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Anatomic evaluation of the retromolar canal by histologic and radiologic analyses

조선대학교 대학원

치의학과

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2016년 8월 25일

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조선대학교 대학원

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ABSTRACT in KOREAN

조직 및 방사선학적 접근을 통한 어금니뒤관의 해부학적 평가

강 한 수

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어금니뒤삼각은 임상에서 매복 셋째큰어금니의 발치, 뼈이식술의 제공 부위, 임플란트 시술, 및 시상골절단술 등의 외과적 시술과 밀접한 관련이 있다. 턱뼈관에서 일어나는 어금니뒤관은 셋째어금니의 뒤쪽으로 주행하여 어금니뒤삼각 부위의 이틀뼈 표면에서 어금니뒤구멍을 통해 열린다. 이러한 어금니뒤구멍의 발현 빈도는 인종과 연구방법에 따라 7.7%에서 75%로 매우 다양하다. 따라서 본 연구에서는 조직 및 방사선학적 접근을 통하여 어금니뒤관의 형태와 조직학적 특징을 조사하여, 임상의들의 수술 전 초기 평가에 유용한 해부학적 자료를 제공해 주고자 한다.

본 연구에서는 조선대학교 치과병원에 내원하여 전산화단층촬영을 한 환자 72명에서 얻은 144쪽의 영상과 조선대학교 의학전문대학원에 기증된 시신 11구에서 얻어진 22쪽의 아래턱뼈를 사용하였다. 어금니뒤관의 위치를 포함한 형태학적 특징을 분석하기 위하여 얻어진 전산화단층촬영 영상에서 발현, 경로, 열리는 구멍 위치, 및 둘째큰어금니로부터의 거리를 측정하였다. 얻어진 아래턱뼈는 통상적인 조직처리 방법을 거쳐 염색을 시행한 후, 광학현미경을 이용하여 어금니뒤관의 면적을 포함한 조직학적 특징을 분석하였다.

전산화단층촬영 영상에서 어금니뒤관은 26.4%의 38쪽(개개인 평가에서는 43.1%의 31명)에서 관찰되었으며, 대부분 턱뼈관으로부터 수직으로 주행하여 어금니뒤삼

각의 중간 부분에서 어금니뒤구멍으로 열렸다. 어금니뒤관은 조직학적 표본에서도 27.3%(6쪽)의 유사한 발현 빈도로 나타났다. 최대 수평 및 수직 직경은 평균 0.82, 0.90mm로 수직으로 긴 타원의 형태를 보였다. 어금니뒤관의 신경혈관다발, 및 다발 안의 동맥과 신경의 평균 면적은 순서대로 0.590±0.415, 0.072±0.060, and 0.045±0.049mm^2 이었다.

본 연구 결과 어금니뒤관은 환자 개개인의 평가에서 43.1%의 매우 높은 빈도로 나타났으며, 그 안에 비교적 더 큰 동맥과 신경을 둘 다 포함하고 있었다. 따라서 임상의들은 어금니뒤삼각 부위에서 외과적 시술시 신경손상뿐만 아니라, 출혈성 손상에 더 주의를 기울일 필요가 있겠다.

중심어: 어금니뒤관, 전산화단층촬영, 조직학적 구성, 어금니뒤삼각

I. INTRODUCTION

The retromolar canal arises classically from the mandibular canal, travels superiorly behind the third molar, and opens into the retromolar foramen located on the retromolar fossa or retromolar triangle, which is a small triangular shaped region bounded by the anterior border of the mandibular ramus and temporal crest (Potu, Kumar, Salem & Abu-Hijleh, 2014: Bilecenoglu & Tuncer, 2006: Park, Ryu, Kim & Gwak, 2014: von Arx et al., 2011). The prevalence of this foramen varies markedly from 7.7% to 75% according to race, research methods, and the criteria used to define it, such as choosing a diameter cutoff of 0.5 or 1.0 mm (Potu, Kumar, Salem & Abu-Hijleh, 2014: Bilecenoglu & Tuncer, 2006: Lizio et al., 2013: Han & Hwang, 2014: Park, Ryu, Kim & Gwak, 2014: Sawyer &, Kiely, 1991: Patil et al., 2013: Potu, Kumar, Salem & Abu-Hijleh, 2014). In particular, a previous study using panoramic radiographs found its prevalence to be less than 1% (Langlais, Broadus &, Glass, 1985).

