Skull Base Approach to Carotid Artery Lesions: Technique, Indications, and Outcomes

Alexander Langerman, M.D.[1] Thomas C. Naslund, M.D.[2] James L. Netterville, M.D.[3]

[1] Department of Otolaryngology, Vanderbilt University Medical Center, Nashville, Tennessee
[2] Division of Vascular Surgery, Vanderbilt University Medical Center, Nashville, Tennessee
[3] Head and Neck Oncologic Surgery, Vanderbilt University Medical Center, Nashville, Tennessee

address for correspondence and reprint requests James L. Netterville, M.D., Mark C. Smith Professor of Otolaryngology, Director of Head & Neck Oncologic Surgery, Vanderbilt University Medical Center 7209 Medical Center East, South Tower, Nashville, TN 37212 (e-mail: james.netterville@vanderbilt.edu).

J Neurol Surg B 2012;73:163–167.

Abstract

Operative approaches to lesions of the carotid artery at the skull base are challenging and place multiple cranial nerves at risk. Herein, we describe a preauricular approach utilizing anterior dislocation of the temporomandibular joint with microscopic drill-out of the medial glenoid and Eustachian tube to identify and skeletonize the carotid artery in the foramen lacerum. The facial nerve remains undissected during this approach. Nine of 10 patients presented with aneurysm, six spontaneous and three following blunt trauma, and one patient presented with carotid artery rupture after penetrating trauma. Three of the patients presented with cranial nerve (CN) deficits that persisted. One patient was unevaluable preoperatively due to trauma but awoke with multiple CN deficits. Only one of nine evaluable patients suffered a new long-term CN deficit (XI). One patient had persistent temporomandibular joint dysfunction. All patients had long-term patency of the graft or anastamosis and no new neurologic symptoms were reported with a mean follow-up of 55 months. Open approaches to the carotid artery at the skull base are feasible and with careful anatomic dissection can be performed with minimal morbidity in most cases. We present full details and images of the operative approach.

Keywords

- carotid aneurysm
- glenoid fossa
- saphenous vein graft
- facial nerve

Operative exposure of the high parapharyngeal and intrapetrous segments of the carotid artery presents a challenge to the skull base surgeon. Endovascular approaches have enhanced the accessibility of this area, but some lesions may not be amenable to endovascular management and long-term results are lacking. Open approaches therefore remain an important part of the treatment strategies for lesions in this area.

The mandible and temporal bone limit wide exposure from a lateral approach. However, with anatomic release of the mandible and judicious removal of petrous bone, an adequate access can be achieved. The pathway must be designed carefully to protect the multiple critical neurovascular structures immediately adjacent to the carotid in this area.

Fisch first described an approach to these lesions requiring anterior displacement of the facial nerve and middle ear obliteration.[1] Since that time, several authors have reported variations of this technique with more or less perturbation of the facial nerve, temporal bone, and mandible – still with significant functional morbidity.[2–4] Liu et al described a cervical to supraclinoid bypass technique that avoided petrous drilling and facial nerve mobilization, but requires a pterional craniotomy for distal anastamosis.[5]

Malikov et al recently reported excellent long-term results of a transglenoid approach to the petrous carotid with

received
July 13, 2011
accepted
November 13, 2011
published online
February 22, 2012

DOI http://dx.doi.org/10.1055/s-0032-1301401.
ISSN 2193-6331.

temporary division of the external auditory canal and dissection of the facial nerve with partial parotidectomy.[6] However, their patients all experienced transient facial nerve weakness. We have found that the facial nerve, mastoid, and external auditory canal need not be disturbed to gain access to the carotid in this area. We first described this procedure in brief in 2002 [7] and have doubled our experience since that time.

Herein, we describe in detail our operative approach to lesions involving a transcervical approach with or without additional transglenoid exposure and present illustrative cases and a summary of our results and long-term outcomes.

Operative Procedure

The patient is positioned supine with head turned away from the operative side. The head, neck, and upper chest are prepped and draped with exposure of the face to allow monitoring of the facial nerve. An incision is designed from the temporal area, along the preauricular crease, around postauricularly to a prominent neck crease to provide access to both the cervical and transglenoid approaches.

