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Fidelity of orthopantamograms and CBCT in predicting position of impacted canines

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Abstract
The maxillary canine is the most frequently impacted teeth second to third molars. The canines are not only of high aesthetic value but also play an important role in guiding occlusion and maintaining the smile line. The most commonly used diagnostic aids for diagnosing the position of the impacted canines are IOPAR and orthopantomograms. The advent of CBCT has not only made diagnosis more predictable but it is also a more reliable technique.
The final therapeutic decision (canine extraction or orthodontic traction; type and timing of orthodontic traction) could be a quandary for both the patient and the orthodontist, and in these cases treatment duration and difficulty degree are factors of crucial importance to consider for this reason, several authors tried to elaborate different methods to estimate them, utilizing radiographic images such as OPG, occlusal films, periapical radiographs, and lateral cephalograms.
The aim of this study was to correlate the position of impacted maxillary canines on panoramic radiography with cone beam CT (CBCT) and analyse the labio-palatal position of canines and root resorption of permanent incisors in CBCT according to the mesiodistal position of canines on panoramic radiographs.
The labiopalatal position of the impacted canines and root resorption of permanent incisors were evaluated with CBCT. The sector location on panoramic radiographs was compared with the labiopalatal position of impacted maxillary canines on CBCT.

Keywords: OPG, CBCT, sector analysis, KPG index, impacted canine, treatment planning

Introduction
The maxillary canine is the most frequently impacted teeth second to third molars. The prevalence of impaction of maxillary canine ranges from 0.9-3.0%.[1] the canines are not only of high aesthetic value but also play an important role in guiding occlusion and maintaining the smile line. The instabilities in the eruption of maxillary permanent canines are common due to the long period of development, the most superior area of development and a tortuous course of eruption in comparison to other teeth. Impacted canines may result in several complications such as displacement and root resorption of adjacent teeth, cystic degeneration, canine ankylosis, loss of arch width or a combination of these factors
The most commonly used diagnostic aids for establishing the position of the impacted canines are periapical radiographs, occlusal films and orthopantomograms. All these aids provide the location of the impacted tooth in two dimensions. Localization relies on the Buccal Object Rule to determine the position of the tooth. In this technique, separate radiographs are taken by changing the mesiodistal direction of the x-ray beam. Relative to each other, the apparent movement of the impacted canine between these radiographs indicates the buccolingual location. If the tooth moves in the same direction as the beam, the tooth is determined to be palatal to the arch. If the tooth moves in the opposite direction, it is buccal to the arch. With 2-D radiographs, however, tissue superimposition occurs frequently, thus they are not the ideal means of localization of an impacted tooth and its surrounding structures.
The advent of CBCT has made diagnosis more predictable by providing evidence in all three planes of space. Cone-beam computed tomography (CBCT) uses a cone-shaped X-ray to acquire maxillofacial images with higher spatial resolution. The software from the manufacturer enables multiplanar and 3D reconstructions valuable for orthodontic assessment.

These secondary reconstructions provide different frames of interest, including coronal or frontal, sagittal, and axial or horizontal, allowing for evaluation of the impacted tooth and surrounding structures. The proximity of the impacted canine to incisors is shown to be significantly correlated with incisor resorption. The radiation dose of cone beam CT (CBCT) is significantly lower than convention CT and the usual overlap of dental structures visualized on panoramic radiographs is not observed using this tool. The precise position of the impacted tooth in all 3 dimensions of space provides a significant insight not just about the position but also helps in planning the course and duration of treatment.
The aim of this study was to correlate the position of impacted maxillary canines on panoramic radiography with cone beam CT (CBCT) and analyse the labio-palatal position of canines and root resorption of permanent incisors in CBCT according to the mesiodistal position of canines on panoramic radiographs.

Materials and Methods

Patients reporting to the Outpatient Department of the Department of Orthodontics and Dentofacial Orthopaedics, JSS Dental College and Hospital with impacted maxillary canines noted on the periapical films or OPG's were chosen for the study. Subsequently as a part of routine diagnosis and treatment planning, they were advised for CBCT for localisation of the impacted canine.
The mean age of the patients was 19.15 years.
The orthopantomogram (OPG) was taken using PLANMECA SCARA-3 (ProMax saw 1.20.1.0.R, Proline XCGUI1.4.0.0. 1PK 5.60.pg5.60, Helsinki, Finland). The parameter was set at 80kvp, 320ma, 0.37s.
The CBCT was taken using CS9300 machine using the following parameters of 90 KV 5Ma 8.01s.The unit has 3 field-of-view (FOV) modes named facial (F), panoramic (P) and implant (I) modes, size of the FOV and voxels for each mode are, respectively 192.2mm in diameter and 0.36mmin F mode, 150 mm in diameter and 0.293mm in P mode, and 102.4mm in diameter and 0.200mm in I mode. Images from F and P modes only will be selected. The CBCT was evaluated using CS9300 Select software.

