Submandibular-Infratemporal Interpositional Carotid Artery Bypass for Cranial Base Tumors and Giant Aneurysms

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ONLINE DIGITAL VIDEO

OBJECTIVE: Cerebral revascularization is an important strategy in the surgical management of some complex cranial base tumors and unclippable aneurysms. A high-flow bypass may be necessary in planned carotid occlusion or sacrifice. The cervical-to-supraclinoid internal carotid artery bypass or cervical carotid-to-middle cerebral artery bypass are useful procedures to bypass lesions at the base of the cranium. We describe technical modifications of the submandibular-infratemporal interpositional saphenous vein (or radial artery) graft bypass technique specifically designed to avoid removal of the zygoma.

METHODS: The saphenous vein or radial artery interpositional graft is tunneled through a burr hole created in the floor of the middle fossa via a submandibular-infratemporal route avoiding removal of zygoma and attachments of the masseter or temporalis muscles.

RESULTS: The technique is demonstrated in one patient with removal of a malignant cavernous sinus tumor and in another patient with an unclippable giant carotid bifurcation aneurysm.

CONCLUSION: The advantages of this approach include preservation of the facial anatomy and creation of a short and safe route for passage of the saphenous vein or radial artery graft.

KEY WORDS: Cranial base tumor, Interpositional bypass, Radial artery, Revascularization, Saphenous vein

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Cerebrovascular bypass techniques remain an important strategy in the surgical management of complex aneurysms and cranial base tumors (2, 3, 5, 7–9, 11–15). Giant and fusiform aneurysms that are not amenable to direct clipping may require parent vessel occlusion and a subsequent bypass procedure. Cranial base tumors that involve the internal carotid artery (ICA) may require its sacrifice if an oncological resection is desired, especially with malignant tumors. When acute sacrifice of the ICA is necessary, revascularization with a high-flow interpositional saphenous vein graft (SVG) may be indicated, either to restore adequate collateral flow in a patient with insufficient cerebrovascular reserve or to preserve cerebrovascular reserve in a young patient with a long life expectancy (9). Several high-flow bypass strategies using saphenous vein reconstruction have been described, including the cervical-to-petrous ICA, petrous-to-supraclinoid ICA, cervical-to-supraclinoid ICA, and cervical-to-M2 bypass (1, 2, 5, 7, 9, 11, 13, 14).

The tunneled route of the graft is of importance because it has implications for reducing the overall length of the graft, thereby improving patency rates. Preauricular and postauricular subcutaneous tunneling techniques have been described (7, 9, 13). The senior author (WTC) has previously developed a submandibular route for the cervical-to-supraclinoid SVG bypass (1). In that technique, the zygoma is removed and reflected inferiorly with the masseter and temporalis muscles to allow a bone trough to be made at the middle fossa cranial base. This provides room for the graft and helps avoid graft compromise by mandibular movement. We describe here a modification of this bypass that uses a direct submandibular–infratemporal route that spares a zygomatic osteotomy. This technique is illustrated in two patients, one of whom underwent surgical resection of a malignant cranial base tumor encasing the cavernous and petrous ICA and another with a giant unclippable carotid terminus aneurysm.

OPERATIVE TECHNIQUE
(*see video at web site*)

Positioning and Skin Incision

The patient is placed supine with the head elevated 10 to 15 degrees above the heart to facilitate venous return (*Fig. 1*). The head is fixed in a three-pin Mayfield head holder and rotated approximately 30 degrees away from the side of the craniotomy. The neck is slightly hyperextended so that the malar eminence is at the highest position in the field. The ipsilateral shoulder is elevated with a gelatin roll. All pressure points are adequately padded to prevent pressure sores. The patient is secured to the table with adjustable belts and adhesive tape to allow safe tilting of the patient during surgery.

The patient is started on 325 mg of aspirin daily before surgery and takes another dose on the morning of the surgery. Intraoperative monitoring with motor evoked potentials, somatosensory evoked potentials, and electroencephalography are used during the operation. The frontotemporal incision starts approximately 1 cm anterior to the tragus at the level of the zygoma, extends superiorly, and curves towards the midline, staying behind the hairline if possible. The incision can be modified if additional exposure is needed. A myocutaneous flap is elevated and retracted with fish hooks and rubber bands. The neck incision follows the anterior border of the sternocleidomastoid muscle.

Craniotomy and Extradural Drilling of the Middle Fossa

A frontotemporal craniotomy is elevated and the sphenoid ridge is removed using rongeurs and a high-speed drill. If the supraclinoid segment of the ICA is the desired recipient vessel, then the anterior clinoid process is removed extradurally with a high-speed drill. This step is not necessary if the M2 branch is the desired recipient vessel.

