Localization of impacted maxillary canine teeth: a comparison between panoramic and buccal object rule in intraoral radiography

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Objectives   This study aimed to compare the efficacy of panoramic radiography and the buccal object rule in intraoral periapical radiography for localization of impacted maxillary canine teeth.

Methods   A total of 20 panoramic radiographs depicting 28 displaced maxillary canines were evaluated. The ratio of the mesiodistal width of the impacted canine to the mesiodistal width of the ipsilateral central incisor was calculated and referred to as the canine-incisor index (CII). The height of the crown of each displaced canine was classified in vertical plane relative to the adjacent incisor as apical, middle or coronal. Position of impacted maxillary canines was also determined on two periapical radiographs using the buccal object rule. Surgical exposure and direct observation of impacted teeth were later performed and served as the gold standard. The data were analyzed using SPSS and t-test.

Results   There was an overlap in the CII range of the buccally (0.78–1.48) and palatally (1.15–1.75) positioned impacted canines. When considering the height factor in the middle and coronal zones, a significant difference was noted between the CII of buccally (0.78–1.1) and palatally (1.15–1.75) positioned teeth enabling determination of their buccolingual orientation ($P < 0.05$).

Conclusion   For the impacted maxillary canines located in the middle and coronal zones (90% of cases), the CII of 1.15 and higher represents palatal impaction while the CII smaller than 1.15 represents buccal impaction.

Keywords   cuspid, tooth, impacted, radiography, panoramic

Introduction

Maxillary canine impaction is not rare and has a prevalence of 1–3% in different populations.[1] Although canine impaction may not be problematic, complications such as cystic changes of the follicles of impacted teeth, neoplastic transformation, crowding, infection and caries in the adjacent teeth may occur. Also, this condition may sometimes result in dull pain of unknown origin.[2]

According to Becker et al.,[3] the prevalence of canine impaction in subjects with a missing lateral incisor is 2.4 times the rate in individuals with normal dentition. Irrespective of the causes of maxillary canine impaction, the first step in treatment of patients is accurate localization of the impacted canine three-dimensionally. Generally, two methods are available for localization of impacted canines: Clinical assessment and radiographic assessment. Clinical assessment by use of the following clinical symptoms can help in detection and localization of impacted canines:

(I) Delay in eruption of permanent canine tooth or prolonged retention of the primary canine beyond the age of 14–15 years; (II) absence of normal canine bulge in the palatal surface; (III) presence of canine bulge in the palatal surface; and (IV) displacement, distal inclination or delay in eruption of lateral incisor. According to Ericson and Kurol[4] canine bulge at a young age is not a prognostic/diagnostic indicator of impaction and must be accompanied by radiographic assessment. Since clinical symptoms may be rarely seen in patients with an impacted canine, in many cases the clinicians must only rely on radiographic assessment.

Radiographic assessment can be done using the following four techniques. The same lingual opposite buccal (SLOB) rule also known as the Clark's rule, buccal object rule or the parallax method, which is based on two periapical radiographs captured at different angles.[5] In 1952, Richards[6] changed the tube angle in the vertical plane. Keur[7] suggested two occlusal films instead of two periapical films (the occlusal method); however, this method was also based on the Clark's rule. In 1987, Keur[7] combined an occlusal radiograph with a panoramic radiograph using the vertical tube shift (VTS) method (combined method). Panoramic radiography is also routinely prescribed for patients with impacted teeth. This method only increases the radiation dose to the level of an occlusal radiograph, which is an advantage.[7,8]

Panoramic radiography technique is based on a main rule in radiography; that is, an object closer to the radiographic film and farther from the X ray tube has a smaller image than an object farther from the film and closer to the X ray tube. Thus, if the impacted canine is closer to the X ray tube than the contralateral canine, the image of the impacted tooth would be larger than that of the contralateral tooth on a panoramic radiograph. Unfortunately, this method has low accuracy and reliability.[9,10] Panoramic radiography is routinely prescribed for orthodontic patients and thus, finding an accurate method to enhance the localization of impacted canines using panoramic radiography would be cost effective and eliminate the need for additional radiographs. Also, panoramic radiographs show a wide view of anatomical structures and thus can visualize the relationship of the impacted canine with the neighboring anatomical structures.