The cervical approach is performed first. Subplatysmal flaps are raised to expose the sternocleidomastoid muscle (SCM) and tail of the parotid gland. The greater auricular nerve usually must be divided but may be done so sharply to allow neurorrhaphy at the conclusion of the procedure. The tail of parotid is released from the SCM but the facial nerve trunk is not dissected; rather it is left enshrouded in the fibrous connections between the gland and stylomastoid foramen to protect it from stretch trauma. A selective neck dissection can be performed to improve exposure, but should be avoided in thin individuals where volume loss will be cosmetically unfavorable.

The approach proceeds deep to the posterior belly of the digastric with care to preserve the spinal accessory nerve. The stylomandibular ligament is identified and released, along with the styloid musculature. The glossopharyngeal nerve can be identified and preserved in most cases. The styloid process is then trimmed back toward the temporal bone with caution to avoid injury to the facial nerve. The jugular vein is now well exposed and is retracted posteriorly away from the cranial nerves (CNs) anteriorly. Hypoglossal, spinal accessory, vagus, and glossopharyngeal are all identified and freed from the carotid. It is imperative that the connections between the vagus and hypoglossal are not separated as this results in damage to both nerves. The carotid is followed to the skull base and a determination is made whether exposure is sufficient to address the vascular lesion. In general, if 2 cm of carotid can be exposed distal to the lesion, there is sufficient exposure. However, this is dependent on the lesion and vascular repair.

If more exposure is needed, the preauricular incision is made up into the temporal area. The superficial layer of the deep temporal fascia is identified and soft tissue is elevated anteriorly in this plane until the posterior aspect of the intermediate fat pad above the zygoma is identified. Elevating deep to the fascia in this area becomes necessary to protect the temporal branch of the facial nerve. The fascia is incised posteriorly and the periosteum is stripped from the zygomatic arch, again elevating anteriorly now in a subperiosteal plane to expose the glenoid fossa.

The temporomandibular joint (TMJ) is freed, intact, from the glenoid fossa. Dense fibrous tissue attaches the posteromedial portion of the TMJ to the petrotympanic fissure and this must be sharply divided with a periosteal elevator to allow full mobilization of the joint. This maneuver necessarily sacrifices the chorda tympani nerve at its emergence of the petrotympanic fissure. Once released, the TMJ is distracted anterior to the articular eminence. The sphenomandibular ligament is then identified and cut, further allowing anterior displacement.

The eustachian tube is identified and removed using a high-speed drill via the glenoid fossa. The middle meningeal artery is usually ligated to allow greater access. The mandibular branch of the trigeminal nerve emerging from the foramen ovale serves as an anterior landmark, and may need to be displaced to allow access to the carotid at the foramen lacerum. Bone is removed over the proximal ascending and horizontal portions of the petrous carotid until sufficient exposure is gained for the planned vascular repair.

At the conclusion of the case, the TMJ is replaced in the glenoid fossa and the posterior joint capsule is sutured back into place. The parotid tail is returned to the SCM and the greater auricular nerve is repaired. Drains are placed in both operative cavities, and then fascia, platysma, and skin are closed in layers.

Illustrative Case 1

Trauma

A 72-two-year-old cab driver suffered a gunshot wound to the right zygomatic region. He had an uncertain neurologic status and was intubated, but demonstrated purposeful movement of all four extremities. Imaging demonstrated a stable rupture of the petrous carotid. A transcervical approach to the injury necessitated sacrifice of the glossopharyngeal nerve. The carotid was exposed, demonstrating massive injury and brisk bleeding once clot was removed. The bleeding was controlled while the transglenoid exposure was gained, and the damaged artery was resected. The patient had sufficient redundancy to allow primary reanastamosis.

Postoperatively, the hypoglossal, spinal accessory, vagus, and facial nerves were paretic, although the nerves were intact at the conclusion of the case. The patient also suffered transient seizure activity and was found to have right CVA on CT. The facial paresis resolved completely and no new neurologic deficits occurred. The patient underwent vocal cord medialization and palatal adhesion for the vagal paralysis. Over a period of years, some function was regained in CNs X, XI, and XII.