FIGURE 1. *Intraoperative photograph demonstrating the frontotemporal skin incision and neck incision.*

Next, the temporal lobe is elevated extradurally to expose the bony floor of the middle fossa. Intravenous mannitol, given at the time of skin incision, and lumbar drainage are used to facilitate brain relaxation during this step. The relaxed temporal lobe is held in place with self-retaining brain retractors to maintain exposure of the middle fossa. A high-speed drill is used to create a burr hole at the base of the middle fossa lateral to the foramen ovale and anterior to the temporomandibular joint (*Fig. 2*). The hole should be large enough to accommodate the diameter of the SVG and to avoid kinking of the graft with mandibular movements. The capsule encasing the infratemporal fossa soft tissue contents is visualized at the base of the craniectomy. The capsule should be kept intact during the drilling to minimize blood loss.

Neck Dissection

The skin incision is made along the anterior border of the sternocleidomastoid muscle. The platysma is divided along the plane of the skin incision, and sharp dissection is continued medial to the sternocleidomastoid muscle. The common carotid artery is exposed by incising the deep cervical fascia on top of the artery up towards the bifurcation. The external and internal carotid branches are exposed distally. The hypoglos-

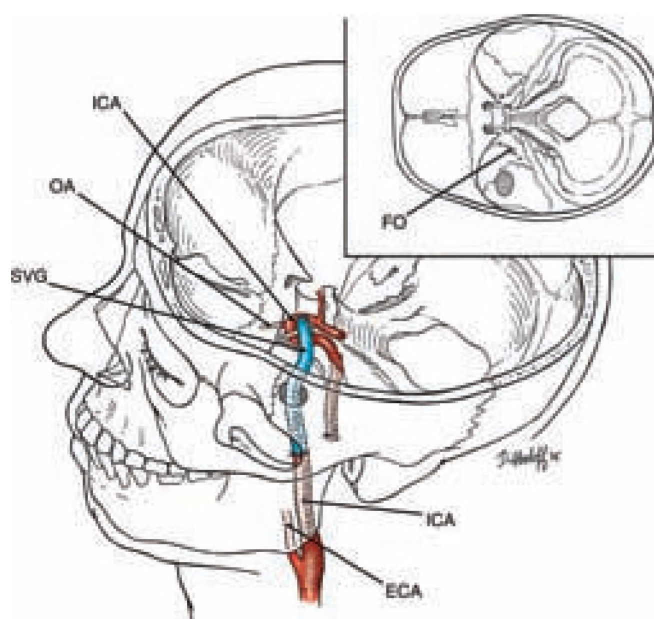


FIGURE 2. *Illustration showing the cervical-to-supraclinoid ICA bypass using an interpositional SVG. The graft is tunneled through the submandibular–infratemporal route via a middle fossa craniectomy* (shaded region, *see inset) that is located lateral to the foramen ovale. In this example, the graft is anastomosed to the supraclinoid ICA in an end-to-side fashion. An aneurysm clip is placed just proximal to the ophthalmic artery takeoff.* ICA, *internal carotid artery;* ECA, *external carotid artery;* SVG, *saphenous vein graft;* OA, *ophthalmic artery;* FO, *foramen ovale.*

sal nerve is identified and isolated to prevent injury to the nerve.

Submandibular Infratemporal Bypass

From the intracranial exposure above, a tonsil clamp is passed through the middle fossa craniectomy and infratemporal fossa, staying beneath the mandible, and into the neck exposure. Care must be taken to pass the clamp superficial to the hypoglossal nerve, which is visualized in the operative field. A finger is placed underneath the mandible in the neck exposure to palpate the tip of the tonsil clamp. This allows safe and controlled guidance of the tonsil clamp through the infratemporal fossa and into the neck exposure to avoid injury to the hypoglossal nerve and cervical carotid vessels with passing the instrument. A 14-French chest tube is then threaded from the neck incision back through the middle fossa craniectomy (*Fig. 3*). An SVG is harvested from the leg (or, alternatively, a radial artery graft is harvested from the arm) and passed through the chest tube from the neck incision and brought up into the intracranial cavity. Operative details of SVG extraction and preparation have been described by Sundt and Sundt (16).

The patient is placed under hypothermia, burst suppression, and total intravenous anesthesia, and 5000 units of intravenous heparin are administered before the bypass is performed. The cervical ICA is ligated as high in the neck as possible and the distal end is mobilized inferiorly into the neck exposure. An end-to-end anastomosis is performed between the distal cervical ICA and the proximal end of the SVG using 7–0 Prolene suture (Ethicon, Inc., Somerville, NJ). Alternatively, the external carotid artery (ECA) may be used as the proximal donor vessel, anastomosed either end to end or end to side. This is used when performing an ECA-M2 bypass.

