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MAIN ARTICLE

# Open and endovascular repair of aneurysms affecting the distal extracranial internal carotid artery: case series

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## Abstract

*Objective*: Three cases of internal carotid artery aneurysm affecting the distal cervical segment were retrospectively reviewed.

*Methods*: Two patients underwent open surgical repair requiring petrous segment exposure for bypass of the affected segment using a Fisch type A lateral skull base approach. The third patient underwent endovascular stenting.

*Results*: There were no cerebrovascular complications post-operatively. Both open repair patients experienced temporary lower cranial nerve palsies. One required facial nerve grafting. All patients had patent grafts at follow up. The stent graft patient had a small endoleak at six months.

*Conclusion*: Endovascular and open approaches both have advantages and disadvantages. Treatment needs to be tailored to the lesion and the patient. An open surgical approach is difficult but well established. Endovascular treatment of these lesions is a relatively recent technique, and new cases need to be continually reported with a view to attaining long-term data.

**Key words:** Internal Carotid Artery; Aneurysm; Petrous Segment Exposure; Open Repair; Endovascular Repair; Morbidity

## Introduction

Aneurysms affecting the internal carotid artery (ICA) at the base of the skull are uncommon. Mycotic aneurysms affecting the extracranial carotid arteries are rare, with only 99 cases reported in the literature between 1950 and 2012.[1,2] Internal carotid artery aneurysms are life-threatening lesions with a high risk of thromboembolic sequelae and devastating haemorrhage,[3] but the optimal management remains unclear.[4]

The well-established open surgical approach requires optimal distal arterial access, which poses a risk to adjacent cranial nerves, and may lead to temporary or permanent dysfunction, particularly of the facial nerve. Endovascular repair is an attractive minimally invasive option.[5] However, long-term results are lacking,[5,6] and anatomical limitations such as tortuosity may restrict stent placement. Mycotic aneurysms warrant excision of the affected segment, limiting endovascular options.

This study aimed to retrospectively review the outcome of three patients who underwent repair of a distal ICA aneurysm.

## Materials and methods

### *Patient history*

*Patient one.* A 50-year-old male presented with odynophagia and fever following extraction of an infected left lower molar tooth. Examination revealed a left peritonsillar swelling and left Horner's syndrome. Computed tomography (CT) and magnetic resonance imaging (MRI) scans revealed a 4 cm aneurysm of the left cervical internal carotid artery (ICA), extending from vertebrae C1 to C3, and two areas of cerebral infarction in the left ICA territory. The provisional diagnosis was a mycotic aneurysm, and the patient was commenced on intravenous clindamycin and ciprofloxacin.

*Patient two.* A 64-year-old male presented with a right occipital infarct. A CT angiogram revealed a right cervical ICA aneurysm at its transition with the petrous ICA (Figure 1).

*Patient three.* A 68-year-old male presented with headaches. A CT scan revealed a distal ICA aneurysm, which CT angiogram showed to be 1.8 cm in diameter

