The Tough Fibrous Tissue of The Supracondylar Groove As A Useful Landmark Via The Endoscopic Endonasal Approach To The Lower Clivus

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Research

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Abstract

Background: The hypoglossal canal (HGC) is the most important structural landmark for the endoscopic endonasal approach to access the lower clivus (LC). We explored the feasibility of using the tough fibrous tissue covering the supracondylar groove (SCG) as a useful landmark to identify the location of the HGC.

Methods: Four cadaveric specimens were dissected and analyzed. The craniovertebral junction (CVJ) region was accessed utilizing 4-mm endoscope with either 0° or 30° lenses. CVJ exposure and the surgical corridor areas were measured. The relationship between the tough fibrous tissue covering the SCG and the HGC was analyzed.

Results: Tough fibrous connective tissue was tightly attached the SCG and ran superomedially to inferolaterally. The angle between the horizontal plane and the long axis of the SCG was 30°. Separating the tough tissue inferolaterally, we could locate the external orifice (EO) of the HGC to further accurately isolate the hypoglossal nerve.

Conclusion: The tough fibrous connective tissue covered the SCG to the upper part of the HGC EO. The course of the tough fibrous connective tissue was superomedial to inferolateral. Using the tough fibrous connective tissue covering the SCG as a landmark, it was possible to accurately locate the HGC EO via the endoscopic endonasal approach to access the LC.

Background

Conventional surgery of the craniovertebral junction (CVJ) region is particularly challenging and often results in considerable morbidity and mortality because the CVJ is located closely to critical neurovascular structures and the brainstem [1, 2]. Hence, endoscopic approaches continue to gain popularity and acceptance as additions to the neurosurgical armamentarium [3, 4]. Cadaveric studies and several clinical studies [5–9] investigating the endoscopic endonasal approach to the CVJ region have noted that a thorough comprehension of the CVJ anatomy is necessary for neurosurgeons when a lesion involves the hypoglossal canal (HGC) or the anterior part of occipital condyle; as identification and constant awareness of the hypoglossal nerve (HGN) is key. Sreenath et al. [10] described the Eustachian tube as a landmark for dissection, while Morera et al. [11] described the supracondylar groove (SCG) as a reliable anatomical landmark to estimate the position of the external orifice (EO) of the HGC. Due to the presence of a tough mucosal flap and a muscle layer covering the HGC EO, we found that it is still difficult to accurately estimate the location of the HGC, even when referencing these landmarks. Therefore, the aim of this study was to explore the feasibility of using the tough fibrous tissue covering the SCG as a useful landmark for identification and location of the HGC EO and HGN. In addition, some quantitative measurements are reported.

Methods

All anatomical dissections were performed at the Skull Base Laboratory and Minimally Invasive Neurosurgery Laboratory. Four embalmed human cadaveric heads were studied and measured. Microscopic anatomical dissections were performed under optical magnification at $\times 3-40$ using a surgical microscope (Global Instruments, Inc., Trenton, MO, USA). Endonasal anatomical dissections were performed using a Hopkins II endoscope (rod-lens, 0° and 30° ; diameter, 4-mm; length, 18-cm; KARL STORZ GmbH & Co. KG, Tuttlingen, Germany) attached to a high-definition camera and projected onto a monitor. All collected data were digitally recorded and stored in a Gefen workstation (Core Brands, Petaluma, CA, USA).

Results

Exposure of the lower clivus (LC) was consistent with that of the standard endoscopic endonasal approach as reported in previous studies [10, 11]. The mucosal and muscular layers of the posterior wall of the nasopharynx were removed to expose the LC, pharyngeal tubercle, foramen magnum, and C1 vertebrae (Fig. 1A). During resection of the mucosal and muscular layers of the nasopharynx, it was easy to access the entire posterior wall, with the exception of the bilateral SCG, which was tightly attached to tough fibrous connective tissue that was difficult to resect, even with the use of bone rongeur forceps and a suction microdebrider (Stryker Corporation, Kalamazoo, MI, USA) (Fig. 1B). A tough fibrous connective tissue covering the SCG was noted in all four of the human cadaveric heads (Fig. 1A, B). After drilling the LC bone, it was still difficult to resect the tough fibrous connective tissue covering the SCG (Fig. 1C). After drilling the SCG bone to the HGC, the tough fibrous connective tissue remained. Due to its tight adhesion with the SCG, the tough fibrous connective tissue was immobile. Therefore, we believed that the tough fibrous connective tissue covering the SCG could serve as a landmark to judge the intraoperative location of the atlanto-occipital joint and HGN under an endoscope (Fig. 1D).

