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Author(s)	Shiozaki, H; Abe, S; Tsumori, N; Shiozaki, K; Kaneko, Y; Ichinohe, T
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Macroscopic Anatomy of the Sphenomandibular Ligament Related to the Inferior Alveolar Nerve Block

Hideya Shiozaki, D.D.S., Ph.D.; Shinichi Abe, D.D.S., Ph.D.;
Nobuaki Tsumori, D.D.S.; Kazunari Shiozaki, D.D.S., Ph.D.;
Yuzuru Kaneko, D.D.S., Ph.D.; Tatsuya Ichinohe, D.D.S., Ph.D.

ABSTRACT: We performed macroscopic observations of the sphenomandibular ligaments, and measured the space that is surrounded by the mandibular ramus and the ligament by using computed tomography. The materials used in this study were 40 heads of 40 adult cadavers. The cadaver head was cut on the mid sagittal plane. The medial pterygoid muscles of the cadavers were removed to observe the ligaments. The attaching style of the sphenomandibular ligament to the mandibular ramus was classified into three types: Type I (5 in 40 samples; attached only to the mandibular lingula), Type II (12 in 40 samples; attached to the mandibular lingula and extended toward the rear part of the internal surface of the mandibular ramus), and Type III (23 in 40 samples; attached to the mandibular lingula and toward the posterior border of the mandibular ramus). There was no statistical difference in the length of the ligament among the three types. However, Type III showed the largest width, and the space was approximately eight and three times as large as those of Type I and II, respectively. This indicated that the Type III ligament covered a larger area over the mandibular foramen than Type I. These results suggest that the three-dimensional morphology of the sphenomandibular ligament, as represented by Type III, may affect the effectiveness of anesthesia.

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Address for correspondence:
Dr. Hideya Shiozaki
Dept. of Dental Anesthesiology
Tokyo Dental College
1-2-2 Masago, Mihama-ku,
Chiba 261-8502
Japan
E-mail: hshio@tdc.ac.jp

Dr. Hideya Shiozaki *received his D.D.S. degree from Tokyo Dental College in 2002. He graduated from post-doctoral school in 2006. At present, he is a staff member in the Dental and Oral Surgery Section of the Tochigi National Hospital.*

The use of nerve block is widely applied in the field of dentistry. A nerve block at the mandibular foramen is the most frequently used procedure. In the current procedure, it is proposed that the injection needle should be as close to the inferior alveolar nerve as possible.[1] Usually, it is generally recommended to fill the pterygomandibular space with a sufficient volume of local anesthetics for efficient delivery and effectiveness,[2,3] because this procedure is a kind of infiltration anesthesia into the space. This technique can prevent nerve injury. However, in some cases, it is difficult to attain sufficient effectiveness, even if enough volume of anesthetics is injected into the pterygomandibular space.[4-6]

The pterygomandibular space consists of connective tissue that includes the inferior alveolar nerve, artery, and vein. The volume and morphology of the pterygomandibular space were studied using computed tomography.[7] The results suggested that the anesthetic effect of a nerve block at the mandibular foramen depended on the position of the injection needle. The diffusion dynamics

of injected anesthetics were reported in another study, concluding that local anesthetics rapidly diffuse into the pterygomandibular space.[8]

There are three ligaments around the temporomandibular joint (TMJ): the main lateral ligament, and the sphenomandibular ligament and the stylomandibular ligament as accessory ligaments. Among these ligaments, the sphenomandibular ligament goes inside the pterygomandibular space. The upper attachment of the sphenomandibular ligament is localized in the sphenoid spine alone or extends to the petrotympanic fissure and malleus. The lower attachment of the ligament is localized on the mandibular lingula. Therefore, the sphenomandibular ligament may be a septum of the pterygomandibular space. This means that the sphenomandibular ligament might prevent local anesthetic diffusion injected into the pterygomandibular space.

Several reports provided information about the origin of the sphenomandibular ligament and ligament structure.[11-14] However, few reports[15] described the attaching style of the sphenomandibular ligament to the mandible. Therefore, in this study, the sphenomandibular ligament and its attaching style to the mandible was observed. In addition, a morphometrical analysis was done that included the length and width of the ligament and the capacity that is surrounded by the mandible ramus and the ligament, based on a 3-dimensional image reconstructed using computed tomography. The effect of the morphology of the sphenomandibular ligament on a successful nerve block is discussed.

