Combined Endoscopic Transoral and Endonasal Approach to the Jugular Foramen: A Multiportal Expanded Access to the Clivus

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■ BACKGROUND: **The expanded endoscopic endonasal ("far medial") approach to the inferior clivus provides a unique surgical corridor to the ventral surface of the pontomedullary and cervicomedullary junctions. However, exposing neoplasms involving the jugular foramen (JF) through this approach requires extensive nasopharyngeal resection and lateral dissection beyond the boundaries of the endonasal corridor, limiting the extent of resection and restricting to use of this approach to expert surgeons. Here we describe a multiportal endoscopic transoral and endonasal approach to maximize surgical access to the JF and clivus.**

■ METHODS: **A multiportal endoscopic transoral and endoscopic approach to the JF and lower clivus was simulated in 8 specimens. A transoral corridor was created through a soft palate incision. The JF and parapharyngeal space were dissected through the transoral trajectory under endoscopic endonasal view. The length of the corridor of the transnasal and transoral trajectories was measured.**

■ RESULTS: **The JF was exposed intracranially and extracranially. The exposure extended superiorly to the sphenoid floor, inferiorly to the anterior atlanto-occipital space, and laterally to the internal acoustic meatus and parapharyngeal space. The cisternal parts of the cranial nerves VII–XII and C1 nerve bundles were accessible. Exposure of the JF contents and parapharyngeal space was possible using straight scopes, without Eustachian tube resection. The working corridor to the JF was significantly shorter through the mouth than through the nose ($P < 0.0001$).**

■ CONCLUSIONS: **This approach provides access to the JF from a ventromedial trajectory, enabling panoramic views, and outlines an expanded surgical exposure (superolateral intradural and inferolateral extracranial). It may provide optimal access for resection of dumbbell-shaped lesions of the JF.**

The jugular foramen (JF), formed by the petrous part of the temporal bone and the jugular part of the occipital bone, is an orifice in the lateral wall of the posterior fossa that is extremely rich in neurovascular contents. Its 3 compartments—petrous (inferior petrosal sinus), neural (cranial nerves [CNs] IX–XI and the meningeal branch of either the ascending pharyngeal or occipital arteries), and jugular (jugular tubercle)—may give rise to various neoplasms, including schwannomas, glomus jugulare tumors, and meningiomas. The epicenter of the neoplasm can be intracranial, foraminal, or extracranial, or the neoplasm may be dumbbell-shaped, with the intracranial and extracranial parts linked via the JF.[1-4]

Lesions involving the JF can be surgically accessed from posterior, lateral, and anterior trajectories, although in some cases access may require a combination of 2 or more approaches.[2,5-16] These traditional approaches may involve condylar, craniovertebral, or

Key words
- Expanded endoscopic endonasal approach
- Far-medial approach
- Jugular foramen
- Skull base
- Transoral approach

Abbreviations and Acronyms
CN: cranial nerve
EEFMA: endoscopic endonasal "far medial" approach
HC: hypoglossal canal
ICA: internal carotid artery
JF: jugular foramen
RCAM: rectus capitis anterior muscle

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Citation: World Neurosurg. (2016) 95:62-70.
http://dx.doi.org/10.1016/j.wneu.2016.07.073

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

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temporomandibular joint resection, carotid and vertebral artery transposition, facial nerve transposition, sigmoid sinus or internal jugular vein manipulation, labyrinth and cochlear resection, and cerebellar and brain stem retraction.[2,5-16] These approaches are associated with a high rate of complications and a risk of postoperative CN palsies. A systematic review of outcomes after the surgical removal of jugular paraganglionomas found a 26.1% rate of major postoperative complications, with an incidence of CN palsies of 0.9%.[17] Similarly, new CN deficits or worsened lower cranial neuropathies are common (rate of 13%–44%) after resection of JF schwannomas through the far-lateral approach.[18-22] The endoscopic endonasal approach to the lateral aspect of the lower clivus ("far-medial") was proposed to minimize morbidity (i.e., CN palsies and cerebellar infarcts) related to using a transcranial trajectory for accessing a lesion within the ventromedial compartment of the posterior fossa.[23,24] The endonasal trajectory provides optimal exposure to the ventromedial compartment of the brainstem, but its lateral exposure is limited by the nasopharynx (e.g., eustachian tube) and the depth of the nasal cavity. Thus, minimally invasive surgical exposure of the JF and its surroundings remains a challenge.