A factor related to the presence of this canal that is especially important to clinicians is that it contains thin myelinated nerve fibers and several arteries and venules (Bilecenoglu & Tuncer, 2006: Fukami et al., 2012: Kodera & Hashimoto, 1955: Schejtman, F. C. H. Devoto & N. H. Arias, 1967). After passing through the foramen, the nerve component is distributed mostly on the temporal tendon, the buccinators muscle, the third molar, and the retromolar pad, and then it continues to the buccal gingiva up to the first molar region anteriorly (M. H. K. Motamedi et al., 2016: R. Schejtman, Devoto & Arias, 1967). The artery component has the same distribution areas as the nerve, anastomosing with the branches of the buccal and facial arteries, and giving off the superior and inferior labial arteries (Bilecenoglu & Tuncer, 2006: Kodera & Hashimoto, 1955: Schejtman, Devoto & Arias, 1967). However, the origin of these components as well as its histologic composition including the presence of striated muscle fibers are still unclear due to the small number of samples (von Arx et al., 2011).

The retromolar triangle is intimately related to surgical procedures involving the retromolar area, such as extraction of an impacted third molar, sagittal split ramus osteology, dental implant placement, and harvesting bone blocks, and to dental treatments such as inferior alveolar nerve block and planning the margins of prosthetic appliances (Bilecenoglu & Tuncer, 2006: Han & Hwang, 2014: Fukami et al., 2012: Rashsuren, Choi, Han & Kim, 2014: Park, Ryu, Kim & Gwak, 2014: Patil et al., 2013). The neurovascular bundle passing through the retromolar canal and opening into the relevant area can be damaged during routine dental surgery, resulting in various complications such as paresthesia, traumatic neuroma, excessive bleeding, and postoperative hematoma (Han & Hwang, 2014: Fukami et al., 2012: Rashsuren, Choi , Han & Kim, 2014: Patil et al., 2013). It can also act as a route for the spread of tumors or infection (Bilecenoglu & Tuncer, 2006).

Therefore, to provide detailed anatomic information on the retromolar canal for use by clinicians in preoperative assessments, the aims of this study were to determine its topography including course and location using cone-beam computed tomography (CBCT) and to reveal its morphology including its histologic composition and dimensions using histologic sections.

II. MATERIALS AND METHODS

This study performed anatomic assessments of the retromolar canal using CBCT images obtained from 72 patients (144 sides) who were referred to the Department of Oral and Maxillofacial Radiology, Chosun University Dental Hospital. They comprised 40 males and 32 females, and ranged in age from 18 to 82 years (mean age, 53.9 years). In addition, 22 embalmed dentulous hemimandibles (from 9 males and 2 females with a mean age at death of 57.3 years) were examined that had been donated for educational purposes to the Department of Anatomy, Chosun University School of Medicine. This study followed the Declaration of Helsinki with respect to the medical protocol and ethics, and was approved by the Institutional Review Board of Chosun University Dental Hospital.

CBCT scanning was performed using the CB MercuRay^{TM} device (Hitachi, Tokyo, Japan), and the field of view of each scan was spherical, with a diameter of 150 mm and a basic voxel size of 0.292 mm. The three-dimensional volumetric data were reconstructed as 512 axial images after acquiring 288 X-ray images during 1 rotation lasting about 10 seconds. The exposure parameters were 120 kVp and 15 mA. The coronal, sagittal, axial, and cross-sectional sections and three-dimensional images were reconstructed to allow the retromolar canal to be detected with the aid of image analysis software (OnDemand3D^{TM}, Cybermed, Seoul, Korea).

