Reliability of Panoramic-Radiograph to Determine the Position of Third-Molar from Inferior-Alveolar-Canal

(Azizah Ahmad Fauzi*, Mohamed Ebrahim Parker, Ej Norval & Phrabhakaran Nambar)

ABSTRACT

Cone-beam-computed-tomography (CBCT) has been useful in providing insights of relevant anatomy prior to surgical procedures, including the assessment of the proximity of impacted mandibular-third-molar to the inferior-alveolar-canal (IAC). It is important to understand the reliability of conventional panoramic-radiograph in the assessment of this criterion since it is more commonly used as first line radiographic approach due to its availability and lower radiation dose. This study aimed to investigate the reliability of conventional panoramic-radiograph in the evaluation of the proximity of impacted mandibular-third-molar root tip to the IAC by correlating the results with CBCT. A total of 65 root tips of impacted mandibular-third-molars that had both panoramic radiographs and CBCT images were included in this retrospective study. Two trained observers participated in all image evaluations. A prepared standard 1 cm ruler was used to measure the proximity of the third-molar root apices to the IACs. Measurements recorded in this study were categorized into positive (root apex above a roof of IAC), zero (root apex was superimposed on IAC) and negative (root apex below a roof of IAC). Data analysis was carried out using student t-test. In this study, both observers recorded statistically significant differences in the measurement between third-molars root apices and the IAC from panoramic radiographs and CBCT images. The low reliability of panoramic radiograph to assess the vertical proximity between these two anatomical structures suggests the importance of additional assessment with CBCT in cases where panoramic radiograph shows superimposition of the third molar root on the roof of the canal and presence of root below the roof of the IAC.

Keywords: Panoramic radiography; third molar

INTRODUCTION

Knowing the exact position of the mandibular-third-molar root apex to the IAC will help the surgeon to determine the risk of inferior-alveolar-nerve injury following surgical removal of mandibular-third-molar. This is important prior to obtain inform consent from the patient and decide the most appropriate treatment plan.

There are several radiographic approaches which have been used for preoperative assessment of the relationship between the roots of mandibular-third-molar to the IAC (Ghaemini et al. 2009). Panoramic radiography has been used as a common diagnostic modality in dentistry, including the assessment of the impacted mandibular-third-molar. Despite being an inexpensive radiography
procedure, this imaging modality suffers from image magnification, superimposition, ghost images and distortion (Hassan 2010).

In the presence of CBCT scanners which have been developed specifically for dental and maxillofacial imaging (Scarfe & Farman 2008), this technology is becoming more commonly used in dentistry. The geometric and small size of the isotropic voxels of the CBCT volumetric data sets which range from 0.076 to 0.4 mm provides high pixel resolution with CBCT images (Scarfe & Farman 2008).

The absence of both magnification and distortion in secondary reconstructed images from CBCT volumetric data has also been described, hence, measurements performed on this reconstruction slice can be assumed to have a one: one relationship with the actual object (Snyder 2007). Unlike panoramic radiography which uses an average dental arch as focal trough, the ability of the CBCT technology to customize the focal trough shape to suit an individual dental arch allows for improved visualization of the anatomical structures of the region of interest. It is generally agreed that CBCT proved to be a reliable technique for visualizing anatomical structures in the maxillofacial region including the IAC, and for assessing its relationship to the adjacent roots of teeth (Angelopoulus et al. 2008; Sawamura et al. 2003; Tantanapornkul et al. 2007). However, the higher radiation dose and cost of CBCT in comparison to panoramic radiography limits the use of this modality to cases where conventional radiographic findings justify further assessment with CBCT (SEDENTEXCT project 2011). Understanding the reliability of panoramic-radiograph in the assessment of third-molar to the IAC will provide better insight about the need of CBCT assessment prior to removal of impacted mandibular-third-molar.

The aim of this study was to investigate the reliability of conventional panoramic-radiograph in the evaluation of the proximity of impacted mandibular-third-molar root tip to the IAC by correlating the results obtained by means of CBCT.

MATERIALS AND METHODS

SAMPLE COLLECTION

A sample size of 65 root tips of impacted mandibular-third-molars that had both panoramic radiographs and CBCT images were included in this retrospective study. Approval from the research ethics committee, University of Western Cape and medical ethics committee, University of Malaya were obtained prior to commencement of the study.

Initially, CBCT images were selected from existing records of patients who went for CBCT assessment prior to surgical removal of the third-molar. Then, the matching conventional panoramic images were searched from a patient records database for subsequent comparison with the CBCT images. Panoramic and CBCT machines with their operating kVp and mA that were used for radiographic acquisition in this study were described in Table 1.

