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Anatomical dissection of the greater palatine artery and the palatal spine, and their topographical relationship: reference data for periodontal surgery

조선대학교 대학원

치의학과

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ABSTRACT in KOREAN

치주수술을 위한 큰입천장동맥과 입천장가시의 해부 및 두 구조물 간의 위치관계

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단단입천장은 잇몸과 조직학적으로 유사한 특징을 가지고 있어, 치주수술의 주요 공여부위로 사용된다. 이때 단단입천장에 주요 혈액을 공급하는 큰입천장동맥은 큰입천장신경과 함께 입천장고랑에 위치하여 전방으로 주행하며 분포하므로, 시술 시 주의해야 할 해부학적 구조물이다. 따라서 본 연구에서는 큰입천장동맥의 입천장에서 분지 양상과 경로를 확인하고 안쪽과 가쪽의 입천장고랑을 나누는 입천장가시의 골격적 분석을 통해, 두 구조물 간의 형태학적 위치관계를 파악하여 입천장의 치주수술 시 큰입천장동맥의 위치 및 경로에 관한 해부학적 자료를 제공해 주고자 한다.

본 연구에서는 조선대학교 의학전문대학원에 기증된 한국인 시신 24구에서 얻어진 36쪽의 위턱을 사용하여 큰입천장동맥의 주행 양상을 확인하고(남 18구, 여 6구; 평균연령 60.8세), 해부학 실습용 머리뼈 25개(50쪽)를 이용하여 입천장가시의 골격적 분석을 추가로 시행하였다. 우선 위턱의 입천장에서 미세현미경을 이용하여 해부를 시행한 후 큰입천장동맥가지의 분지 양상을 바깥쪽가지, 안쪽가지, 및 송곳니가지를 기준으로 4가지로 분류하였다. 디지털 캘리퍼를 이용하여 각각 치아의 백악법랑경계에서 큰입천장동맥의 바깥쪽가지까지의 거리를 계측하여 입천장에서의 경로를 확인하였다. 또한 입천장 뼈융기의 형태를 분류하고, 디지털 캘리퍼를 사용하여 골표지점을 통한 입천장가시의 크기 및 위치를 계측하였다. 큰입천장동맥의 분지 양상

과 입천장 뼈융기의 형태 간의 상관관계를 분석하였다.

큰입천장동맥의 분지 양상은 Type I 인 바깥쪽가지, 안쪽가지, 및 송곳니가지가 입천장가시 이후에 분지되어 양쪽의 각각 입천장고랑을 따라 주행하는 경우가 41.7% (15쪽)로 가장 많았다. 백악법랑경계에서 큰입천장동맥의 바깥쪽가지까지의 거리는 송곳니부터 둘째큰어금니까지 치아순서대로 9.04±2.93, 11.12±1.89, 13.51±2.08, 13.76±2.86, 13.91±2.20mm로, 첫째작은어금니 부위에서부터 급격하게 감소하였다. 또한 입천장고랑을 나누는 뼈융기로는 입천장가시의 형태가 66.3% (57쪽)로 가장 빈번하게 발견되었으며, 이러한 입천장가시는 큰입천장구멍의 앞쪽경계로부터 6.49±1.76mm 이후부터 나타나기 시작하여 10.42±2.45mm의 길이로 전방으로 위치하였다. 큰입천장동맥의 분지 양상과 입천장 뼈융기의 형태 간에 특별한 상관관계는 나타나지 않았다.

이를 종합하여 보면 대부분의 큰입천장동맥은 주로 가쪽입천장고랑을 따라 주행하면서 치아에 인접한 치은에 분포하는 바깥쪽가지와 정중입천장봉합에 근처 입천장샘과 지방조직에 분포하는 안쪽가지로 나뉘어 주행하는 것을 알 수 있다. 그러므로 이러한 결과는 입천장의 치주수술 시 큰입천장동맥의 위치 및 경로에 관한 해부학적 자료를 제공해 줄 수 있을 것으로 사료된다.

