Retrospective Study of the Anterior Loop of the Inferior Alveolar Nerve and the Incisive Canal Using Cone Beam Computed Tomography

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Purpose: *The mental foramen is an important landmark during surgical procedures such as osseous grafting or the placement of dental implants. To avoid injuring the mental nerve, it is important both to carefully assess the location of the mental foramen and to determine whether an anterior loop of the mental nerve or the incisive canal lies mesial to it. The objective of this study was to quantify the ability of cone beam computed tomography (CBCT) to measure the length of the mental nerve loop, the length and diameter of the incisive nerve canals, and the incisive canal path.* ***Materials and Methods:*** *The study included 352 CBCT scans that had originally been used for preoperative planning of implant placement in the interforaminal region of the anterior mandible. For each scan, the length of the mental nerve loop and the length, diameter, and path of the incisive canal were determined. Mean values were compared between groups based on sex, right versus left side, and whether the patient was edentulous.* ***Results:*** *The inferior alveolar nerve loop and incisive canal had a mean length of 2.40 ± 0.93 mm and 9.11 ± 3.00 mm, respectively. The mean incisive canal diameter was 1.48 ± 0.66 mm and showed a downward path in 51.3% of CBCT images and a linear or upward path in 38.29% and 10.41% of scans, respectively. Conclusions: CBCT provides an accurate means to identify critical anatomical features in the anterior mandible during preoperative surgical planning.* J Oral Maxillofac Implants 2013;28:388–392. doi: 10.11607/jomi.2648

Key words: *anterior loop, cone beam computed tomography, dental implant*

The mandibular canal is a bilateral, intraosseous pathway that carries the inferior alveolar nerve from the mandibular foramen to the mental foramen, providing innervation to the teeth of the anterior mandible, the soft tissues adjacent to the foraminal area, and the integument of the chin.[1,2]

Anatomical variations in the path of the mandibular canals, such as bifid canals and anterior loops of the mental nerve, are common (Fig 1).[3,4] This consideration becomes important when planning surgical procedures of the anterior mandible, such as osteotomy, bone harvesting, and the placement of dental implants. Although these are generally considered to be safe elective procedures,[1,2,5,6] sensory disturbance has been reported as a complication in up to 37% of patients in the first 2 weeks following surgery, with 10 to 15% of patients continuing to complain of problems after 15 months.[6,7] Sensory disturbance occurs most commonly after placement of a mandibular fixed prosthesis between the mental foramina. This is because biomechanical considerations dictate that the distal margin of the implants should be as close as possible to the mental foramen so as to reduce the length of the distal cantilever, which increases the risk of injury, particularly in cases where a loop of the inferior alveolar nerve is present.

A variety of mechanisms may explain sensory disturbance following surgery to the anterior mandible. For example, direct surgical trauma to the mental nerve during surgery can result in either transient or persistent paresthesia, anesthesia, or even disabling dysesthesia most often affecting the lip and chin region.[8,9] Similarly, sensory disturbance due to direct damage of the incisive nerve has been reported in 17% of patients after the placement of implants in the anterior mandible.[10] Indirect damage secondary to hematoma

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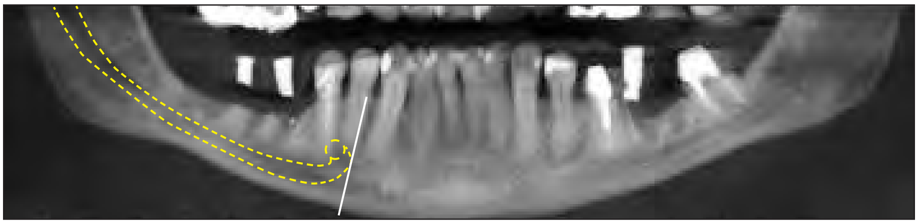
Fig 1 *(left)* Cross-sectional slice anterior to the mental foramen in which a superior and inferior canal could be visualized (circles).

Fig 2 *(below)* Schematic representation of the measurement of the anterior extension of the mental nerve anterior loop on panoramic image. The plane α (full line) inferior perpendicular to the inferior margin of the mandible passes through the anterior-most margin of the mandibular anterior loop; the shortest straight-line distance between the plane α and anterior wall of the mental foramen.



formation in the incisive canal may also lead to sensory impairment due to edema of the aponeurosis that then spreads to the mental nerve.[11,12]

In view of these potential complications, preoperative radiographic examination is essential prior to surgical procedures involving the mandible.[13] In particular, the potential presence of an anterior loop of the mental nerve should be carefully assessed, and if present, its length should be measured. It is also important to determine the path and length of the incisive nerve canals.