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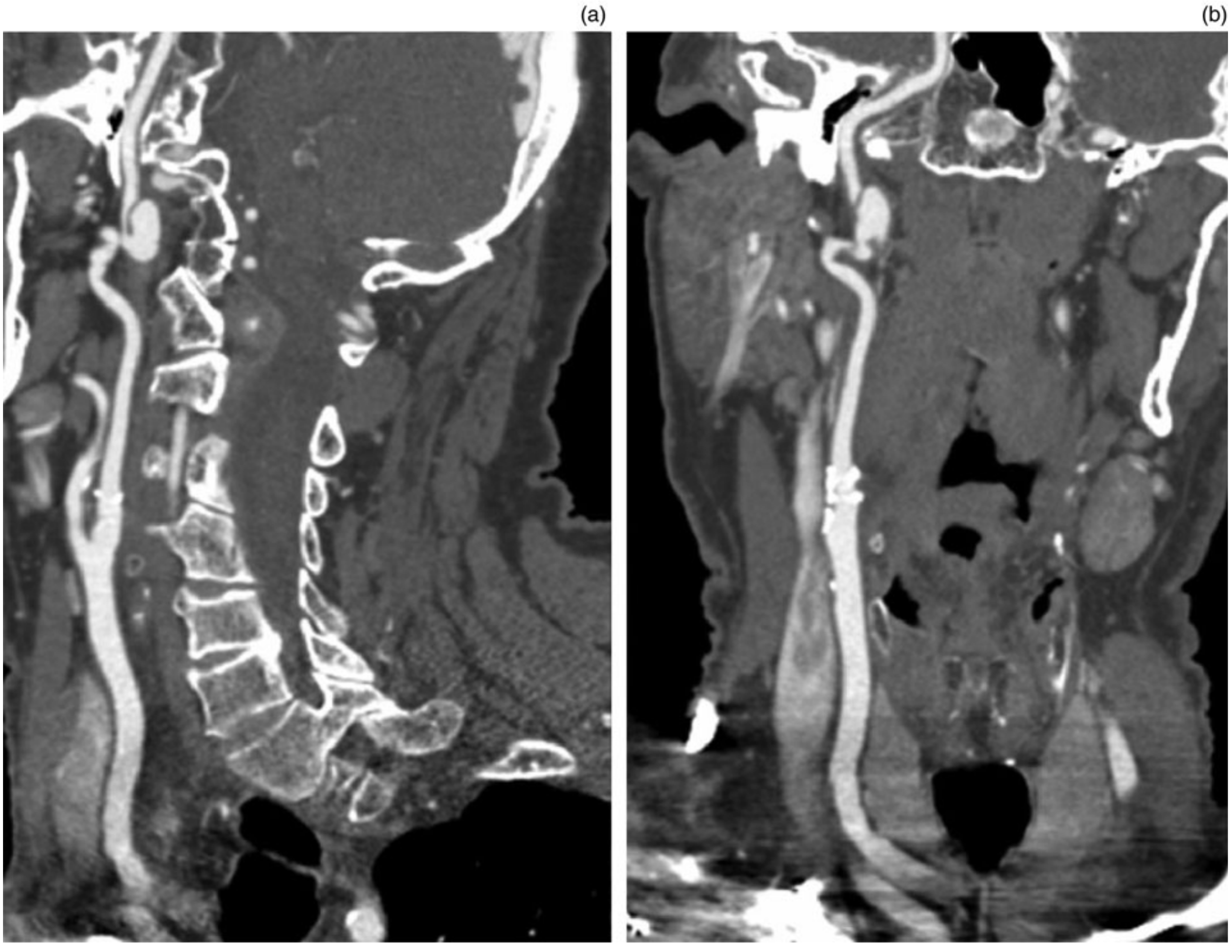


FIG. 1
(a) Lateral and (b) coronal views of pre-operative computed tomography angiograms of right cervical internal carotid artery aneurysm in patient two.

and saccular (Figure 2). Medical history included prior abdominal aortic aneurysm repair, and bilateral popliteal and femoral artery aneurysms not requiring intervention.

*Intervention*

Patients one and two both underwent pre-operative balloon occlusion testing, angiograms, CT and MRI. Both patients tolerated balloon occlusion testing. The distal limit of both aneurysmal sacs extended into the petrous segment of the artery. Endovascular stenting was deemed unsuitable in both patients because of vessel tortuosity.

Patients one and two underwent open repair (Figure 3), involving the combined skills of a skull base otologist and a vascular surgeon. A Fisch type A approach,[7] including blind sac closure and facial nerve transposition, was employed for exposure. A reversed long saphenous vein graft was used in both patients, with proximal and distal anastomoses being constructed end to end.

In patient two, the distal arterial wall was friable, and, despite the exposure, suture placement and anastomotic repair was found to be technically very challenging. The facial nerve was thin and friable, and during retraction of the wound, the nerve was divided. It was repaired using a greater auricular nerve interposition graft. The patient underwent gold weight insertion and medial canthoplasty of his right eye for corneal protection during his admission.

The length of the procedure for patients one and two was 11 hours and 9 hours, and length of stay was 20 days and 19 days respectively.

Patient three underwent a stent graft repair of his aneurysm (Figure 2) using a Jostent® polytetrafluoroethylene-covered coronary stent graft measuring 5 × 26 mm over a 0.36 mm (0.014 inch) guide wire. Angiography performed immediately after stent deployment showed successful exclusion of the aneurysm sac. The length of the procedure was under 2 hours and the length of stay was 4 days.

## Results

The aneurysms were successfully repaired in all patients, with no embolic or ischaemic sequelae. All patients had graft patency at follow up.

Patients one and two both experienced deficits of the facial and lower cranial nerves immediately following