Illustrative Case 2

Aneurysm

A 21-one-year-old man was involved in a motor vehicle collision with multiple fractures 1 year prior to presentation and suffered a right carotid artery dissection resulting in stroke and right hemiparesis. The hemiparesis slowly resolved, but a right pseudoaneurysm developed in the petrous carotid (►Fig. 1).

The aneurysm was exposed using a combined transcervical/transglenoid approach and repaired with a reverse saphenous vein graft (►Fig. 1). The patient's postoperative course was uncomplicated and he experienced no new neurologic symptoms. At 7 years of follow-up he is doing well with a patent graft.

Illustrative Case 3

Cervical Approach

A 17-year-old high-school student was involved in a motor vehicle collision and sustained multiple bodily injuries including a skull fracture and intracranial hemorrhages. CT prior to discharge demonstrated bilateral carotid pseudoaneurysms. On follow-up, the left aneurysm resolved but the right increased in size and the patient was referred for bypass (►Fig. 2). Preoperatively, the patient had a right abducens palsy.

Intraoperatively, the entire aneurysm was able to be exposed transcervically and 1.5 cm of distal normal carotid was identified entering the carotid canal. The distal vein graft anastamosis was technically challenging given the access but successful and allowed avoidance of additional incisions in this young woman (►Fig. 2).

Postoperatively, the patient had a transient right palate weakness that resolved within 6 months. Her preoperative abducens palsy also improved during follow-up. The patient did not experience any weakness of her vocal cords. She did have one emergency room visit for transient right arm weakness approximately 8 months after the surgery that resolved completely. At over 3 years of follow-up the patient is neurologically stable with a patent graft.

Summary of Outcomes

Nine of the patients presented with aneurysm and one with a ruptured carotid from a gunshot (►Table 1). Six of the aneurysms were spontaneous and three were discovered following blunt trauma. Seven of the nine patients with aneurysms presented with definitive neurologic symptoms: three with CN deficits, three with TIA, one with hemiparesis, and one with Horner's syndrome. The patient with carotid rupture was unable to be fully assessed neurologically prior to surgery (Patient no. 7, Illustrative Case 1).

All patients were initially exposed transcervically. For two patients, this exposure allowed sufficient access to the skull base for exposure of the carotid distal to the lesion. The remaining eight required the addition of a transglenoid approach to allow exposure and distal anastomosis. Eight patients underwent reverse saphenous vein grafting and two had resection with primary reanastomosis.

The patients who presented with CN deficits continued to have these deficits postoperatively. The patient with the gunshot awoke from the surgery with significant deficits of

