Surgical Approaches to the Hypoglossal Canal

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ABSTRACT

Objective: To describe and illustrate three distinct surgical approaches that permit exposure and resection of extradural, intradural, and transdural lesions involving the hypoglossal canal. **Study design:** Case series. **Setting:** University medical center. **Patients:** Four patients with lesions of the hypoglossal canal were reviewed to illustrate our philosophy when selecting a surgical approach to the hypoglossal canal. **Interventions:** Three separate surgical approaches were used to approach lesions involving various segments of the hypoglossal canal. **Main outcome measures:** Initial clinical presentation, tumor type, treatment course, complications and functional outcomes of hearing, lower cranial nerves, and great vessels. **Results:** A modified pre- and postauricular infratemporal fossa approach was used to permit the complete resection of an extradural hypoglossal canal schwannoma. The far lateral approach was used to remove a posterior fossa meningioma that involved the intradural hypoglossal canal. A transjugular craniotomy was used to resect a jugulotympanic paraganglioma with transdural hypoglossal canal involvement. Postoperatively, there were no major complications. However, one patient had cerebrospinal fluid rhinorrhea that resolved with lumbar subarachnoid drainage and another had a pseudomeningocele that resolved spontaneously. Dysphagia was not observed in any patient and all were discharged within 1 week of surgery. All patients are free of recurrence by clinical and radiographic examination with at least 2 years of follow-up. **Conclusions:** Lesions of the hypoglossal canal can be safely and effectively resected using the appropriate skull base approach. The three skull base approaches described herein provide access to selected portions of the hypoglossal canal and allow for preservation of hearing, the lower cranial nerves, and great vessels.

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Lesions involving the hypoglossal canal are rare, usually benign, and pathologically often include hypoglossal nerve schwannomas, posterior fossa meningiomas, and jugulotympanic paragangliomas.¹ The decision to intervene surgically is based on multiple factors including tumor type, size, patient age, symptoms, and comorbid conditions. If surgery is to be undertaken, the objectives of modern skull base surgery should be considered. These include anatomic and functional cranial nerve preservation, protection of the great vessels, and microscopic gross total tumor removal.² In most patients with a lesion of the hypoglossal canal, cranial nerve XII is nonfunctional preoperatively. Thus, the relevant structures which the surgeon would like to preserve are cranial nerves VII to XI, the middle ear space, the tympanic membrane, the internal carotid artery, and the vertebral arteries.

The goal of this article is to describe the three surgical approaches the senior author uses to access lesions involving the hypoglossal canal. Because of the rarity of these lesions, only four cases in the form of representative examples are presented. Lesions involving the hypoglossal canal can be classified into those that are extradural, intradural, or transdural (Fig. 1). We select our surgical approach based on the extent of the tumor. These include a modified infratemporal fossa approach for extradural tumors, the far lateral approach for intradural tumors, and the transjugular craniotomy for transdural tumors. The infratemporal fossa approach to the extradural hypoglossal canal we describe herein involve previously unreported modifications to the traditional Fisch type A infratemporal fossa approach.^{3,4} The far lateral approach has been well described for tumors of the foramen magnum.^{5,6} The transjugular craniotomy has recently been described for tumors involving the jugular foramen.⁷

REPORT OF CASES

Case 1: Extradural Hypoglossal Canal Involvement

A 61-year-old female presented with a 1-year history of right-sided facial fullness and occasional pain in

Figure 1 Variations in the extent of tumors that involve the hypoglossal canal. Anterior view of the brainstem, lower cranial nerves, and great vessels. The arrow points to the hypoglossal canal. The degree of extradural, intradural, and transdural involvement of the hypoglossal canal defines our decision-making strategy when choosing a surgical approach to this region. The arrowhead points to the jugular foramen.

the upper right neck. The patient denied having any dysphagia, change of speech, facial twitching, numbness, or diplopia. Her past medical history was unremarkable and there was no family history of cancer. Physical examination revealed right-sided tongue deviation, atrophy, and fasciculations. Slight ptosis was noted on the right side. An audiometric evaluation showed normal sensitivities across all frequencies with bilateral type A tympanograms.

