Variation in Location of the Mandibular Foramen/Inferior Alveolar Nerve Complex Given Anatomic Landmarks Using Cone-beam Computed Tomographic Scans

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Abstract

Introduction: The inferior alveolar nerve (IAN) injection is 1 of the most commonly administered and useful injections in the field of dentistry. Practitioners use intraoral anatomic landmarks, which vary greatly among patients. The objective of this study was to assist practitioners by identifying a range of normal variability within certain landmarks used in delivering IAN anesthesia. **Methods:** A total of 203 randomly selected retrospective cone-beam computed tomographic scans were obtained from the Midwestern University Dental Institute cone-beam computed tomographic database. InVivoDental5.0 volumetric imaging software (Anatomage, San Jose, CA) was used to measure 2 important parameters used in locating the mandibular foramen (MF)/IAN complex: (1) the angle from the contralateral premolar contact area to the MF and (2) the distance above the mandibular occlusal plane to the center of the MF. The variation of these measurements was compared with established reference values and statistically analyzed using a 1-sample *t* test. **Results:** The angle from the contralateral premolar contact area to the MF for the right and left sides was 42.99° and 42.57°, respectively. The angulations varied significantly from the reference value of 45° ($P < .001$). The minimum height above the mandibular occlusal plane for the right and left sides was 9.85 mm and 9.81 mm, respectively. The heights varied significantly from the minimum reference value of 6 mm but not the maximum reference value of 10 mm ($P < .001$). **Conclusions:** Orienting the syringe barrel at an angulation slightly less than 45° and significantly higher than 6 mm above the mandibular occlusal plane can aid in successfully administering anesthesia to the MF/IAN complex. *(J Endod 2016;42:393–396)*

Key Words

CBCT, IAN, inferior alveolar nerve, mandibular anatomy, mandibular foramen

Inferior alveolar nerve (IAN) injection is 1 of the most commonly administered injections in the field of dentistry. It is also 1 of the most useful because it provides practitioners with the ability to anesthetize an entire quadrant of the mandible with a single injection. However, this occurs only if the injection deposits the anesthetic at the correct location, at or near the mandibular foramen (MF). Unfortunately, an estimated 15%–20% of IAN injections fail when administered by properly identifying intraoral landmarks (1). This suggests that variation in the location of the IAN exists within the patient population. Numerous studies state this variability in anatomy, and several offer alternative anesthesia techniques, such as the Gow-Gates and Vazirani-Akinosi injections (1–16). However, none of the techniques reported has resulted in an increased success rate by delivering consistent IAN anesthesia. Furthermore, most studies do not indicate a range of variation, and almost all do not associate a number within this range (5). If anesthesia is not achieved, the doctor often must administer a second dose because it is assumed that he or she missed the injection site on the first attempt. However, this is often a blind attempt using the same landmarks used to locate the first injection, usually without changing parameters within those landmarks (10, 11).

Two adjustable factors that might be used to locate the MF include syringe and needle angulation and the distance above the mandibular occlusal plane. In this study, to accurately measure these 2 parameters, cone-beam computed tomographic (CBCT) technology was used. CBCT imaging allows for 3-dimensional reconstruction of the mandible, MF, and dentition in an exact 1:1 anatomic depiction, making it extremely accurate (17–22). In other conventional radiographic techniques, distortion and magnification of the anatomic structures occur (18, 20, 22). These imaging flaws range from 3.4% for periapical radiographs to greater than 14% for panoramic radiographs, rendering their modalities inaccurate when attempting to establish accurate measurements with respect to angulation and height above the mandibular occlusal plane (18). Recent studies (17, 22–24) evaluating the accuracy of CBCT imaging software digital measurements reported an error range between 0.07 and 0.27 mm when compared with known standardized measurements. These studies also reported high sensitivity with regard to accurately identifying the structure measured and that the images displayed less than 1.8% distortion (17, 22–24). Our goal was to use CBCT scans to measure the amount of variation within the location of the MF/IAN complex regarding angulation and distance above the mandibular occlusal plane as measured variables. This will provide dental practitioners, professors, and students with essential information in order to deliver, teach, and learn proper IAN anesthesia technique by understanding the ranges in variation among the 2 parameters discussed.

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Methods

After obtaining Midwestern University Institutional Review Board Approval, 203 randomly selected high-resolution large-volume CBCT scans were obtained from the radiology database at Midwestern University College of Dental Medicine-Arizona Dental Institute. All scans were acquired by using the i-CAT Next Generation CBCT (Imaging Sciences International, Hatfield, PA). Scans were transferred from the i-CAT DICOM viewer software to InVivoDental5.0 volumetric imaging software (Anatomage, San Jose, CA) where they were rendered, viewed, and measured. All scans were viewed on an LCD Samsung monitor (Model P2570; Syncmaster, Seoul, South Korea) with the following specifications: 24.6-inch diagonal screen size, 1920 × 1080 high-definition screen resolution, pixel dot size of 0.283 mm, and a contrast ratio of 1000:1. All volumes were standardized in the same orientation, with the sagittal plane parallel to the inferior alveolar canal and the coronal plane perpendicular to the inferior alveolar canal.

