Original Article

Comparison of Conventional Techniques and Higher Imaging Modalities in the Evaluation of Relation between the Third Molar and Inferior Alveolar Nerve Canal: A Pilot Study

Vathsala Patil, Keerthilatha M. Pai, R. Vineetha, K. V. Rajagopal[1], Winniecia Dkhar[2]

Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, [1]Department of Radio-Diagnosis, Kasturba Medical College, [2]Department of Medical Imaging, School of Allied Health Sciences, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, Karnataka, India

Abstract

Context: Mandibular third molars are the most commonly impacted teeth, and their surgical removal can be associated with inferior alveolar nerve (IAN) injury. To avoid the deleterious complication of nerve injury on patients, a thorough visualization of IAN and its localization are essential. **Aims and Objectives:** The aims and objectives of this study were to evaluate the efficacy of two conventional localization techniques in determining the relationship of mandibular third molars to IAN and to assess its reliability in comparison with computed tomography (CT). **Settings and Design:** Panoramic radiograph (PR) was taken using Kodak 8000C Digital Panoramic and Cephalometric system. Intraoral periapical radiographs (IOPAs) were taken using Kodak 2200 Intraoral X-ray machine. CT scan images were taken using multidetector CT scans. **Materials and Methods:** Two IOPAs (0° and −20° vertical angulation) and PR and CT scan images of thirty mandibular third molars were taken. Two combinations were used (i) a combination of two IOPAs and (ii) a combination of PR and IOPA (−20°). Tube-shift localization technique was applied to both these combinations to derive the relation between third molar and IAN canal as "in contact," "separate," "buccal," "lingual," and "in line with the apex" and the results were compared with CT images. **Statistical Analysis:** Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using SPSS software version 15.0. **Results:** The combination of PR and IOPA radiographs showed 14 teeth to be in contact with IAN. This gave a sensitivity of 100%, specificity of 94.1%, PPV of 92.9%, and a NPV of 100% in determining the relation as "in contact" or "separate." 78.3%, 85.7%, 94.7%, and 54.5% were the sensitivity, specificity, PPV, and NPV in localizing it as "buccal," "lingual," or "in line with apex." These results were better than that of the combination of the two IOPAs. **Conclusions:** Localization using PR and IOPA could better deduce the relation between IAN and mandibular third molar.

Keywords: *Localization, mandibular nerve, mandibular third molar, panoramic radiography*

Introduction

Mandibular third molars are the most commonly impacted teeth with a frequency of 20%–30%.[1] Their surgical removal can be associated with various postprocedural complications; one among them is the inferior alveolar nerve (IAN) injury. The risk of IAN damage increases dramatically by 30%, when there is contact or a close relation between the tooth and the nerve.[2] Therefore, to avoid the deleterious complication of nerve injury on patients, a thorough visualization of IAN and its localization are essential not only for third molar extraction, but also for implant placement and sagittal split osteotomy procedures.[1]

Intraoral periapical radiographs (IOPAs) and panoramic radiographs (PRs) were the most common conventional two-dimensional (2D) imaging techniques used for localization of IAN canal. However, with the advent of three-dimensional (3D) imaging such as computed tomography (CT) and cone-beam CT (CBCT), these modalities have become the primary choice of imaging for surgeons. However, is it justified to use higher imaging modalities, exposing patients to higher radiation exposure and high cost for simple cases with no absolute indication, is a debatable issue of the hour.

Previous studies comparing conventional and advanced imaging have shown different results. When authors like Klinge *et al*.,[3]

How to cite this article: Patil V, Pai KM, Vineetha R, Rajagopal KV, Dkhar W. Comparison of conventional techniques and higher imaging modalities in the evaluation of relation between the third molar and inferior alveolar nerve canal: A pilot study. Contemp Clin Dent 2019;10:93-8.