An irregular, right-sided parapharyngeal space mass abutting but not eroding the skull base was identified with computed tomography (CT). T1-weighted magnetic resonance imaging (MRI) identified a mass medial to the internal carotid artery, adjacent to but not entering the hypoglossal canal. T2-weighted MRI demonstrated intense, heterogenous tumor enhancement consistent with various areas of cystic degeneration. Gadolinium administration revealed significant enhancement of the mass (Fig. 2). There were no vascular channels noted within the mass. The physical and radiographic examination findings were most consistent with a hypoglossal nerve schwannoma. Because of the patient's persistent symptoms, operative intervention was undertaken using our modified infratemporal fossa approach to the extradural hypoglossal canal. Postoperatively, the patient did

well and had no new cranial nerve deficits. At her 2-year follow-up, the patient had no evidence of disease. Follow-up audiometric evaluation showed normal sensitivities across all frequencies with type A tympanograms bilaterally.

OPERATIVE TECHNIQUE—PRE- AND POSTAURICULAR INFRATEMPORAL FOSSA APPROACH TO THE EXTRADURAL HYPOGLOSSAL CANAL

The patient was positioned in the supine position and a general anesthetic administered. Orotracheal intubation was performed with an endotracheal tube containing electrodes at the level of the true vocal folds (Xomed, Jacksonville, FL) to monitor cranial nerve X. Additional electrodes were placed to monitor cranial nerves VII, XI, and XII. Cranial nerve IX is not routinely monitored at our institution. A Y-shaped incision was made with a limb 2 centimeters posterior to the postauricular sulcus and a second limb in the preauricular crease. The anterior and posterior limbs were connected down onto a single-neck incision extending to the upper cervical neck two-finger breadths below the mandible (Fig. 3A). The lobule was retracted superiorly and an incision was made through the skin, subcutaneous tissues, and the periosteum of the mastoid. The mastoid cortex was identified and the periosteum was elevated along

Figure 2 Extradural hypoglossal canal pathology. (A) Axial T1-weighted MRI with gadolinium shows a hypoglossal schwannoma (arrows). (B) Coronal T1-weighted MRI with gadolinium image of the same tumor (arrow). MRI, magnetic resonance image.

Figure 3 Surgical technique of the modified infratemporal fossa approach for extradural tumors. (A) A Y-shaped incision with preauricular and postauricular limbs extends down the neck. (B) The sternocleidomastoid muscle is taken down off the mastoid tip. The digastric muscle is removed off the skull base and reflected anteriorly to permit further dissection of the nerves and great vessels up to the skull base. If additional exposure is required, the mastoid process can be drilled away and the facial nerve skeletonized, but left within a thin bony fallopian canal (not shown). (C) Extradural hypoglossal tumor is visible coursing to the foramen. The internal jugular vein is retracted posteriorly and cranial nerves IX, X, and XI are retracted anteriorly.

with the sternocleidomastoid muscle off the mastoid tip. The digastric muscle and spinal accessory nerve were both identified. The spinal accessory nerve was then followed up toward the skull base and cranial nerves X, XI, and XII were identified as they coursed over the top of the internal jugular vein and internal carotid artery. The internal jugular vein and internal carotid artery were identified and skeletonized. The facial nerve was identified at the stylomastoid foramen and dissected distally to the pes anserinus (Fig. 3B). A mastoidectomy was then performed with removal of the mastoid tip. The facial nerve was skeletonized and followed out to the stylomastoid foramen. Although the facial nerve was not rerouted, this maneuver allowed safe removal of the digastric muscle from the skull base, permitting access to the superior aspect of the infratemporal fossa. Cranial nerve IX was identified at this point. The rectus lateralis muscle can be divided between the base of the skull and the transverse process of C1 if needed to improve exposure. Care was taken to identify cranial nerves IX, X, and XI, which are often splayed over the tumor. Dissection was then performed medial to the internal carotid artery between cranial nerves IX, X, and XI. The hypoglossal nerve was identified at its normal inferior location and followed toward the skull base until the schwannoma was identified (Fig. 3C). A window was made in the tumor capsule and the tumor debulked. The capsule was then microdissected off of the surrounding tissues. The use of a microscope to identify and dissect these cranial nerves improves postoperative functional outcome. After total tumor removal, cranial nerves VII, X, and XI were stimulated and found to be functionally intact. The wound was then closed in layers over a suction drain and a sterile dressing was applied.