Methods of scoring for OPG and CBCT

a) OPG

The impacted maxillary canines on the OPG were scored using sector analysis given by Ericson and Kurol modified by Lindauer which is as follows:

Table 1: sector analysis by Ericson and Kurol

Sector	Inference
I	Sector I: this represents the area distal to the line tangential to the distal heights of contour of the lateral incisor crown and root.
II	Sector II: mesial to sector I, but distal to the line bisecting the lateral incisor's long axis.
III	Sector III: mesial to sector II, but distal to the mesial heights of contour of the lateral incisor crown and root.
IV	Sector IV: all areas mesial to sector III.

According to Ericson and Kurol [5], canines with cusp tip position in sectors 1-2, distal to the lateral incisor vertical midline, were considered easier to treat, compared to canines with a more mesial position, corresponding to sectors 3and 4.

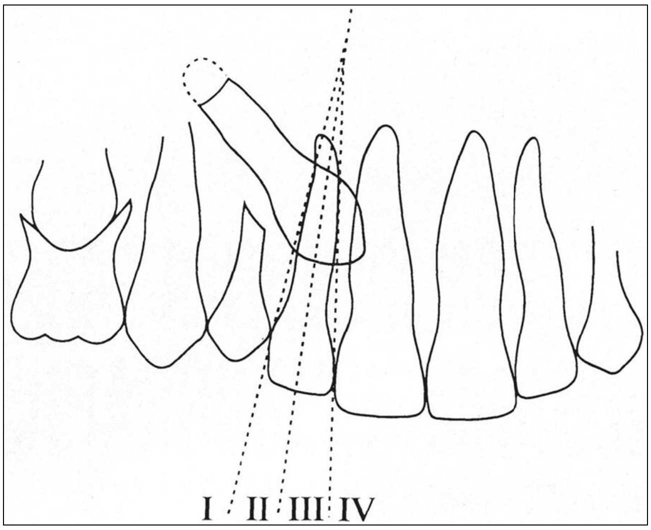

Fig 1: sector analysis-Ericson and Kurol modified by Lindauer

Fig 2: sector analysis on OPG

b) CBCT

The analysis for CBCT was done using the KPG index given by Chung How Kau. The KPG index localises the impacted canine in all 3 spatial dimensions names x, y and z. It describes the position in terms of both cusp tip as well as the root tip of the impacted canine. The values are then added and compared to a scale which determines the ease of difficulty of disimpaction of the canine

The scoring patterns is as follows:

1. X-Axis

Table 2: KPG index: X-axis

0	Canine cusp tip/root tip is in the proper erupted location; no treatment necessary in this dimension.
1	Cusp tip/root tip is within the width of the alveolus on either side of the vertical line bisecting the canine.
2	Cusp tip/root tip is in the area between the edge of the alveolus and a vertical line bisecting the adjacent tooth; either the distal half of the lateral incisor or the mesial half of the first premolar.
3	Cusp tip/root tip is in the further half of the neighbouring tooth; mesial half of lateral incisor or distal half of first premolar.
4	Cusp tip/root tip is in the distal half of the central incisor, or distal to the first premolar but mesial to the midline of the second premolar.
5	Cusp tip/root tip is in the mesial half of the central incisor or distal to the midline or the second premolar

