ORIGINAL ARTICLE

https://doi.org/10.5125/jkaoms.2017.43.6.395
pISSN 2234-7550·eISSN 2234-5930

Assessment of the anterior loop of the inferior alveolar nerve via cone-beam computed tomography

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Abstract (J Korean Assoc Oral Maxillofac Surg 2017;43:395-400)

Objectives: The aim of this study was to evaluate different anatomical variants of the anterior loop of the inferior alveolar nerve (IAN) via cone-beam computed tomography (CBCT).

Materials and Methods: CBCT images of 71 patients (36 males and 35 females) were evaluated. We used the classification described by Solar for IAN evaluation. In this classification, three different types of IAN loops were introduced prior to emerging from the mental foramen. We classified patients according to this system and introduced a new, fourth type.

Results: Type I was seen in 15 sites (10.6%), type II in 39 sites (27.5%), and type III in 50 sites (35.2%). We found a new type in 38 sites (26.8%) that constituted a fourth type.

Conclusion: We found that type III was the most common variant. In the fourth type, the IAN was not detectable because the main nerve was adjacent to the cortical plate and the incisive branch was thinner than the main branch and alongside it. In this type, more care is needed for surgeries including inferior alveolar and mental nerve transposition.

Key words: Anterior, Mental loop, Cone-beam computed tomography, Iran

[paper submitted 2017. 1. 21 / revised 2017. 4. 7 / accepted 2017. 5. 7]

I. Introduction

In surgical procedures, attention to anatomical structures and their precise position is paramount[1]. The inferior alveolar nerve (IAN) canal is an important anatomical landmark in the mandible and contains the clinically important neurovascular bundle[2-5]. The mental foramen is superior to the mandibular canal and is apical to the premolars. The IAN divides into two branches before exiting the foramen. One branch exits into soft tissue via the mental foramen and is then named the mental nerve and provides lip and chin sensation. Another branch called the incisive branch goes forward in the bone to supply anterior teeth sensation[6,7]. In many cases, there is no distinct incisive canal because the nerves are organized in a network and are not detectable on radiographs[8].

The mental foramen in the embryonic period is at the apical area of the canine and first deciduous molar[6]. During the development of the mandible until the eruption of deciduous molars, the mental foramen is displaced anteriorly but after eruption of the second deciduous molar it redirects posteriorly. This displacement is a possible cause for development of an anterior loop of the IAN before it emerges as the mental nerve[6,7]. The anterior loop of the IAN is an important anatomical variation that originates from the IAN. In its first portion, it dips downwards and is then displaced upward and posteriorly to exit the mental foramen[9]. Failure to note this mesial loop may cause complications like sensory disorders in the lower lip. Therefore, precise evaluation of its position before surgery is essential. Pre-surgical evaluation of three-dimensional (3D) cone-beam computed tomography (CBCT)

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images plays an important role in prevention of probable damage. Several cadaver studies using radiological images have classified different shapes of the anterior loops of the IAN. We used the classification described by Solar et al.[10]. In this classification, three different types have been introduced for the anterior loop. According to this classification, the anterior loop is not seen in type I. The anatomy is Y-shaped and incisive branch thickness is similar to the main branch. In type II, the anterior loop is absent but the anatomy is T-shaped. The incisive branch is perpendicular to the main branch and the mental branch enters the mental foramen in a perpendicular direction. In type III, the anterior loop is detectable and the anatomy is Y-shaped. The incisive branch is thicker than the main branch and the mental branch diverges