중심어: 큰입천장동맥, 입천장가시, 가쪽입천장고랑, 치주수술

I. INTRODUCTION

The hard palate, which has similar features to the gingiva, comprises three parts: a keratinized epithelium, a dense lamina propria, and a submucosa located below these two structures.[1] While Sharpey's fibers in the submucosa hold the lamina propria tightly to the periosteum, it is still possible to separate the dense connective tissue from the periosteum via the adipose and glandular tissues.[2,3] Because of the histological similarities and characteristics between the gingiva and the hard palate, the palatal mucosa is used widely as an autogenous donor material for periodontal surgery.

In general, the distal regions of the canine to midpalatal aspects of the first molar in the hard palate are recommended as the donor site because of the presence there of a uniformly thick mucosa, which can provide a maximum tissue graft length of 31.7 mm.[4,5] However, because of variations in the anatomy of the hard palate between patients, particular care must be taken during donor tissue harvesting not to damage structures such as the thin mucosa that exists close to the bulky palatal root of the first molar, the greater palatine foramen in the posterior region of the first molar, the greater palatine neurovascular bundle [which comprises the greater palatine artery (GPA) and the greater palatine nerve (GPN)], and the palatine rugae in the anterior region of the canine distal.[6,7] Thus, the height, length, and thickness of the available donor tissue will vary between patients.[8] In this context, an accurate understanding of the location and course of the GPA is needed to enable clinicians to develop a preoperative plan so that they can determine the amount of donor tissue that can be harvested, while simultaneously reducing the potential risk of damaging the GPA.

The GPA originates from descending palatine artery of the maxillary artery in the pterygopalatine fossa, passes through the pterygopalatine canal, and emerges from the greater

palatine foramen in the palatal aspect of the upper third molar, to reach the hard palate.[9,10] At the hard palate, the GPA, together with the GPN, courses and sends out branches anteriorly, in close contact with the alveolar ridge between the junction of the maxillary alveolar ridge and the horizontal plate of the maxilla, and then enters the nasal cavity superiorly through the incisive foramen.[8,11] Thus far, the branching patterns and courses of the GPA and GPN—in the form of the neurovascular bundle—have been described only vaguely in the literature.[11-14]

Furthermore, the neurovascular bundle runs anteriorly within the bilateral longitudinal grooves of the bony palate,[15] and the palatal bony prominence divides these grooves, forming the margins between the medial and lateral sides.[16] Clinicians can therefore estimate the course of the neurovascular bundle and reduce the risk of damaging by palpation of this prominent bony structure during periodontal surgery and when injecting local anesthetic.[8,15]

The aims of this study were to (1) identify the branching patterns and courses of the GPA in the hard palate, (2) carry out a morphological analysis of the palatal bony prominence that divides the medial and lateral grooves, and (3) determine the topographical relationship between these two parameters.

II. MATERIALS AND METHODS

The GPA and the palatal bony prominence of the hard palate were examined in 24 embalmed Korean cadavers (36 hemimaxillae; 18 males and 6 females). The mean age at death of these cadavers was 60.8 years (range 29-90 years). An additional 25 dry skulls (50 sides) were evaluated to elucidate the morphology of the palatal bony prominence. These cadavers and dry skulls had been prepared for educational purposes and donated to the Department of Anatomy, School of Medicine, Chosun University.

Latex (Neoprene, Lot no. 307L146, DuPont, Barsac, France) containing a red coloring agent (Colorant Universal, Castorama, Templemars, France) was injected through the pterygopalatine canal of all specimens to reveal the course of the GPA in the palatal neurovascular bundle. The epithelium and subepithelial connective tissue were then carefully removed so as not to damage the palatal neurovascular bundle. After exposing the neurovascular bundle, the specimens were immersed in guanidine hydrochloride (0.2 M) for 1 month, and then treated with ultrasonic cleaner for 2 hours to soften the dense connective tissue around it.[17] The GPA and the GPN were dissected meticulously with the aid of a surgical microscope (OPMI-FC, Carl Zeiss, Oberkochen, Germany). The topographic relationship between the two structures was identified, and then the GPN was removed.