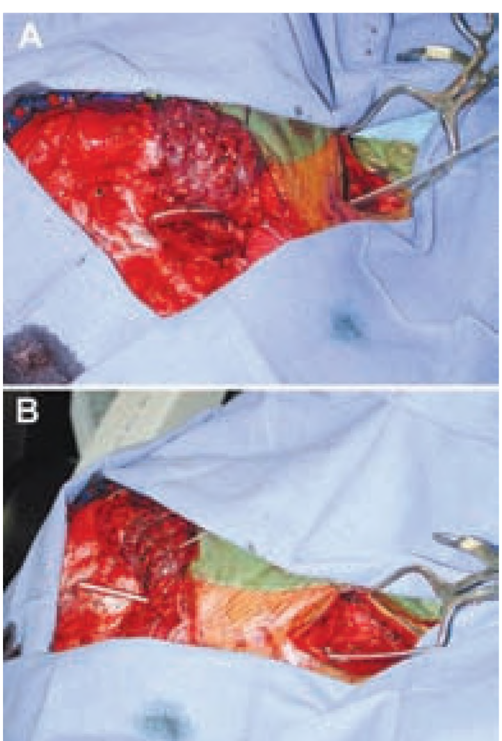


FIGURE 3. A *and* B, *intraoperative photographs demonstrating the passage of the chest tube from the neck exposure to the intracranial exposure via the submandibular-infratemporal route.*

The dura mater is then opened in a C-shaped fashion and reflected with its base towards the sphenoid ridge. The sylvian fissure is opened widely with sharp dissection. The desired recipient vessel is then isolated for the distal anastomosis. This can be either the supraclinoid ICA or the M2 branch of the middle cerebral artery (MCA). If the supraclinoid ICA is the chosen recipient vessel and preservation of the ophthalmic artery is desired, the SVG is anastomosed to the supraclinoid ICA segment between the ophthalmic artery and posterior communicating artery takeoffs in an end-to-side fashion with 8–0 or 9–0 Prolene sutures. Removal of the anterior clinoid process enhances the exposure of the supraclinoid ICA for performing the anastomosis. If the proximal ICA is ligated and the ophthalmic artery is sacrificed, as with removal of the carotid with cranial base tumors, the SVG is anastomosed to the supraclinoid ICA in an end-to-end fashion; otherwise, an end-to-side anastomosis is performed with preservation of the ophthalmic takeoff. If the M2 branch is the recipient vessel, the anastomosis is performed in an end-to-side fashion. The SVG is cut to the appropriate size before the distal anastomosis to ensure that the graft is not too long and redundant or too short so that it is subjected to stretch forces. When the distal anastomosis is nearly complete, vessels are backbled to flush debris and air. Once the distal anastomosis is performed, the microvascular Doppler is used to monitor cerebral blood flow. Both proximal and distal anastomoses are inspected to ensure that there is no kinking of the graft before closure.

Closure

The dura mater is reapproximated incompletely to allow a fenestration for the graft to enter the intradural space. Care is taken not to constrict the graft with the dural closure. Liquid Gelfoam and thrombin mixture is injected into the middle fossa craniectomy defect for hemostasis. Autologous pericranium or fascia lata can be used for facilitating primary closure of the dura mater. For larger cranial base defects after tumor resection, microvascular free flaps may be used for cranial base reconstruction. The bone flap is replaced with titanium miniplates and screws. Multilayer closure of the scalp and neck wound is performed in the standard fashion.

ILLUSTRATIVE CASES

Patient 1

History and Neurological Examination

A 55-year-old man presented with a 1-year history of right-sided tongue and face numbness. Magnetic resonance imaging (MRI) scans demonstrated a paranasal sinus lesion extending from the lateral nasopharynx to the retropharyngeal space, cranial base, and right cavernous sinus. A transnasal biopsy revealed nasopharyngeal carcinoma. The patient underwent chemotherapy and radiation therapy with a good initial response, but subsequently developed worsening vision in the right eye, progressive diplopia, facial asymmetry, tinnitus, and balance difficulties.

Cranial nerve examination revealed markedly diminished visual acuity in the right eye, complete ophthalmoplegia with ptosis of the right eye, decreased facial sensation in all divisions of the right trigeminal nerve, complete right-sided facial nerve palsy, and diminished hearing on the right side. The lower cranial nerves were normal. Motor and sensory examinations were normal in both upper and lower extremities.

Neuroimaging

A follow-up MRI scan revealed tumor recurrence in the right cavernous sinus and middle fossa extending down into the sphenoid sinus and medial petrous bone (*Fig. 4*). The petrous and cavernous segments of the internal carotid artery were completely encased by the tumor. A positron emission tomographic scan of the body did not reveal any evidence of metastatic disease.

Operative Technique

Because the malignant tumor was a local recurrence and the patient already exhibited severe visual loss and complete ophthalmoplegia, a decision was made to perform a radical resection of the extensive cranial base tumor with the encased cavernous and petrous ICA with subsequent ICA reconstruction with an interpositional SVG. A right frontotemporal craniotomy was performed, followed by extradural removal of the sphenoid ridge and the anterior clinoid process. After retraction of the frontal lobe, the tumor was visualized; it had invaded the posterior aspect of right orbit and optic nerve. The posterior orbit was removed and the optic nerve was transected well anterior to the anterior margin of the tumor. The tumor was found to have invaded the cavernous sinus, the lateral aspect of the pituitary gland, the medial aspect of the petrous bone, and the posterior fossa dura mater. All tumor was radically removed; the floor of the middle fossa and the petrous apex was extensively removed with a high-speed drill to encircle all involved bone.