We first observed the relationship of the SCG to the HGC, which is directed backward and medially at a 45° angle to the sagittal plane. The HGC EO is located immediately above the junction of the anterior and middle third of the occipital condyle and laterally to the jugular foramen. The SCG has a horseshoe-shaped outline with an oblique notch downward and inferolaterally pointing to the upper part of the HGC EO. That is to say, the inferior lateral margin of the SCG marks the midpoint of the HGC EO. Additionally, the course of the SCG tough fibrous connective tissue was superomedial to inferolateral. The angle between the horizontal plane and the long axis of the SCG was approximately 30° (Fig. 1B and 2A). The SCG horseshoe-shaped curved notch was at the same level as the upper part of the HGC EO; by drilling the SCG bone, it was possible to arrive at the anterior rim of the occipital condyle (Fig. 2B). The distance from the HGN to the superior rim of the SCG was 9 mm and that from the HGN to the anterior rim of the occipital condyle was 4 mm: note that the latter is about half that of the former.

When performing an endoscopic endonasal approach to the LC, the SCG was used as an anatomic landmark to estimate the position of the HGC EO, which is covered by a tough mucosal flap and a thick solid muscle layer, which renders it difficult to accurately estimate the location of the HGC. The direction of the SCG tough fibrous connective tissue was superomedial to inferolateral, which was useful to

estimate the location of the HGC. By separating the tough tissue inferolaterally, the position of the upper part of HGC EO was accurately estimated (Fig. 3C). Even when the SCG bone was drilled, the remaining SCG tough fibrous connective tissue could still be used as a landmark (Fig. 1D and 3C).

The HGN lies medial to cervical nerves (CNs) IX, X, and XI, which exit the skull via the jugular foramen. CN XII moves laterally and downward to lie next to the occipital condyle and the lateral mass of the C1 vertebrae and the atlanto-occipital joint. Care must be taken when drilling the HGC, occipital condyle, and the lateral mass of C1 (Fig. 3D). The distance from the medial margin of the internal carotid artery (ICA) to the midline was 18.3 mm; while that from the superior ganglion of the vagus nerve and midline was 15.6 mm; and that from the medial margin of the HGN to the midline was 14.1 mm (Fig. 3D)

Discussion

The use of endoscopic techniques as additions to the neurosurgical armamentarium for the diagnosis of lesions located at the skull base continue to gain popularity and acceptance. The CVJ region is closely located to critical neurovascular structures and the brainstem. Some cadaveric studies have reported the usefulness of the endoscopic endonasal approach to access the LC. Morera et al. [11] described two variants of the expanded endoscopic endonasal approach to access the inferior third of the clivus: the transcondylar supra-articular approach and the transjugular tubercle approach. The boundary of the two approaches is the HGC. Benet et al. [12] proposed dividing the lower third of the clivus into ventromedial and dorsolateral compartments. The HGC is the most important landmark to guide surgical planning; therefore, the identification and constant awareness of the HGC is key to the endoscopic endonasal approach to the LC. Morera et al. [11] first reported the SCG as a reliable anatomic landmark to estimate the position of the HGC and its EO. But in our cadaveric studies, we found that the thick muscle layer and the tough mucosal flap covering the HGC rendered it difficult to accurately estimate the location of HGC EO using the SCG as a landmark. In addition, when the groove bone was drilled, this landmark was removed.

The SCG is tightly attached to tough fibrous connective tissue. Morera et al. [11] reported that the shape of the osseous groove facilitates insertion of the rectus capitis anterior muscle and anterior atlanto-occipital membrane. In this report, we refer to the attached rectus capitis anterior muscle and anterior atlanto-occipital membrane as *tough fibrous connective tissue*. Even when the SCG was drilled, it was still difficult to resect with a suction microdebrider or bone rongeur forceps. It is worth noting that the SCG tough fibrous connective tissue was observed in all four human cadaveric heads examined in this study. This tissue can therefore be used to identify and locate the SCG. Even if the SCG bone is drilled, it can still serve as a landmark to estimate the intraoperative location of the HGC EO under an endoscope. The additional use of the HGC compact bone as a landmark [13] would increase the accuracy of the endoscopic endonasal approach to access the LC.