The distribution patterns of the GPA were categorized according to the origins of its three branches:

1. The lateral branch (and main trunk of the GPA) emerged from the greater palatine foramen and ran anteriorly toward the anterior teeth.
2. The medial branch coursed toward the midpalatal suture.
3. The canine branch emerged from the lateral branch and ascended to the canine region.

The branching patterns of the GPA were then classified into four types according to the courses of these three common branches (Fig. 1).

The topographic course of the lateral branch of the GPA from the second molar to the canine was examined. The vertical distance from the cementoenamel junction (CEJ) at the central point of each canine and premolars (corresponding to the meeting point between the lingual groove and the CEJ of the molars) to the lateral branch was measured using a periodontal probe (Hu Friedy, Chicago, IL, USA) with a rubber stopper. The measured values on the probe were taken using digital vernier calipers (Mitutoyo, Kawasaki, Japan) to an accuracy of 0.01 mm (Fig. 1).

The morphological variations of the palatal bony prominence that divides the medial and lateral palatal grooves were investigated in the 36 dissected hemimaxillae and 25 dry skulls. The shape of the palatal bony prominence was classified into three types:

1. Spine type, in which the prominence formed a spine that clearly separated the medial and lateral grooves.
2. Bridge type, in which the bony prominence was shaped like a canal linked by bony or fibrous ligaments.
3. Smooth type, in which the bony prominence was rarely revealed.

A morphometric analysis of the bony prominence was then conducted using digital vernier calipers; (1) start and end points of the bony prominence relative to specific tooth sites, presented from the greater palatine foramen, (2) distance from the anterior margin of the greater palatine foramen to the start point, and (3) length of the bony prominence (Fig. 1).

All measurements were made by two investigators. The interobserver differences and differences between measurements made on the right and left sides were analyzed by one-way ANOVA using SPSS (version 12.0, SPSS, Chicago, IL, USA). Since there were no

significant interobserver differences (P=0.842), and so the mean of the measurements from individual observers was used as the final measurement value. The correlation between the branching patterns of the GPA and the shape of the palatal bony prominences was analyzed using Pearson correlation coefficients. No distinctions were made with regard to either age or gender. All measurements are presented as mean±SD values, and the level of statistical significance was set at P<0.05.

III. RESULTS

The main trunk of the GPA was the lateral branch, and the subsequent GPA branching pattern was classified into four types according to the location of the origins of the medial and canine branches. In type I, which was the most prevalent (41.7%, *n*=15), the lateral branch ran anteriorly in the lateral groove of the bony prominence from the greater palatine foramen, and gave off a medial and a canine branch after the bony prominence. In type II (33.3%, *n*=12), the medial branch arose from the lateral branch before reaching the bony prominence, and ran in the medial groove of the bony prominence. In type III (16.7%, *n*=6), the lateral branch gave off a canine branch immediately after passing through the greater palatine foramen. Finally, in type IV, which was the rarest of the four types (8.3%, *n*=3), the medial branch arose from the lateral branch before it reached the bony prominence, and ran together with the lateral branch in the lateral groove of the bony prominence (Fig. 2).

The main, lateral branch coursed tortuously and was the main supplier of blood to the hard palate. The canine branch spread out over the palatal gingiva adjacent to the canine and premolar teeth, and the medial branch spread out over the palatine glands and adipose tissue in the midpalatal suture region. In all except type III branching pattern, the tooth site from which the canine branch arose from the lateral branch was distributed similarly: 30% arose from around the first premolar, 33.3% from around the second premolar, and 36.7% from around the first molar.

The distances between the lateral branch of the GPA and the CEJ were 9.04±2.93 mm (canine), 11.12±1.89 mm (first premolar), 13.51±2.08 mm (second premolar), 13.76±2.86 mm (first molar), and 13.91±2.20 mm (second molar), decreasing sharply at the first premolar. However, for the canine the difference between the left and right sides of

approximately 1.5 mm was not statistically significantly, with having a relatively small *P* value (Table 1).

