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The inferior alveolar nerve's loop at the mental foramen and its implications for surgery

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ABSTRACT

Background. In this study, the authors aimed to identify and measure the anterior extension of the alveolar loop (aAL) and the caudal extension of the alveolar loop (cAL) of the inferior alveolar nerve by using cone-beam computed tomography (CBCT). They also aimed to provide recommendations for surgery in the anterior mandible.

Methods. In this retrospective case study of the frequency and extension of aAL and cAL, the authors evaluated 1,384 mandibular sites in 694 CBCT scans of dentate and partly edentulous patients, performed mainly for further diagnosis before removal of the mandibular third molars between January 2009 and February 2013, by using multiplanar reconstructions.

Results. The frequency of aAL was 69.73 percent and of cAL was 100 percent. The mean value for aAL was 1.16 millimeters, with a range of 0.3 to 5.6 mm; the mean value for cAL was 4.11 mm, with a range of 0.25 to 8.87 mm. For aAL, 95.81 percent of the sites showed values of 0 to 3 mm; for cAL, 93.78 percent of the sites showed values of 0.25 to 6 mm. Dentate patients showed statistically significantly higher values for cAL than did partly edentulous patients ($P = .043$). CBCT resolution had a statistically significant impact on cAL measurements ($P = .001$), with higher values at higher resolution.

Conclusions. This study showed a high frequency of and large variations in aAL and cAL. In contrast to panoramic radiography, CBCT has been shown to be a reliable tool for identifying and measuring the AL. Therefore, preoperative diagnosis with CBCT is recommended for planning three-dimensional tasks such as implant placement in the vicinity of the mental foramen.

Practical Implications. Owing to the variability of aAL and cAL measurements, it is difficult to recommend reliable safety margins for surgical procedures such as implant placement, bone harvesting or genioplasty. Depending on the indication, the clinician should consider preoperative diagnosis by means of CBCT.

Key Words. Alveolar nerve; risk assessment; implants; oral surgery; mandibular nerve; computed tomography; dental implants; oral and maxillofacial radiology; oral and maxillofacial surgery.

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The mental nerve is a somatic afferent nerve supplying sensitivity to the gingivae in the anterior and premolar region, the lower lip and the chin. It arises from the inferior alveolar nerve (IAN), a branch of the mandibular nerve, in the mandibular canal. The last part of the IAN sometimes runs below the lower border and the anterior wall of the mental foramen. After the incisive nerve branches off, the main branch extends in a curve cranially back to the mental foramen, where it flows as the mental nerve. The caudal and anterior part of the mental foramen can be described as the alveolar loop (AL) of the IAN.

Implant techniques have been developed in recent decades and have become an integral part of the treatment concept for not only partially but also fully edentulous jaws. Accurate preoperative planning is important for the success of treatment and assumes a solid understanding of anatomy and its possible variations.[1-3] The recent literature dealing with this topic displays a wide range of values for both frequency and measurements of the anterior extension of the AL (aAL) and the caudal extension of the AL (cAL),[4] irrespective of whether the researchers were investigating cadavers,[5,6] computed tomographic (CT) scans[7,8] or cone-beam computed tomographic (CBCT) scans.[9,10] Investigators in some studies have questioned the importance or even the existence of these anatomical structures[1,6]; others have pointed to the danger of such disregard, noting that a violation of the neurovascular bundle can cause postoperative hemorrhage and sensory disturbances.[11,12]

Panoramic radiography still is performed in preparation for most oral surgery and especially for implant planning in the anterior mandible, although its deficient reliability in assessing the AL already has been proved.[13-15] CBCT has gained an increasingly important role in dental diagnosis in recent years.[16,17] In comparison with classical multidetector CT, CBCT offers the benefits of reduced radiation exposure at comparable resolution and accuracy[18] and has become widely available and affordable over the years.

Our objective in this retrospective case study was to investigate the frequency of the AL and its anterior and caudal extension in CBCT scans and to derive clinical recommendations for planning surgery, especially three-dimensional (3-D) tasks such as implant placement, in the anterior mandible. We undertook this to aid not only oral surgeons but also general practitioners and to suggest a possibility of breaking old habits in favor of a more reliable diagnostic tool and, consequently, in favor of preventing intraoperative and postoperative complications.

