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Trajectory of the Hypoglossal Nerve in the Hypoglossal Canal: Significance for the Transcondylar Approach

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Abstract

A microanatomical study of the hypoglossal canal and its surrounding area was carried out using dry skulls and cadaveric heads to determine the course of the hypoglossal nerve in the hypoglossal canal, especially the significance for the transcondylar approach. The hypoglossal nerve enters the superomedial part of the hypoglossal canal as two bundles, which then change course abruptly to an anterosuperior direction, and unite as one trunk before exiting the canal. The hypoglossal nerve has an oblique course in the canal rather than being located in the center, and exits through the inferolateral part of the canal. A venous plexus surrounds the entire length of the nerve bundles in the canal. The present results suggest that during drilling the occipital condyle toward the hypoglossal canal from behind, the surgeon does not need to be overly concerned even if some bleeding occurs from the posterolateral edge of the hypoglossal canal.

Key words: foramen magnum, hypoglossal canal, hypoglossal nerve, occipital condyle, transcondylar approach

Introduction

Lateral approaches to the foramen magnum are now frequently used to treat anteriorly located lesions at the craniocervical junction.[5,6,8,11,12,16,19-21] This type of approach provides a wider operating field for this region without the broad retraction of the neural structures required by previous approaches. Several microanatomical studies have been reported on these approaches.[1,2,7,9,11-15,22] The key points include drilling of the occipital condyle, the lateral mass of C-1, and/or extradural drilling of the jugular tubercle.[1,11-13,16] The transcondylar approach requires drilling of the occipital condyle posteriorly and threatens opening of the hypoglossal canal. However, the trajectory of the hypoglossal nerve in the hypoglossal canal is not well known.

The present microanatomical study was carried out to determine what steps are necessary to safely drill around the hypoglossal canal.

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Materials and Methods

Nine adult cadaveric heads from U.S. sources fixed by formalin (11 sides) and 16 dry human skulls from Indian sources (30 sides) were used in this study. The arteries and veins of the cadaveric heads were perfused with colored silicone and examined under the surgical microscope. The condyles of the wet specimens were either cut by an autopsy saw or drilled by a high-speed air drill.

Results

I. Dry skulls

The hypoglossal canal was surrounded by the jugular tubercle superiorly, the jugular foramen superolaterally, the sigmoid sinus laterally, and the occipital condyle inferiorly, with the axis at about 45 degrees in the horizontal plane and directed slightly upward.

The inner orifice was usually oval or seashell-shaped, with the longer diameter directed in an anterosupero-posteroinferior orientation. Two of the

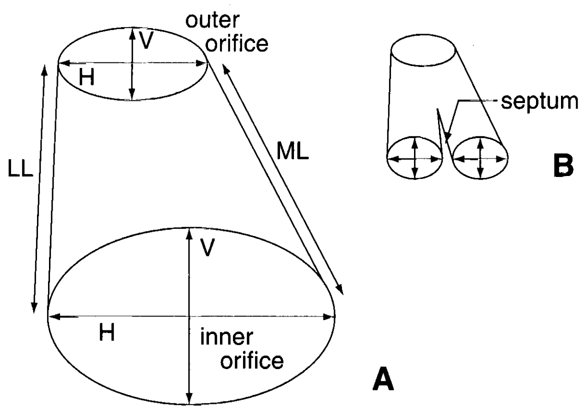

Fig. 1 Drawing showing the left hypoglossal canal observed from behind. Measurements are made as shown in A. H: horizontal diameter, LL: lateral length, ML: medial length, V: vertical diameter. If the inner orifice was divided by a bony septum, measurements were made as shown in B.

16 dry skulls (three of 30 sides, 10%) showed the hypoglossal canals separated by a bony septum at the inner orifice, unilaterally in one specimen and bilaterally in another. More commonly, a bony notch was observed either in the ceiling or on the floor of the hypoglossal canal, or in some cases both. The outer orifice was round or oval-shaped, with the slightly longer diameter in a mediosupero-lateroinferior orientation.

The canals were completely surrounded by the cortical bone in most cases. However, some canals communicated either with the posterior condylar canal or rarely with small bony crypts, which we suspect transmit small emissary veins of the occipital condyle.

The hypoglossal canals of dry specimens were measured as shown in Fig. 1. The length of the hypoglossal canal and the diameter of its inner and outer orifices are shown in Table 1.

II. Wet specimens

After emerging at the pre-olivary sulcus, the roots of the hypoglossal nerve came together to form two groups in the premedullary cistern. The upper and the lower groups ran in the cistern laterocaudally and laterally, respectively, continuing behind the vertebral artery. As the two groups of the roots focused on the dura covering the inner orifice of the hypoglossal canal individually, the upper focus was supero-medio-anterior to the lower one.