A neck incision was then made along the anterior border of the sternocleidomastoid muscle and the cervical ICA was isolated. A segment of approximately 20 cm of the greater saphenous vein was harvested and perfused with heparinized saline. After induction of burst suppression with intravenous propofol and administration of 5000 units of intravenous heparin, the cervical ICA was ligated as high in the neck as possible. The distal end of the cervical ICA was mobilized inferiorly where an end-to-end anastomosis was performed between the distal cervical ICA and the proximal end of the SVG using 7–0 Prolene suture.

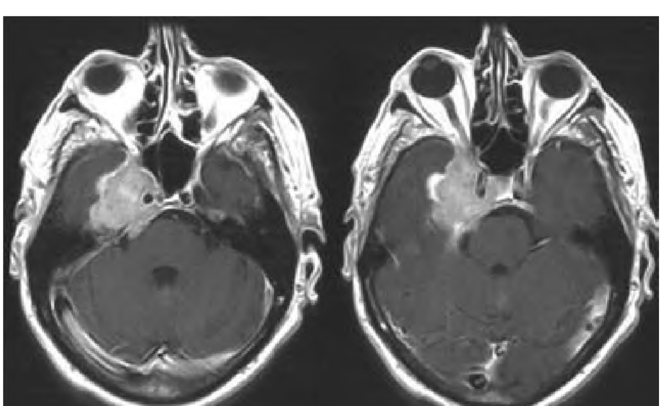


FIGURE 4. *Patient 1. Preoperative postgadolinium MRI scans demonstrating enhancing tumor at the cranial base encasing the petrous and cavernous carotid arteries.*

A submandibular-infratemporal tunnel for the graft was created by the bone removal of the floor of the middle fossa. The zygomatic arch and its muscle attachments were left intact. A 14-French chest tube was then passed through the submandibular-infratemporal tunnel from the high cervical region through the base of the middle fossa. The distal portion of the vein graft was then brought up into the intracranial cavity. The supraclinoid ICA was then ligated between the ophthalmic artery and the posterior communicating artery branch points. The SVG was cut to size and anastomosed end to end to the supraclinoid ICA with 9–0 Prolene suture. The bypass graft was pulsating well and exhibited a good Doppler flow signal. The cavernous and petrous segments of ICA that had tumor encasement were excised entirely.

The cranial base defect was then reconstructed using autologous fascia lata for facilitating primary closure of the dura mater, followed by a radial forearm free tissue transfer. The remainder of the craniotomy closure was performed in the standard fashion. Somatosensory and motor evoked potentials were not changed throughout the entire operation. Temporary lumbar drainage was used to reduce the risk of a cerebrospinal fluid fistula.

Postoperative Course

Postoperatively, the patient was awake, following commands, and moving all extremities. No new neurological deficits were observed. A postoperative computed tomographic (CT) angiogram revealed an intact and patent submandibular SVG (*Fig. 5*). The patient was discharged to inpatient rehabilitation without evidence of a cerebrospinal fluid fistula.

Patient 2

History and Neurological Examination

A 61-year-old man presented with progressive left-sided arm and leg weakness from a giant calcified carotid terminal bifurcation aneu-

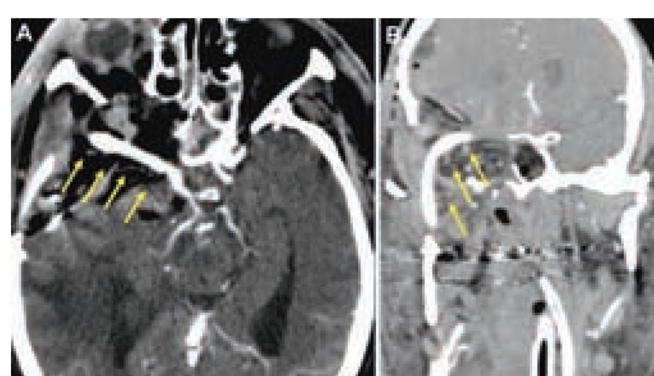


FIGURE 5. *Patient 1. Postoperative axial (A) and coronal (B) CT angiograms showing the patent interpositional SVG (*yellow arrows*) traveling in the submandibular-infratemporal tunnel.*

rysm (*Fig. 6*). Imaging of the cervical carotid arteries and echocardiogram were normal. On examination, the patient was awake, alert, and following commands. Cranial nerve examination was normal. Motor examination demonstrated trace weakness in the left arm and left leg (4/5). Sensory and cerebellar examinations were normal.

Neuroimaging

Cerebral angiography demonstrated a giant right terminal ICA aneurysm (*Fig. 6*). The wall of the aneurysm incorporated the M1 and A1 branchpoint takeoffs. There was also no flow to the contralateral hemisphere on either right or left ICA injections because of a nonpatent anterior communicating artery. Cross compression was performed on the left ICA injection.

Operative Technique

The giant aneurysm was deemed unclippable by our multidisciplinary cerebrovascular team. Our strategy for treatment was to surgically trap the aneurysm and revascularize the right MCA and anterior cerebral artery (ACA) territories. We planned to stage the revascularization procedures.