Computed tomography is among the most accurate techniques for localization of impacted teeth. However, despite high accuracy, high patient radiation dose associated

with this technique minimizes its application for this purpose. The objective of this study was to find a method to increase the accuracy and reliability of panoramic radiography for precise localization of impacted canines.

Methods

This analytical qualitative study was conducted on impacted canines. Data regarding the impacted canines, ipsilateral central incisor and the contralateral canine were collected. Type of impaction (position of impacted canine in the jawbone) was also evaluated. All panoramic and periapical radiographs taken were analyzed using the SLOB method and the respective variables were recorded. Demographic information of patients was also recorded via an interview. The result of direct observation of the tooth during its surgical extraction was also noted. Patients with a clear bulge in the buccal or palatal surface at the site of impaction were excluded. Subjects presenting to the orthodontics and radiology departments of Shahid Beheshti University, School of Dentistry were selected using convenience sampling. Study subjects included 22 patients (13 males and 9 females) presenting to orthodontics and radiology departments of Shahid Beheshti University, School of Dentistry for treatment of unilateral or bilateral canine impaction. All patients had one panoramic and two periapical radiographs (suitable for the SLOB method). All panoramic radiographs had been taken using Planmeca panoramic imaging system (Planmeca, Helsinki, Finland). Intraoral radiographs had been taken with Planmeca intraoral dental X ray unit and processed by a fully automated processor (Velopex, London, England). Patients under orthodontic treatment whose periapical radiographs had been interpreted by the attending orthodontists underwent surgical extraction of the impacted teeth. A flap was elevated and the impacted tooth was directly visualized. Patients presenting to the radiology department underwent the same procedure (2 patients).

Radiographic analysis of panoramic radiographs of patients:

1. The maximum mesiodistal width of canine tooth along a perpendicular line relative to the long axis of the impacted tooth was measured (Fig. 1).
2. The maximum mesiodistal width of the ipsilateral central incisor along a perpendicular line relative to the long axis of the central incisor was measured (Fig. 1).
3. In patients with the contralateral canine tooth in its correct position, the largest mesiodistal width of this tooth was also measured as described above (Fig. 1).
4. The crown height of the impacted canine was assessed relative to the crown height of the ipsilateral central incisor. The ipsilateral central incisor was vertically divided into three zones of coronal third, middle third and apical third. Then, the crown height of the impacted canine was estimated accordingly (Fig. 2).
5. Mesiodistal width of the maxillary first molars of both sides was also measured.

The ratio of the mesiodistal width of the impacted canine to the mesiodistal width of the ipsilateral central incisor was calculated and referred to as the CII.

In patients with unilaterally impacted canine and the contralateral canine in its correct position, the ratio of the mesiodistal width of the impacted canine to the mesiodistal

Fig 1. **Maximum mesiodistal width of canine tooth along a perpendicular line relative to the long axis of the impacted tooth.**

Fig 2. **The crown height of the impacted canine was estimated.**

width of the contralateral canine was calculated and considered as the control group (canine-canine index or CCI).

Using the SLOB rule, buccolingual position of the impacted canine was determined on periapical radiographs again and compared with initial diagnosis. Related data were recorded in separate datasheets for each patient. In case of absence of clinical symptoms such as swelling or buccal or palatal bulge in an interview with patients, the data form was completed.

Mesiodistal width of the maxillary first molars of both sides was measured by a caliper and the panoramic radiographs of cases with more than 5% difference were excluded from the study (2 cases) because it indicated excessive magnification of the image and since this study was based on magnification of impacted canines, the radiographs with excessive magnification would interfere with accurate diagnosis.