Case 2: Intradural Hypoglossal Canal Involvement

A 62-year-old female referred for disequilibrium was found to have left-sided tongue atrophy. MRI

Figure 4 Intradural hypoglossal canal pathology. (A) Axial T1-weighted MRI with gadolinium shows an intradural meningioma ventral to the brainstem that extends into the hypoglossal canal. (B) Sagittal T1-weighted MRI with gadolinium image of the same tumor. MRI, magnetic resonance image.

showed a well-circumscribed intradural meningioma ventral to the brainstem that extended into the hypoglossal canal (Fig. 4). A far lateral approach was used to approach the predominantly intradural tumor because of the degree of brainstem compression. A subtotal tumor removal was performed with small remnants left at the mid clivus and within the hypoglossal canal. The patient was discharged from the hospital 6 days after surgery with no symptoms of dysphagia. A pseudomeningocele was noted 1 week after discharge and resolved with conservative outpatient therapy after 3 months. There has been no radiographic evidence of tumor growth with 2 years of follow-up.

OPERATIVE TECHNIQUE — FAR LATERAL CRANIOTOMY

The patient was placed in the lateral park bench position. An inferiorly based postauricular flap with one limb centered adjacent to the posterior midline of the skull was designed (Fig. 5A). The soft tissues were elevated off of the skull, and the lamina of the C1 and C2 vertebral bodies were skeletonized. A standard retrosigmoid craniotomy was performed with identification of the transverse and sigmoid sinuses. The craniotomy was extended down to the foramen magnum. A C1

laminectomy was then performed. A C2 laminectomy was not required because the tumor had minimal inferior extension. Although it is possible to mobilize the vertebral artery out of C1 to help with anterior exposure, in most cases we have not found this necessary. A standard cortical mastoidectomy was performed with identification of the tegmen, antrum, and descending facial nerve. The sigmoid sinus was followed under the facial nerve toward the jugular bulb. Next, the posterior half of the occipital condyle was drilled away. The dura was opened just behind the sigmoid sinus, across the marginal sinus around the foramen magnum, and down through the C1 laminectomy (Fig. 5B). This provides excellent visualization of cranial nerves V to XII and the C1 and C2 nerve roots. To see the hypoglossal canal, the jugular tubercle was removed with a drill (Fig. 5C, D). Careful microdissection of the tumor was then performed. Although a few component fascicles of the cranial nerve XII had to be sacrificed, several could be preserved. Cranial nerves VII, VIII, IX, X, and XI were completely preserved. When completed, the dura was closed in a watertight fashion and the wound closed in layers.

Figure 5 Surgical technique of the far-lateral approach. (A) An inferiorly based postauricular flap is created. (B) Exposure of the dura after a retrosigmoid craniotomy, C1 and C2 laminectomy, and removal of the posterior half of the occipital condyle. (C) Drilling away the jugular tubercle to expose the hypoglossal canal from the intracranial side. (D) Representative view of a tumor involving the hypoglossal canal after opening the dura. The nerve rootlets of cranial nerves IX, X, and XI as well as C1 and C2 are displaced laterally by the tumor.

Case 3: Transdural Hypoglossal Involvement Canal

A 43-year-old female was referred for management of a left jugulotympanic paraganglioma. On physical exam, she had tumor within her middle ear and an intact tympanic membrane. A left vocal cord paralysis indicative of vagus nerve involvement was noted on physical exam with no other cranial nerve deficits. Audiogram demonstrated a 40-dB air-bone gap along with a symmetric mild high-frequency sensorineural loss. MRI confirmed the presence of a glomus jugulare tumor extending along the length of the hypoglossal canal from the dura to the infratemporal fossa (Fig. 6). We performed a transjugular craniotomy with gross total tumor removal.

Postoperatively, the patient had weakness in cranial nerve XI, but no other new cranial nerve deficits. Her postoperative discharge was delayed because of cerebrospinal fluid rhinorrhea that required temporary lumbar subarachnoid drainage. She recovered without further incident and her spinal accessory paresis resolved. By 3 months after surgery, her audiogram demonstrated significant improvement of her air-bone gap (<10 dB). There was no evidence of tumor by radiographic images 2 years after resection.