The first stage was to revascularize the MCA territory by using an ECA-to-MCA bypass using a submandibular-infratemporal interpositional SVG. Oral aspirin was given on the evening and morning before the operation. A right frontotemporal craniotomy was performed, followed by wide splitting of the sylvian fissure. An M2 branch was dissected out as the recipient vessel. Using a high-speed drill, a small craniectomy was made at the base of the middle fossa lateral to the foramen ovale to accommodate the tunneled SVG.

The carotid bifurcation and the ECA and ICA were exposed in the neck. The SVG was tunneled from the neck incision into the intracranial cavity through the submandibular-infratemporal tunnel using a 14-French chest tube. After 5000 units of intravenous heparin were administered, the cervical ECA was ligated as high in the neck as possible. The distal end of the cervical ECA was mobilized inferiorly where an end-to-end anastomosis was performed between the distal cervical ECA and the proximal end of the SVG using 7–0 Prolene interrupted suture.

The distal portion of the vein graft was then brought up into the intracranial cavity through the submandibular–infratemporal tunnel and an end-to-side anastomosis to the M2 branch was performed with 9–0 Prolene suture (*Fig. 7*). The bypass graft was pulsating well and exhibited a good Doppler flow signal. Autologous pericranium was harvested to facilitate the dura mater closure at the cranial base around the graft.

One week later, the pterional bone flap was extended medially to allow an interhemispheric approach for an A3-to-A3 side-to-side in situ bypass. During the same sitting, the aneurysm was surgically trapped by placing aneurysm clips on the terminal carotid, M1, and A1 branches arising from the dome of the aneurysm through the previous pterional approach.

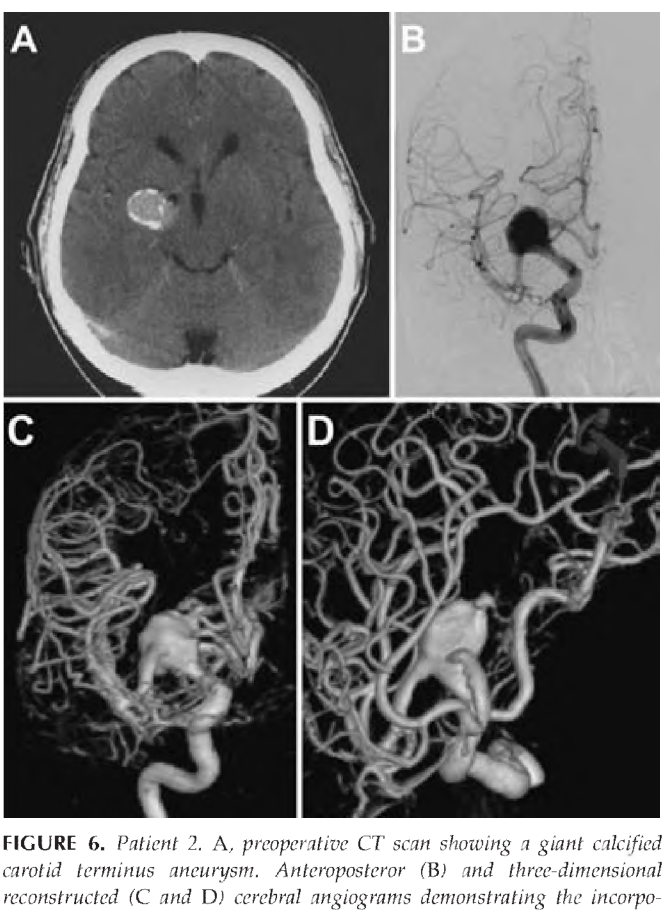


FIGURE 6. *Patient 2. A, preoperative CT scan showing a giant calcified carotid terminus aneurysm. Anteroposteror (B) and three-dimensional reconstructed (C and D) cerebral angiograms demonstrating the incorporation of the M1 and A1 branchpoint takeoffs in the wall of the giant aneurysm.*

Postoperative Course

Postoperatively, the patient was awake, following commands, and moving all extremities. Postoperative angiography demonstrated successful trapping of the aneurysm and revascularization of the right MCA and ACA territories (*Fig. 8*). The right MCA territory was supplied by the SVG and the right ACA territory was supplied by the contralateral A3. The patient was eventually discharged to inpatient rehabilitation in stable condition.

DISCUSSION

Reconstruction of the ICA with the use of interpositional SVGs for the management of giant aneurysms was popular-