The shape of the palatal bony prominence was most commonly the spine type (66.3%, *n*=57), whereby it definitively divided the palatal groove through which the palatal neurovascular bundle passes into the medial and lateral grooves. For the bridge type (19.8%, *n*=17), the two crests of which were linked by bony or fibrous ligaments that covered the neurovascular bundle, there was no bony canal (Fig. 3). The smooth type occurred infrequently (13.9%, *n*=12) in this study. In addition, both the spine and bridge types frequently appeared 6.49±1.76 mm from the anterior margin of the greater palatine foramen at the second molar, with a length of 10.42±2.45 mm, mostly disappearing at the first molar (Table 2).

While the GPA and GPN-which make up the palatal neurovascular bundle and supply blood and sensation to the hard palate-had a similar course, the main trunks of this artery and nerve did not appear to run together. The lateral (main) branch of the GPA lay deeper than the GPN, the main trunk of which was located more medially and superficially closer to the oral mucosa than that of the GPA (Fig. 4). There was no correlation between the branching pattern of the GPA and the shape of the palatal bony prominence (r=0.060).

IV. DISCUSSION

The GPA is the main artery that passes through the greater palatine foramen in the hard palate and distributes its branches over the gingival tissue, the palatine glands, and the mucous membrane of the hard palate.[18] Accurate and safe administration of local anesthesia and periodontal surgery require estimation of the location and course of the GPA through easily identifiable and palpable structures, such as the molar teeth, the midpalatal suture, and the posterior border of the hard palate.[10,15,18]

The GPA and GPN together form the neurovascular bundle; Benninger et al[19] reported that the main trunk of the artery traverses the lateral palatal groove and the main trunk of the nerve traverses the medial palatal groove. However in the present study, the main trunks of the artery and nerve had different courses. The branches of the artery and nerve also appeared in other grooves in which the main trunk did not traverse, and the GPA was more deeply located (i.e., further from the oral mucosa) than the GPN.

While the GPA sends branches to all areas of the hard palate, they are more prevalent on the side of the alveolar process particularly in the premolar region, compared to the midpalatal suture.[18] The type I branching pattern was the most common in the present study, whereby the medial and canine branches arose after the bony prominence. In the case of the type III branching pattern, the canine branch was observed immediately passing through the greater palatine foramen. Although the canine branch is not the main trunk of the GPA, unexpected bleeding could occur on incision since it is located closer to the CEJ. For the type IV branching pattern, both the lateral and medial branches traversed in the lateral groove, more attention should therefore be paid to this type because the lateral branch is located closer to the CEJ than for the other types. Furthermore, an anastomosis has been observed between the

GPA and the ascending palatine artery at the posterior border of the hard palate.[20,21] Additional studies are thus needed to determine the topography of the branches of the GPA in the posterior region of the hard palate.

The GPA is 7~17 mm from the CEJ, depending on the palatal vault depth, and is located at 77% of the palatal height, and courses close to the CEJ from the canine distal.[8,19] However, according to the finding of a discrepancy between the estimated location of the greater palatine neurovascular bundle on models and the true location on the cadavers, the height in most of the participants tended to be underestimated by about 4 mm.[22] It is clear then that it is necessary to establish the average distance with respect to the course of the GPA. In the present study, the distance from the CEJ to lateral GPA branch was about 13 mm at the second molar, and decreased sharply to 11 mm at the first premolar. In addition, the canine branch arose from lateral branch at a right angle, near the premolar region. Therefore, when the height of donor tissue is determined in the recommended area, which is from the distal regions of canine to the midpalatal aspects of the first molar, the location of the GPA should be evaluated particularly carefully at the first premolar.