OPERATIVE TECHNIQUE — TRANSJUGULAR CRANIOTOMY

In our experience, the glomus jugulare tumor is the most common lesion that involves the length of the

Figure 6 Transdural hypoglossal canal pathology. Axial T1 MRI with gadolinium shows a glomus jugulare tumor extending along the length of the hypoglossal canal from the dura to the infratemporal fossa.

hypoglossal canal. We approach these tumors with a modified postauricular infratemporal fossa approach which preserves the external auditory canal and facial nerve in their normal anatomic position. Increased exposure can be achieved by performing a standard infratemporal fossa approach by closing the external auditory canal and rerouting the intratemporal facial nerve. Intracranial extension that requires a dural opening with transaction of the sigmoid sinus is termed a transjugular craniotomy (Fig. 7).⁷

This patient had a standard mastoidectomy and an extended facial recess was performed. The vertical portion of the facial nerve was delineated using the fallopian bridge technique, maintaining a thin layer of bone around the entire length of the nerve. Thus, facial nerve rerouting was not required. After occluding the sigmoid sinus in its mid portion and ligating the internal jugular vein, the lateral aspect of the jugular bulb was resected and the majority of the tumor removed. Tumors that involve the hypoglossal canal extend anteriorly, medially, and inferiorly. Thus, the internal carotid artery, dura, and nerves of the jugular foramen also tend to be involved. Care was taken to try to

Figure 7 Surgical technique of the transjugular craniotomy. This is the view after initial surgical exposure. A mastoidectomy with extended facial recess and a fallopian bridge has been performed. The dura has been opened across the sigmoid sinus and the lateral aspect of the jugular bulb removed. To access the hypoglossal canal, the medial wall of the jugular bulb must be resected and the bone anterior and inferior to it drilled away.

preserve the jugular foramen nerves as much as possible while still achieving gross total tumor resection. Dura medial to and inferior to the jugular bulb that had obvious tumor infiltration was removed. For this patient, the entire hypoglossal canal had to be removed. Finally, leaving the ear canal and tympanic membrane intact, tumor within the middle ear was carefully microdissected off the ossicular chain. The dura was closed in a watertight fashion with DuraGen (Integra Neurosciences, Plainsboro, NJ) and Tisseel (Baxter Healthcare Corporation, Deerfield, IL), and the wound closed in layers. A pressure dressing was applied.

DISCUSSION

Surgical approaches to the anterior foramen magnum are often complex and lengthy procedures.^{6,8-11} They may be associated with significant morbidity. Our objective when addressing pathology of the hypoglossal canal is to maximize exposure of the particular area of the tumor to be resected while

reducing the risk of associated morbidities. We believe that the three techniques described herein meet these objectives.

Previously described approaches to address extradural pathology of the hypoglossal canal include the supracondylar, extended posterolateral, and infratemporal fossa approaches. The supracondylar approach provides access to benign lesions of the hypoglossal canal and of the jugular tubercle to decompress tumors or cysts with minimal morbidity.¹² A case series of three patients was used to describe the approach. The first patient described was found to have a cholesterol cyst and postoperatively the patient suffered from a transient dysphagia. The second patient had a hypoglossal neurinoma and suffered from transient weakness of the right trapezius and sternocleidomastoid muscles consistent with injury to the spinal accessory nerve. Last, a nonspecific hypoglossal cyst was removed from a third patient with an uneventful postoperative course.

Myatt and associates¹³ used a case report of a hypoglossal neurilemmoma to demonstrate the value of an extended posterolateral approach. This approach involved a suboccipital craniectomy, mastoidectomy, and removal of the lateral process of the atlas. The postoperative course was complicated by a permanent unilateral right vocal cord paralysis and a transient House-Brackmann Grade II facial palsy.

The Fisch type A infratemporal fossa approach was first fully described in 1979 by Fisch and Pillsbury⁴ and later that year modified by Glasscock and colleagues.¹⁴ This approach requires anterior facial nerve mobilization to access the jugular bulb, closure of the auditory canal, and resection of the jugular bulb itself. Several other authors^{10,15} have demonstrated that the Fisch infratemporal fossa approach in conjunction with microsurgical techniques provides excellent exposure for the surgical management of temporal bone lesions, including lesions involving the hypoglossal canal. Hadley and Shelton¹ recently provided the anatomic measurements of the regional anatomy of the hypoglossal canal as seen through a transtemporal approach.