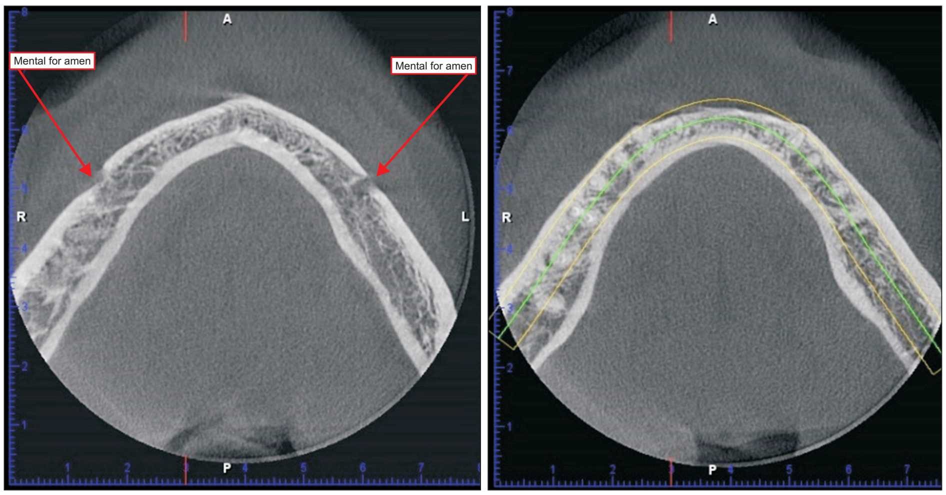

Fig. 1. Both left and right mental foramina on the axial section and panoramic curve drawn on the axial section.
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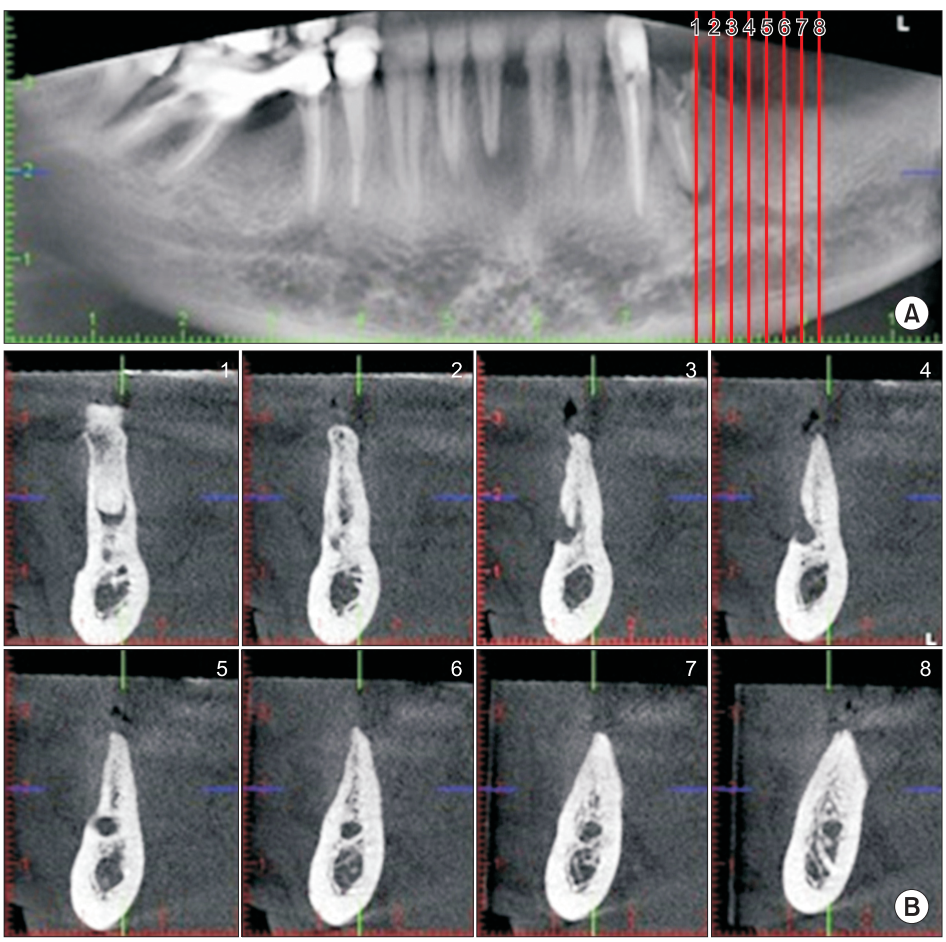

Fig. 2. A. Panoramic section showing type I on both sides; the guide plans for cross sections are also seen. B. Cross-sectional images showing type I.
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from the IAN anterior to the mental foramen. The aim of this study was to evaluate different IAN loop anatomical variants in an Iranian population via CBCT.

II. Materials and Methods

CBCT images of 71 patients (36 males and 35 females) from the radiology department archive of Mashhad Dental School were evaluated. The mean age of the patients was 43.54±9.72 years (range, 20-68 years). All images were taken by the same radiographic device (Planmeca Oy, Helsinki, Finland) and under the same exposure settings of 90 kVp, 10 mA, 12 seconds, and 18×18 cm field of view. All patients with history of trauma to the mandible, developmental anomalies, and pathological lesions were excluded. To ensure precise evaluation, all images were assessed by three post-graduate students who were trained to evaluate the IAN loop and its different types. All data were checked by an associate professor of oral and maxillofacial radiology. Both sides of all images were scanned with 0.2 mm^3 voxel size and 2 mm interslice distances. Axial, sagittal, and coronal sections were obtained. All images were similarly evaluated to standardize the procedure. First, the axial section was generated in a way that both left and right mental foramina could be seen. Panoramic curves were then drawn from the right to the left mental foramen.(Fig. 1) Panoramic sections were used to generate the cross-sections.(Fig. 2, 3)