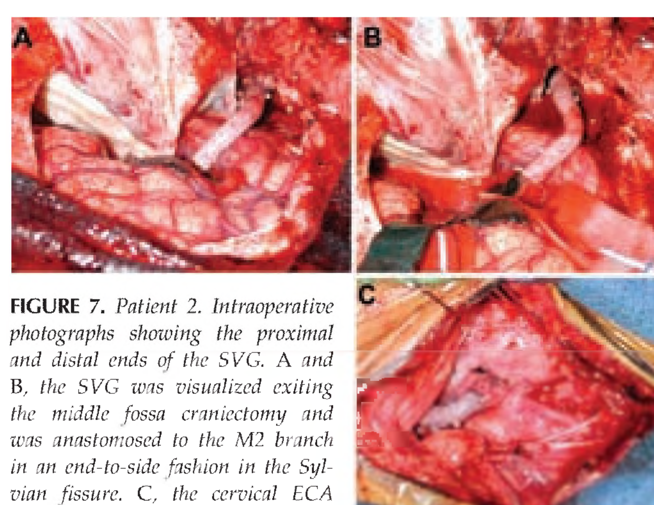
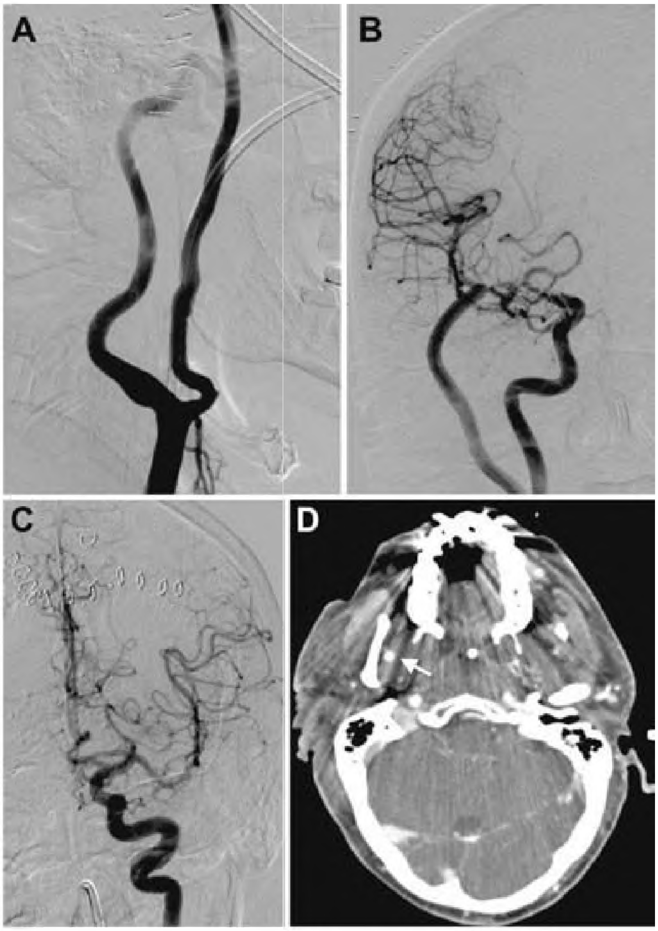


FIGURE 7. *Patient 2. Intraoperative photographs showing the proximal and distal ends of the SVG. A and B, the SVG was visualized exiting the middle fossa craniectomy and was anastomosed to the M2 branch in an end-to-side fashion in the Sylvian fissure. C, the cervical ECA was anastomosed to the SVG in an end-to-end fashion.*



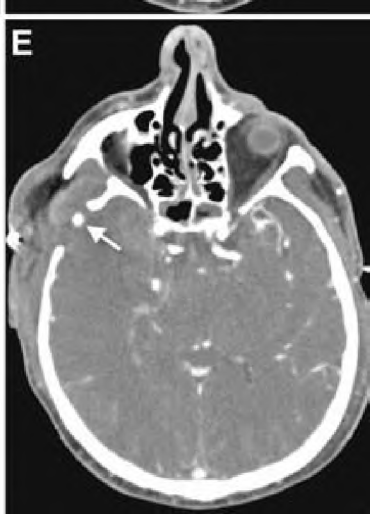


FIGURE 8. *Patient 2. A to C, postoperative angiograms demonstrating an intact ECA–SVG–MCA bypass. A, the right common carotid injection showing that the proximal ECA-SVG anastomosis is visualized passing underneath the mandible. B, the distal SVG-middle cerebral anastomosis is visualized with revascularization of the MCA territory. The aneurysm has been trapped and excluded from the circulation. C, left carotid injection showing that the right ACA territory is supplied by the contralateral ACA via the A3–A3 bypass. D and E, postoperative CT angiograms demonstrating the patent SVG (arrows) routed beneath the mandible (D) and into the middle fossa craniectomy (E).*

ized by Sundt et al. (17, 18) in the early 1980s. Sehkar and Kalavakonda (9) recently reported their experience using high-flow revascularization strategies in the treatment of 72 patients with cranial base tumors and 50 patients with aneurysms, with a 95% graft patency rate. False-negative results of balloon occlusion tests have been reported as high as 22%, resulting in ischemic complications after acute sacrifice of the ICA (4, 6, 10). This has prompted some authors to recommend a universal approach to revascularization whenever the ICA is sacrificed to avoid an ischemic stroke (3, 9). Sekhar and Kalavakonda (9) advocated a high-flow bypass for all patients with cranial base tumors who undergo ICA sacrifice, but the issue of selective versus universal revascularization when planning ICA sacrifice remains controversial.

