the two exposures resulting in the shift of the image of the impacted maxillary canine being easier to determine. Frequently, part or the entire crown or the root of the impacted maxillary canine is not captured on one or both periapical radiographs. The radiation dose from two occlusal radiographs is comparable with that from two periapical radiographs.

In vertical parallax, the localization is based on the rule of thumb which implies that the objects which appear to move with the central ray are located behind the reference object. For vertical tube shift, a rotational panoramic radiograph and an occlusal radiograph are recommended. This latter combination is usually the combination of choice because the panoramic radiograph, which provides the information about all the teeth in both the arches, the two jaws and the surrounding structures, is often taken as an initial radiograph and this combination just requires one additional exposure i.e. occlusal radiograph.

Some clinicians favour the use of vertex occlusal view of millimetre rule which provides a plan view of the maxillary teeth with the central ray travelling down the root canal of the central incisors permitting buccopalatal localization possible in this region. However, these radiographs are questionable from the radiation safety point of view since it requires a long exposure time with commonly used dental X- ray machine. In addition, there is the superimposition of the various anatomical structures in the area and absorbed dose of radiation to various radiosensitive organs like the brain, the pituitary, salivary glands, thyroids, eye lens.[10, 16-18] For these reasons, vertex occlusal radiographs are rarely used in patients even when taken with intensifying screens/ cassettes.[19]

A dental panoramic radiograph is widely used in dental practice and is most likely the first choice of radiographs to be taken for the orthodontic patients. The localization by panoramic radiographs is based on the principle of magnification which states that an object placed closer to the panoramic film (i.e. farther from the X-ray source) is less magnified than an object placed at a greater distance from the film and closer to the X-ray source (Fig 3). Unfortunately, the reliability of such a system has been found to

be low because the influence of the distance of the impacted maxillary canine from the radiation source on the vertical location of the object on the panoramic radiograph is not being considered.[20, 21]

The central ray in panoramic radiography is directed from a slightly negative angulation. Accordingly, palatally located teeth will be projected higher, even though they may be at the same height above the occlusal plane. As a result, the height of the tooth on the panoramic radiograph will be exaggerated both by its buccopalatal displacement as well as by its vertical height above the occlusal plane. An expression of the vertical factor is therefore necessary to achieve a valid magnification index.[22]

On the panoramic radiographs, the widest mesiodistal dimensions of impacted canine, homolateral central incisor and the contra laterally normally erupted canine were measured and following ratios were obtained (Canine - Incisor Index i.e. CII, Canine - Canine Index i.e. CCI and Canine - Incisor Index of the controls i.e. CII-c) (Fig 4). On the panoramic view, the height of the crown of each impacted canine was also assessed in the vertical plane relative to its erupted central incisor which were divided into three zones as Apical zone including the apical 3rd of the root, Middle zone including the middle 3rd of the root and Coronal zone including the remainder of the root (Fig 4).

The mesiodistal dimension of the canine on an average is about 90% of the mesiodistal dimension of the central incisor or 1mm less.[23-24]

In an ideal dental arch, the canine is slightly more distant from the panoramic film than its homolateral central incisor. The result is 10% magnification of the canine on the resultant radiograph yielding nearly identical mesiodistal dimensions; this represents the key of using central incisor as the reference in the CII.

The Canine – Incisor index of the controls (CII-c) obtained in this study was 0.98 (Table 6). Therefore, based on the principle of magnification and CII of the controls, the canines whose CII were above 0.98 were considered to be palatal and the canines whose CII was under 0.98 were considered to be buccal. As such, 27 impacted canines were predicted to be placed palatally but only 21 turned out to be true palatal after surgical exposure giving an accuracy of 77.77%. For the buccally placed teeth, 03 impacted canines were predicted to be placed buccally and all the three were located to be true buccal after surgical exposure giving an accuracy of 100% with an overall buccopalatal accuracy of 80.00% (Table 1). It could also be appreciated that the impacted canines that were placed in coronal and middle zones were localized more accurately than the canines that were placed in the apical zones (Table 1).

The present study was designed on the concept of magnification index and vertical restriction on the panoramic radiograph and compared with occlusal radiographs and two intraoral periapical radiographs. Panoramic radiographic technique based on magnification index revealed an accuracy of 80.00% in the localization of impacted maxillary canines (Table 1) whereas 60% accuracy was seen with parallax method using two intraoral periapical radiographs (Table 4) and 63.33% with millimetre rule using occlusal radiographs (Table 5).

Previous studies have shown that the accuracy in the localization of the impacted maxillary canines by the panoramic radiograph was 80-90%.[20,21,22,25,26] Recently Computed Tomography has been proposed as a superior, easier and less laborious option but is more expensive with high radiation dose. Its use should therefore be limited in cases of complex anatomical situations, in cases of multiple impactions combined with supernumerary teeth or congenital facial anomalies. [14]

In this study, panoramic radiograph was used as a preference for exact localization, since these radiographs are widely used in general practice and are the choice of radiographs to be taken in patients undergoing orthodontic appraisal; no additional radiation exposure would therefore be necessary, and of course the procedure is inexpensive.

Table 6: Showing range and mean of CII of the controls, (CII-c)

Total	Range of CII-c	Mean
16	0.88 – 1.08	0.98

CONCLUSION

It was concluded that provided both the vertical restriction and a magnification index are used, the panoramic radiograph is a reliable indicator for localization of the bucco-palatal position of the impacted maxillary canine.

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