The palatal bony prominence, together with the greater palatine neurovascular bundle, has been studied with reference to anthropometry and dental prosthetics.[15,23,24] In the present study, the spine type prominence, which has a long and sharp shape, was similar to that described elsewhere as a ridge or crest, and was the most common type (66.3%).[15,23] This spine appears to exist regardless of the presence (or lack) of a tooth, and the clinician can usually palpate it because it forms the margins of the grooves at both sides.[8,19] The bridge type, which is characterized by a short, blunt, and distinct bony prominence, was found to be formed by incomplete canals linked by a fibrous band. The presence of bony or incomplete fibrous bridges may cause problems when infiltrating the GPN for local anesthesia.[15,16]

There was no correlation between the branching patterns of the GPA and the shape of the bony prominence. Thus, it was not possible to define the branching type of the GPA by palpation of the palatal bony prominence. However, the GPA could have a predictable course in the hard palate, because a palatal spine or bridge could be observed in most people between the second and first molars, anteroposteriorly, with a length of 10 mm. This is a helpful tip for surgery of the hard palate. Excessive palpation at the posterior region of the third molar may cause a gagging sensation in the soft palate, so care should be taken.[15]

In conclusion, the GPA was found to run in the lateral groove of the bony prominence and commonly to divide into a lateral, a medial, and a canine branch after passing the palatal spine. The lateral branch mostly spread out over the palatal gingiva adjacent to the teeth, and the medial branch mostly spread out over the palatine glands and adipose tissue. These anatomical findings could provide the clinician with reference data for periodontal surgery regarding the location and course of the GPA.