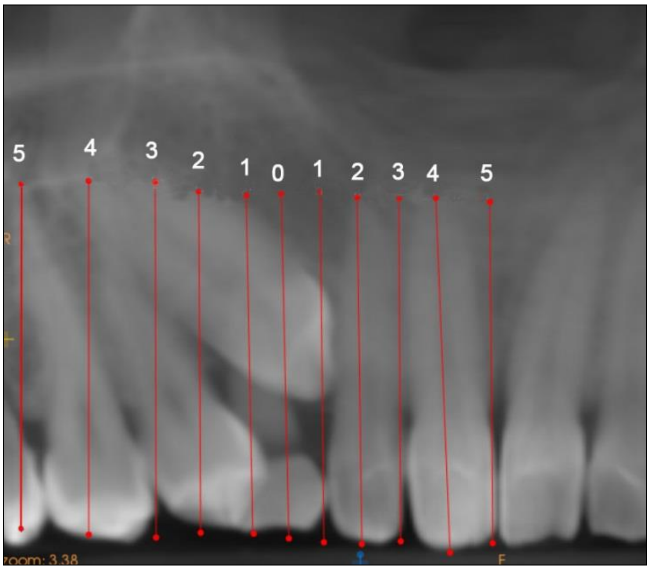

Fig 3: X-axis

The cusp tip and the root tip are each graded separately, with the value of this dimension being designated in the X column. Areas 2 and 3 correspond to the cusp tip/root tip being located in the area of the lateral incisor or first premolar. Areas 4 and 5 correspond to the cusp tip/root tip being located in the area of the central incisor or the second premolar. The further away the tip is from its normal position, the higher the number

2. Y-axis

The zones for the vertical dimension are similar to those used in the study by Liu *et al*. (2): coronal, cervical one-third of the root, middle one-third of the root, apical one third of the root, and supra-apical. The scale for grading the canine cusp tip in the vertical dimension in the y axis is as follows:

Table 3: KPG Index-Y axis for cusp tip

0	Canine cusp tip is in the proper vertical location.
1	Cusp tip is in the coronal region.
2	Cusp tip lies in a horizontal plane with the cervical third of the incisor root.
3	Cusp tip lies in a horizontal plane with the middle third of the incisor root.
4	Cusp tip lies in a horizontal plane with the apical third of the incisor root.
5	Cusp tip is supraapical to the incisor root.

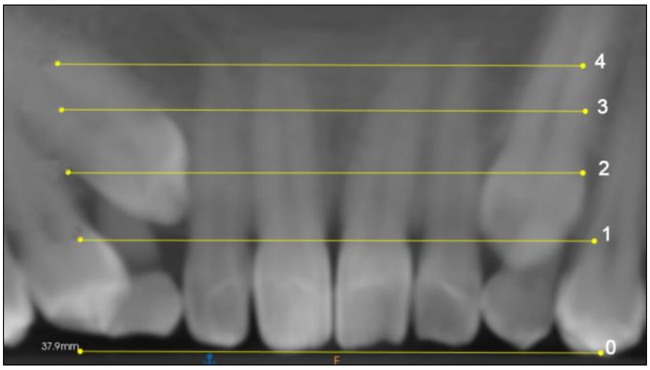

Fig 4: Y-axis

Since the root tip and the cusp tip are at opposite ends of the tooth, the scale for the location of the root tip is almost a direct opposite of the cusp tip

Table 4: Y axis for root tip

0	Canine root tip is in the proper vertical location.
1	Root tip lies in a horizontal plane with the apical third of the incisor root.
2	Root tip lies in a horizontal plane with the middle third of the incisor root.
3	Root tip lies in a horizontal plane with the cervical third of the incisor root.
4	Root tip is in the coronal region.
5	Root tip is extending past the coronal region

3. Z-axis

The z axis for the canine was established using the axial views on the CBCT images and makes the index unique, as this section is not normally seen with traditional radiographs. This scale uses distances measured perpendicularly in 2 mm increments from the cusp or root tip to the curved line of the occlusal arch. The divisions of the scale are based solely on the distance of the impacted tip to the occlusal reference arch, different from the other two views, which are based more on anatomical location.