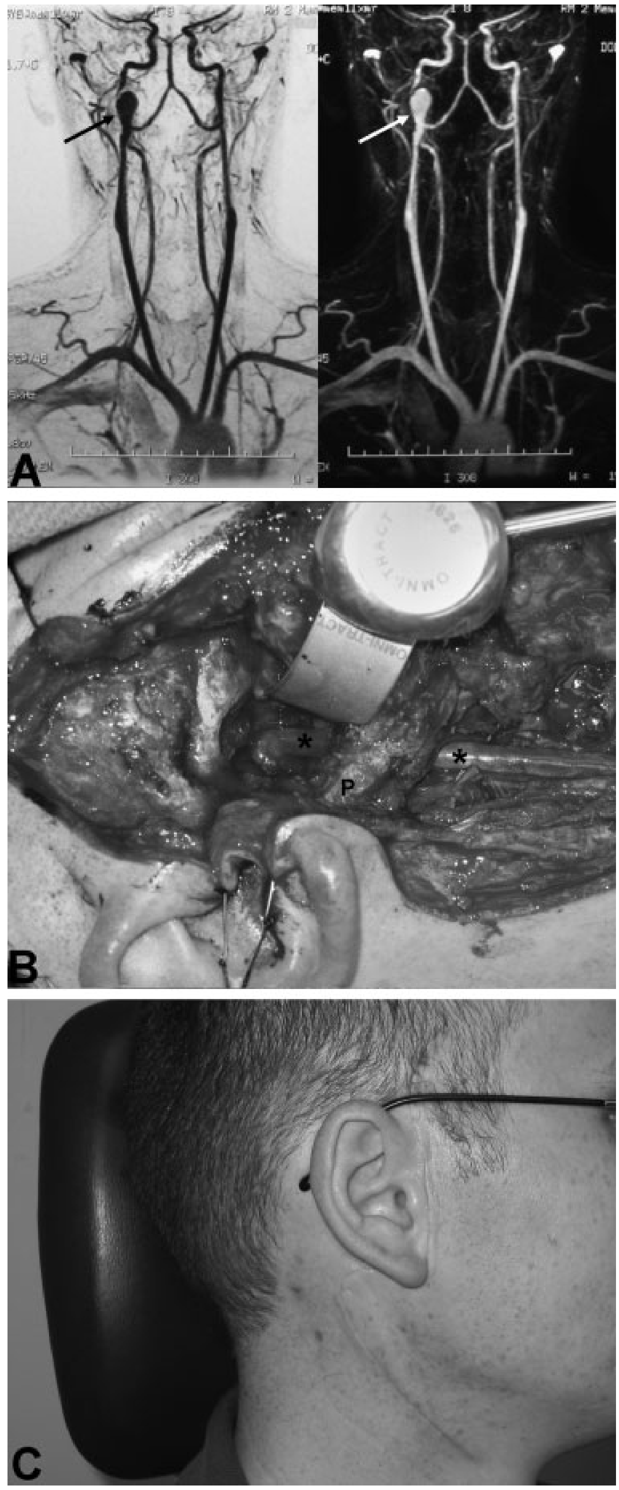

Figure 1 Illustrative case no. 2 (see text). (A) Magnetic resonance angiogram demonstrating an aneurysm of the right carotid artery near the skull base (arrows). (B) Operative exposure using combined transcervical/transglenoid approach with the graft (asterisks) in place. Note that the facial nerve remains undissected by maintaining the fibrous connections of the parotid (P) to the mastoid. (C) Cosmetically acceptable scar at follow-up.