We sought to design a novel surgical technique combining the endoscopic transoral and endonasal trajectories to access the lower clivus, and specifically the JF, from the ventral skull base. We used a cadaveric surgical simulation model to design and develop our proposed technique, and assessed its advantages and shortcomings. We describe how to best use both the nasal and oral cavity to optimize surgical manipulation.

METHODS

Eight adult cadaveric specimens were prepared for dissection at the University of California San Francisco's Skull Base and Cerebrovascular Laboratory, following our protocol for surgical simulation.[25] The endoscopic transoral and endonasal corridors were used simultaneously in each procedure.

After an oral retractor was placed, a 1.5-cm incision was made in the soft palate in the midline, beginning from the posterior edge of the hard palate (hard-to-soft palate intersection) (Figure 1A). A 30-degree endoscope was passed through the endonasal corridor with minimal to no damage to the nasal cavity. The transoral approach was performed to gain access and pass surgical instruments to the JF and lower clivus (Figure 1B and C). For some parts of the procedure (e.g., dissecting around the foramen magnum), the instruments were passed through the nose through the inferior meatus, which provided ease of manipulation and allowed for 2-surgeon, multiportal, 4-handed access.

Nasopharyngeal Stage

A horseshoe-shaped myomucosal flap was obtained on the nasopharyngeal wall, extending from the midline laterally to the medial wall of the eustachian tube, superiorly to the floor of the sphenoid

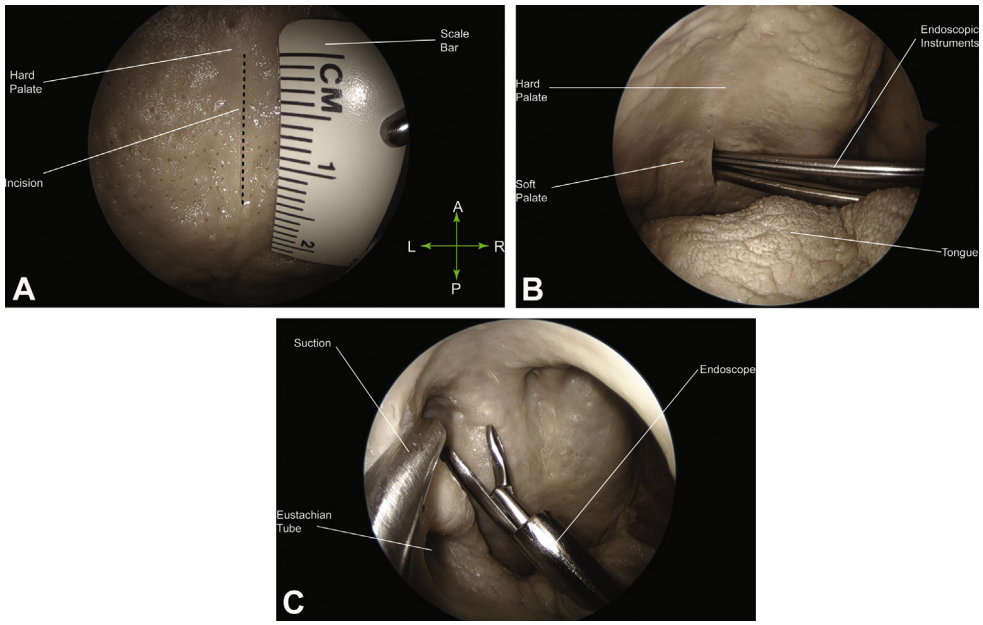

Figure 1. Endoscopic images depicting the soft palate incision and passage of the endoscope and instruments via the multiportal corridor. (**A**) The midline incision on the soft palate began at the posterior edge of hard palate and extended 1.5 cm posteriorly. (**B**) Endoscopic instruments were passed through the transpalatine incision using the available width of the oral cavity. (**C**) The endoscope was passed through the nasal cavity together with the suction, with minimal distortion of the nasopharynx. *A*, anterior; *L*, left; *P*, posterior; *R*, right.

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