III. Results

In our study, CBCT images of the mandible obtained from 71 patients, 36 male patients (50.7%) and 35 female patients

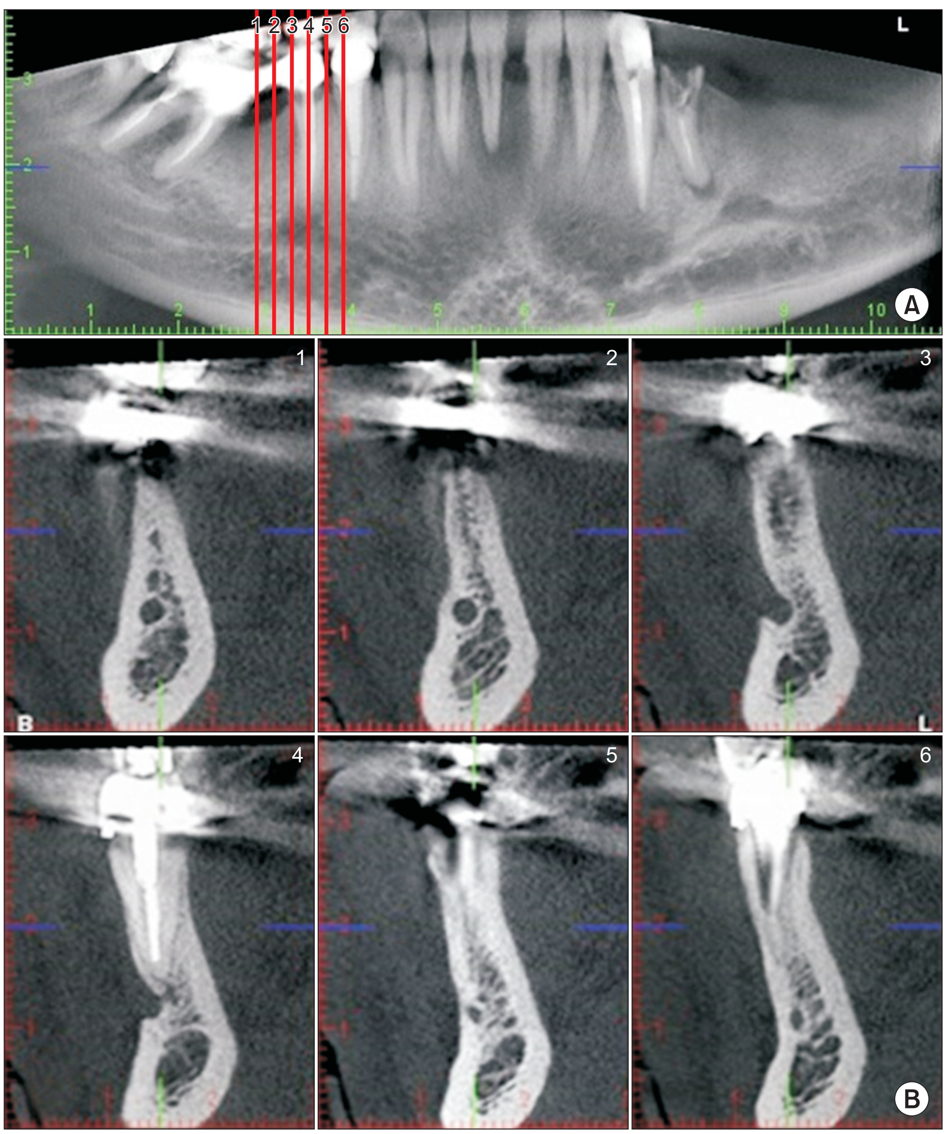

Fig. 3. A. Panoramic view of type IV. B. Cross-sectional images of type IV.
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(49.3%), were evaluated bilaterally. Type I was seen at 15 sites (10.6%), type II at 39 sites (27.5%), and type III at 50 sites (35.2%). We identified a new type of the anterior loop at 38 sites (26.8%) that could not be classified into any of the defined types. We found that in some radiographs the shape of the mental nerve was different from type III. In this new type, the inferior alveolar canal is adjacent to the buccal cortical plate of the mandible. The IAN divided into two branches but the mental nerve was not detectable because the main branch was adjacent to the cortical plate in the mental foramen area. The anatomy of this type was neither Y nor T-shaped and the incisive branch was along the main branch and this branch was thinner than the main branch. Panoramic and cross-sectional images of type IV are shown in Fig. 3.