The CBCT images were reviewed retrospectively by an oral and maxillofacial radiologist and experienced dentist. The retromolar canal was classified as being “visible” only if it was detected by both observers, and its prevalence was investigated. Its course in the sagittal plane was classified into three types (vertical, oblique, and horizontal types), and as was its opening position at the retromolar triangle (buccal, middle, and lingual portions). The distance from the distal surface of the second molar to the midpoint of the retromolar foramen was measured.

For histologic investigations, all hemimandibles were decalcified in 10% nitric acid for 10days and then washed with distilled water for 12 hours. Each hemimandible specimen was sectioned serially at the third molar (or in the retromolar region if it was not a third molar), second molar, and first molar, parallel to the long axis of each tooth. The specimens were prepared using a routine histologic preparation technique, stained with hematoxylin-eosin, and then observed with the aid of a light microscope (EZ4HD, Leica, Wetzlar, Germany) equipped with an image acquisition system (LAS Basic version 4.0, Leica).

The prevalence of the retromolar canal was investigated in the histologic sections, and its maximum horizontal and vertical diameters were measured. Also, the areas of the neurovascular bundle with surrounding connective tissue, and the artery and nerve contained within it were measured by two observers using image-analysis software (iSolution Capture, iMT, Vancouver, Canada).

Statistical analysis was performed using IBM SPSS Statistics (version 23.0, IBM Corporation, Somers, NY, USA). Differences in the prevalence rate by gender and side were analyzed using the chi-square test. One-way ANOVA was used to analyze differences between observers, side, and gender in the distance from the second molar. No distinction was made with regard to age. All measurements are presented as mean±SD values, and the significance level was set at $P<0.05$.

III. RESULTS

The retromolar canal was visible on CBCT images in 26.4% of cases (*n*=38), and it was detected in 31 patients (43.1%; 24 unilateral and 7 bilateral cases). The prevalence rate did not differ significantly with gender (*P* = 0.394) or side (*P* = 0.449). With regard to the topography of the retromolar canal, in most cases it arose vertically from the mandibular canal (vertical type; 71.0%, 27 cases), followed by having an oblique course (23.7%, 9 cases), with a horizontal course being rare (5.3%, 2 cases) (Fig. 1). In terms of its buccolingual opening position, it opened in the middle (57.9%, 22 cases), lingual (31.6%, 12 cases), or buccal (10.5%, 4 cases) portion of the retromolar triangle (Fig. 2). The distance from the second molar to the retromolar foramen was 13.13±3.24 mm, and even though p value was greater than 0.05, its value of males had longer than that of females (Table 1).

After comparing the change in composition of the inferior alveolar neurovascular bundle according to tooth site sequentially on the histologic sections, the retromolar canal was found in six cases (27.3%), which was consistent with the results from the CBCT images (Fig. 3). With regard to the morphology of the retromolar canal, its mean maximum horizontal and vertical diameters were 0.82 and 0.90 mm, respectively, and it had an oval shape in the vertical direction. The areas of the retromolar neurovascular bundle, and of the artery and nerve contained within it were 0.590±0.415, 0.072±0.060, and 0.045±0.049 mm^2, respectively (Table 2). The artery appeared to be larger than the nerve in all six cases (Fig. 4), but the difference was not significant due to the small number of samples.

IV. DISCUSSION

The retromolar canal has been described as a rare anatomic structure or an uncommon anatomic variation that bifurcates from the mandibular canal (Langlai, Broadus &, Glass, 1985: Ossenberg , 1987: Sawyer &, Kiely, 1991), and so it has rarely been reported either in the research or anatomic textbooks, and so is often overlooked by clinicians (Bilecenoglu & Tuncer, 2006: Yu et al., 2015). However, recent studies have found the retromolar canal to be a normal anatomic structure observed at a relatively high prevalence rate and therefore requiring attention during surgical procedures in the retromolar area of the mandible (Motamedi et al., 2016: Rashsuren, Choi, Han & Kim, 2014: Park, Ryu, Kim & Gwak, 2014: Sisman, Erean-Sekeri, Payveren-Arikan & Sahman, 2015). This situation prompted the present study to investigate these fine normal anatomic structures using histologic and radiologic approaches with the aim of improving the knowledge of clinicians.