The two bundles of the nerve, the meningeal branch of the ascending pharyngeal artery, and the surrounding venous plexus were observed in the hypoglossal canal. After piercing the dura, the two bundles changed course abruptly to an anterosuperior direction, and continued straight until merging just before exiting the canal. The venous plexus in the hypoglossal canal (anterior condylar

Table 1 Measurements of 30 hypoglossal canals

Septum (−) (n = 27; L: 14, R: 13)

	Length (mm)		Diameter (mm)			
			Inner orifice		Outer orifice	
	Lateral	Medial	Horizontal	Vertical	Horizontal	Vertical
Mean	10.6	7.3	7.1	4.2	5.9	4.4
SD	1.5	1.3	1.1	0.7	0.9	0.8
Maximum	13.0	10.0	9.5	6.0	7.5	6.0
Minimum	8.0	5.5	5.0	3.0	3.5	2.5

Septem (+) (n = 3; L: 1, R: 2)

	Length (mm)		Diameter (mm)					
			Inner orifice, medial		Inner orifice, lateral		Outer orifice	
	Lateral	Medial	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Mean	11.2	9.2	4.7	5.5	2.3	2.3	6.8	6.3
SD	1.0	1.8	0.6	0.5	0.3	0.3	0.3	0.8
Maximum	12.0	1.0	5.0	6.0	2.5	2.5	7.0	7.0
Minimum	10.0	7.5	4.0	5.0	2.0	2.0	6.5	5.5

L: left hypoglossal canal, R: right hypoglossal canal.

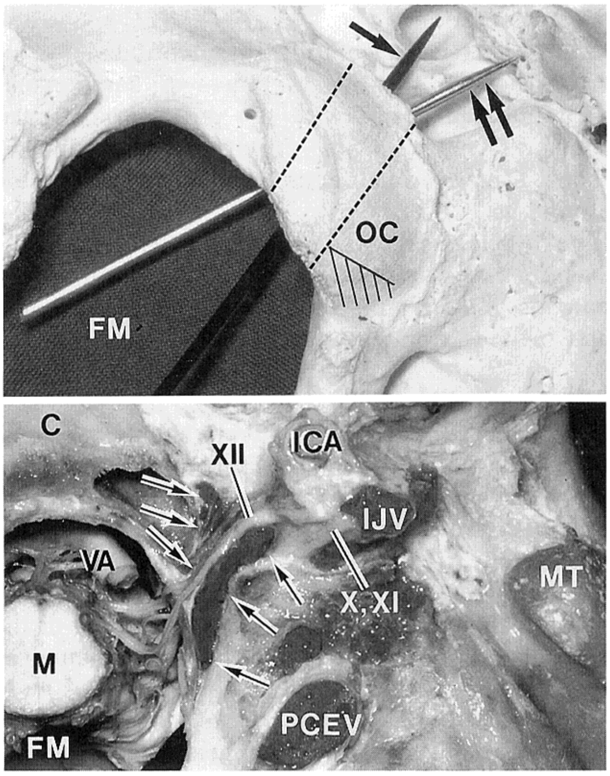

Fig. 2 ***upper*: Inferior view of the left occipital condyle. Two needles are inserted into the hypoglossal canal. The black needle represents the axis of the hypoglossal canal (*arrow*), and the silver needle shows the trajectory of the hypoglossal nerve (*double arrow*). The *broken lines* indicate the hypoglossal canal. The *shaded area* represents the extent of bone drilling in the transcondylar approach. *lower*: Horizontal section of the left hypoglossal canal viewed from below showing the oblique trajectory of the hypoglossal nerve (XII) in the hypoglossal canal. Soon after leaving the hypoglossal canal, the hypoglossal nerve enters the carotid sheath and runs behind the vagus nerve (X). *Arrows* indicate the contour of the hypoglossal canal. C: clivus, FM: foramen magnum, ICA: internal carotid artery, IJV: internal jugular vein, M: medulla, MT: mastoid tip, OC: occipital condyle, PCEV: posterior condylar emissary vein, VA: vertebral artery, XI: accessory nerve.**

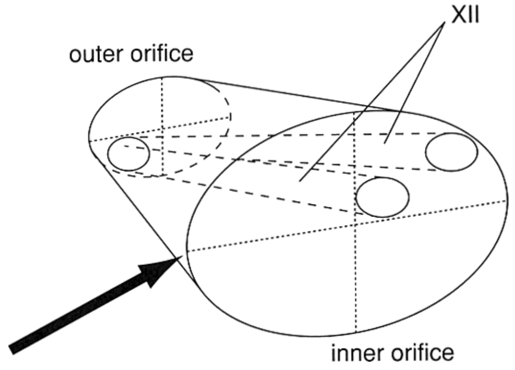

Fig. 3 **Drawing showing the three-dimensional trajectory of the hypoglossal nerve (XII) in the left hypoglossal canal. The nerve roots gather together to form two bundles at the superomedial quadrant of the inner orifice of the canal. Each bundle follows a diagonal course until they unite just before exiting the outer orifice of the canal. After exiting, the hypoglossal nerve descends vertically as a nerve trunk. The *arrow* indicates the direction of drilling of the occipital condyle in the transcondylar approach.**

vein) surrounded the two bundles of the hypoglossal nerve over the whole length of the canal. However, the nerve bundles were located superomedially as they entered the inner orifice of the hypoglossal canal, and inferolaterally as they exited the outer orifice, running obliquely rather than in the center of the venous plexus (Fig. 2).