While the classic infratemporal fossa approach provides excellent exposure of the hypoglossal canal, it is not without morbidity. The facial nerve is mobilized from the fallopian canal, which has a 25 to 43% chance of temporary facial nerve paresis and a 15% incidence of long-term facial paresis.^{3,15} In addition, the incus, malleus, and tympanic membrane are removed and the external auditory canal is closed, resulting in a maximum conductive hearing loss (~60 dB). There is a small risk of occult cholesteatoma formation from residual rests of squamous epithelium from the tympanic membrane and ear canal. Our pre- and postauricular infratemporal fossa approach to the extradural hypoglossal canal is a modification of the classic Fisch type A approach that permits preservation of hearing and facial nerve function.

We recommend addressing intradural pathology involving the hypoglossal canal using the far lateral approach. This approach provides excellent exposure to the extradural hypoglossal canal. Robinson and coworkers¹⁶ were among the first to report complete resection of an intracranial hypoglossal neurilemmoma using the far-lateral approach. Postoperatively the patient had a short course of hoarseness, hiccups, and persistent hypoglossal nerve and unilateral lower extremity weakness. Since that time, several authors^{5,6,11} have further described the use of the far-lateral approach to access intradural pathology near the hypoglossal canal and foramen magnum. Spektor et al¹¹ describe a six-step approach that provides improved exposure of the petroclival region after removal of the jugular tubercle.

The removal of two transdural tumors involving the intra- and extracranial segments of the hypoglossal nerve has been reported. Rächinger and associates¹⁷ described a 32-year-old male with a hypoglossal schwannoma that was excised via a two-stage approach. The intracranial component was addressed first using a suboccipital craniotomy, and the extracranial component was removed at the second stage via a transcervical approach. The postoperative course after each stage was uneventful. The patient was discharged symptom-free

Figure 8 A 14-year-old male with neurofibromatosis type 2 and a right transdural bilobed hypoglossal schwannoma.

without any further therapy.¹⁷ Smith et al⁹ described a transcondylar approach to remove a transcranial hypoglossal schwannoma. The patient had an uneventful postoperative course and was discharged 5 days after surgery with no new cranial nerve deficits.⁹

The single-stage transjugular craniotomy can be used to address a dumbbell-shaped tumor of the hypoglossal canal. However, if one of the tumor lobes is small and asymptomatic, consideration should be given to using one of the other surgical approaches to remove only the large lobe. If required at a later date, stereotactic radiation could be used to treat the remnant. The much more common situation, however, is an intracranial glomus tumor involving the length of the hypoglossal canal, and this is the main indication to perform a transjugular craniotomy. While most glomus tumors can be completely resected with a transjugular craniotomy, tumors that extend anteriorly along the internal carotid artery require a standard Fisch type A infratemporal fossa approach with rerouting of the facial nerve and closure of the ear canal for improved anterior exposure.

It is important to note that not all lesions of the hypoglossal canal require surgery. One such

example is a 14-year-old boy with neurofibromatosis type 2 being followed in our skull base clinic. This patient has several cranial neuropathies from multiple intra- and extracranial schwannomas, including bilateral tumors of cranial nerves III, V, VI, VIII, and X. He also has unilateral VI and VII nerve schwannomas, as well as a small transdural hypoglossal schwannoma (Fig. 8). This hypoglossal tumor has been stable over several years and continues to be asymptomatic except for right-tongue paresis. Our plan is to continue to observe this patient with serial imaging. Surgery and/or stereotactic radiation will be considered with tumor growth or new symptoms related to this lesion.

CONCLUSIONS

Extradural tumors of the hypoglossal canal can be reached via a modified infratemporal fossa procedure designed to allow access to the superior aspect of the infratemporal fossa. Intradural tumors of the hypoglossal canal are best managed using a standard far-lateral craniotomy. When indicated, we prefer to access transdural tumors using the transjugular craniotomy.

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Commentary

Calzada and colleagues provide a practical review of three surgical approaches for pathology in the hypoglossal canal region. Although it is useful to compartmentalize each approach to a given tumor location, the reader must keep in mind that larger tumors such as giant intra- and extradural tumors of the skull base may require use of combination approaches, which may occur over a single or multiple stages. Moreover, the authors point out that large extra- and intradural dumbbell-shaped lesions may require combined approaches. Notably, they also contend that for asymmetric dumbbell lesions in which only the larger lobule is symptomatic, the approach solely for the larger lesion can be selected, with close monitoring or stereotactic radiosurgery considered for the smaller lobe. Given the potential for morbidity using these procedures, even in the best of hands, this strategy is a reasonable one as well. These tumors emphasize the importance of team-based neurotology and neurosurgery approaches.

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