The inclusion criteria employed in this study were patients older than 18 years old, the presence of fully visible impacted mandibular third molars and visible IACs. Any radiographic record which showed incomplete root formation, pathology or resorption in apical area of mandibular third molars was excluded in this study.

SAMPLE PREPARATION AND DATA COLLECTION

All the images were viewed by two trained observers in Maxillofacial Radiology. The procedures for image preparation and assessment were summarized in Figure 1.

STATISTICAL ANALYSIS

All measurements from both observers were collected and entered into a spread sheet. Means and standard deviation of the measurements recorded by both observers were calculated for each imaging modality. The reliability of panoramic radiographs in the assessment of the proximity of the root apex to the IAC was evaluated statistically by comparing panoramic radiographs measurements with CBCT image measurements using the student t-test. The student t-test was also used to evaluate the inter-observer agreement in this study.

RESULTS

In the assessment of the vertical position of 65 mandibular third molar root apices from the roof of IACs (Table 2), 44 of the cases showed negative measurement from the panoramic radiography image evaluation. This finding also showed that most of the impacted mandibular third molars showed intrusion of the root into the IAC when panoramic radiographs were assessed. The lengths of these roots within the IACs were measured to be between 0.15

<table>
<thead>
<tr>
<th>Name of machines</th>
<th>kVp</th>
<th>mA</th>
<th>Type of radiograph</th>
<th>Magnification factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Veraview</td>
<td>60 to 70 kVp</td>
<td>5 to 10 mA</td>
<td>Digital panoramic radiograph</td>
<td>1.3</td>
</tr>
<tr>
<td>PC-1000</td>
<td>80 to 90 kVp</td>
<td>6 mA</td>
<td>Film based (analogue) panoramic radiograph</td>
<td>1.23</td>
</tr>
<tr>
<td>i-CAT</td>
<td>120 kVp</td>
<td>8 mA</td>
<td>CBCT images</td>
<td>none</td>
</tr>
<tr>
<td>NewTom VGi</td>
<td>110 kVp</td>
<td>15 mA</td>
<td>CBCT images</td>
<td>none</td>
</tr>
</tbody>
</table>
SAMPLES PREPARATION (PHASE 1): COMPENSATION OF IMAGE MAGNIFICATION FACTOR & RECONSTRUCTION OF CBCT IMAGES

- All analogue panoramic radiographs were digitized with Epson Perfection V750 Pro scanner. Thus, vertical and horizontal enlargements of 1 mm from the digitized radiograph were removed.
- The magnifications of horizontal and vertical components of all panoramic radiographs were also compensated by dividing these components with 1.23 or 1.3. This depends on the panoramic machine used.
- All CBCT images were reconstructed into three panoramic views. The panoramic reconstruction plane which showed the closest proximity of the root apex to the IAC was selected for subsequent comparison with the matched conventional panoramic radiograph.

SAMPLES PREPARATION (PHASE 2): STANDARDISATION OF IMAGES

- Resized panoramic radiographs and panoramic reconstruction CBCT images were cropped and entered in Microsoft Word’s spread sheets, viewed at 100%.
- When image was viewed at 500%, a prepared standard 1 cm ruler with the same magnification was positioned at an angle to the roof of the IAC (Figure 2). This was performed to achieve standardization of vertical measurement from panoramic radiographs and CBCT images.
- Further magnification of the image and the standard ruler were performed to allow better visualization of the ruler’s scale and the point made on the root apex.

IMAGES MEASUREMENT & DATA COLLECTION

- 3 categories of image measurements were recorded in this study:
  - Positive measurement (when the root apex was measured above the roof of the IAC)
  - Negative measurement (when the root apex was measured below the roof of the IAC)
  - Zero measurement (when the root apex was superimposed on the IAC)
- All measurements in this study were recorded in the data collection table, where the registration number of the patient was used as a reference of data from the same subject. A similar table was used to record the measurements made by the second observer.

FIGURE 1. A flow chart to describe the procedures which were followed for preparation of samples (panoramic radiographs and CBCT images) as well as its assessment

FIGURE 2. The standardize position of the magnified 1 cm ruler which is placed at an angle to the roof of the canal
and 5.6 mm. On CBCT, only 33 root apices were found within the alveolar canal, and the lengths ranged between 0.05 and 4.2 mm.