Periapical or panoramic radiographs are commonly used for diagnosis and for planning oral surgeries.[14,15] However, some studies have suggested that the length of the anterior loop of the mental nerve cannot be measured with panoramic radiography unless the mental canal is connected to the mandibular canal, since it can easily be confused with a large incisive canal.[16,17] Another factor that can interfere with the accurate measurement is that panoramic views produce an inherent magnification distortion, typically in the range of 20% to 30%.[12]

Cone beam computed tomography (CBCT) scans have significantly improved the precision of preoperative oral surgery planning, primarily because they are effective in any type of bone.[3] CBCT scanning is also noninvasive and allows for higher-resolution images with lower radiation doses.[18] The objective of this retrospective study was to quantify the ability of CBCT scanning to measure the length of the mental loop and the length, diameter, and course of the incisive nerve canals.

MATERIALS AND METHODS

The sample consisted of 352 CBCT scans obtained from 197 women and 129 men, which were randomly selected, using Epi Info Software (Centers for Disease Control and Prevention), from a total of 540 scans in the database of the Slice Clinic of Radiology and CT of Dentistry in Belo Horizonte, Brazil. The scans were acquired using the i-CAT 3D Imaging System (i-CAT Vision Software, Imaging Sciences International) and included the entire mandible. The CBCT parameters were 110 kV and 1 to 20 mA with emission of x-rays over an interval of 18 seconds, yielding an effective dose of 100 μSV. Sagittal sections, 0.5-mm thick, were obtained as CBCT reconstructions. CBCT data was exported in DICOM format and processed using a Pentium IV computer (Intel). All patients gave their informed and written consent, and patients were not identifiable in any way.

Measurement Procedures

A previously calibrated examiner assessed all radiographs under standard viewing conditions. For each CBCT image, the length of the mental loop as well as the length, diameter, and path of the incisive canals was determined. All measurements were repeated 2 weeks later to evaluate the reproducibility of the recordings. The examiner took the second set of measurements without having access to the first set.

The mental loop was determined from panoramic CBCT views, in which the α plane was assumed to be perpendicular to the inferior margin of the mandible and to pass through the anterior-most margin of the mandible's anterior loop, coincident with the origin of the incisive canal. In the panoramic view of the CBCT images, a visual criteria for the difference in their thicknesses had to be used to differentiate the mandible and incisive canals since the mandibular canal is wider.[8,9] The length of the anterior loop was defined as the shortest straight-line distance between the α plane and the anterior wall of the mental foramen (Fig 2). The incisive canal diameter was measured as the internal diameter of the incisive canal formed by the α plane (Fig 3), and the length of the incisive canal was defined as the shortest straight-line distance between the α plane and the anterior-most margin of

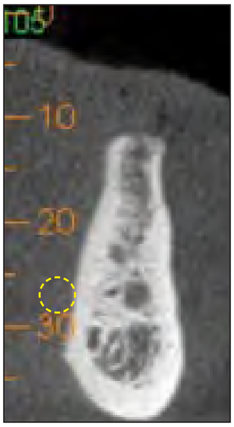


Fig 3 *(left)* Schematic representation of the incisive canal diameter on CBCT image (circle).

Fig 4 *(below)* Schematic representation of the length of the incisive canal on panoramic image. The inferior α plane perpendicular to the inferior margin of the mandible passes through the anterior-most margin of the mandibular anterior loop; shortest straight-line distance between the α plane and anterior anterior-most margin of the incisive nerve.

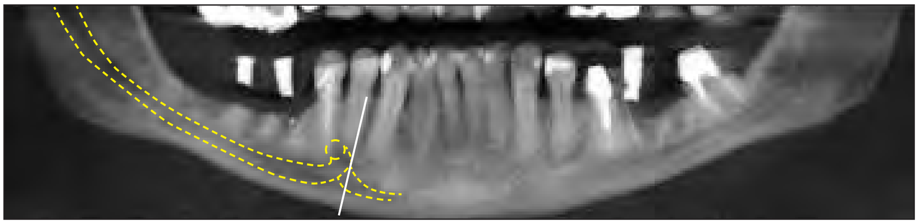


Table 1 Length of the Inferior Alveolar Nerve Loop

	Edentulous			Dentate		
		95% CI			95% CI	
Side (n)	**Mean ± SD**	**Min**	**Max**	**Mean ± SD**	**Min**	**Max**
Right (326)	2.43 ± 0.97	0.61	6.60	2.26 ± 0.96	0.65	6.03
Left (326)	2.39 ±0.88	0.15	4.63	2.55 ± 0.97	0.77	7.00
Total (652)	2.40 ± 0.93	0.15	6.60	2.41 ± 0.98	0.65	7.00

SD = standard deviation; CI = confidence interval.

the incisive nerve (Fig 4). In the CBCT view, the path of the incisive canal was categorized as being downward, upward, or linear with respect to the inferior margin of the mandible.