Localization of impacted canine using the panoramic radiography method alone is based on magnification of impacted canine on the radiographs. In other words, if the impacted tooth was palatally positioned, the tooth would have a larger image than a normally positioned tooth with the X ray tube behind and the radiographic film in front of the patient.

Also, if we assume that the ratio of the mesiodistal width of a normal canine tooth relative to the mesiodistal width of the ipsilateral central incisor is relatively constant (with a specific range), we expect this ratio to increase in the image as well for a palatally positioned tooth (since it would have a magnified image) and vice versa.

Data including the mesiodistal width of the impacted canine on a panoramic radiograph, mesiodistal width of the ipsilateral central incisor on a panoramic radiograph, mesiodistal width of the contralateral normal canine (if present), mesiodistal width of the maxillary first molars of both sides on panoramic radiographs and clinically measured mesiodistal width of the maxillary first molars of both sides were collected.

For the purpose of data analysis, the crown height of the impacted canine was measured and categorized as apical, middle or coronal relative to the crown height of the ipsilateral central incisor. These data along with the CCI and CII values were analyzed using SPSS via t-test. Level of significance was set at $P < 0.05$.

Results

Of 20 patients, eight had bilaterally impacted canines (40%); out of which, four had palatally positioned bilateral impacted canines (20%) and three had buccally positioned bilateral impacted canines (15%); in one patient, one impacted canine was buccally positioned while the other one was palatally positioned (5%). Table 1 presents the frequency distribution of the vertical orientation of buccally positioned canines. Table 2 shows the frequency distribution of the vertical orientation of palatally positioned canines.

General assessment of samples irrespective of their vertical orientation relative to the ipsilateral central incisor with regard to the CII revealed that the CII varied from 1.15 to 1.75 for the palatally positioned impacted canines and from 0.78 to 1.48 for the buccally positioned impacted canines. An overlap existed between the above-mentioned results, which makes accurate localization of impacted canines difficult. Thus, it is not possible to rely on these figures for this purpose. However, assessment of these results based on the crown height of the impacted canine At the apical zone, an overlap existed in the results of CII for the buccally and palatally positioned impacted canines (Tables 3 and 4). However, in the coronal and middle zones, a significant difference existed in the results of CII for the palatally and buccally positioned impacted canines. This difference within these ranges enables accurate localization of the impacted canines based on CII. In other words, in the middle and coronal zones, the impacted canine is buccally positioned if the CII is between 0.78–1.1 and palatally positioned if the CII is between 1.15–1.75.

The results of t-test yielded a P value of 0.001 for the middle and coronal zones; however, the P value for the apical zone was 0.151.

The values for CCI are shown in Tables 5 and 6. As seen, the CCI varied from 0.87 to 1.07 for the buccally positioned

impacted teeth in the middle and coronal zones. This range was 1.09–1.44 for the palatally positioned impacted canines.

As stated earlier, this index is used for unilaterally impacted canines and since the range of variations of this index is close for the buccally and palatally positioned canines (1.09–1.07 = 0.02), this index is often used to confirm the results of CII and confirm the initial findings. As mentioned earlier, the CII can be used with 100% accuracy for localization of impacted canines in the middle and coronal zones.

The value of 1.15 can be used as a cut-off point for CII; values smaller than 1.15 indicate buccally positioned teeth while higher values indicate palatally positioned impacted canines in the middle and coronal zones.

Also, the results of SLOB method were compared with those of panoramic radiography and showed full agreement with the results of surgical exposure and direct observation of impacted teeth. Thus, in all cases where the results of panoramic radiography were in line with the findings of direct

Table 1. Frequency distribution of the vertical orientation of buccally positioned canines

Vertical orientation	N	Total (%)	Buccally positioned (%)
Apical	2	7.1	18.1
Middle	2	7.1	18.1
Coronal	7	25	63.6
Total	11	39.2	100

Table 2. Frequency distribution of the vertical orientation of palatally positioned canines