On the other hand, the numbers of root apices located above the IACs which gave positive measurements in panoramic radiographs as well as CBCT images were 17 and 27 root apices, respectively. On panoramic radiographs, the thickness of bone height separating the root apices from the roof of the canal ranged from 0.2 to 2.75 mm. Meanwhile, on CBCT images the height ranged from 0.1 to 4.75 mm. Several superimpositions of the root apices on the roof of IACs had also been found in both imaging modalities and these were recorded as zero measurement. There were four root apices found to be superimposed on the roof of inferior alveolar canals from panoramic radiographs and five root tips on CBCT images.

An additional finding in this study indicated that eleven out of forty roots were located within the canal from panoramic radiographs but were actually located superior to the canal on CBCT images. Two out of seventeen roots which were located less than 1 mm above the IAC in panoramic radiographs showed root protrusion into the canal in the CBCT images. In these two cases, we also found that the impacted molars were also associated with other special panoramic features. These additional radiographic features include interruption of lamina dura at the apex of third molar and narrowing of IAC. On both cases, CBCT images showed interruption of IAC’s cortical roof with 0.1 - 0.5 mm of third molar root apices within the canal.

From this study, both observers showed significant difference between CBCT images and panoramic radiographs when measuring the vertical position between the root apices to the roof of the canals. The mean difference between panoramic radiographs and CBCT images when measuring the vertical distance between impacted mandibular third molar root apices and the roof of the IACs, recorded by the first observer was 0.580 mm (p<0.001), which also indicated a significant difference between both methods. The finding was demonstrated in the plot of CBCT image measurements against panoramic radiograph measurements (Figure 3). It could be seen from this plot that the red points representing CBCT image measurements were widely dispersed around the trend line of panoramic radiograph measurements, thus, indicating real bias between both methods.

In addition to this, the mean differences between the observer’s measurements for both methods were also evaluated to determine the presence of bias. Using the paired version of the t-test, the mean difference in panoramic radiograph measurements between the first and the second observers was 0.047 mm, which was small but turned out to be significantly different from zero (p=0.020). At this stage, one might assume that the inter-observers agreement in the measurement of panoramic radiographs was low. However, by plotting panoramic measurements made by the first observer on the X-axis and panoramic measurements by the second observer on the Y-axis, the points clustered closely around the straight line reflecting the presence of only small bias between the observers’ measurements on panoramic radiographs (Figure 4). The significant difference in the paired version of the test was explained by comparing the numbers of negative and positive differences in these two sets of panoramic radiograph measurements. From the assessment, the proportion of the negative difference was 0.3. This value was significantly different from 0.5; thus contributing to the significant difference in the paired version of the t-test, although a good inter-observers agreement was demonstrated from the plot of panoramic measurements by the first observer versus panoramic measurements by the second observer.

The mean difference in the measurements of CBCT images between the two observers was 0.0031 mm and was not significantly different from zero (p=0.837). This showed the absence of bias in the CBCT measurements made by both observers. A good inter-observers agreement

<table>
<thead>
<tr>
<th>Evaluation categories</th>
<th>Panoramic radiograph</th>
<th></th>
<th>CBCT images</th>
<th>No. of roots</th>
<th>m</th>
<th>M</th>
<th>No. of roots</th>
<th>m</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root apices below the</td>
<td>44 0.15±0.071 5.6±0.141</td>
<td>33 0.05±0.071 4.2±0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>roof of alveolar canal</td>
<td>(-ve measurement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root apices above the</td>
<td>17 0.2±0.000 2.75±0.071</td>
<td>27 0.1±0.014 4.75±0.071</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>roof of alveolar canal</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Root apices superimposed</td>
<td>4</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
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</table>
in CBCT measurements was also demonstrated in Figure 5, which showed a close relationship of the clustering of points around the straight line.

**DISCUSSION**

Understanding the limitation of conventional radiograph in the assessment of impacted third molar is paramount in determining the need of CBCT in selected cases and avoids unnecessary radiation exposure to the patient. Several studies have been made to compare the diagnostic accuracy of panoramic radiograph with CBCT and their findings are recorded as in Table 3.

From the literature reviews which are listed in Table 3, it can be concluded that five out of seven studies (71.4%) suggest panoramic radiograph is less accurate than CBCT. Quantitatively, we found that CBCT proved more accurate by ± 0.53 to 0.58 mm than panoramic radiograph in the measurement of the vertical position of mandibular third molar root apices to the IAC. This result is statistically significant between the two imaging modalities.