METHODS

Our database consisted of 699 CBCT scans of the mandibular jaw obtained between January 2009 and February 2013 in the Clinic of Oral and Maxillofacial Surgery, University of Zurich. The scans were performed mainly for further diagnosis before removal of the mandibular third molars; other reasons included implant planning, trauma and assessment of cystic lesions, assessment of impacted teeth and identification of bone pathology. The selection criteria for scans included in our study were as follows:

- The lower border and the anterior part of the mandible, at least 2 centimeters distal to the mental foramen, were included in the volume.
- There was no pathology in the area to be examined that could affect the position of the mental foramen, mandibular canal or AL.
- Images were of adequate diagnostic quality (for instance, no movement or radiation artifacts).
- To allow for investigation of the proportion of measurements between the right and left sides in a single patient, both sides were available for evaluation in each case.

All data sets were acquired by three radiographers by using a CBCT scanner (KaVo 3D eXam, KaVo Dental, Brugg, Switzerland) with the exposure data being 90 to 120 peak kilovoltage, 3 to 8 milliamperes (pulsed) and a record volume of 16 cm in diameter × 13 cm. The radiographers applied one of two modes: "standard resolution," with a scan speed of 8.5 seconds and a voxel size of 0.40 millimeters or 0.30 mm, or "high resolution," with a scan speed of 24 seconds and a voxel size of 0.25 mm.

We performed axial, coronal and panoramic reconstructions as well as obtained cross sections by using reconstruction software (ExamVision, Version 1.9.3.13, Kavo Dental) on a standard personal computer (HP Compaq 6200 Pro Microtower with a HP Compaq LA2306x monitor, Hewlett-Packard, Palo Alto, Calif.) and evaluated the reconstructions for the following factors:

- aAL: the distance between the anterior border of the mental foramen and the anterior border of the AL (Figure 1; the distance between lines a and b, which are set perpendicular to the occlusal plane [chosen for its reproducibility during surgery[19]]), determined in the cross sections as the difference between the section with the visible anterior border of the mental foramen and the section with the transition of the AL in the incisive canal, which is defined as the point at which the canal diameter constricts to less than 3 mm[9];
- cAL: the distance between the lower border of the mental foramen and the lowest point of the mandibular canal (Figure 1; the distance between lines c and d, perpendicular to the occlusal plane [chosen for its reproducibility during surgery[19]]), measured in the cross sections between the marking of the lower border of the mental foramen in the scan with the largest vertical diameter and the cross section with the lowest point of the mandibular canal;
- the distance from the mental foramen to the cementoenamel junction (CEJ) of the corresponding tooth: measured in the panoramic reconstruction (Figure 2, page 263) as the distance between the upper border of the mental foramen to the visible CEJ of the corresponding tooth, after determination of the upper border of the mental foramen in the cross section with the largest vertical diameter of the mental foramen.

In addition, we collected patients' dental statuses and demographic data (ages and sexes). In terms of patients' dental status, we divided patients into two groups: fully dentate and partly edentulous with at least one missing tooth anterior and posterior to the mental foramen. There were no edentulous patients in the population.

All analysis and linear measurements were performed by one of the authors (K.F.), an oral surgeon with three years of experience in evaluation of CBCT scans. She used an optical mouse (HP DC172B, Hewlett-Packard) on the screen at maximum magnification. She performed each measurement twice, at an interval of four weeks, then used the arithmetic mean of the two measurements for further analysis. She coded data in spreadsheet software (Excel 2010 for Windows, Microsoft, Redmond, Wash.) and analyzed them by means of statistical software (IBM SPSS Statistics, Version 20, IBM, Armonk, N.Y.).

She provided descriptive statistics: for discrete variables, she computed relative frequencies, whereas for continuous variables, she provided mean (standard deviation [SD]), minimum, maximum, median and interquartile

ABBREVIATION KEY. aAL: Anterior extension of the alveolar loop. **AL:** Alveolar loop. **cAL:** Caudal extension of the alveolar loop. **CBCT:** Cone-beam computed tomographic/tomography. **CEJ:** Cementoenamel junction. **CT:** Computed tomography. **IAN:** Inferior alveolar nerve. **IC:** Incisive canal. **IN:** Incisive nerve. **MC:** Mandibular canal. **MN:** Mental nerve. **OP:** Occlusal plane. **2-D:** Two-dimensional. **3-D:** Three-dimensional.