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ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 6, Issue 04, pp. 1319-1322, April, 2015

RESEARCH ARTICLE

ASSESSMENT OF THE RELATION OF MANDIBULAR THIRD MOLARS TO THE MANDIBULAR CANAL: A META-ANALYSIS COMPARING PANORAMIC RADIOGRAPHS TO CONE-BEAM CT

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ARTICLE INFO

Article History:
Received 30th January, 2015
Received in revised form
04th February, 2015
Accepted 15th March, 2015
Published online 30th April, 2015

Key words:
Cone-beam CT,
Panoramic,
Third molar

ABSTRACT

Objectives: Extraction of mandibular third molars carries the risk of injuring the inferior alveolar nerve. The risk can be minimized by modifying the surgical approach or technique but this requires a thorough assessment of the relationship between the third molar and the mandibular canal. This study aims to analyze available data that compares the accuracy of panoramic radiographs and Cone Beam CT images in assessment of the relationship between the mandibular third molars and the inferior alveolar nerve canal.

Methods: A systematic search of the English literature using several databases was conducted. Articles between the years 2004 and 2014 were selected on the basis of predetermined inclusion criteria. They were then reviewed against a checklist for diagnostic tests and analyzed for pertinent data.

Results: Only two studies met the inclusion criteria and were included in the meta-analysis. Overall sensitivity for CBCT was 0.94 and overall specificity was 0.51, both of which were higher than panoramic radiographs but not statistically significantly different than panoramic radiographs.

Conclusions: The limited available evidence suggests that panoramic radiographs are as accurate as Cone Beam CT is assessing the relation of the mandibular third molar to the mandibular canal. Although Cone Beam CT offers vital information in the buccolingual dimension that is valuable in the pre-extraction treatment-planning phase.

INTRODUCTION

Evolution of the human race has resulted in a significant increase in the number of surgical procedures to extract third molars. Extraction of mandibular third molars specifically carries a significant risk of injury to the inferior alveolar nerve (IAN). The severity of the injury may vary resulting in transient or permanent postoperative symptoms such as dysesthesia or paresthesia. These symptoms are characterized by sensory deficit and/or abnormal sensation in the mandible, mental region, and the lower lip of the affected side. The risk of these symptoms post dental extraction of mandibular third molars ranges between 0.4% and 8.0% (Nakagawa *et al.,* 2007). Furthermore, permanent dysesthesia or paresthesia is believed to affect the quality of life (Koong *et al.,* 2006). Exposure of the IAN during surgery increases the risk of postoperative paresthesia by 15%-25% (Tay and Go, 2004). This usually happens when the relation between the roots of the mandibular third molar and the IAN is intimate.

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However, there is a great amount of anatomic variability in this relationship (Koong *et al.,* 2006). Therefore, it is of paramount importance to try to estimate this relationship and thus assess the risk of IAN injury preoperatively. This is most often than not done using radiographic images but the question remains, which imaging modality is most accurate at assessing the topographic relationship between the roots of the mandibular third molars and the mandibular canal. Panoramic radiographs are a standard imaging technique for pre-dental extraction assessment of mandibular third molars. They are readily available, inexpensive, and they have well-established features that are indicative of an increased risk of IAN exposure during surgery. These features are: darkening of the mandibular roots, narrowing of the roots, interruption of the cortical boundaries of the mandibular canal, mandibular canal diversion, or mandibular canal narrowing (Nakagawa *et al.,* 2007; Nakayama *et al.,* 2009; Monaco *et al.,* 2004; Tantanapornkul *et al.,* 2007; Jerjes *et al.,* 2006; Suomalainen *et al.,* 2010). Cone Beam CT (CBCT) is an imaging technique that has revolutionized dentistry with its many advantages and numerous applications. Two advantages are especially well suited for the application of assessing mandibular third molars prior to extraction; these are: the three dimensional (3D)

capabilities and the sub millimeter spatial resolution.(9) On the other hand and in comparison to panoramic radiographs, CBCT imaging is not readily available, is relatively expensive, and potentially can deliver a higher radiation dose than panoramic radiographs depending on the technical factors chosen (Scarfe, 2013). The objective of the current meta-analysis is to compare the sensitivity and specificity of CBCT imaging to panoramic radiographs in terms of assessing the relationship of the mandibular third molar to the mandibular canal prior to extraction. The greater aim of the analysis is to determine if CBCT imaging can be efficiently used to predict the risk of IAN injury.