Vertical orientation	N	Total (%)	Buccally positioned (%)
Apical	1	3.5	5.8
Middle	13	46.4	76.4
Coronal	3	10.7	17.6
Total	17	60.8	100

Table 3. The mean, standard deviation and range of changes in CII for the buccally positioned impacted teeth

Vertical orientation	N	Range	Mean	Standard deviation
Apical	2	0.91–1.48	1.18	0.17
Middle	2	1–1.1	1.03	0.03
Coronal	7	0.78–1.02	0.93	0.07
Middle + coronal	9	0.78–1.1	0.94	0.07

Table 4. The mean, standard deviation and range of changes in CII for the palatally positioned impacted teeth

Vertical orientation	N	Range	Mean	Standard deviation
Apical	1	1.15–1.3	1.26	0.05
Middle	13	1.15–1.75	1.28	0.12
Coronal	3	1.15–1.32	1.22	0.06
Middle + coronal	16	1.15–1.75	1.26	0.12

Table 5. The mean, standard deviation and range of changes of CCI in buccally positioned impacted canines

Vertical orientation	N	Range	Mean	Standard deviation
Apical	2	1.13–1.38	1.28	0.13
Middle	2	0.94–1	0.94	0.04
Coronal	7	0.87–1	0.97	0.05
Middle + coronal	9	0.87–1.07	0.97	0.05

Table 6. The mean, standard deviation and range of changes of CCI in palatally positioned impacted canines

Vertical orientation	N	Range	Mean	Standard deviation
Apical	1	1.19–1.23	1.21	0.03
Middle	13	1.1–1.44	1.23	0.08
Coronal	3	1.09–1.29	1.2	0.06
Middle + coronal	16	1.09–1.44	1.22	0.8

observation, these results were also found to be in agreement with those of SLOB method and vice versa.

Discussion

Previous studies on localization of impacted canines on panoramic radiographs did not introduce a reliable general solution or a specific method for this purpose. In 2015, Kumar et al.,[11] in their study on localization of impacted canines concluded that occlusal radiography or the Clark's method by use of two periapical radiographs is commonly used in the clinical setting for localization of impacted canines. They also stated that some adjunct radiographic techniques such as panoramic radiography and lateral cephalometry could also be used to determine the prognosis of impacted canines.

In 2014, Rajathi et al.,[12] assessed the validation of panoramic radiography for localization of impacted maxillary canines and reported that panoramic radiography can serve as a reliable screening aid for localization of impacted maxillary canines by use of magnification criteria. In the current study, we found that this method was 100% accurate for detection of impacted teeth in the coronal and middle zones. By taking into account the impacted canines in the apical zone, this value was calculated to be 90%. Furthermore, the SLOB method can also be used as an adjunct for this purpose. In 2014, Lai et al.,[13] in their study on localization of impacted maxillary canines and root resorption of the adjacent teeth concluded that orthodontists had higher likelihood of determining the labiopalatal position of impacted maxillary canines merely based on panoramic radiographs. However, maxillofacial surgeons mostly required further three-dimensional imaging studies.

In 2014, Serrant et al.[14] assessed the accuracy of cone beam computed tomography and conventional horizontal or vertical Parallax for localization of ectopic maxillary canines and concluded that CBCT was more accurate for this purpose. This indicates that the SLOB method has been previously used for localization of teeth in the literature since it lowers the patient radiation dose.

In 2009, Sudhakar et al.,[15] evaluated localization of impacted permanent maxillary canines using panoramic radiography alone and concluded that only one panoramic radiography can reliably determine the buccolingual orientation of impacted canines if they are positioned in the middle and coronal zones; however, localization of those in the apical zone requires advanced imaging modalities or other conventional radiographs. Their results are in line with our findings.