One cadaveric head showed the hypoglossal canal with a bony septum at its inner orifice, separating the two bundles of the hypoglossal nerve. However, the specimen conformed with the above findings. Figure 3 shows the three-dimensional image of the trajectory of the hypoglossal nerve in the hypoglossal canal.

Discussion

Previous studies have reported larger dimensions for the hypoglossal canal than found in our study.[4,10] The differences can be attributed to differences in size or race of the specimens used. The skulls used in our study were obviously smaller than the Caucasian specimens used by other authors, supported by the fact that our wet specimens obtained from U.S. sources had larger dimensions than our dry skulls.

The division of the hypoglossal canal was established in 300 skulls.[3] The hypoglossal canal is completely separated by a bony septum along its whole length in 1–3% of cases, has a septum at either inner or outer orifice in 15–20%, has one or two notches (trace of division) in 35%, and is a simple canal in 45%. Our observations of wet specimens indicate that the notch or septum develops either between the two bundles of the hypoglossal nerve or along the dural septum of the venous plexus.

The course of the hypoglossal nerve in the hypoglossal canal and the significance for surgery were not clarified before.[17,18] The topographical relationship between the hypoglossal nerve and the area of bone drilling required in the transcondylar approach is shown in Fig. 2. Since both branches of the hypoglossal nerve are located in the superomedial portion of the entrance of the hypoglossal canal, the posterolateral bony wall of the hypoglossal canal can be drilled off without damaging the nerve either mechanically or by heat. The surgeon does not need to be overly concerned even if some bleeding occurs from the posterolateral edge of the hypoglossal canal. However, care should be taken not to injure the hypoglossal nerve by packing hemostatic materials too tightly.

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Commentary

The authors should be commended for a good piece of anatomical work on nerve XII in the hypoglossal canal on 30 specimens. The location, orientation, as well as the inner and outer orifices of the hypoglossal canal are well presented. The finding of septum in the canal, dividing it into two separate canals, is important. The positioning of the fascicles of nerve XII at the entry point into the canal, the coursing of nerve XII through the canal, as well as converging of the fascicles into one single nerve toward the periphery of the canal, is a practical and meaningful piece of information for the surgeon. Important, too, is the information on the other two structures: the meningeal branch of the ascending pharyngeal artery and the surrounding venous plexus, located in the hypoglossal canal. For the surgeon dealing with the pathologies at the foramen magnum region necessitating the far lateral approach and resection of the occipital condyle, the actual measurements of the occipital condyle mass which could be safely resected would be very welcome too. In my personal opinion, I prefer to offer a warning rather than to stimulate surgeons to drill off the occipital condyle without showing much concern about the possible opening of the hypoglossal canal. The authors, however, have pointed out that putting too much hemostatic material too tightly into the open hypoglossal canal might be dangerous for nerve XII. Apart from the above remarks, by reading this paper the surgeon gets the important message that one should anticipate the positioning of the hypoglossal canal while drilling off the occipital condyle. To know exactly the location of the hypoglossal canal is not only necessary in obtaining more space at the approach to the intradural pathologies at the region, but is also important when operating tumorous lesions extending into the hypoglossal canal. In such cases, opening of the hypoglossal canal and dissecting the two bundles of nerve XII, and then following them retrogradely into the intradural space, could be of great help in identifying all the fascicles of nerve XII intradurally, where they might be displaced, stretched or encased in the tumorous lesion.

This anatomical work — well designed, conducted and described — offers very useful and practical information to the reader.

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This paper provides a concise description of the contents of the hypoglossal canal and its course. The surgeon working in this region must understand this well and also the surrounding relations of the hypoglossal canal. It is important to remember the depth and direction at which the surgeon will encounter the canal when drilling the condyle from laterally. It courses through the middle of the condyle. The direction of the canal is such that its contents appear to be traveling laterally and superiorly from its intracranial to extracranial opening. This is different from the course of the nerves in the jugular foramen, which travel laterally and inferiorly. In the case of intradural lesions, only a small amount of the condyle is drilled from posterolaterally. This almost never results in entry into the canal. In the case of extradural tumors which invade the condyle, the entire condyle may be drilled away, putting the nerve at risk within the canal as well as in the cistern. Venous bleeding may be the first hint that the canal is being entered and must be carefully controlled while avoiding compression of the nerve, as the authors have pointed out. This is an important report providing the surgeon with useful information regarding the hypoglossal canal.

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