MATERIALS AND METHODS

A systematic search of the English literature was conducted using the OVID MEDLINE, EMBASE, and the Cochrane Library databases and MeSH terms such as: radiography/ dental, cone beam/CBCT, molar/third, mandibular and tooth extraction. Reference lists were searched for further identification of relevant articles. The research parameters were outlined to include the population of adult patients with at least one impacted mandibular third molar. The diagnostic tests under examination were panoramic radiographs and CBCT imaging, while the gold standard was IAN exposure reported during the extraction procedure.

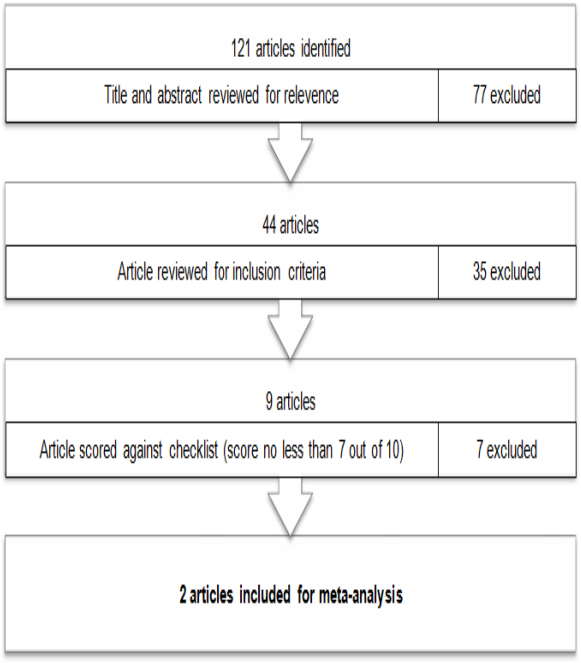

Figure 1. The stepwise process of selecting, reviewing and scoring the articles included in the meta-analysis.

Finally, the endpoint outcome of the comparison was defined as altered sensation that was defined as permanent if it lasted for more than six months. Inclusion criteria for the articles were defined as:

- Original peer reviewed articles of human subjects
- Included both a panoramic radiograph and CBCT imaging in the pre-dental extraction workup for mandibular third molars
- Reported success rates as symptom free and free of paresthesia

The search included studies spanning 10 years from 2004 to 2014. The two authors independently reviewed the selected articles against the "Checklist for Assessing a Diagnostic or Predictive Test" (Appendix 1) (Azarpazhooh *et al.,* 2008). Disagreement was resolved by consensus. The process of article selection and review is detailed in Figure 1. Next, the authors extracted the relevant data including the sample size, sensitivity, specificity, and accuracy. The meta-analysis was performed using a random effects model to calculate the sensitivity and specificity.

RESULTS

Two studies were included in the meta-analysis. The findings from these studies are summarized in Table 1. IAN exposure was observed in 27 of the 142 (19%) extracted mandibular third molars in the Tantanapornkul *et al* study. Of these 27cases, six (22%) went on to experience postoperative dysesthesia. Four other patients also experienced postoperative dysesthesia without having IAN exposure. There was a statistically significant difference between patients who experienced dysesthesia and had IAN exposure and those who experienced dysesthesia but did not have IAN exposure ($p<$ 0.005). In the Ghaeminia *et al* study, 23 cases (43%)reportedly had IAN exposure but only five cases (9%) experienced altered sensations postoperatively. Four of theses five cases were among the patients that had IAN exposure.

The overall sensitivity of CBCT imaging from the two studies included in this meta-analysis was 0.94 and the overall sensitivity for panoramic radiographs was slightly lower at 0.89. This slight difference in overall sensitivity between CBCT and panoramic