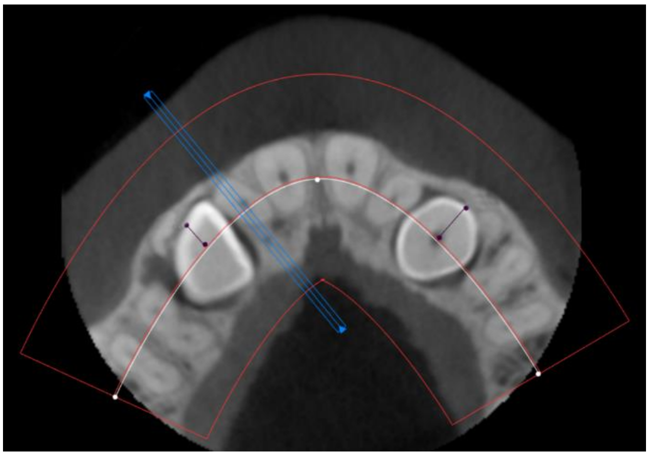

Fig 5: Z-axis

Table 5: KPG Index-Z axis

0	Canine cusp/root tip is in its proper location along the occlusal arch.
1	Cusp/root tip is 0-2.0 mm away from the occlusal arch of the cusp tip or root tip, either buccally or lingually.
2	Cusp/root tip is located in the area 2.0-4.0 mm away from the occlusal arch, either buccally or lingually.
3	Cusp/root tip is located in the area 4.0-6.0 mm away from the occlusal arch, either buccally or lingually.
4	Cusp/root tip is located in the area 6.0-8.0 mm away from the occlusal arch, either buccally or lingually.
5	Cusp/root tip is more than 8.0 mm away from the occlusal arch of the normal canine cusp or root tip, either buccally or lingually

The sum of all scores for each individual tooth. Scores in the range 0-9 fall into the category of easy; 10-14 are moderate; 15-19 are difficult; and 20 and above are extremely difficult.

Results

In the present study orthopantomograms and CBCTs of 20 patients were evaluated to compare the reliability between orthopantomograms and CBCTs. The mean age of the patients was 19.15 years, 4 patients had bilaterally impacted canines and 16 had unilaterally impacted canines. Sector analysis by Ericson and Kurol was used to predict the position in orthopantomogram (OPG) and KPG index given by Kau was used to predict the position on the CBCT software. CBCT was designated as D1 and OPG as D2.

Table 6: Wilcoxon Signed rank test for statistical analysis

N	Median	Mean rank	Z value	P value
20	2.00	8.88	2.507	0.012

The median for was and non-parametric Wilcoxon signed rank test values showed that prediction of ease of disimpaction was higher in CBCT than OPG.

Discussion

The greatest challenge an orthodontist poses in treatment of impacted teeth is the prediction of the exact location of the impacted teeth and duration of treatment for disimpaction, longer treatment duration poses dangers such as enamel demineralisation, root resorption and periodontal complications. Treatment planning completely depends on the localisation of the tooth which helps in deciding the type of traction to be given, extraction vs non-extraction protocols, condition of the adjacent teeth and effect of traction on the adjacent structures. Radiographs have long been used for assessing impacted teeth and the adjacent structures, though these tools have proven to be of help but the images are in 2 dimensions and hence the reliability is not adequate.

OPG is the first diagnostic tool used to locate the impacted tooth, adjunct radiographs such as periapical and occlusal films also play an important role in diagnosis. The use of these radiographs may not provide a complete picture of the location and involvement of the adjacent structures. These tools prove to be cost efficient ad also have lower radiation doe in comparison to CBCT and hence may be the preferred diagnostic tools for the clinician. The use of sector analysis given by Ericsson and Kurol provides adequate information on the location of the impacted canine in relation to the long axis of the lateral incisor. They predicted that canines presented in sector III and IV show difficulty in disimpaction. According to the present study canines present in Sector 4 show a KPG index value lesser than equal to 10 which shows that the canine may be easily disimpacted.

The use of CBCT which provides images in all the 3 spatial planes provides us with valuable information not just about the position but also provides us with an insight for planning treatment protocols and effective duration of the treatment. The relationship of the impacted teeth with adjacent structures and its effects during traction can also be studied using these scans. Though the radiation exposure of CBCT's is higher the valuable information it provides annuls the amount of exposure. The availability of these scans may be a challenge but when available should be used as they prove as an indispensable tool during treatment planning, exposure of the impacted tooth and to decide on effective methods of providing traction thereby reducing treatment time and the risks associated with it.

Conclusion

From the present study results we conclude that

1. CBCT is a better predictor of position of impacted maxillary canine compared to OPGs.
2. The ease of prediction of disimpaction is higher using KPG index in comparison with sector analysis.

Lower radiation exposure and ease of using the CBCT software has made clinicians find increasing acceptance and application in the diagnosis and treatment, with a subsequent phasing out of conventional radiographs. Ongoing development of 3D imaging promises to enhance the precision and effectiveness of our diagnosis and treatment planning. Further clinical studies with larger sample size comparing the use of these methods intra-operatively with follow ups, is required to validate the study.

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