In a study of the proximity of maxillary third molars to the maxillary sinus by Hassan (2010), it had been described that superimposition of anatomical structures on conventional radiographs may result in over-projected root in the sinus. In the same manner, superimposition of buccal and lingual roots in conventional radiographs may also lead to over projection of mandibular tooth roots into the IAC.

In panoramic radiography, vertical magnification associated with this imaging modality is small and fairly constant. However, objects that are oblique which present with both vertical and horizontal components can appear slightly curved because of the significant change in the magnification of the horizontal component (Geist 2001). Since most molar roots are oblique, image distortion of this anatomical structure is likely to be present on panoramic radiographs.

In this study, although the magnification factors of panoramic radiographs were compensated before any measurements were made, the influence of the magnification factor may not be totally eliminated as the vertical and horizontal magnifications on conventional panoramic images performed by a single panoramic machine vary from one another at different rates, even when the object is placed within the focal trough. Thus, superimposition of the anatomical structures, image distortion and magnification remain the main factors which
are responsible for the inaccurate measurements of the conventional panoramic images found in the present study. The low reliability of panoramic radiographs to determine the vertical distance between the third molar root apices and the canal as demonstrated in this study suggest the importance of employing CBCT as additional diagnostic modality for better evaluation of the impacted tooth.

In this study, we also found that two out of seventeen roots which were located above the IAC on panoramic radiographs showed protrusion into the canal from the CBCT images. Whereas, eleven out of forty four roots which were located within the canal on panoramic radiographs were actually located superior to the roof of the IAC on CBCT images.

In relation to the findings, it can be concluded that eleven of forty four cases (25%) with a high risk of nerve injury on panoramic radiographs showed alteration from the high risk to low risk after CBCT panoramic reconstruction slices were analyzed. On the other hand, two of seventeen cases (11.8%) with a lower risk of nerve injury where the root apices were located above the canals changed into high risk, as CBCT images demonstrated root protrusion into the canal. In consistent to the study by Susarla and Dodson (2007), we found that, additional preoperative evaluation of impacted mandibular third molar with CBCT can be significant in terms of determination of the risk associated with inferior alveolar nerve injury following extraction of the tooth.

As described by Hasegawa et al. (2013) and Neves et al. (2012), this study recommends additional assessment of impacted mandibular third molar with CBCT when panoramic radiographs suggest the presence of a root in the IAC or superimposition of the root on the canal.

Presences of these panoramic features are more commonly associated with the risk of IAC exposure in impacted mandibular third molar cases. In such cases, further evaluation with CBCT may be necessary to determine the most appropriate treatment plan such as coronectomy or extraction of the third molar. It is also important for clinician to inform the patient about the possibility of IAC exposure even though panoramic radiograph shows the root is located above the IAC. As demonstrated in this study, the presence of root above the IAC in panoramic radiograph may also associated with IAC exposure, although the risk is low. This may occur particularly in cases where there is less than 1 mm bone height between mandibular third molar and IAC, narrowing of canal or interruption of lamina dura at the third molar root apex.

CONCLUSION

The presence of protrusion of mandibular third molar roots in the IAC on panoramic radiographs does not always signify association of the root apices to the neurovascular bundle within the canal. In a similar fashion, the absence of root protrusion in the IAC on panoramic radiograph does not necessary indicate dissociation of the root apices from the canal on CBCT images.

The reliability of panoramic radiograph to assess the vertical proximity of the mandibular root apex to the IAC is low. It is recommended in this study to use CBCT as secondary diagnostic modality when panoramic radiograph
shows superimposition of the third molar root on the roof of IAC and the presence of root below the roof of the canal. Additional evaluation with CBCT in such cases is important to determine the actual risk associated with the inferior alveolar nerve injury following surgical removal of impacted mandibular third molar.

REFERENCES


Azizah Ahmad Fauzi
Department of Oral Biology (Clinical), Faculty of Dentistry
Universiti Kebangsaan Malaysia
Jalan Raja Muda Abd Aziz
50300 Kuala Lumpur, Federal Territory
Malaysia

Mohamed Ebrahim Parker & EJ Norval
Department of Oral & Maxillofacial Diagnostic Imaging
University of the Western Cape
Robert Sobukwe Road
Bellville, 7535
Republic of South Africa

Phrabhakaran Nambiar
Department of Diagnostic & Integrated Dental Practice.
University of Malaya
50603 Kuala Lumpur, Federal Territory
Malaysia

*Corresponding author; email: azizah_fauzi@yahoo.com

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