Data and Statistical Analysis

SPSS 17.0 software (IBM) was used for all statistical calculations. The level of significance was fixed at 5%. The intraobserver reproducibility of the measurements was calculated using kappa statistics based on the difference between duplicate recordings made by the same examiner.

The mean value, standard deviation, and confidence interval of each measurement (length of the mental loop and length and diameter of the incisive canal) were calculated. Mean values were compared between groups based on sex, right versus left side, and whether the patient was edentulous, using the *t* test for paired values and assuming equal and unequal variances.

RESULTS

No significant statistical differences were found between the paired results obtained by each examiner ($P > .05$), indicating that the study was reliable. The Cohen kappa coefficient was 0.68.

The mean, standard deviation, and confidence interval for measurements of the length of the inferior alveolar nerve loop are shown in Table 1. In 21 of the CT scan images, the length of loop exceeded 4.5 mm, with the greatest length being 7 mm. No significant differences were found between left and right sides or between edentulous and dentate subjects. However, the loop was significantly longer in men than in women ($P = .001$).

As has been reported previously,[3,4,7,8,13,19–22] the inferior alveolar nerve loop and the incisive canal could be identified as a round, radiolucent area within the mandibular trabecular bone, surrounded by a radiopaque rim representing the canal walls.

The incisive canal was identified in all but two CT scan images on the right side (0.6%) and three on the left side (0.9%) and showed a downward path in 333 images (51.3%), whereas 248 (38.29%) and 67 (10.41%) images showed linear and upward paths, respectively. When the course of the canal was assessed with respect to the buccolingual axis, a lingual path was followed in 462 cases (71.06%) while a buccal path was followed in 185 (28.94%). The mean length of the incisive canal was 9.11 ± 3.00 mm, and the diameter was 1.48 ± 0.66 mm. These values were not significantly different when compared using sex, left and right side, and edentulous or dentate state.

DISCUSSION

In the current study, CBCT scans and panoramic radiographic reformatted cross-sectional images were used to study several clinically important anatomical landmarks in the anterior region of the mandible, including the mental foramen, anterior loop of the mental nerve, and the incisive nerve.

This study found that the mean length of the mental nerve loop was 2.4 mm. This suggests that surgical trauma to the mental nerve is possible during placement of fixed prostheses or osseous bone grafting at sites lying between the mental foramina. This finding is in accordance with the results of other studies using panoramic radiography,[4] CBCT scan,[15] or cadaver dissection.[1,7] In agreement with Uchida et al,[14] there was no significant difference in the length of the mental nerve loop when either left versus right side or dentate versus edentulous patients were compared. However, there was a statistical difference for sex, with the length of the loop significantly greater in men.

The incisive canal could not be visualized in five CBCT images. This might be explained by the fact that the incisive canal is smaller in diameter and is surrounded by less cortical bone than the mandibular canal.[4] In addition, the incisive nerve becomes progressively smaller as it passes from the distal to the most anterior and midline portions of the mandible.[23] These findings are in accordance with a number of other CBCT studies of the region, in which the incisive canal was reported to be visible in 97% of scans.[14,24] However, Pires et al[23] identified the incisive canal in only 83.1% of CBCT scan images. Similarly, the appearance of the incisive canal in panoramic radiographs was assessed by Jacobs et al,[4] and the incisive canal was detected in only 15% of radiographs (n = 545), with visibility considered good in only 1% of scans.

The anterior extension of the incisive canal is not well documented.[16] If the topography of the incisive canal is not thoroughly evaluated by CBCT scan prior to implant placement or osseous grafting procedures, the terminal branch of the inferior alveolar nerve can be easily damaged, resulting in hypoesthesia, hyperesthesia, or paresthesia. This is especially true when procedures are carried out at the origin of the incisive canal, where the rate of sensory damage secondary to stretching of the nerve approaches that found in the loop of the mental nerve.[16] In addition, a number of studies have demonstrated that, following implant application, bleeding or nerve disruption can occur due to the unrecognized presence of the incisive canal.[12,25] The results of this current study showed that the incisive canal followed a downward course in 51.3% of CT scan images compared with 38.29% and 10.41% of cases, in which the nerve showed a linear or upward path, respectively. The present study found that the incisive canal had a mean inner diameter of 1.48 mm. Although Mardinger et al[26] reported a mean diameter of 1.8 ± 0.5 mm for this canal, the present findings are in closer agreement with other studies that reported mean diameters of 1.3[12] and 1.2 mm.[5]

CONCLUSION

When planning implant placement or osseous grafting procedures in the anterior mandible, CBCT scan images can enable the anatomy of the inferior nerve loop and incisive canal to be evaluated accurately.

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