Technical Report

Spatial Relationship between Mandibular Third Molars and Inferior Alveolar Nerve using a Volume Rendering Software

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Abstract

Precise localization of the third molars in relation to the inferior alveolar nerve canal is critical from a clinical point of view and strongly affects the surgical treatment outcome. Recently, by using three-dimensional modeling software, the relationship of third molar root apices and inferior alveolar nerve canal can be better understood. In this study, the spatial relationship of two surgical sites of 19 impacted third molars with close relationship to the inferior alveolar nerve canal is described by using imaging data from a cone beam computed tomography system. This study aimed to investigate the ability of three-dimensional modeling of tooth-nerve relationship using the data imported to Amira 5.2.2 imaging software.

Key Words: Cone beam computed tomography, inferior alveolar nerve, mandibular third molar, volume rendering.

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Introduction

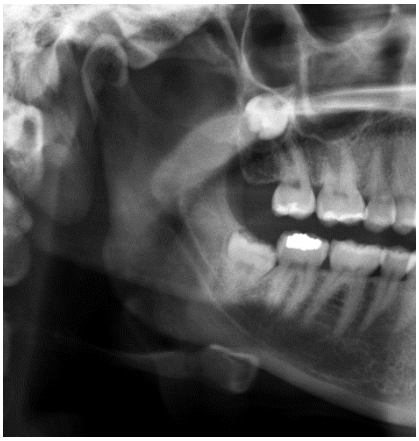
The risks resulting from potential treatment complications and the associated involvement concerning third molars with complicated impaction are well known (1,2). The incidence of the impacted mandibular third molars in adolescents has been reported 11-84% in various studies (3-6). There is a great concern about inferior alveolar nerve (IAN) damage during surgical extraction of impacted teeth whose roots have an intimate relationship with nerve. In these situations, nerve damage occurred 0.4-5.5%, irreversible damages ranged 0.3-0.9% (1-7). Another issue involved in this field is the limitations of the common two-dimensional radiographs (8,9). The application of three-dimensional imaging has been suggested to improve risk assessment (10-12). Despite the production of 3-D images in multiple planes, the observer still needs to organize multiple two-dimensional images into a mental model for the proposed surgical site.

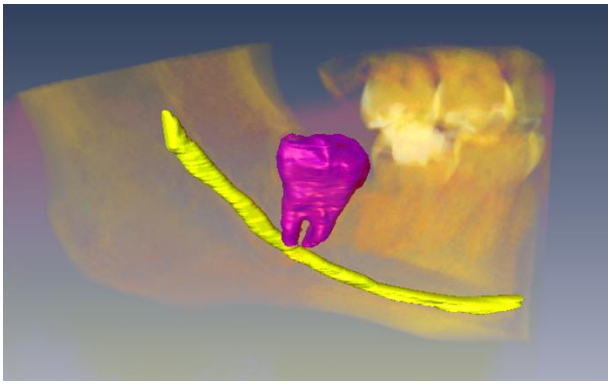
The aim of this study was to reconstruct a virtual model of the designated surgical site for a mandibular third molar using a cone beam computed tomography imaging system. Creation of a true virtual model may be considered as a valuable score for improving the risk assessment.

Method

In this study, three-dimensional rendered and cropped panoramic images of Planmeca Promax 3D (Planmeca, Helsinki, Finland) imaging system have been presented from two surgical sites of mandibular third molars relevant to the collection of 19 wisdom teeth with very close relationship to the IAN (Figs. 1 and 2). Fifteen patients with mean age and standard

deviation of 22.86±3.04 were included in this collection (Table 1). The images were prepared from 30 August 2011 to 1 September 2012. The minimum and maximum age of the patients were 18 and 27 years, respectively; consisted of 10 females and 5 males. It is necessary to mention that the CBCT imaging was performed in both right and left sides in 4 patients. The cases with blurred IAN canals images due to patients' slight movement through imaging time were excluded.





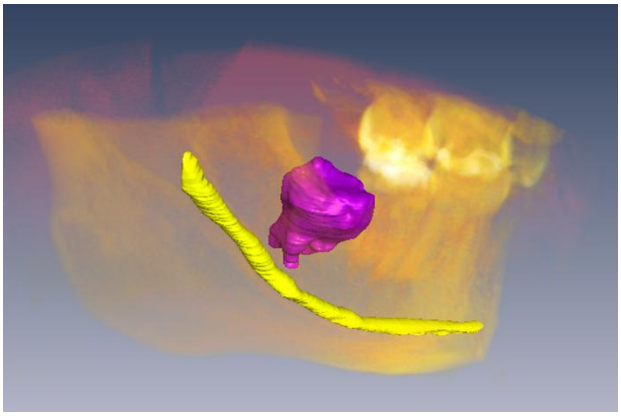
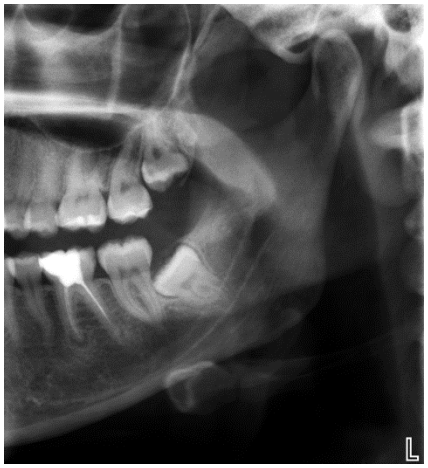
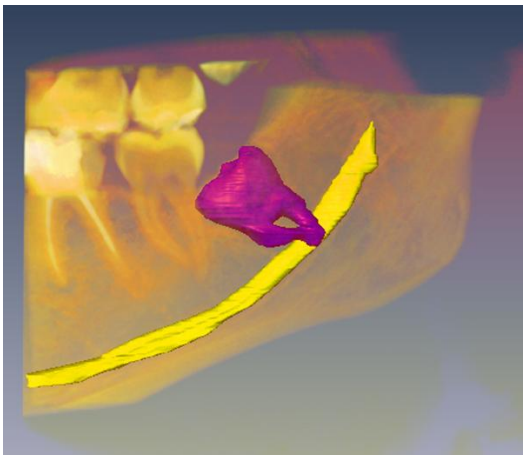