Materials and Methods

The materials used in this study were 40 heads of 40 adult Japanese cadavers (25 males, 15 females), provided for anatomical practice to the Department of Anatomy, Tokyo Dental College. The age of the cadavers ranged from 53 to 87 years (mean age 72 years). The cadavers had been preserved in 10% formaldehyde.

Attaching style of the sphenomandibular ligament: The cadaver head was cut on the mid-sagittal plane. To observe the attaching style of the lower part of the sphenomandibular ligament macroscopically, the medial pterygoid muscle was removed. Attaching style was observed in the mouth closed position. Attaching style of the lower part of the sphenomandibular ligament was classified into three types. In Type I (**Figure 1**), the sphenomandibular ligament attached only to the mandibular lingula and is not attached to the mylohyoid groove. In Type II (**Figure 2**), the sphenomandibular ligament covered the mylohyoid groove and attached to the rear part of the internal surface of the mandibular ramus. In Type III

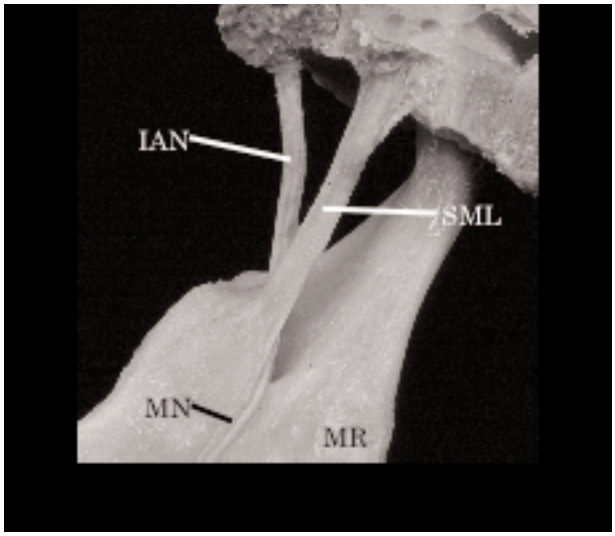

Figure 1
Sphenomandibular ligament of Type I. Sphenomandibular ligament (**SML**); inferior alveolar nerve (**IAN**); mandibular ramus (**MR**); mylohyoid nerve (**MN**).

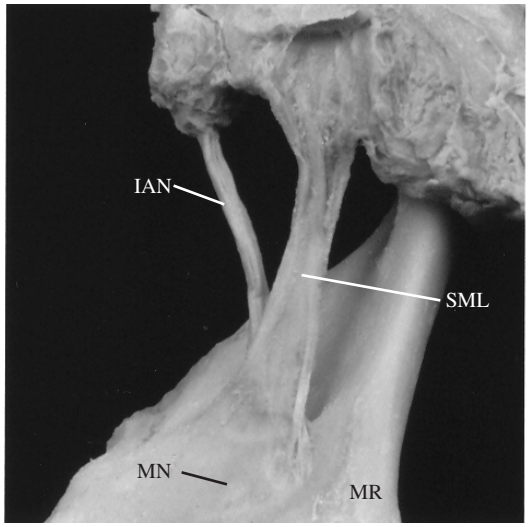

Figure 2
Sphenomandibular ligament of Type II. Sphenomandibular ligament (**SML**); inferior alveolar nerve (**IAN**); mandibular ramus (**MR**); mylohyoid nerve (**MN**).

(**Figure 3**), the sphenomandibular ligament covered a wide range from the mandibular lingula to the posterior border of the mandibular ramus.