Ideally, the interpositional graft should be as short as possible and it should provide blood flow that approximates that of the bypassed ICA (1, 7). Flow mismatch because of size disparity between the donor graft and the recipient artery may promote graft occlusion. End-to-end anastomosis at both ends of the graft is preferred to reduce turbulent blood flow and promote graft patency (11). An end-to-end anastomosis is preferred at the proximal site to avoiding kinking of the graft. At the distal site, the graft is sized appropriately and anastomosed to the ophthalmic segment of the supraclinoid ICA between the ophthalmic artery and posterior communicating artery takeoffs. This is usually performed end to side to preserve the ophthalmic takeoff, or, if the ophthalmic artery is not preserved, as observed in Patient 1, the anastomosis is performed end-to-end (13). Alternatively, the M2 branch can also serve as a recipient vessel if the supraclinoid ICA is not a suitable for the bypass, as observed in Patient 2. The choice of bypass conduits (radial artery versus saphenous vein) is reviewed elsewhere. Cerebral protection with burst suppression and intravenously administered heparin during the anastomosis is critical for successful revascularization. We place these patients on oral aspirin preoperatively and indefinitely postoperatively.

Sekhar et al. (7, 8) and Sekhar and Kalavakonda (9) have described both preauricular and postauricular subcutaneous tunnel techniques for routing of the graft. Of these, the preauricular tunnel is preferred for the cervical-to-supraclinoid ICA bypass because it allows the graft length to be shorter and to assume a more physiological orientation. The zygoma and lateral floor of the temporal fossa must be removed to create a groove to accommodate for the tunneled graft. In general, subcutaneously tunneled grafts are longer and are at risk of external compression and torsion from head and neck movements.

The senior author (WTC) has used the submandibular route because it permits a more direct routing of the bypass graft to the recipient supraclinoid ICA or MCA. When the graft is tunneled superiorly and cut to the proper length, the overall length of the graft is shortened, promoting graft patency (1). In addition, the submandibular placement of the graft provides physical protection of the graft under the mandible, temporalis muscle, and zygoma. The technique provides a direct submandibular-infratemporal subtemporal passage through a small hole created in the middle fossa cranial base. The bony defect made in the floor of the middle fossa cranial base should be large to ensure that the graft does not kink on the bone edge during mandibular movements. Care should be taken to place the hole anterior to the temporomandibular joint to avoid injury to it. The hole is situated in the lateral aspect of the middle fossa and, therefore, very minimal temporal lobe retraction is needed after intravenous mannitol is administered for brain relaxation. We have not had any complications of temporal lobe edema in our experience. A zygomatic osteotomy is avoided and the insertions of the temporalis and masseter are left intact. The technique of submandibular passage with the tonsil clamp can be performed safely with simultaneous digital palpation and guidance. We have not experienced any injury of the lingual nerve, inferior alveolar nerve, hypoglossal nerve, or internal maxillary artery. This approach is located lateral to the oral cavity and thus avoids violation of the cavity. The advantages of this approach include a shorter surgical time, preservation of the facial anatomy, and creation of a short and safe route for passage of the saphenous vein or radial artery graft.

CONCLUSION

Direct submandibular-infratemporal interpositional SVG bypass can be performed without removal of zygomatic arch or detachment of the masseter or temporalis muscle insertions. This technique provides a direct and shorter route for revascularization, which helps promote graft patency and preserves normal facial anatomy.

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COMMENTS

The authors have described a new way to tunnel vein or arterial grafts from the neck to the intracranial compartment. One of the problems with high-flow bypasses occurs in the tunnel, wherein kinking or narrowing can occur, causing graft occlusion. The authors' experience with this technique is small, consisting of two cases, but both were successful. When the distal bypass is performed to the supraclinoid internal carotid artery (ICA), and some space exists in the infratemporal fossa because of tumor resection, then this type of bypass routing may be attractive. However, if the graft or the suture line is exposed to the nasopharynx because of malignant tumor resection, graft blow out can occur because of infection (V. Schramm, personal communication, 2002).

When the distal anastomosis of the graft is performed into the MCA, the graft has to turn sharply over the temporal lobe, and this may create flow problems, especially for vein grafts, wherein it is better to have them course as straightly as possible. I would be interested to know how the authors do with their next 48 patients.

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This article highlights the successful management of the most complex cases a neurosurgeon may face and is a credit to the senior author's expertise and skill. Submandibular positioning of the saphenous vein graft has been reported previously (1) along with its putative advantages of shorter graft length and graft protection. Preservation of the zygoma is an innovative addition that further decreases the potential approach-related morbidity. In Patient 1, we would have used an orbitozygomatic osteotomy in conjunction with a pterional craniotomy to allow the temporalis muscle to be displaced as inferiorly as possible. We think that this technique would lessen brain retraction and provide a wider working corridor for the middle fossa and petrous apex work than was performed. The authors' results, however, speak for themselves.

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1. Couldwell WT, Zuback J, Onios E, Ahluwalia BS, Tenner M, Mosctello A: Giant petrous carotid aneurysm treated by submandibular carotid-saphenous vein bypass. Case report. **J Neurosurg** 94:806–810, 2001.