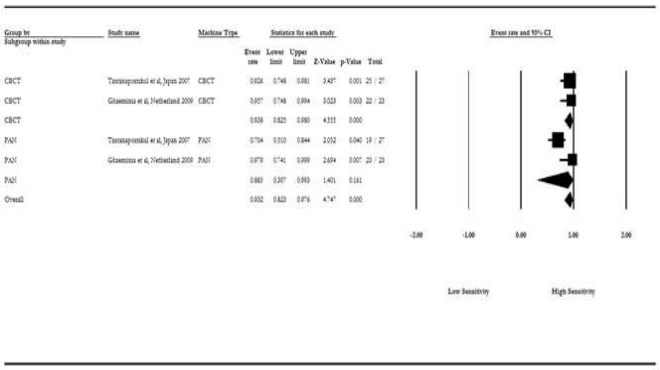

Figure 2. The sensitivity of CBCT imaging and panoramic radiographs for the two studies included in the meta-analysis. Also shown in this figure is the overall sensitivity of CBCT and panoramic radiographs.

radiographs was not statistically significant. This result is shown in Figure 2. As for the overall specificity, it was higher for CBCT imaging (0.51) than for panoramic radiographs (0.22). However, this difference in specificity between CBCT and panoramic radiographs was found to be not significant statistically (p= 0.75). The specificity results are shown in Figure 3. There is a pressing need for evidence-based practices in both medicine and dentistry. These practices include both interventional and diagnostic procedures. Therefore, this meta-analysis was undertaken to determine if the relatively new modality of CBCT is more or less accurate than panoramic radiographs, which are considered the standard of practice for

Table 1. A summary of the findings of the two articles included in the meta-analysis

Author, country, and year	Sample size (number of mandibular third molars)	Imaging modalities	Results	Conclusion
Tantanapornkul et al Japan 2007	142	**Pan:** Super Veraviewepocs(Morita Corp.) 60-80 kVp and 5-10 mA with a PSP plate	**Sensitivity:** 70% **Specificity:** 63% **PPV:** 31% **NPV:** 90% **Accuracy:** 64% **IOA:** 56%-87%	CBCT is superior to pan in predicting IAN exposure during surgical extraction
		CBCT: 3DX multi-image micro CT (Morita Corp.) FOV: 29X38 mm, 80 kV, 2 mA, 0.12 mm voxel size	**Sensitivity:** 93% **Specificity:** 77% **PPV:** 49% **NPV:** 98% **Accuracy:** 80% **IOA:** 75%	
Ghaeminia et al Netherland 2009	53	**Pan:** digital SoredexCranex Tome (Soredex, Helsinki, Finland)	**Sensitivity:** 100% **Specificity:** 3% **PPV:** 44% **NPV:** 100% **Accuracy:** 45% **IOA:** 35%-52%	No significant difference between pan and CBCT in predicting IAN exposure during surgical exposure of mandibular third molars
		CBCT: i-CAT 3-D imaging system (Imaging Sciences International Inc, Hatfield, PA, USA) FOV: 6cm, 1 20 kVp, 3-8 mA, 0.25 mm voxel size	**Sensitivity:** 96% **Specificity:** 23% **PPV:** 49% **NPV:** 88% **Accuracy:** 55% **IOA:** 78%-80%	

Pan: panoramic radiograph, PPV: positive predictive value, NPV: negative predictive value, IOA: inter observer agreement, PSP: photo-stimulate phosphor, FOV: field of view

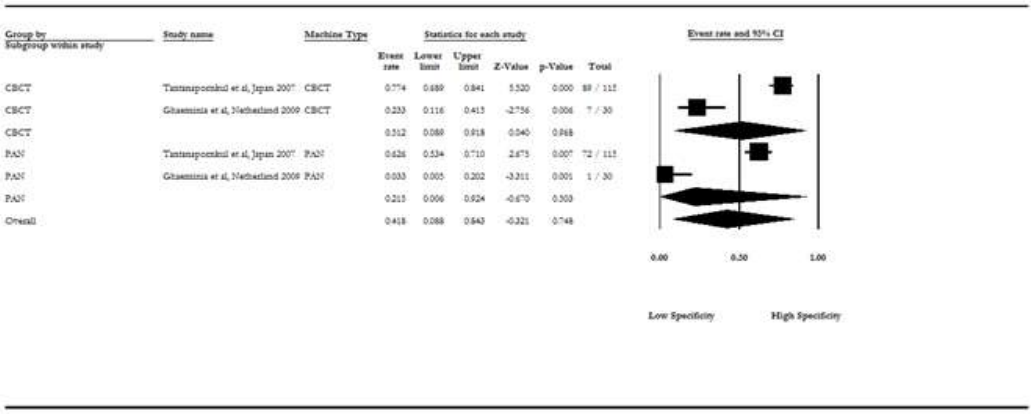

Figure 3. The specificity of CBCT imaging and panoramic radiographs for the two studies included in the meta-analysis. Also shown in this figure is the overall specificity of CBCT and panoramic radiographs.