In 2009, Nagpal et al.,[16] assessed the localization of impacted maxillary canines using panoramic radiography and concluded that panoramic radiography cannot be used alone for reliable localization of impacted teeth. Accurate localization of palatally positioned impacted canines by the magnification criteria based on panoramic radiographs was only possible in 77% of cases. Our study showed 100% accuracy for localization of teeth in the middle and coronal zones. In 1999, Chaushu et al.,[17] evaluated the reliability of a method for localization of ectopic maxillary canines by use of only one panoramic radiograph and reported that this method was valid for differentiation of palatally and buccally positioned teeth. In 1995, Fox et al.,[10] used panoramic radiography to determine the location of impacted canines and concluded that panoramic

radiography wrongfully reported the position of impacted canines in 19% of cases. In 1979, Wolf and Mattila[9] reported an error rate of 21% for panoramic radiography, mainly attributed to difference in magnifications of different panoramic radiography systems.

Although the above-mentioned studies were based on the magnification rule (object closer to the X ray tube has a larger image), they neglected one issue, that is the distance from the object to the X ray tube in the vertical position. In panoramic radiography, the central beam exposes the radiographic film at a negative angle. Thus, a palatally positioned impacted tooth would have a more coronal image compared to a buccally positioned impacted tooth at the same vertical level. Accordingly, the height of the impacted tooth image is determined based on two factors namely the buccolingual factor (described earlier) and the vertical position of the impacted tooth. Thus, to obtain the magnification of an image, vertical position of the impacted tooth must be necessarily taken into account.

In the current study, 63.6% of the buccally positioned impacted canines were in the coronal zone of the ipsilateral central incisor; 76.4% of the palatally positioned impacted canines were in the middle zone of the ipsilateral central incisor. As expected, magnification of a palatally positioned impacted tooth in the middle zone is greater than the magnification of the same tooth positioned coronally.

In impacted canines in the middle and coronal zones of the ipsilateral central incisor, the range of changes of CII was significantly different for the buccally and palatally positioned teeth. In the middle zone, the mean CII was 1.03 ± 0.03 for the buccally positioned canine teeth.

If we add twice the standard deviation value to the mean, we obtain the value of 1.09, which is still smaller than all CII values for the palatally positioned teeth in the middle zone (minimum CII of 1.15) (Tables 3 and 4).

In the coronal zone, the mean CII for the buccally positioned impacted canines was 0.93 ± 0.07. If twice the standard deviation value is added to the mean, the value of 1.07 is obtained (minimum CII for the palatally positioned impacted teeth in this zone was 1.15).

The mesiodistal width of a canine tooth is averagely 90% of that of a central incisor.[18] In other words, the mean mesiodistal width of a canine tooth is one millimeter smaller than the mesiodistal width of a central incisor of the same individual.[19] In a panoramic radiograph, when canines and central incisors are ideally positioned in the dental arch, canine has a magnification of approximately 10% greater than that of a central incisor. Thus, the mesiodistal width of these two would be approximately the same. Therefore, we recommend the use of central incisors as a reference to obtain CII.

For the CCI, since 40% of patients had bilaterally impacted canines, this index was not suitable for all positions of impacted canines and CII was preferred for this purpose because the CCI has lower accuracy for the impacted teeth in a vertically higher position. Also, the anatomy of the bone plate in the anterior maxilla plays a role in this regard. The angle between the incisor teeth and the palatal plate is approximately 112°.[20] Thus, a buccally impacted tooth in the apical zone may be in the same anterior-posterior plane as a palatally impacted tooth in the coronal zone and therefore, they both would have the same magnification on a radiograph.

Conclusion

The accuracy of panoramic radiography alone in our study was found to be equal to the value obtained by previous studies (90%). But, the accuracy of this method reached 100% when the impacted canines in the apical zone (10%) were excluded.

The CII > 1.15 shows palatal position of the impacted canines in the coronal or middle zones of the ipsilateral central incisor; the CII < 1.15 indicates the buccal position of the impacted canines in the coronal or middle zones of the ipsilateral central incisor.

The results of the panoramic radiography method were in line with those of the SLOB method in 90% of the cases; the main advantage of the SLOB method is lowering the patient radiation dose.

Acknowledgement

Conflict of Interest

"None Declared." ■

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