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VI. FIGURES

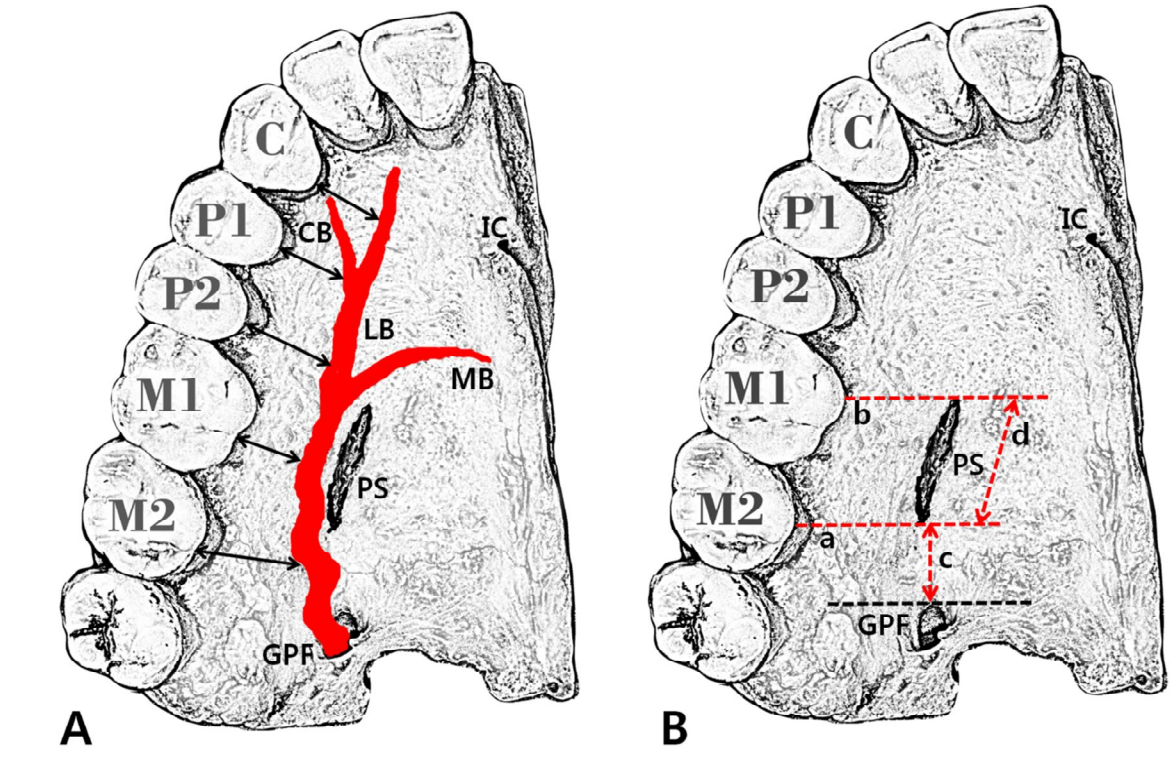

Fig. 1. Diagram showing the parameters of the greater palatine artery (GPA) and the palatal bony prominence that were measured. (A) Branches of the GPA and the various distances measured. The arrows indicate the distance between the lateral branch of the GPA from the cementoenamel junction. (B) Morphometric analysis of the bony prominences: a, start point of the bony prominence relative to the tooth site; b, end point of the bony prominence relative to the tooth site; c (arrow), distance from the anterior margin of the greater palatine foramen to the start point of the bony prominence; d (arrow), length of the bony prominence. CB, canine branch; GPF, greater palatine foramen; IC, incisive foramen; LB, lateral branch; MB, medial branch; PS, palatal spine; C, canine; P1, first premolar; P2, second premolar; M1, first molar; M2, second molar.