The present study found the retromolar canal in approximately 27% of cases both histologically and using CBCT. The prevalence rate did not differ significantly with either gender or side, which was consistent with the findings of previous studies (Han & Hwang, 2014: Rashsuren, Choi, Han & Kim, 2014: von Arx et al., 2011: Sisman, Erean-Sekeri, Payveren-Arikan & Sahman, 2015). Especially, it was observed on patients (in individual assessments) at a relatively high prevalence rate rather than on side, and half of them had at least one canal. This indicates the importance of considering this structure even when performing routine dental surgery.

Several histologic studies have found that the retromolar foramen contains nerve fibers and arteries of similar sizes (Bilecenoglu & Tuncer, 2006: Fukami et al., 2012: Kodera & Hashimoto, 1955: Schejtman, Devoto & Arias, 1967). However, the origin of these components remains uncertainly, in terms of where they enter or exit the bone (von Arx et al., 2011). Yu et al. (Yu et al., 2015) reported that the retromolar neurovascular bundle was likely to be present, based on their finding that the area of the inferior alveolar neurovascular bundle decreases rapidly from the third molar to the first molar. The inferior alveolar nerve comprises the mental nerve that innervates the lower lip and chin and the dental nerve that innervates the mandibular teeth (Lee, Kim, Kim & Yu, 2015), and so the dental nerve is divided into retromolar, molar, and incisor branches (Fukami et al., 2012). The histologic findings of the present study indicated that the inferior alveolar neurovascular bundle also branched off the retromolar neurovascular bundle at the third molar or retromolar region, with the remainder continuing to the anterior teeth. It is therefore likely that the neurovascular bundle in the retromolar canal originates from the inferior alveolar neurovascular bundle.

The most common complication during and after dental surgery has been reported to be sensory disturbance (Bilecenoglu & Tuncer, 2006). In contrast, it has also been suggested that only blood vessels and not both blood vessels and nerves need to be considered during surgery in the retromolar region (Grover & Lorton, 1983). However, the present study found both blood vessels and nerves within the retromolar canal, indicating that the possibility of both vascular and nerve injuries needs to be considered during surgery. Furthermore, since the area of the artery was larger than that of the nerve, clinicians need to be aware that hemorrhagic damage might be more likely than nerve injury.

The prevalence rate of the retromolar canal varies widely between populations, sample types, measurement methods, and how it is defined, and the rate found in the present study differs from those reported previously (Potu, Kumar, Salem & Abu-Hijleh, 2014: Filo et al., 2015: Alves & Deana, 2015: Capote, Goncalves & Campos, 2015). The type of retromolar canal with regard to its course could influence the prevalence rate. Based on histologic findings, the present study considered the retromolar canal that arose only from the mandibular canal and coursed toward the retromolar triangle. In contrast, Patil et al. (Patil et al., 2013) includes the radicular type that is not connected to the mandibular canal and opens into the periodontal ligament space and has a very high prevalence. The temporal crest canal is a rare anatomic variant that opens anterior to the temporal crest outside the retromolar triangle and includes an aberrant buccal nerve (Jablonski, Cheng, Cheng & Cheung, 1985: Ossenberg, 1986: Kawai et al., 2014). Therefore, it is thought that both the radicular type and the temporal crest canal are excluded from this category, and so further studies need to apply gross anatomic dissections to elucidate the nerve origin in these two variants.

In the present study, the mean maximum horizontal diameter of the retromolar canal was 0.82 mm. This is similar measurement item to the width of previous researches, including of a 95% confidence interval of 0.87–1.10 mm (Han & Hwang, 2014: von Arx et al., 2011). The mean distance from the second molar to the retromolar foramen of 13.13 mm in the present study is also similar to that found previously (Han & Hwang, 2014: Filo et al., 2012: von Arx et al., 2011).