The SCG is horseshoe-shaped with a curved lateral notch that points to the upper part of the HGC EO. In our cadaveric heads, the tough fibrous connective tissue attached the SCG also pointed to the upper part

of the HGC EO. Notably, the course of the SCG tough fibrous connective tissue was superomedial to inferolateral with a 30° angle between the horizontal plane and the long axis of the SCG (Fig. 1B and 2A). By separating the tough tissue inferolaterally, it was possible to locate the upper part of the HGC EO and to further accurately isolate the HGN, while retaining some of the SCG tough fibrous connective tissue as a landmark (Fig. 3A). In addition, CNs IX, X, and XI, and the ICA lie on the lateral margin of the SCG. Hence, the surgeon must be especially careful not to injure the lower cranial nerve or ICA when separating the tough tissue inferolaterally (Fig. 3D).

Conclusion

The tough fibrous connective tissue attached the SCG points to the upper part of the HGC EO. The course of the tough fibrous connective tissue is superomedial to inferolateral. The SCG tough fibrous connective tissue can be used as a landmark to accurately locate the upper part of the HGC EO when performing endoscopic endonasal approaches to access the LC.

Abbreviations

HGC, hypoglossal canal; LC, lower clivus; SCG, supracondylar groove; CVJ, craniovertebral junction; EO, external orifice; HGN, hypoglossal nerve; CNs, cervical nerves; ICA, internal carotid artery

Declarations

Ethics approval and consent to participate

The research was approved by the Ethics Committee for Shanxi Provincial People's Hospital, Shanxi Medical University.

Consent for publication

Not applicable.

Availability of data and materials

The data supporting the conclusions of this article are included within the article and its figures.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conception and design: CH. Acquisition of data: LZ. Analysis and interpretation of data: JL, KW, PL, ML, YZ and HL. Drafting the article: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: CH. Statistical analysis: HJ and SZ. Administrative / technical / material support: GZ, SC and JZ. Study supervision: CH.

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Figures

Figure 1

An endoscopic endonasal transcondylar view of the supracondylar groove (0°). (A) Removal of the mucosa covering the lower clivus to expose the supracondylar groove. (B) The supracondylar groove surface is often covered with a layer of tough fibrous tissue that can be used to identify the supracondylar groove. The black line represents the long axis of the supracondylar groove. (C) After removing the supracondylar groove, the relationship of the tough fibrous tissue and hypoglossal nerve can be assessed under an endoscope. (D) A view the relationship of the tough fibrous tissue and hypoglossal nerve under an endoscope after further removal of the occipital bone.

Figure 2

(A) The relationship between the supracondylar groove and hypoglossal canal. The yellow arced line indicates the supracondylar groove. The blue arced line indicates the occipital condyle. The horizontal dotted line indicates the distance from the external orifice of the hypoglossal canal to the midline). The oblique dotted line indicates the superior, middle, and inferior borders of the hypoglossal canal. Hypoglossal canal is directed backward and medially at a 45° angle to the sagittal plane. The external orifice is located immediately above the junction of the anterior and middle third of the occipital condyle and medial to the jugular foramen. The supracondylar groove (yellow arced line) is at the same level as the upper part of the external orifice of the hypoglossal canal. The black line indicates the long axis of the supracondylar groove. The inferior lateral border of the supracondylar groove marks the midpoint of the hypoglossal canal outside of the orifice that acts as a limiting lateral point. (B) Drilling the supracondylar groove bone will expose the anterior rim of the occipital condyle. The distance from the hypoglossal nerve to the anterior rim of the occipital condyle is the half of the distance from the hypoglossal nerve to the superior rim of the supracondylar groove.

Figure 3

(A, B) Microscopic and (C, D) endoscopic views of the supracondylar groove. (C) The yellow circle indicates the external orifice of the hypoglossal canal. (D) The distance from the ICA to midline (a), from the superior ganglion of the vagus nerve to the midline (b), and from the medial margin of the hypoglossal nerve to the midline (c).