Archives of Oral Biology 60 (2015) 1736–1741

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/aob

Histologic features and fascicular arrangement of the inferior alveolar nerve

Myoung-Hwa Lee[a], Heung-Joong Kim[a], Do Kyung Kim[b], Sun-Kyoung Yu[a,*]

[a] Department of Anatomy and Orofacial Development, School of Dentistry, Chosun University, Gwangju, Republic of Korea
[b] Oral Biology Research Institute, School of Dentistry, Chosun University, Gwangju, Republic of Korea

ARTICLE INFO

Article history:
Received 9 April 2015
Received in revised form 23 July 2015
Accepted 9 September 2015

Keywords:
Inferior alveolar nerve
Inferior alveolar artery
Mental nerve
Dental nerve

ABSTRACT

Objectives: Knowledge of the various possible morphologies and courses of the inferior alveolar nerve and artery is important for successful and safe surgical procedures in the mandibular region. The purpose of this study was to verify the histologic features and fascicular arrangement of the inferior alveolar nerve and artery relative to tooth region.
Materials and methods: Twenty embalmed dentulous hemimandibles were examined (eight males and two females; mean age, 58.2 years). The hemimandibles were prepared for routine histology and stained with hematoxylin–eosin and Masson's trichrome. The histologic features, fascicular arrangement, courses, and areas of the inferior alveolar nerve and artery were investigated with the aid of a light microscope.
Results: The inferior alveolar neurovascular bundle comprised the inferior alveolar nerve, which appeared as a large trunk comprising two major nerves (the mental and dental nerves), and the inferior alveolar artery, which occupied a relatively small portion of the bundle. The mental nerve was located inferolingually in the third molar region and turned to the buccal side in the first molar region, separating from the dental nerve before reaching the mental foramen. The mandibular incisive canal with a bony wall was not found in the lateral incisor region; instead, small dental nerve fascicles and arteries presented consistently in the intertrabecular spaces. The inferior alveolar artery traveled above the inferior alveolar nerve over the entire mandibular canal.
Conclusions: These results provide data that are relevant to treatment planning for operative procedures such as implant placement, endodontic treatment, and osteotomy in the mandibular region.

1. Introduction

The inferior alveolar nerve (IAN) is one of the large branches of the mandibular nerve that innervates the mandibular teeth, periodontium, lower lip, and jaw. It enters the lower jaw through the mandibular foramen with a circular shape surrounded connective tissue tightly and then runs downward and forward within the mandibular canal, generally below the root apex (Rodella, Buffoli, Labanca, & Rezzani, 2012; Tan, Andrawos, Ghabriel, & Townsend, 2014). Within the mandibular canal, it runs with the inferior alveolar artery (IAA), vein, and lymph vessels, constituting the inferior alveolar neurovascular bundle (Rodella et al., 2012; Yaghmaei et al., 2011; Pogrel, Dorfman, & Fallah, 2009). The IAA is a branch of the maxillary artery, supplies blood to the mandible, divides into the mental and incisal branches in the first molar region, and finally makes an anastomosis with branches of the facial artery or its contralateral mate through the mandible accessory foramina (Naitoh et al., 2010; Flanagan, 2003).

The inferior alveolar neurovascular bundle can be affected by excessive intrusion of the drill or fixture into the mandibular canal during implant placement, resulting in the formation of an adjacent intraneural hematoma (Lamas Pelayo, Peñarrocha Diago, Martí Bowen, & Peñarrocha Diago, 2008). Surgical procedures such as third molar extraction and segmental osteotomy near the mental foramen are also common causes of IAN damage (Genú & Vasconcelos, 2008; Hwang, Lee, Song, & Chung, 2005). Damage to the IAN causes sensory disturbances such as paresthesia or anesthesia in the mandibular region, including the labiomental region. Furthermore, hemorrhagic accidents can frequently occur during surgical procedures since the IAA is located at the superior buccal aspect of the mandibular canal in the ramus and body of the

Abbreviations: IAN, inferior alveolar nerve; IAA, inferior alveolar artery; MN, mental nerve; DN, dental nerve.

* Corresponding author at: Department of Anatomy and Orofacial Development, School of Dentistry, Chosun University, 309 Pilmun-daero, Dong-gu, Gwangju 501-759, Republic of Korea. Fax: +82 62 224 3706.
E-mail address: sky@chosun.ac.kr (S.-K. Yu).

http://dx.doi.org/10.1016/j.archoralbio.2015.09.007
0003-9969/

mandible (Hur et al., 2013). It is thus clear that knowledge of the morphologic configuration, course, and histologic features of the neurovascular bundle within the mandibular canal is strategically important for clinical dental procedures in terms of aiding in diagnosis, treatment planning, and surgery (Bavitz, Harn, Hansen, & Lang, 1993; Tsuji, Muto, Kawakami, & Takeda, 2005).

While the IAN enters the mandible through a single canal, its intraosseous course varies among the previous researches: it may run as a single trunk giving off many branches, as two large trunks comprising the mental and dental nerves (MN and DN, respectively), or as a plexus, like the brachial plexus of the upper limb (Rodella et al., 2012; Hur et al., 2013; Zoud and Doran, 1993; Kqiku, Weiglein, Pertl, Biblekaj, & Städtler, 2011). Accordingly, numerous investigations have utilized various methods to examine the locations within the mandibular canal and intramandibular courses of the IAN in the dentulous and edentulous jaw (Kim et al., 2009; Kieser, Paulin, & Law, 2004; Wadu, Penhall, & Townsend, 1997; Kilic et al., 2010). However, the histologic structures and topographic relationships of the neurovascular bundle have yet to be completely characterized. Therefore, the purpose of the present study was to verify the histologic features and fascicular arrangement of the IAN and IAA relative to tooth region through histologic examinations.