Morphometrical analysis of the sphenomandibular ligament: The distance between the tip of the sphenoid spine and the tip of the mandibular lingula was defined as the length of the sphenomandibular ligament. To measure the width of the ligament, three points (**Figure 4**, points 1, 2, and 3) at 1/4, 1/2 and 3/4 of the length from the sphenoid spine were defined. Then, the length of a line crossing

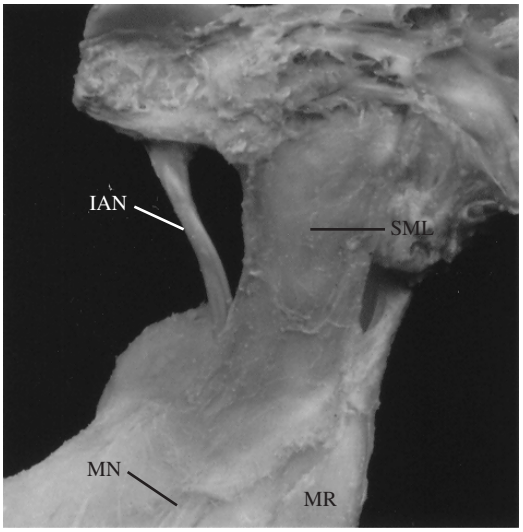

Figure 3
Sphenomandibular ligament of Type III. Sphenomandibular ligament (**SML**); inferior alveolar nerve (**IAN**); mandibular ramus (**MR**); mylohyoid nerve (**MN**).

perpendicular to each point was measured as the width of the ligament at each point. A putative line was set parallel to the occlusal plane and measured two distances from the inner oblique line to the anterior border of the ligament at the level of the center of the mandibular foramen and one cm superior to that point (**Figure 5**, points 4 and 5). Finally, at the position of one cm superior to the center of the mandibular foramen, the distance between the ligament and the internal surface of the mandibular ramus in the frontal plane was measured (**Figure 6**, point 6).

Space surrounded by the mandibular ramus and the sphenomandibular ligament: In nine specimens (three

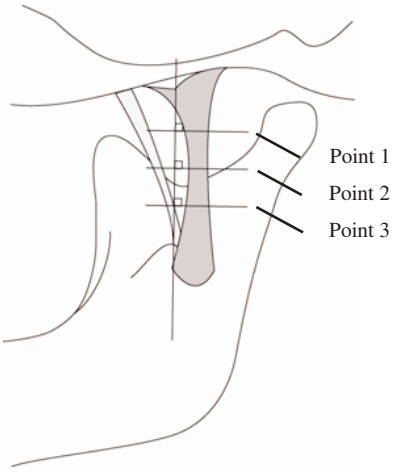

Figure 4
Total length and width of the ligament.

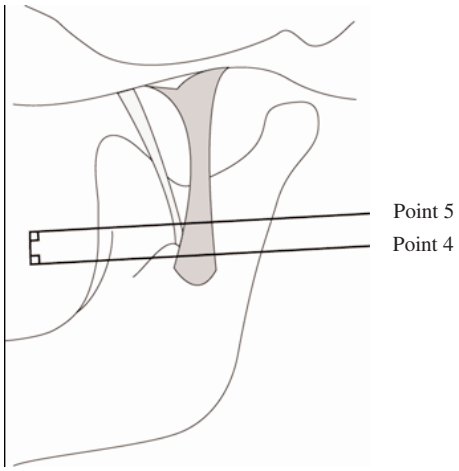

Figure 5
Distance from inner oblique line to anterior border of the ligament.

specimens in each group), the space that surrounded the mandibular ramus and the sphenomandibular ligament was analyzed based upon the 3-dimensional image reconstructed using computed tomography. The space was calculated using 3-dimensional reconstitution software, TRI/3D surface (RATOC System Engineering Co., Ltd., Tokyo, Japan) The upper part of the region was defined as the plane parallel with the occlusal plane and crossing the lowest point of the mandibular notch. The lower part of the region was defined as the plane parallel with an attachment border of the mandibular ramus and the ligament. The anterior plane was defined as the plane perpendicular to the mandibular ramus including the frontal border of the ligament. The posterior plane was defined as the plane perpendicular to the mandibular ramus including the posterior border of the ligament.

*Statistical Data***:** Metrical data were shown as mean value ± standard deviation. The Kruskal-Wallis-H-test was used for calculated data set of Type I, Type II, and Type III. Multiple comparisons were tested using the Mann-Whitney U-test with Bonferroni correction. A p value less than 0.05 was considered as significant.