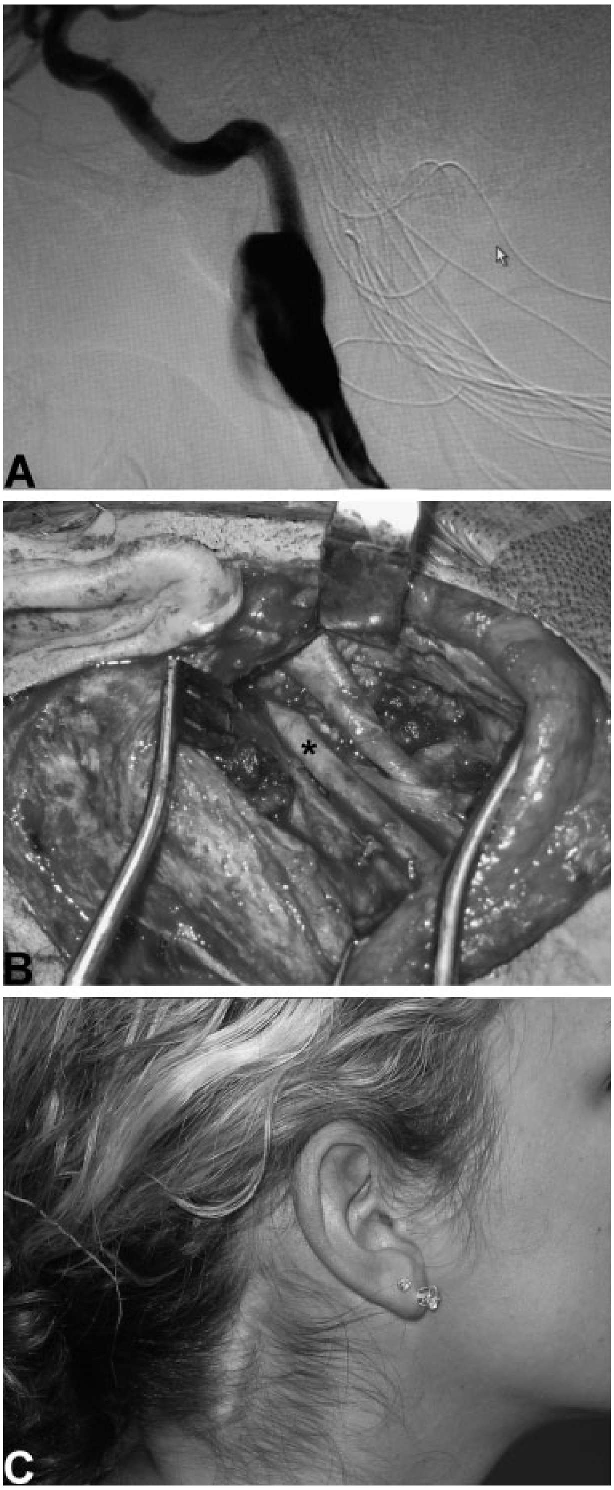

Figure 2 Illustrative case no. 3 (see text). (A) Angiogram demonstrating aneurysm of right carotid artery near the skull base. (B) Operative exposure using a facelift incision and a transcervical only approach with graft in place (asterisk). (C) Excellent cosmetic outcome.

CNs VII, IX, X, XI, and XII, but it is unclear which of these were due to the mechanism of injury or to our operative intervention; CN IX was knowingly sacrificed during the case, but the remainder of the nerves were identified and preserved (X, XI, XII) or left unperturbed (VII). The VII weakness in this patient involved both upper and lower divisions and was transient; the other deficits were durable.

One patient without preoperative CN deficits developed a permanent CN XI deficit. Three others had temporary deficits that resolved within 6 months (two palate weakness, one mild marginal mandiblar nerve weakness). Two patients suffered small strokes in the postoperative period but neither had permanent neurologic disability.

If we assume that patient no. 7 with the gunshot had normal CN function preoperatively, then 8 (80%) of the 10 patients in this series suffered no new long-term neurologic deficits as a result of surgery. If we exclude patient no. 7, then the long-term CN preservation rate increases to 89%. Facial nerve weakness was observed in two patients, and both resolved completely. Medialization laryngoplasty and palatal adhesions were ultimately performed on two patients with durable CN X deficits.

All eight patients who underwent transglenoid exposure had permanent eustachian tube dysfunction, and three of these patients required myringotomy and tube placement for symptomatic relief. One patient had persistent but mild temporomandibular joint (TMJ) dysfunction, and one patient had symptomatic taste disturbance form loss of the chorda tympani nerve. All patients were monitored with serial ultrasound or MRA and had long-term patency of the graft or anastomosis with a mean follow-up of 55 months.

Recommendations

We and others have demonstrated that open surgical approaches to the skull base and petrous carotid can be performed with acceptable morbidity. While our previous report consisted of spontaneous aneurysms, since that time we have expanded our indications with three posttraumatic aneurysms and a posttraumatic ruptured carotid.

The anatomic dissection of the glenoid avoids disruption of the TMJ and we believe this prevents significant morbidity. Only one patient in our series had symptomatic “clicking” of the joint but she was able to tolerate a full diet. Additionally, only two of our patients suffered any weakness of CN VII postoperatively, and in both patients this resolved completely. We believe that maintaining a protective shroud of parotid and fibrous tissue around the facial nerve as it exits the mastoid prevents traction injury and does not significantly limit exposure of the infratemporal fossa.

Many lesions of the carotid at the skull base are now amenable to endovascular management and significant experience has been gained with embolization and covered stents. We believe that patients who are appropriate candidates should be offered a minimally invasive endovascular management first. The open procedure should be reserved for lesions unsuited for endovascular management, failure of endovascular management, and patients with contraindications for stent placement. Additionally, in selected cases young patients may be better served with autogenous vein grafting rather than stent placement, and this exposure offers this option.