Address for correspondence:
Dr. Keerthilatha M. Pai, Department of Oral Medicine and Radiology, Manipal College of Dental Sciences, Manipal Academy of Higher Education, Manipal - 576 104, Karnataka, India.
E-mail: keerthilatha.pai@manipal.edu

Access this article online

Website: www.contempclindent.org

DOI: 10.4103/ccd.ccd_430_18

Quick Response Code:

Lindh *et al*.,[4] Ylikontiola *et al*.,[5] and Sonick *et al*.[6] have concluded that 3D imaging is very essential for IAN visualization, studies by Pawelzik *et al*.[7] and Nakagawa *et al*.[8] showed conventional imaging to be as good as 3D advanced imaging. Since IOPA and PR are routinely used in our setup, we conducted this study with an aim to evaluate the efficacy of two conventional localization techniques in determining the relationship of mandibular third molars to IAN and to assess its reliability in comparison with CT images as gold standard. Only two studies have been done in the past, using vertical tube-shift technique; hence, a need for confirming this unique and simple localization technique as a replacement for advanced imaging modality was identified.[9-11]

Materials and Methods

This study was conducted for 6 months after obtaining approval from the Institutional Ethical Committee. Twenty dry human mandibles, in good condition and intact lower border, having a total of thirty third molars (unilateral or bilateral), were selected. Mandibles with irregular lower border where stabilization was not possible, missing third molars, molars with periapical lesions revealed on radiographic images, and unaccepted quality of radiographic images were all excluded from the sample size.

Mandibles were given a code from 1 to 20 for identification and underwent the following radiographic examinations:

1. Digital PR using Kodak 8000C Digital Panoramic and Cephalometric system at exposure parameters of 66 kVp, 12 mA, and 14 s. The mandibles were positioned on the chin rest of the machine using thermocol base and adhesive tapes, simulating the position of the patient [Figure 1]. Central beam and canine beam were oriented to the midline and canine regions, respectively
2. IOPA using Kodak 2200 Intraoral X-ray machine. Two radiographs were taken of each mandibular third molars, one with 0° vertical angulation (0° IOPA) taken in paralleling technique and second with −20° vertical angulation (−20° IOPA) using E speed film. The mandibles were stabilized on the same thermocol base used for PR [Figure 2]. The exposure parameters were 60 kVp, 7 mA, and 0.25 s, and the exposed films were processed using an automatic processor
3. CT imaging in a Philips 64 slice Multidetector CT scanner (Philips medical systems, The Netherlands). Each specimen was placed on a custom-made thermocol stand in a way that the lower border of the mandible was perpendicular to the floor. High-resolution, 1-mm-thick slices with 1-mm/s table feed (5-mm reconstruction); 120 kVp and 160 mA tube current; and field of view 12 cm with a 512 × 512 matrix was all constituted the scanning protocol. The data were transferred for postprocessing using Dental CT reformation software (Philips medical systems, The Netherlands).

Radiographic techniques used for localization

- Localization technique 1 (LT 1) – Combination of two IOPAs with 0° and −20° vertical angulation
- Localization technique 2 (LT 2) – Combination of PR with −20° vertical angulation.

All the images were subjectively evaluated by two trained observers considering the tip of the mandibular third molar root as the reference point. The images were viewed in a room with reduced ambient light wherein the peripheral light from the view box was masked. Using the two techniques and applying Richards buccal object rule of localization, the relation between the IAN and third molar root was interpreted as follows: (a) in contact or separate and (b) central, buccal, or lingual.

Interpretation of localization techniques applying Richards buccal object rule

Richards buccal object rule states that "When two radiographs are made of a pair of objects, the image of buccal object moves, relative to the image of lingual object, in the same direction as that of the X-ray beam."[12] In LT 1, if the IAN canal appeared to move in the upward direction in −20° IOPA, in comparison to 0° IOPA, applying Richards buccal object rule, as canal moved along the direction of the beam, its relationship with