Anatomage InVivoDental5.0 volumetric imaging software was used to divide right and left halves of the mandible, identify, and mark the center of the MF using bone and soft tissue modalities (Fig. 1*A*). Measurements were conducted using calibration software provided by Anatomage InVivoDental5.0 imaging (Figs. 1*B* and 2). A database of approximately 3000 CBCT scans was searched, and the first 203 patients who conformed to the following inclusion and exclusion criteria were selected for the study. Inclusion criteria were as follows:

1. Known age between 21 and 70 years
2. Known sex
3. CBCT scans containing the mandibular second molar for the mandibular occlusal plane parameter measurement

The exclusion criterion was any pathology that might alter the relationship of the mandibular foramen exit site containing the IAN. One observer conducted all anatomic measurements. Standards for viewing and measuring periods were kept at 5 scans per day. Scans were viewed with optimal low-level lighting for observing scans and collecting measurements. All data were collected, coded, and stored on a secure password-protected computer.

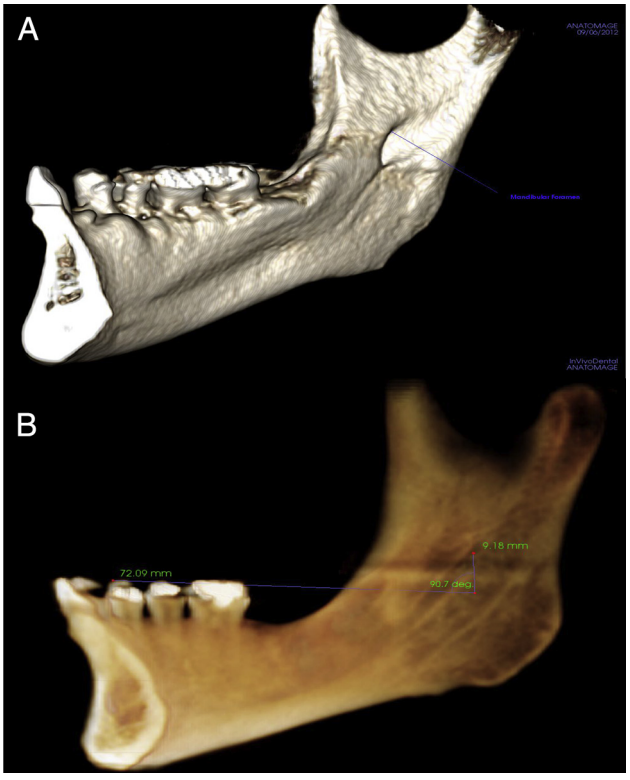

Figure 1. (*A*) Localization of the MF on the CBCT image. (*B*) Measurement of the height above the mandibular occlusal plane as measured to the center of the MF.

Figure 2. The measurement of the angle from the contralateral premolar contact area to the MF.

Measurements studied were the angle from the contralateral premolar contact area to the mandibular foramen in millimeters using the horizontal axis as the mandible and vertical axis as the midline of the face and the distance above the mandibular occlusal plane as measured from the distal lingual cusp tip of the second mandibular molar to the center of the mandibular foramen.

Measurements were verified by using coronal, axial, and sagittal views, and measurement landmarks were defined in a data table. Scans were randomly selected from either the right or left side of each patient, using the previously described inclusion and exclusion criteria. This allowed for statistical independence of observations because analysis that included both sides of the mandible may have produced correlated observations. Values obtained were tabulated, and the mean average and respective standard deviations were calculated for all distances studied. The distances were calculated for each of the measurements on the right and left sides. The mean values of the measurements were compared using a 1-sample Student *t* test. Statistical significance was determined at $P < .0001$.

Results

A CBCT database was searched, and the first randomly selected 203 CBCT scans that met the inclusion criteria were used. The scans were from 107 women and 96 men, with ages ranging from 22 to 70 years and a mean of 44.85 years. The angle from the contralateral premolar contact area to the MF for the right and left sides was 42.99° and 42.57°, respectively. As shown in Table 1, angulations varied significantly from the reference value of 45° ($P < .001$) by less than 3°.

The minimum height above the mandibular occlusal plane for the right and left sides was 9.85 mm and 9.81 mm, respectively. As shown in Table 1, the heights varied significantly from the minimum reference value of 6 mm but not the maximum reference value of 10 mm