Various opinions have been expressed concerning the opening position of the retromolar canal from a buccal aspect (Motamedi et al., 2016: Park, Ryu, Kim & Gwak, 2014) or a lingual aspect (Potu, Kumar, Salem & Abu-Hijleh, 2014: Alves & Deana, 2015). In the present study, its opening position was classified into three portions, with it opening mostly in the middle portion of the retromolar triangle. If the prosthetic restoration or implant placement crosses over distally to the retromolar area, this could cause paresthesia and pain (Muto & Kanazawa, 1997). In addition, because it opened mostly in the middle part and the area of the artery was larger than that of the nerve, pressure on the retromolar pad is very likely to induce complications associated with ischemia.

This study found that the retromolar canal appeared with a frequency of approximately 27% both histologically and using CBCT. However, in individual assessments it was detected at a higher rate of 43.1% (31 patients). The retromolar canal, which included both a larger artery and nerve, arose vertically from the mandibular canal and opened in the middle portion of the retromolar triangle with a diameter of about 0.8 mm. Clinicians therefore need to pay closer attention to hemorrhagic damage rather to nerve injury when they are performing surgical procedures in the retromolar area of the mandible.

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FIGURES

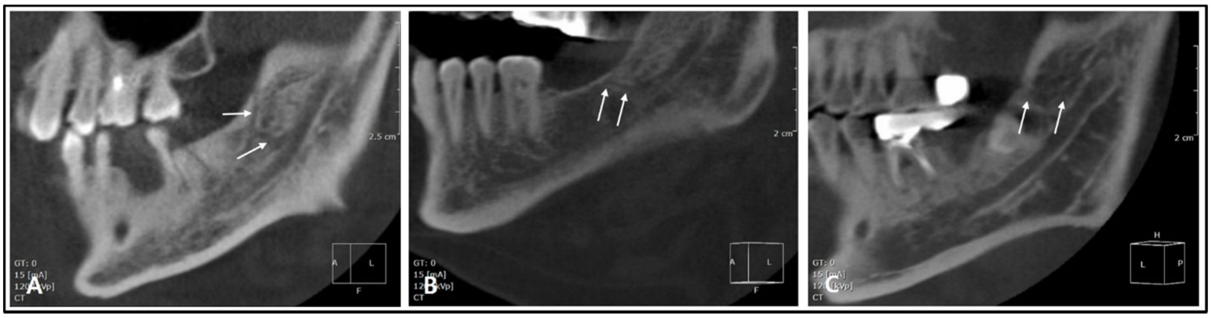

Fig. 1. CBCT images of the course of the retromolar canal in the sagittal plane. A, Vertical type; B, oblique type; and C, horizontal type. Arrows indicate the retromolar canal.

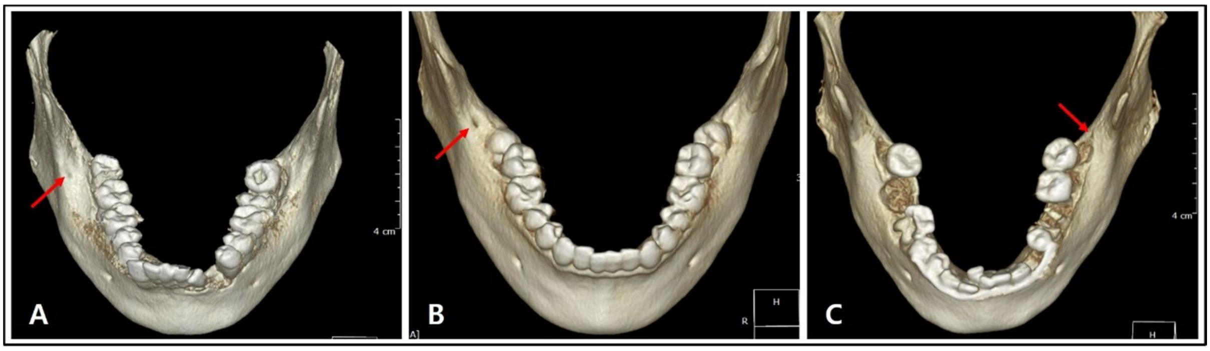

Fig. 2. Three-dimensional reconstructions of CBCT images at the opening position of the retromolar canal. A, Buccal opening; B, middle opening; and C, lingual opening. Arrows indicate the retromolar foramen.