2. Materials and methods

Twenty embalmed dentulous hemimandibles (eight males and two females) were obtained from human cadavers that had been donated for educational purposes to the Department of Anatomy, Chosun University School of Medicine. The age of the cadavers at death ranged from 29 to 75years (mean, 58.2years). This study followed the Declaration of Helsinki with respect to the medical protocol and ethics.

All specimens were decalcified in 10% nitric acid for 10 days and then rinsed with distilled water for 12 h. The decalcified mandibles were cut buccolingually at the midline of the third molar, first molar, first premolar, and lateral incisor, parallel to the long axis of each tooth. The tissues were then dehydrated and embedded in paraffin. Histologic sections were cut at a thickness of 8 μm, and stained with hematoxylin–eosin and Masson's trichrome. The histologic features of the IAN concerning the fascicular arrangement and bony wall of the mandibular canal were then observed with the aid of a light microscope (EZ4HD, Leica, Wetzlar, Germany) equipped with a built-in digital camera (LAS Basic v4.0, Leica).

The intramandibular courses and topographical relationships of the MN and DN, which are separately wrapped in perineural sheaths and enclosed in the main trunk of the IAN (Kqiku et al., 2011), and IAA were observed in relation to tooth region on the obtained histologic specimens. The areas of the IAN, MN, DN, and IAA were measured using image-analysis software (iSolution Capture, iMT, Vancouver, Canada) to an accuracy of 0.01 mm^2, twice each by two investigators, to standardize the measurements. The areas of the IAN and MN were not measured in the regions of the first premolar and lateral incisor, because the MN exits through the mental foramen, which is generally situated below the second premolar (Hwang et al., 2005) (Fig. 1).

Statistical analysis was performed using SPSS 12.0 (SPSS, Chicago, IL, USA). One-way ANOVA was used to analyze the interobserver differences and the differences between the right and left sides. Since no significant interobserver differences were found ($P = 0.890$), the average of the measurements obtained by the two investigators was used as the final measurement value. Similarly, there were no significant differences between the right and left sides ($P = 0.655$). In addition, measurements were analyzed according to tooth region by one-way ANOVA with a post-hoc comparison using Scheffé's method. Statistical significances between gender and age were not considered. All measurements are presented as mean ± SD values, and the threshold for statistical significance was set at $P < 0.05$.

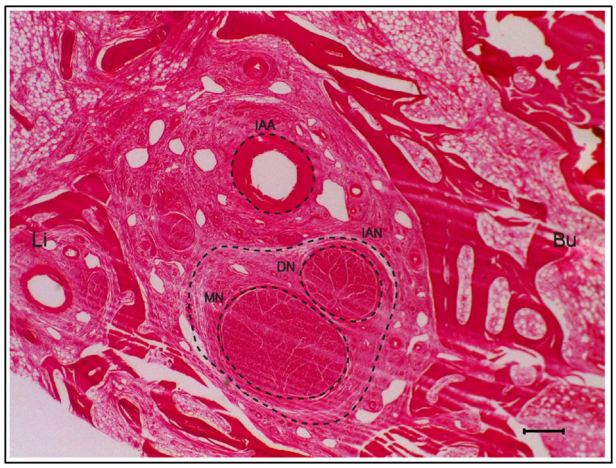

Fig. 1. Measurements of the inferior alveolar nerve (IAN) and artery (IAA) in a histologic section. The broken lines indicate the areas of the IAN, which includes the mental nerve (MN) and dental nerve (DN), and the IAA. Li, lingual side; Bu, buccal side. Hematoxylin–eosin (H & E) stain; scale bar = 500 μm.

3. Results

3.1. Histologic features

In all specimens, the inferior alveolar neurovascular bundle was composed of the IAN, which appeared as a large trunk comprising two major nerves (MN and DN), and the IAA, which occupied a relatively small portion of the bundle, within a connective tissue sheath. It was reconfirmed that the MN and DN were separately enclosed in perineurium, and ultimately surrounded by a distinct epineurium of the IAN. The IAN divided definitively in the first molar region into the MN and DN in all except four specimens, in which it divided in the third molar region. The MN usually consisted of three or four close nerve fascicles, each wrapped with perineurium; the number of MN fascicles in the mandibular canal was fairly consistent between specimens, while that of the DN varied (Fig. 2).

In the third molar region, the mandibular canal had a complete bony canal composed of cancellous bone, but in some sections the canal lay alongside the inner plate of the lingual cortical bone that formed part of its wall. The mandibular canal had a partial bony canal in the first molar region. In all except four of the specimens (Fig. 3), the incisive canal with a bony wall was not found in the lateral incisor region, however, small nerve fascicles and arteries of various sizes were still present in intertrabecular spaces. As the nerve fascicles and arteries divided into smaller branches anteriorly, the connective tissue surrounding them became looser, but they were still surrounded by an epineurium and a fibrous sheath, respectively. And at five samples in the lateral incisor, the DN and IAA ran in their own independent spaces without forming a single neurovascular bundle (Fig. 2g,h).

3.2. Courses and topographical relationships

The MN was located inferior to the DN and IAA within the mandibular canal, lying lingually to the DN in the third molar region, and passing it buccally in the first molar region, to finally emerge through the mental foramen. The DN was located between the IAA and MN, running lingually to the MN in the first molar