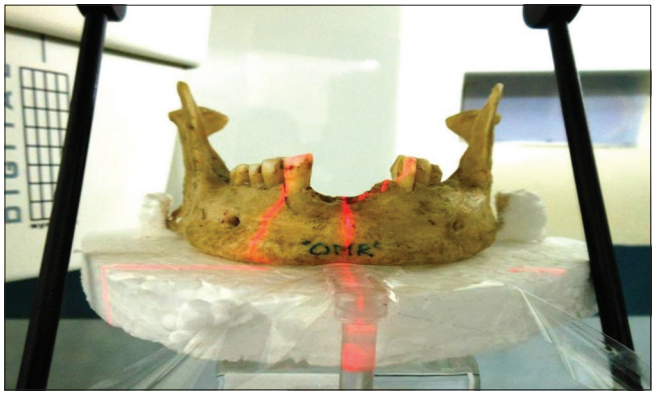

Figure 1: Stabilization of the mandibles on panoramic machine

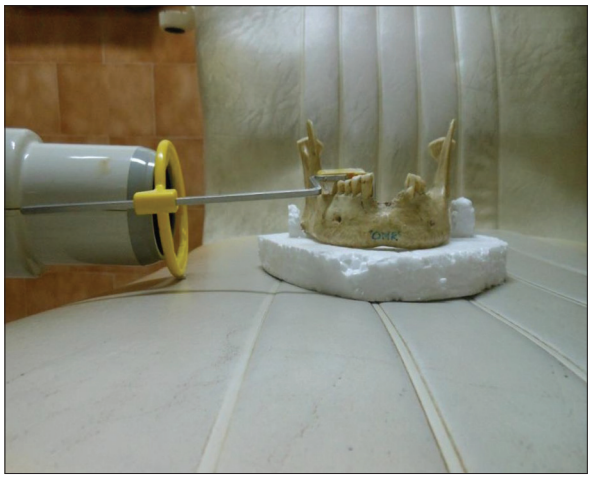

Figure 2: Stabilization of the mandible while taking intraoral periapical radiographs

respect to the mandibular third molar was localized to be "buccally" placed. If the canal moved downward (i.e., in the opposite direction of the beam), then it was localized to be "lingually" placed. If the canal showed no movement on the radiographs, it was localized to be in the "central" position or in the same plane as the third molar.

In LT 2, the projection of the X-ray beam in PR is from the lingual aspect; for ease of interpretation, it was translated to be from the buccal aspect, which yields a positive +8° as illustrated in Figure 3. Thus, interpretation was done in the similar way as LT1 considering two different projection angles of +8° and −20°.

Statistical analysis

- The results of LT1 and LT 2 were compared with the gold standard – CT images, and their sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated
- Statistical Package for the Social Sciences SPSS 15.0, (IBM SPSS Statistics software, Chicago, USA) was used for statistical evaluation.

Results

Out of the twenty mandibles, thirty third molars were considered for the study. Two trained observers, with good interobserver agreement (Kappa value for LT 1 is 0.92 and for LT 2 is 0.95), evaluated all the images. The recorded relation was compared with the findings of gold standard CT images.

Findings showing the relationship between IAN canal and mandibular third molar, detected from CT images and the two localization techniques, are presented in Table 1. Tables 2 and 3 show comparison between both the techniques and gold standard CT in detecting the relation between the canal and tooth. The mean sensitivity of LT1 and LT 2 in detecting the relation as "contact" and "separate" was 92.3% and 100%, respectively. The mean specificity of LT 1 and LT 2 in detecting the relation as separate was 88.2% and 94.1%, respectively. The mean sensitivity of LT 1 and LT 2 in detecting the relation as "buccal," "lingual," and "in line of apex" was 69.6% and 78.3%, respectively. The mean specificity of LT1 and LT 2 in detecting the relation as "buccal," "lingual," and "in line of apex was 57.2% and 85.7%, respectively.

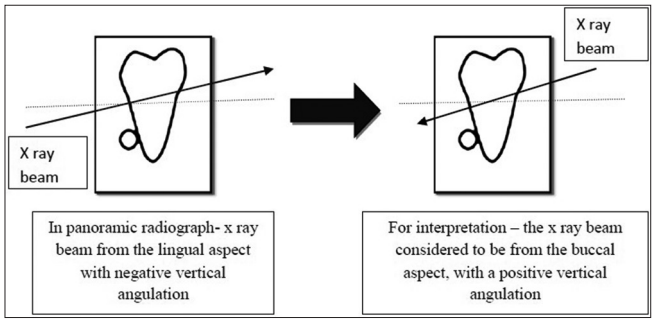

Figure 3: The interpretation of panoramic radiograph, the X-ray beam considered to be from the buccal aspect with positive vertical angulation

Discussion

IAN injury is a common and deleterious complication of third molar extraction which can be avoided by understanding the IAN nerve-to-tooth relation. IOPA and Panoramic Radiographs (PRs) are the conventional imaging techniques used for evaluating the nerve-to-tooth relation. However, as these provide images in two dimensions, surgeons often choose 3D imaging techniques such as CT and CBCT. CBCT, since the time of its introduction, has become the indispensable third eye of dentistry. Even though CBCTs and CTs are more accurate in localization, they pose high radiation risk to the individual. The relative exposure of CBCT is about 4–42 times than single PR and CT which accounts to 25–800 times higher relative