DISCUSSION

pre-extraction assessment of mandibular third molars. A systematic review of the literature revealed several studies that made an attempt at comparing the two imaging modalities but only two studies actually compared the findings of the imaging modalities to the gold standard, inspecting the IAN during surgery and reporting any exposure. The findings of the two studies were slightly different and hence their recommendations were different. This was highlighted in a systematic review of the literature that was conducted by Guerrero et al in 2011 (Guerrero *et al*., 2011). Therefore, in an attempt to reach a more definitive conclusion regarding this matter, this meta-analysis was undertaken. The sensitivity of both CBCT images and panoramic radiographs in assessing the relationship between mandibular third molars and the inferior alveolar nerve canal prior to extraction was high. CBCT images were slightly more sensitive but this difference between the two imaging modalities was not statistically significant.

This translates to an equal ability of both imaging techniques to assess the intimate relationship between the roots of mandibular molars and the mandibular canal. This finding is unusual especially when taking into account the 3D capabilities of CBCT. One would think that the lack of superimposition and the added information from the third dimension would significantly increase the ability of CBCT to assess the topographic relation of mandibular third molars to the mandibular canal. The calculated overall specificity for CBCT images was higher when compared to panoramic radiographs. However, this difference was not statistically significant either. This translates to an equal ability of panoramic radiographs and CBCT to rule out an intimate relationship between the mandibular third molar and the IAN canal. This finding also means that even when an intimate relationship is observed on imaging, that does not necessitate IAN exposure during extraction. Several other factors during the procedure itself such as the surgical technique, the surgical approach, and the surgeon's experience dictate weather IAN exposure will occur or not (Jerjes *et al*., 2010).

Inter observer agreement was for CBCT images was substantial and generally higher than panoramic images.(13) Whereas for panoramic radiographs the agreement varied from moderate to almost perfect, depending on the specific feature being observed (Viera *et al*., 2005). Interestingly, inter observer agreement was generally higher in the Tantanapornkul et al where the observers were oral radiologists. This finding was especially true for panoramic radiographs because they are difficult to interpret owing to the difficult anatomy, superimposition, and ghost shadows (Mallya, 2013). The observers in the Ghaeminia et al study were oral surgeons. The choice of imaging modality for extraction treatment planning purposes is not limited to the knowledge of sensitivity and specificity indicators. The decision is much more encompassing and involves many other factors such as availability of and accessibility to the imaging modality. CBCT imaging is becoming widely available but is still less so than panoramic imaging. Another important factor is cost and panoramic radiographs by far are still much less expensive than CBCT images.

Radiation dose and risk is always an important factor to consider. Recent reports indicate that the effective radiation dose (ICRP 2007) from CBCT scans can range anywhere between 25 μSv and 1025 μSv depending on the CBCT machine and the imaging parameters used during scans. This is equivalent to approximately 1 to 42 digital panoramic radiographs. Therefore, care must be taken in choosing the exposure parameters during CBCT scans and every effort should be made to reduce the radiation dose to the patient regardless of the imaging modality. Finally and foremost, the ability to accurately interpret the images should be a factor in the choice of imaging modality. If the interpretation of any radiographs or images is felt to be challenging then the services of an oral and maxillofacial radiologist should be sought.

Based on the results of this meta-analysis and the high NPV reported in both studies included in the meta-analysis, it can be concluded that panoramic radiographs are an accurate diagnostic tool for the assessment of the relationship of mandibular third molars and the mandibular canal. CBCT imaging should be reserved for cases in which positive features are noted from the panoramic radiograph. More well designed studies such as the ones included in the current meta-analysis are needed in the near future so that a more robust conclusion can be reached regarding this topic of pre-extraction assessment of mandibular third molars. It would also be interesting to have both oral and maxillofacial radiologists and oral and maxillofacial surgeons interpret the same images so that a comparison can be made regarding the qualifications of the observers.

Conflict of interest statement

Authors Jadu and Jan have declare no conflict of interest. This article does not contain any studies with human or animal subjects performed by the any of the authors

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