Figure 1. Upper image: Cropped panoramic image of case 1. Middle and lower images: Volume rendered models show that the IAN canal passes in between the roots of right third molar





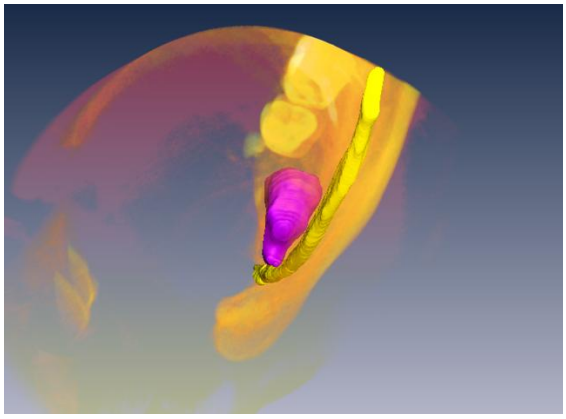


Figure 2. Upper image: Cropped panoramic radiograph of case 2. Middle and lower images: Three-dimensional models show that he IAN canal is buccal to the roots of left third molar

Table 1. Age distribution of studied individuals categorized by genders

Gender	N	Minimum (year)	Maximum (year)	Mean (year)	Std. Deviation
Female	10	19	27	23.50	2.71
Male	5	18	27	21.60	3.57
Total	15	18	27	22.86	3.04

The Planmeca Promax 3D imaging system used in the current study has a 12-bit sensor with 4096 gray values. For the imaging of the third molar region, we selected the region of interest of "Ramus+TMJ". The diameter and height of the image were chosen 8^{cm} (full) and 5^{cm} (lower), respectively. Other adjustments of the system were as follows for all patients: high Resolution (Voxel size = 160 µm), exposure factors: kVp=84, mA=16, and exposure time=12.1^{s}.

Amira 5.2.2 (Mercury Computer Systems Inc., 199 Riverneck Rd., Chelmsford, MA 01824) is advanced three-dimensional visualization software. The DICOM (Digital Imaging and Communications in Medicine) data from CBCT scanning can be loaded in this software and used for automatic and interactive segmentation. The process is followed by creation of 3-D meshes for three-dimensional visualization of anatomic landmarks.

The CBCT axial images of the patients were exported in DICOM format and then were imported in Amira software. Following contrast enhancement and gray level adjustment, the mandibular canal and the third molar were segmented manually in Amira software by use of 'label field' tool (the segmentation procedure took 35 to 40 minutes according to the complexity of each case). By 'SurfaceGen' application in Amira software, a mesh or three-dimensional model was created. The resultant three-dimensional model could be in various colors and was observable in any direction. Furthermore, the segmented mandibular canal and third molar might be apparent beyond the context of the mandibular bone by using 'Voltex' tool. Mandibular opacity is adjustable by use of 'alpha value'. This model has the ability to rotate in the virtual space which allows, the visualization of anatomic details from different angles (Figs.1 and 2).

Discussion

Two evaluated patients were imaged with Planmeca Promax 3D imaging system. As observed in (Figs. 1 and 2), three-dimensional visualization of the tooth and IAN canal can aid the surgeon in three-dimensional perception of the tooth and nerve relationship. This assessment is not possible on routine panoramic radiographs that roots and canal are superimposed.

Tymofiyeva et al. (13) planned a study aimed to detect the location and angulation of impacted teeth using dental magnetic resonance imaging (MRI). They found that dental MRI compared to conventional radiography has the advantage of presenting full three-dimensional morphology and elimination of ionizing radiation. Volumetric rendering and segmentation were done using Amira software. Massey et al. (14) in an *in vitro* study mentioned that current imaging modalities may not be accurate in diagnosis of the IAN position. They scanned 8 cadaveric mandibles using micro-computed tomography (µCT). The acquisitioned images were imported to Amira segmentation and measuring software. Superior-inferior and bucco-lingual bone distance measurements surrounding the IAN were acquired by direct digital caliper and, compared with corresponding µCT measurements using Amira. Their findings showed that all the measurements except than superior bone distance to the mandibular canal had high spatial accuracy. Li et al. (15) reported that the study on human mandible cadaver is best done using Amira reconstruction software. Also, the position and trend of inferior alveolar canal was clearly appeared in the transparent model of mandible. Encisco et al. (16) studied three imaging systems: NewTom 9000, MercuRay Hitachi, and 3DX Accuitomo and came to the conclusion that all of these three systems have the ability to visualize the IAN and third molar relationship appropriately by Amira 3.1 software. They have reported no differences in the quality of the resultant 3 three-dimensional images between these systems. Also, Hassan et al. (17) used Amira software 4.2.0 to evaluate vertical root fractures. They concluded that the sensitivity of root fracture diagnosis is higher in CBCT images rather than periapical radiographs (79.4% Vs 37.1%).

The recent study excels the Encisco et al. (16) study which was the only study in this field, in the number of patients which were imaged by three-dimensional system, and the type of imaging system (Planmeca Promax 3D).

Conclusion

Using this study, we performed an interactive virtual model of the mandibular third molar surgical site and IAN canal. The anatomical accuracy, the risk assessment and the cost-benefit of this model need further investigations.

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