Table 1: Localization of inferior alveolar nerve canal as "separate," "in contact," "central," "buccal," and "lingual"

Techniques	In contact	Separate	Central	Buccal	Lingual
LT 1	14	16	19	11	-
LT 2	14	16	19	11	-
CT	13	17	23	7	-

LT: Localization technique; CT: Computed tomography

Table 2: Comparison between localization technique 1 and localization technique 2 and gold standard in determining contact between third molar and inferior alveolar canal

	Gold standard CT		
	In contact	Not in contact	Total
LT 1			
In contact	12	2	14
Not in contact	1	15	16
LT 2			
In contact	13	1	14
Not in contact	0	16	16

LT: Localization technique; CT: Computed tomography

Table 3: Comparison between localization technique 1 and localization technique 2 and gold standard in determining relation between third molar and inferior alveolar canal as "central," "buccal," or "lingual"

	Gold standard CT		
	Central	Buccal	Total
LT 1			
Central	16	3	19
Buccal	7	4	11
LT 2			
Central	18	1	19
Buccal	5	6	11

LT: Localization technique; CT: Computed tomography

exposure.[13] Therefore, their hyped and injudicious use subjects individuals to unnecessary radiation risk. Henceforth, a shift from as low as reasonably achievable to as low as diagnostically acceptable is very important.[14] Studies by Klinge *et al*.,[3] Lindh *et al*.,[4] Ylikontiola *et al*.,[5] and Sonick *et al*.[6] have compared conventional radiographic techniques with higher imaging modalities such as CT, CBCT, and high-resolution CT in the visualization of IAN canal and have found the higher imaging modalities to be more accurate. Sonick *et al*. have found periapical radiographs to give better visualization of inferior alveolar canal compared to PRs.[6] However, Neugebauer *et al*.,[15] Ghaeminia *et al*.,[16] and Pawelzik *et al*.[7] have considered the diagnostic quality of PR images equal to that of CT and CBCT and have dissented the regular use of the higher imaging techniques such as CT and CBCT prior to all the third molar surgeries. Localization principle in dentistry helps us to deduce a 3D information from the two-dimensional imaging modalities. This principle which is frequently used to localize the position of impacted teeth can be used for assessing IAN-to-tooth relation. Till date, only three studies have evaluated the use of localization technique, out of which only two studies evaluated the vertical tube-shift technique.[9-11] Hence, this study was conducted to evaluate the efficacy of conventional imaging modality in comparison with higher imaging modality in deriving the relation between IAN canal and third molar using localization principle.

Out of the thirty third molars evaluated, IAN canals were clearly visualized bilaterally on all the mandibular CT images and IOPAs. Only one PR failed to show distinctly the upper cortical outline of the inferior alveolar canal; however, the band of radiolucency was considered as the nerve canal in this case for interpretation. CT images revealed 43.3% of teeth to be in contact with the IAN canal and 56.7% of teeth to be separate. Nakagawa *et al*.[8] reported 76.7% of the teeth to be in contact with the nerve and Kositbowornchai *et al*.[9] reported 68.6% of teeth to be in contact with the third molar.

LT 1, which used a combination of two IOPAs, revealed 14 teeth to be in contact with IAN, while 16 teeth were found to be separate. When compared with gold standard, the sensitivity was 92.3%, specificity was 88.2%, PPV was 85.75%, and NPV was 93.38%. The study by Kositbowornchai *et al*.[9] also used the combination of two IOPAs for localization and showed a sensitivity of 84.8% and a specificity of 44.4%, a PPVof 78.3%, and a NPV of 78.3%.

LT 2, which used a combination of PR and IOPA, showed 14 teeth to be in contact with IAN, while 16 teeth were found to be separate. This gave a sensitivity of 100%, a specificity of 94.1%, a PPV of 93.8%, and a NPV of 100%. The study by Kositbowornchai *et al*.[9] reported a sensitivity of 97.9% and a specificity of 100%. When the two techniques of localization used in our study were compared with the study done by Kositbowornchai *et al*.,[9] our study showed both the techniques to have an excellent ability to identify the true negatives and therefore, less chance for mistakenly reading the relationship between mandibular third molar and IAN as "in contact" when it should be "separate."