IV. Discussion

Many studies have shown the unreliability of plain radiographs for detection of anatomical structures[11]. Panoramic radiography is an appropriate imaging modality for observation of the mandibular canal. Vazquez et al.[12] evaluated the efficiency of panoramic radiographs for treatment planning of implant surgery. These images effectively evaluated the bone height available for posterior mandibular implants and 3D imaging was not necessary[12]. However, panoramic radiography is not an efficient imaging modality for evaluation of nerve loop morphology because processing errors and incorrect patient position strongly affect image quality. In addition, the anterior loop is an intermedullary structure that is covered with thick cortical bone[13]. The absence of the anterior loop in panoramic radiographs does not mean that it does not exist in those cases[14,15]. 3D imaging is necessary for evaluation of the anterior IAN loop[16,17]. CBCT is an imaging method that has advantages including easy technique, precise images, decreased artifacts, lower costs, and decreased patient radiation dose compared to computed tomography (CT)[18]. However, decreased resolution and contrast in comparison to CT are disadvantages. The American Academy of Oral and Maxillofacial Radiology (AAOMR) suggested CBCT for evaluation of periodontal and orthodontic treatment and implant surgeries[14,19-22]. According to the results of our study, type I was seen in 10.6%, type II in 27.5%, and type III in 35.2% of patients. Most patients had anterior loops. The results of our study were similar to a study on a Turkish patient population[23]. They showed that type III was the most prevalent type (59.5%), and type I (8.6%) was the least prevalent type. Several studies (anatomical, radiographic, and combination of both) have evaluated the prevalence of an anterior loop and its morphological characteristics. The findings of these studies are summarized in Table 1[2,8,9,11,23-26].

In our study, this anatomical structure was visible in 50 sites (35.2%). But the prevalence of the anterior loop cannot provide enough information for surgeons because determination of the safety margin for interforaminal surgeries is a major issue. Despite many studies, a distinct distance from the mesial aspect of the mental foramen is still not recommended as a guideline. Different studies suggested a safety margin of 1-9 mm from the anterior margin of the mental foramen[10,24,27-34]. In a study by Wismeijer et al.[13], a protocol with a 3 mm safety margin was considered for all patients, and sensory disorders due to damage to the anterior loop was seen in 7% of cases. A standard distance from the mental foramen as a safe margin still cannot be recommended. Due to fear from this complication, many clinicians place implants anterior to their ideal position to avert damage to the mental nerve and sensory disorders in the lower lip[35]. In our study, we found a new variant of the anterior loop in 26.8% of sites that could not be classified into any defined type. In this new variation, the nerve was not detectable because the main branch was adjacent to the cortical plate and the incisive branch was along

Table 1. Results of anatomical and radiographic studies on the prevalence of the anterior mental loop and its morphological characteristics

Author	Year	Country	Evaluation tools	Sample size (n)	Prevalence of anterior mental loop
Rosenquist[24]	1996		Cadaver	58	15%
Arzouman et al.[9]	1993		Cadaver (anatomic and radiographic evaluation)	25	Anatomic (96%), radiographic (12%)
Jacobs et al.[2]	2002	Belgium	Panoramic	545	11%
Kaya et al.[25]	2008	Turkey	Panoramic, CBCT	73	Anatomic (28%), CBCT (34%)
Ngeow et al.[8]	2009	Malaya	Panoramic	33	40.2%
Benninger et al.[26]	2011	USA	Cadaver	15	26%
Kajan and Salari[11]	2012	Iran	CBCT	84	36.9%
Demir et al.[23]	2015	Turkey	CBCT	279	59.5%
Our study		Iran	CBCT	91	48%

(CBCT: cone-beam computed tomography)

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the main branch and this branch was thinner than the main branch. The presence of this type is very important in nerve transpositioning. Superficial IAN positioning in this variant can more likely render damage to the nerve.

In our study, all radiographs available in the archive that matched inclusion criteria were evaluated. Future multicenter studies with a larger sample size can provide more accurate information regarding the prevalence of different mental nerve variants.

V. Conclusion

We found type III to be the most common variant. In the fourth type, the IAN was not detectable because the main nerve was adjacent to the cortical plate and the incisive branch was thinner than the main branch and alongside it. For this type, more care is needed in surgeries including inferior alveolar and mental nerve transposition.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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