Results

Attaching style of the sphenomandibular ligament: **Table 1** indicates the frequency of the attaching style. Nearly 60% of the total cases were classified as Type III. In Type I, the ligament fiber had a width from the anterior border of the mandibular lingula to the anterior border of the mylohyoid groove. This means that the ligament fiber covered the whole area of the mandibular lingula in Type I. In contrast, in Type III, ligament fiber had a width from

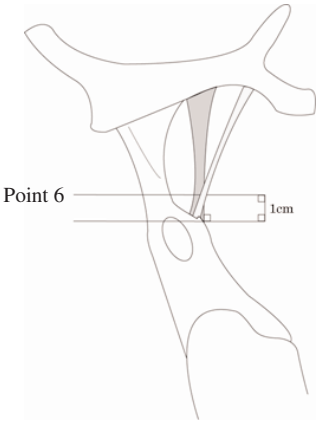

Figure 6
Distance between the ligament and the internal surface of the mandibular ramus.

Table 1
Attaching Style of the Ligament to the Mandible (n=40)

Ligament type	Type number
Type I	5 (12.5%)
Type II	12 (30.0%)
Type III	23 (57.5%)

the anterior border of the mandibular lingula to the posterior border of the mandibular ramus. At the posterior border of the mandibular ramus, the maxillary artery and vein penetrated through the ligament in Type III.

Morphometrical analysis of the sphenomandibular ligament: The lengths of the ligaments in each group were about 33-34 mm. There was no significant difference among the three groups. The widths of the ligaments were 3-6 mm in Type I, 8-10 mm in Type II and 11-14 mm in Type III. These results showed that the widths of the ligaments became larger in order of Type I, Type II and Type III (**Tables 2**, **3**, and **4**). The distances from the inner oblique line to the anterior border of the ligament at the level of the center of the mandibular foramen were 11.4±3.5 mm in Type I, 18.0±8.7mm in Type II and 18.8±9.4 mm in Type III (**Table 5**). The distances at the level of one cm superior to the center of the mandibular foramen were 14.8±5.3 mm in Type I, 21.4±6.8 mm in Type II and 22.8±6.7 mm in Type III. The distances of the ligaments from the internal surface of the mandibular ramus in the frontal plane were 6.2±1.7 mm in Type I, 7.9±1.8 mm in Type II and 8.5±2.7 mm in Type III. There was no significant difference in each measured value of Type I, Type II, and Type III, though values in Type I were slightly smaller than those in Types II and III.

Table 2
Width of the Ligament at Point 1

Ligament type	n	Mean	SD		
Type I	5	6.28 mm	2.24	*	
Type II	12	10.33 mm	2.86	*	*
Type III	23	13.28 mm	2.32		

*p<0.05

Table 3
Width of the Ligament at Point 2

Ligament type	n	Mean	SD		
Type I	5	3.32 mm	0.36	*	
Type II	12	7.83 mm	2.29	*	*
Type III	23	11.23 mm	2.38		

*p<0.05

Table 4
Width of the Ligament at Point 3

Ligament type	n	Mean	SD		
Type I	5	4.64 mm	1.11	*	
Type II	12	9.92 mm	2.02	*	*
Type III	23	13.54 mm	2.60		

*p<0.05

Table 5
Distance from the Inner Oblique Line to Anterior Border of the Ligament in the Center of the Mandibular Foramen (Point 4)

Ligament type	n	Mean	SD
Type I	5	11.4 mm	3.5
Type II	12	18.0 mm	8.8
Type III	23	18.8 mm	9.4

The space surrounded by the mandibular ramus and the sphenomandibular ligament: The measurement values of all specimens in all three types are shown in **Table 6**. The averages in Type I, Types II and III were 73.3±20.4 mm^3, 207.1±66.6 mm^3, and 544.3±71.4 mm^3, respectively. The widths of Types II and III were about eight and three times higher than that of Type I, respectively.

Discussion

The pterygomandibular space is surrounded by the mandible, the medial pterygoid muscle, the glandula parotis, and the lateral pterygoid muscle. The space consists of connective tissue including an adipose tissue, artery and vein. The sphenomandibular ligament, the lingual nerve, and the inferior alveolar nerve go inside the pterygomandibular space.