Lubbers *et al*.[17] in their study also observed the course of IAN to be situated buccally in 52.8%, lingually in 37.3%, and inter- or intra-root in 10%. In our study, 76.6% of teeth on CT images showed inferior alveolar canal to be in line with the apex and the remaining teeth of 23.4% to be buccally placed, and none of the teeth showed a lingually placed IAN. The difference between our study results pertaining to the course of IAN could be due to the difference in the sample size of mandibular teeth being evaluated.

The sensitivity of LT 1 in localizing the position of the inferior alveolar canal as "buccal" or "central or in the same plane" with respect to third molars was 69.6%. The specificity, PPV, and NPV were 57.1%, 84.2%, and 36.4%, respectively. Kositbowornchai *et al*.[9] evaluated the sensitivity for each position (buccal, lingual, and in line with the apex) separately using a combination of two IOPAs. They found a sensitivity of 85.7% and a specificity of 38.9% in identifying the relation as buccal, a sensitivity of 50% and a specificity of 100% in identifying the relation as lingual, and a sensitivity of 31.3% and a specificity of 81.3% in identifying the position as in line with the apex. Their mean sensitivity was 55.6% and specificity was 73.4%. Our results showed better sensitivity but a slightly low specificity when compared to those of Kositbowornchai *et al*.[9]

When LT 2 was compared with the gold standard in localization of the position of IAN canal as "buccal" or "central or in the same plane," the sensitivity, specificity, PPV, and NPV were 78.3%, 85.7%, 94.7%, and 54.5%, respectively. The average sensitivity and specificity reported by Kositbowornchai *et al*.[9] for a combination of PR and IOPA were 52.83% and 69.2%, respectively. Our results exhibited excellent sensitivity and specificity compared to the previous study.

Images of tube-shift technique depend on various factors such as the distance between the third molar root and inferior alveolar canal and tube movement. Greater shift of the inferior alveolar canal is seen if the distance between the third molar and inferior alveolar canal is more. If there is no movement of the canal, the inferior alveolar canal is considered to be in contact with the third molar root. Similarly, if the tube movement is larger, shift of the image also is more. Hence, tube movement between PR and −20° periapical radiograph had greater difference in incidence angle compared to two different angled periapical radiographs and showed different results.

In our study, we found LT 2, a combination of PR and negative 20° vertical angulation, to have better sensitivity, specificity, PPV, and NPV when compared to that of LT 1. This could be attributed to the following reasons:

a. In LT 2, digital panoramic images of all the mandibles were obtained, which added advantage by providing better images with optimum density and contrast and less processing errors
b. As the images here were digital, they could be magnified to clearly view the region of interest; hence, better visualization was possible
c. Difference in the incidence angle of the X-ray beam was more when PR and –20° periapical radiograph were considered, as compared to the incidence angles used in taking two periapical radiographs. Hence, even minor movement in the IAN canal could have been clearly visualized and correctly interpreted.

Thus, we believe that conventional imaging with localization techniques has to be essentially used to assess the relation of third molar to nerve prior to advising for any higher imaging modalities with high radiation exposure.

This was an experimental *in vitro* study conducted on human mandibles. Extrapolating the results of this study to real-life clinical situations will need consideration of patient positioning. Patient positioning while taking PR plays a vital role. During PR, the structures that lie outside the focal trough have poor definition. Change in the vertical head position may depict variation in the relationship between the inferior alveolar canal and the third molar root due to change in the path of X-rays. Hence, a good knowledge and understanding of direction of the beam and image formation is required for correct interpretation. According to Stromotas *et al*.,[18] vertical tilting of head up to 10° has no effect on the linear and angular measurements, beyond which there can be distortion.

Limitations of this pilot study were the comparison of two different localization techniques and judgment of the movement of the IAN canal was made subjectively. Objective measurement of the distance between the root tip and IAN would be more accurate. Furthermore, this was an *in vitro* pilot study; further studies on a large number of symptomatic patients, using optimum negative angulations to validate the reliability of these techniques, should be done.

Conclusion

Combination of Panoramic Radiograph and –200 periapical radiograph showed more accurate results in localizing the relation between the inferior alveolar nerve and the mandibular third molar in comparison to CT images. Hence IAN canal imaging with conventional techniques should be a priority before advising higher imaging modalities, with higher radiation exposure like CT, CBCT.