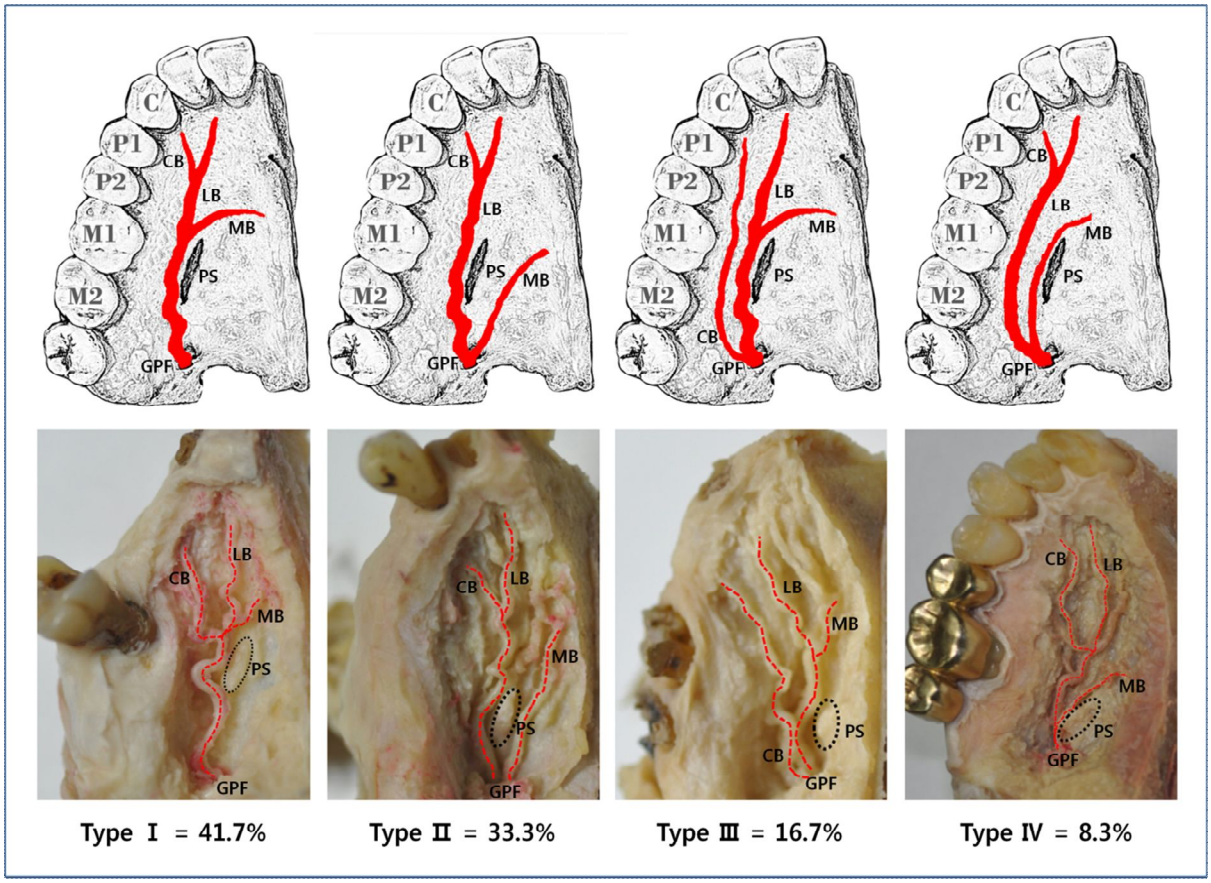

Fig. 2. Illustrations of the four branching patterns of the GPA. In type I, the lateral branch ran anteriorly in the lateral groove of the bony prominence from the greater palatine foramen, and then gave off a medial and a canine branch after the bony prominence. In type II, a medial branch was given off from the lateral branch before the bony prominence, and ran in the medial groove of the bony prominence. In type III, the lateral branch gave off a canine branch immediately after passing through the greater palatine foramen. In type IV, a medial branch, which arose from the lateral branch before the bony prominence, ran in the lateral groove of the bony prominence along with the lateral branch.

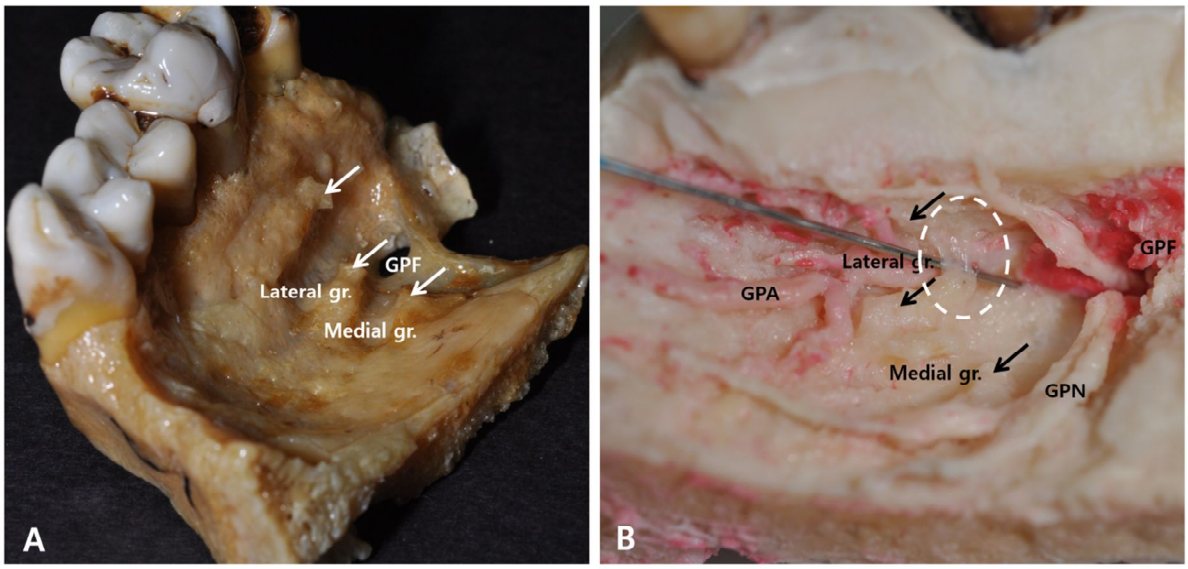

Fig. 3. Photographs showing the bridge-shaped bony prominence in the bony palate (A) and the dissected GPA (B). The solid arrows indicate the bridge. The dashed line encircles the fibrous ligament in the lateral groove of the bridge. The greater palatine nerve (GPN) was reflected bilaterally to reveal the fibrous ligament. gr., groove.