Table 1 Clinical Data for 10 Patients Undergoing Repair of Carotid Artery Lesions at the Skull Base

Patient	Age	Preoperative Deficits	Type of Lesion	Approach	Repair	Postoperative Deficits	Permanent Deficits	Other Therapy
1	53	CN X	Aneurysm	TC/TG	RSVG	CN X	CN X	ML, PA
2	51	Horner's	Aneurysm	TC/TG	RSVG	CVA, CN XI[a]	CN XI[a]	PET
3	68		Stenosis and aneurysm	TC/TG	RSVG			
4	80		Aneurysm	TC/TG	RSVG	CN IX/X[a]		PET
5	66		Stenosis and aneurysm	TC/TG	RSVG			
6	76		Pseudoaneurysm	TC	PR	CN VII[a]		
7	72	(unevaluable)	Traumatic Rupture	TC/TG	PR	CVA, CN VII, IX, X, XI, XII[b]	CN IX, X, XI, XII[b]	ML, PA
8	21	hemiparesis	Traumatic Pseudoaneurysm	TC/TG	RSVG			PET
9	19	CN X, XI, XII	Traumatic Psuedoaneurysm	TC/TG	RSVG	CN X, XI, XII	CN X, XI, XII	
10	17	CN VI	Traumatic Aneurysm	TC	RSVG	CN VI, IX/X[a]		

[a]Indicates new cranial nerve deficit, wither transient or long-term.
[b]Indicates cranial nerve deficits were difficult to categorize as patient was obtunded and unevaluable prior to surgery.
CN, cranial nerve; CVA, cerebrovascular accident; ML, medialization laryngoplasty; PA, palatal adhesion; PET, pressure equalizing (ear) tube; PR, primary reanastamosis; TC, transcervical; TG, transglenoid; RSVG, reverse saphenous vein graft.

This procedure is contraindicated for lesions that extend through the lacerum portion of the petrous carotid as exposure of the distal carotid would be insufficient for anastomosis.

Patients who undergo the transglenoid approach should be counseled to anticipate eustachian tube dysfunction with the possible need for myringotomy and tube placement. Patients should also be advised of possible TMJ discomfort and taste disturbances.

All patients undergoing management of the carotid in this area are at risk of CN deficits. Medialization laryngoplasty and palatal adhesion [8,9] should be employed as necessary.

Note
Presented at the North American Skull Base Society Annual Meeting, February 18, 2011, Scottsdale, Arizona.

References

1 Fisch UP, Oldring DJ, Senning A. Surgical therapy of internal carotid artery lesions of the skull base and temporal bone. Otolaryngol Head Neck Surg 1980;88(5):548–554
2 Welsh P, Pradier R, Repetto R. Fibromuscular dysplasia of the distal cervical internal carotid artery. J Cardiovasc Surg (Torino) 1981;22(4):321–326
3 Glassock ME III, Smith PG, Bond AG, Whitaker SR, Bartels LJ. Management of aneurysms of the petrous portion of the internal carotid artery by resection and primary anastomosis. Laryngoscope 1983;93(11 Pt 1):1445–1453
4 Alimi YS, Di Mauro P, Fiacre E, Magnan J, Juhan C. Blunt injury to the internal carotid artery at the base of the skull: six cases of venous graft restoration. J Vasc Surg 1996;24(2):249–257
5 Liu JK, Gottfried ON, Amini A, Couldwell WT. Aneurysms of the petrous internal carotid artery: anatomy, origins, and treatment. Neurosurg Focus 2004;17(5):E13
6 Malikov S, Thomassin JM, Magnan PE, Keshelava G, Bartoli M, Branchereau A. Open surgical reconstruction of the internal carotid artery aneurysm at the base of the skull. J Vasc Surg 2010;51(2):323–329
7 Eliason JL, Netterville JL, Guzman RJ, Passman MA, Naslund TC. Skull base resection with cervical-to-petrous carotid artery bypass to facilitate repair of distal internal carotid artery lesions. Cardiovasc Surg 2002;10(1):31–37
8 Netterville JL, Stone RE, Luken ES, Civantos FJ, Ossoff RH. Silastic medialization and arytenoid adduction: the Vanderbilt experience. A review of 116 phonosurgical procedures. Ann Otol Rhinol Laryngol 1993;102(6):413–424
9 Netterville JL, Fortune S, Stanziale S, Billante CR. Palatal adhesion: the treatment of unilateral palatal paralysis after high vagus nerve injury. Head Neck 2002;24(8):721–730