Acknowledgment

We would like to acknowledge the Department of Radiodiagnosis, KMC Manipal, and Department of Medical Imaging Technology, SOAHS, Manipal, for their technical support. We are also grateful to Dr. Kalyan C. Pentapati, Associate Professor, Department of Public Health Dentistry, MCODS, Manipal, for the statistical help rendered during this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Andreasen JO, Peterson JK, Laskin DM. Textbook and Color Atlas of Tooth Impactions. Copenhagen: Munksgaard; 1997.
2. Wofford DT, Miller RI. Prospective study of dysesthesia following odontectomy of impacted mandibular third molars. J Oral Maxillofac Surg 1987;45:15-9.
3. Klinge B, Petersson A, Maly P. Location of the mandibular canal: Comparison of macroscopic findings, conventional radiography, and computed tomography. Int J Oral Maxillofac Implants 1989;4:327-32.
4. Lindh C, Petersson A, Klinge B. Visualisation of the mandibular canal by different radiographic techniques. Clin Oral Implants Res 1992;3:90-7.
5. Ylikontiola L, Moberg K, Huumonen S, Soikkonen K, Oikarinen K. Comparison of three radiographic methods used to locate the mandibular canal in the buccolingual direction before bilateral sagittal split osteotomy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;93:736-42.
6. Sonick M, Abrahams J, Faiella RA. A comparison of the accuracy of periapical, panoramic and computed tomographic radiographs in locating the mandibular canal. Int Oral Maxillofac Implants 1994;9:455-60.
7. Pawelzik J, Cohnen M, Willers R, Becker J. A comparison of conventional panoramic radiographs with volumetric computed tomography images in the preoperative assessment of impacted mandibular third molars. J Oral Maxillofac Surg 2002;60:979-84.
8. Nakagawa Y, Ishii H, Nomura Y, Watanabe NY, Hoshiba D, Kobayashi K, *et al.* Third molar position: Reliability of panoramic radiography. J Oral Maxillofac Surg 2007;65:1303-8.
9. Kositbowornchai S, Densiri-aksorn W, Piumthanaroj P. Ability of two radiographic methods to identify the closeness between the mandibular third molar root and the inferior alveolar canal: a pilot study. Dentomaxillofac Radiol 2010;39:79-84.
10. Arora A, Patil BA, Sodhi A. Validity of the vertical tube-shift method in determining the relationship between the mandibular third molar roots and the inferior alveolar nerve canal. J Korean Assoc Oral Maxillofac Surg 2015;41:66-73.
11. Jasa GR, Vizzotto MB, Silveira PF, Silveira HE, Silveira HL, Correa LR, *et al*. Buccal-lingual localization of the mandibular canal in relationship with the third molar using the lateral oblique technique. J Oral Maxillofac Radiol 2014;2:15-20.
12. Richards AG. The buccal object rule. J Tn State Dent Assoc 1953;33:263-8.
13. Jaju PP, Jaju SP. Cone-beam computed tomography: time to move from ALARA to ALADA. Imaging Sci Dent 2015;45:263-5.

14. Brooke SL, Atchison KA. Guidelines for prescribing dental radiographs. In: oral radiology principles and interpretation. White SC, Pharoah MJ, editors. 5th edition (South- East Asia) 2003. Mosby, Inc.p 265-81.
15. Neugebauer J, Shirani R, Mischkowski RA, Ritter L, Scheer M, Keeve E, *et al.* Comparison of cone-beam volumetric imaging and combined plain radiographs for localization of the mandibular canal before removal of impacted lower third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:633-42.
16. Ghaeminia H, Meijer GJ, Soehardi A, Borstlap WA, Mulder J, Bergé SJ, *et al.* Position of the impacted third molar in relation to the mandibular canal. Diagnostic accuracy of cone beam computed tomography compared with panoramic radiography. Int J Oral Maxillofac Surg 2009;38:964-71.
17. Lübbers HT, Matthews F, Damerau G, Kruse AL, Obwegeser JA, Grätz KW, *et al.* Anatomy of impacted lower third molars evaluated by computerized tomography: Is there an indication for 3-dimensional imaging? Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:547-50.
18. Stramotas S, Geenty JP, Petocz P, Darendeliler MA. Accuracy of linear and angular measurements on panoramic radiographs taken at various positions *in vitro*. Eur J Orthod 2002;24:43-52.