In this study, the attaching style of the sphenomandibular ligament to the mandibular ramus was classified into three types. These three types showed a significant difference in the attaching area of the mandible. As a result, the space that is surrounded by the mandibular ramus and the sphenomandibular ligament was largest in Type III. The sphenomandibular ligament in Type III was like a wide septum in the pterygomandibular space. The fact that nearly 60% of the total cases were classified into Type III means that the sphenomandibular ligament may become a barrier against the local anesthetic diffusion in more than half of the patients undergoing a nerve block at the mandibular foramen. In these patients, anesthetic effects may not be expected, if the tip of the injection needle was located medially or inferiorly to the ligament as previously reported by Garg.[15] In contrast, anesthetic effects may be sufficiently expected, if the tip of the injection needle was located laterally to the ligament, because a local anesthestic solution injected into this area is easily trapped and stagnated in the space surrounded by the mandibular ramus and the sphenomandibular ligament. It is reported that a mixture of lidocaine and contrast media hardly infiltrate through fibrous connective tissue such as fascia.[8] This finding supports the fact that ligament tissue may also be a barrier of local anesthetic infiltration, especially in large widths such as Type III.

Table 6
The Space Surrounded by the Mandibular Ramus and the Sphenomandibular Ligament

Ligament type	n	Capacity (mm)		
Type I	3	53.4	72.3	94.1
Type II	3	176.0	161.9	283.6
Type III	3	462.0	580.3	590.5

Therefore, in clinical consideration, it is suggested that 3-dimensional relationships between the sphenomandibular ligament and the position of the injection needle become a critical factor for the success of anesthesia. Several reports described the effective position and the effective depth of the injection needle.[16,19,20] In general, it is recommended that the tip of the injection needle be positioned at one cm superior to the mandibular foramen.[18] This recommendation agrees with the findings that the sphenomandibular ligament may become a barrier against local anesthetic diffusion when it is injected below the ligament.

The distances from the inner oblique line to the anterior border of the sphenomandibular ligament at the level of one cm superior to the mandibular foramen were about 17 mm and 21 mm in average. These values are comparable with previous reports.[16,17] However, there was wide variety in these distances. Therefore, the depth of the injection needle should be deliberately decided. The fact that the mandibular foramen is positioned almost at the center of the mandibular ramus would help to predict the depth. Additionally, it seems quite important to position the tip of the injection needle close to the internal surface of the mandibular ramus to prevent local anesthetic injection medially to the sphenomandibular ligament.

In a clinical situation, injury of the inferior alveolar and the lingual nerves should be avoided during the nerve block at the mandibular foramen. Injury of the lingual

nerve is 3.5 times more common than that of the inferior alveolar nerve.[21] Therefore, the pathway of the lingual nerve is of importance for a safe nerve block at the mandibular foramen. This study did not investigate the pathway of the lingual nerve, therefore, it will be the next topic of a study to analyze the pathway of the lingual nerve in the pterygomandibular space.

Conclusion

The attaching style of the sphenomandibular ligament to the mandibular ramus was classified into three types. Nearly 60% of the total cases fell into Type III classification. It is suggested that the sphenomandibular ligament may become a barrier against the local anesthetic diffusion during a nerve block at the mandibular foramen.

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Dr. Shinichi Abe *received his D.D.S. degree from Tokyo Dental College in 1989. He graduated from post-doctoral school in 1993. Currently, he is an assistant professor in the Department of Anatomy at Tokyo Dental College.*

Dr. Nobuaki Tsumori *received his D.D.S. degree from Tokyo Dental College in 2003. Currently, he is studying anatomy under Professor Ide at Tokyo Dental College.*

Dr. Kazunari Shiozaki *received his D.D.S. degree from Tokyo Dental College in 1993. He graduated from post-doctoral school in 2001. Currently, he is an instructor in the Department of Oral Anatomy I at Tsurumi University School of Dental Medicine.*

Dr. Yuzuru Kaneko *received his D.D.S. degree from Tokyo Dental College in 1964. He graudated from post-doctoral school in 1968. Currently, Dr. Kaneko is a professor in the Department of Dental Anesthesiology at Tokyo Dental College.*

Dr. Tatsuya Ichinohe *received his D.D.S. degree from Tokyo Dental College in 1981. He graduated from post-doctoral school in 1985. Currently, Dr. Ichinohe is a professor in the Department of Dental Anesthesiology at Tokyo Dental College.*