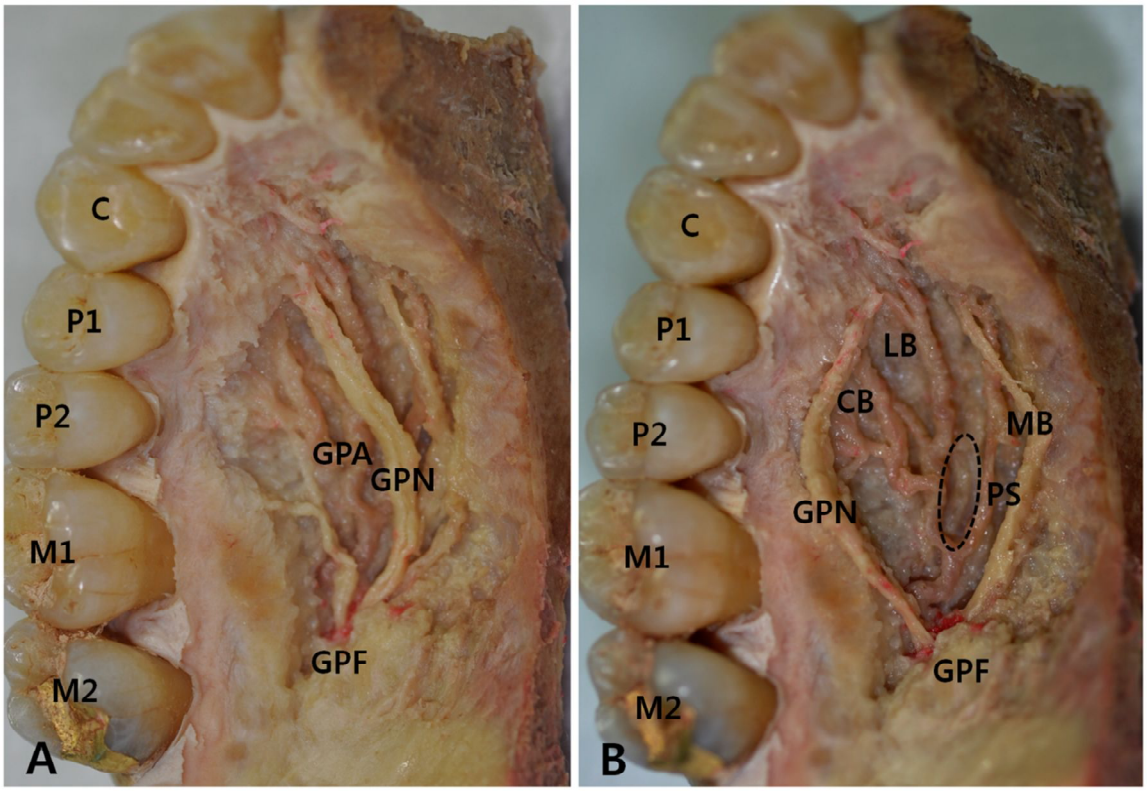

Fig. 4. (A, B) Photographs showing the GPA and GPN. In (B), the GPN was reflected bilaterally to reveal the GPA. The main trunk of the GPN was located more medial and superficial (closer to the oral mucosa) than the GPA.

VII. TABLES

Table 1. Distances between the lateral branch of the greater palatine artery and the cementoenamel junction at different tooth sites.

	Left	Right	Total	[a]*P*
C	9.82±3.11	8.31±2.63	9.04±2.93	0.156
P1	11.14±2.16	11.09±1.63	11.12±1.89	0.945
P2	13.79±2.36	13.24±1.82	13.51±2.08	0.485
M1	14.07±3.57	13.48±2.14	13.76±2.86	0.572
M2	13.63±2.54	14.14±1.93	13.91±2.20	0.547

Abbreviations: C, canine; P1, first premolar; P2, second premolar; M1, first molar; M2, second molar.

The data (in mm) are mean±SD values. [a], *P* values represent the difference between the right and left sides at each tooth site ($P<0.05$ is significant).

Table 2. Start and end points of the bony prominence relative to the greater palatine foramen at different tooth sites.

	M3	**M3-M2**	**M2**	**M2-M1**	**M1**	**M1-P2**	**P2**	**P2-P1**	**P1**
Start point	1 (1.7%)	2 (3.4%)	38 (64.4%)	11 (18.6%)	7 (11.9%)				
End point			2 (3.4%)	1 (1.7%)	22 (37.3%)	11 (18.6%)	14 (23.7%)	8 (13.6%)	1 (1.7%)

Data are *n* (%) values at each tooth site.