The authors describe an elegant refinement of carotid artery revascularization with their submandibular-infratemporal interpositional graft from the cervical carotid artery to either the supraclinoid ICA or MCA. With this technique, the bypass graft is tunneled through a burr hole in the middle fossa floor, thereby avoiding removal of the zygoma and detachment of the temporalis and masseter muscles. This more direct route shortens the length of the bypass graft, which is a particularly important advantage with radial artery grafts. The available length of radial artery grafts is typically less than saphenous vein grafts and often barely enough to extend across the standard subcutaneous tunnel. Consequently, these radial artery grafts can have unwanted tension. The submandibular-infratemporal route eliminates this problem effectively and might also improve long-term patency rates, although this potential benefit is unproven. The authors have provided an innovative contribution that should be considered when carotid revascularization is planned.

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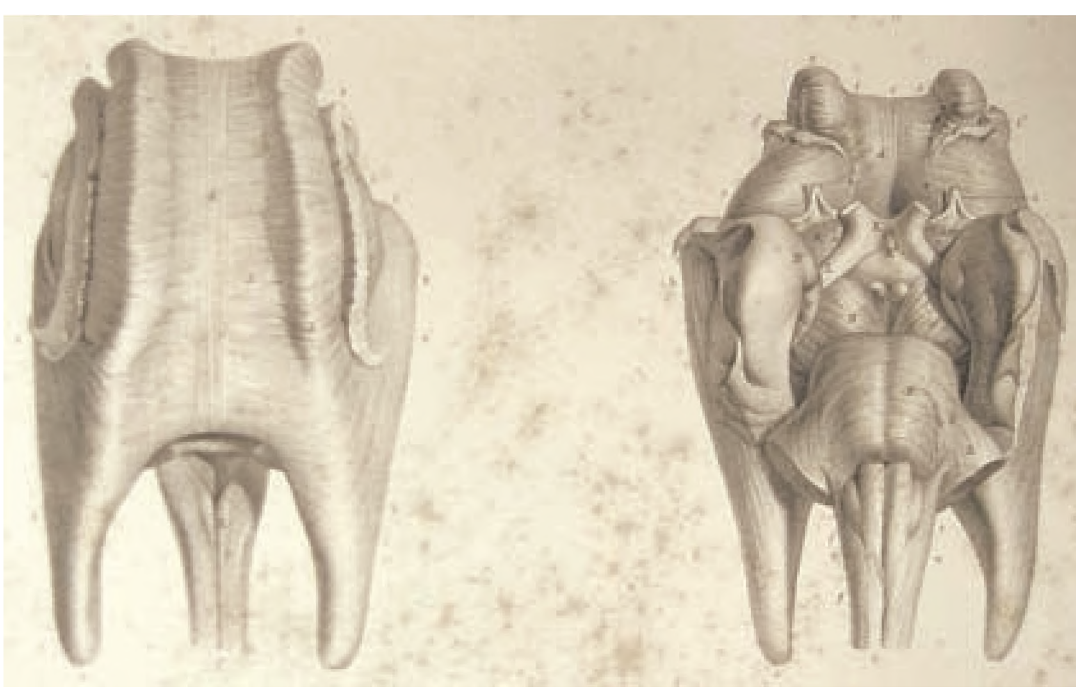
Couldwell et al. illustrate a technical modification in the interpositional carotid artery bypass procedure when the ICA should be acutely sacrificed for complex cranial base surgery and cerebral aneurysms not amenable of direct clipping or endovascular treatment. The proposed technique allows shortening of the graft using a middle cranial fossa window without the need for a zygomatic osteotomy. The article is well illustrated, and the two cases describe the proposed technical modification.

In the second patient, I think that a superficial temporal artery-MCA bypass should supply enough blood flow for the acute sacrifice of the MCA. The authors' choice reflects a different strategy in which a higher-flow bypass assures a more than sufficient supply to the MCA territory. Both choices (superficial temporal artery-MCA bypass and external carotid artery-MCA bypass) have advantages and disadvantages, and the surgical strategy should be tailored, in my opinion, to the experience and preference of the surgeon and, obviously, the diameter of the superficial temporal artery (1).

Even if the number of procedures using this advanced surgical technique decreased in recent years because of improved endovascular therapies and more reliable information for tolerance of ICA occlusion, I agree that the high-flow bypass between the cervical (or petrous) ICA and petrous or intracranial ICA through interpositional saphenous vein or radial artery graft should be in the armamentarium of each cranial base surgeon and neurovascular surgeon dealing with complex lesions.

Francesco Tomasello
Messina, Italy

1. Kawashima M, Rhoton AL Jr, Tanriover N, Ulm AJ, Yasuda A, Fujii K: Microsurgical anatomy of cerebral revascularization: Part II–Posterior circulation. **J Neurosurg** 102:132–147, 2005.



*Achille Louis Foville, 1799-1978, **Traité Complet de l'anatomie, de la Physiologie et de la Pathologie du Système Nerveux Cérébro-spinal.** Paris: Fortin, Masson, 1844 (Courtesy, Rare Book Room, Norris Medical Library, Keek School of Medicine, University of Southern California, Los Angeles, California.)*