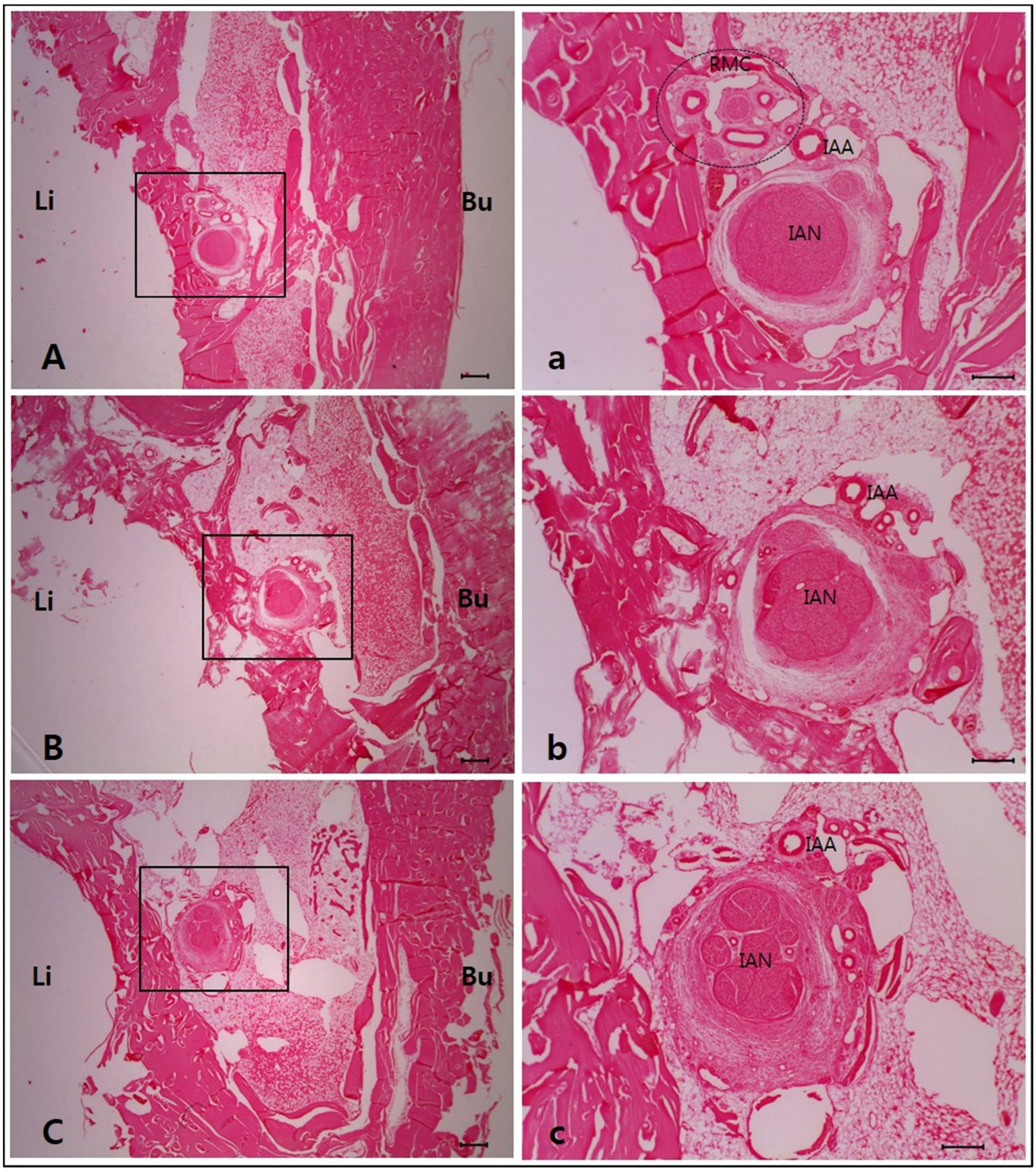

Fig. 3. Histologic sections of the neurovascular bundle according to tooth region. A and a, Third molar or retromolar region; B and b, second molar; and C and c, first molar. The areas within the black rectangles in A, B, and C are shown at higher magnification in a, b, and c, respectively. The dashed circle indicates the retromolar canal (RMC). IAN, inferior alveolar nerve; IAA, inferior alveolar artery; Li, lingual side; Bu, buccal side. Hematoxylin-eosin stain. Scale bars: 1000 µm in A, B, and C; and 500 µm in a, b, and c.

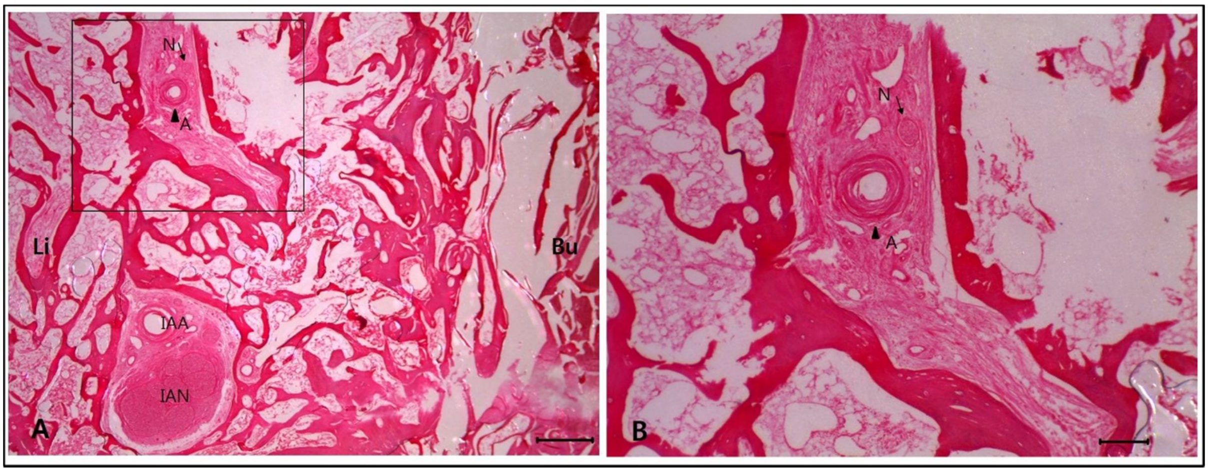

Fig. 4. Histologic sections of a different sample from Fig. 2 showing the retromolar canal in the retromolar region. The area of the artery is larger than that of the nerve. The arrow indicates the nerve (N) and the arrowhead indicates the artery (A). Hematoxylin-eosin stain. Scale bars: 1000 μm in A and 500 μm in B.

TABLES

Table 1. Distance from the second molar to the retromolar foramen by gender.

	Male (*n*=19)	**Female (*n*=9)**	**Total (*n*=28)**	***P***
Distance	13.72±3.21 mm	11.88±3.13 mm	13.13±3.24 mm	0.166

Data are mean±SD values.

Table 2. Measurements of the retromolar neurovascular bundle in the retromolar canal on histologic sections.

	Minimum	**Maximum**	**Mean±SD**
Maximum horizontal diameter (mm)	0.613	1.579	0.823±0.373
Maximum vertical diameter (mm)	0.598	1.241	0.897±0.264
Area of neurovascular bundle (mm^2)	0.339	1.415	0.590±0.415
Area of artery (mm^2)	0.031	0.191	0.072±0.060
Area of nerve (mm^2)	0.016	0.143	0.045±0.049