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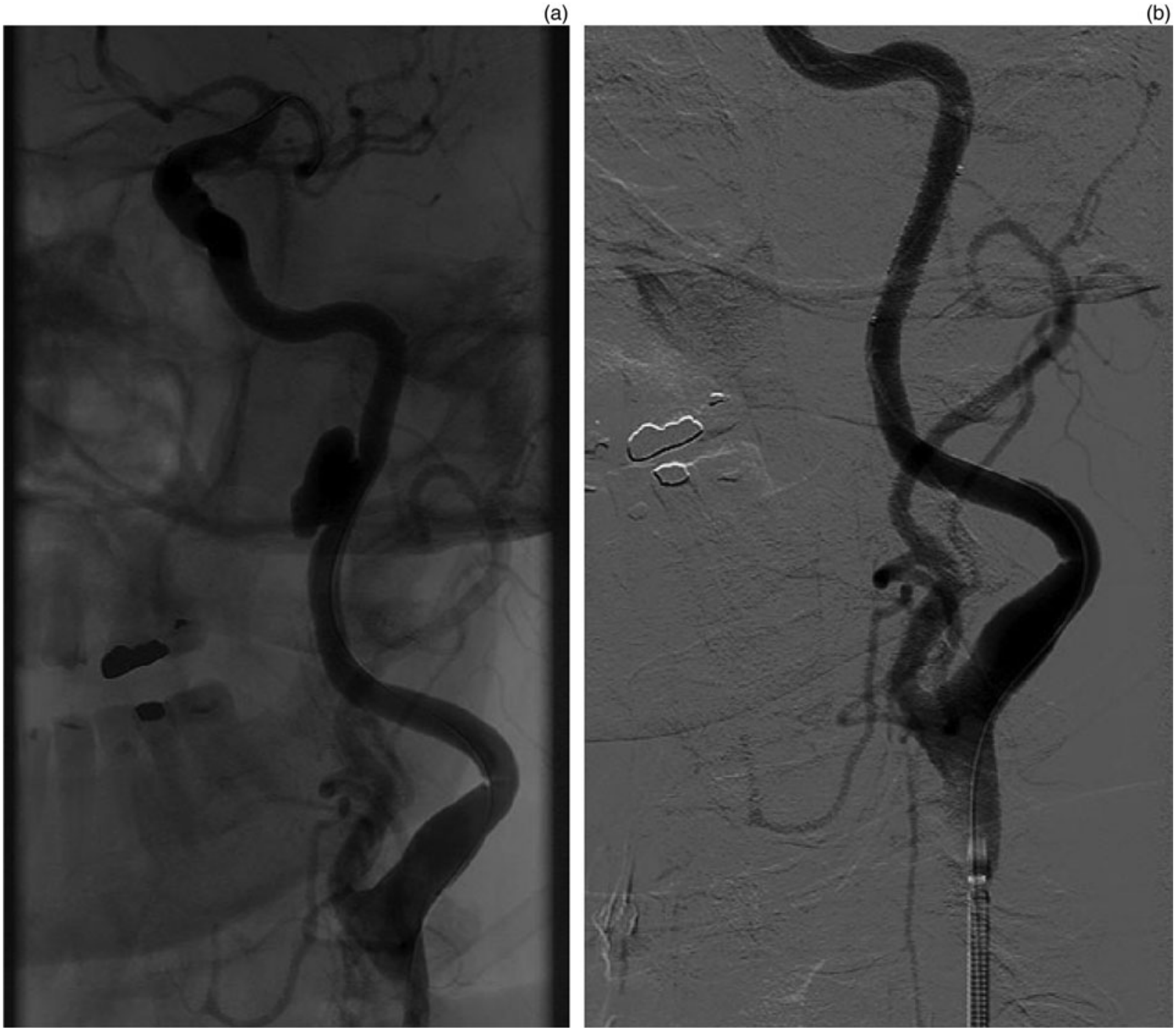


FIG. 2
Angiograms of left internal carotid artery aneurysm before (a) and after (b) stent deployment in patient three.

the operation, which recovered completely within eight and two months respectively, except the recovery of the facial nerve in patient two. At 12 months post-operation, patient two is starting to have movement in his face. Neither patient required the support of a tracheostomy or gastrostomy tube.

Patient one was found to be α1 antitrypsin deficient, and he required ongoing care by a neurologist and a vascular physician. Ultrasound examination showed graft patency 16 months post-operatively. He was implanted with a bone-anchored hearing aid (BAHA) to correct the conductive hearing loss following blind sac closure. His aided speech score was 99 per cent, compared to an unaided score of 46 per cent.

Patient two underwent a CT angiogram at six months; this revealed a 50–60 per cent distal anastomotic stenosis, which is being observed. Unfortunately, he continues to smoke.

Patient three had no neurological sequelae. Clopidogrel was added to his warfarin therapy. At six-months' follow up, CT angiogram revealed a patent stent, with a small endoleak possibly at the proximal fixation of the stent. The aneurysm sac is almost entirely excluded from flow and there is little embolic risk. Therefore, this is being monitored conservatively. An additional stent graft may be required in the future.

## Discussion

Untreated internal carotid artery (ICA) aneurysms are associated with a high risk of thromboembolic sequelae,[4] with a reported mortality and stroke risk of 50 per cent.[8–10] These complex lesions are uncommon and require a multidisciplinary approach to management. The treatment options include occlusion (surgical or endovascular), surgical repair or bypass (including extracranial-intracranial), or endovascular repair.

Carotid occlusion carries a 24 per cent risk of ischaemic complications,[11] and pre-operative balloon occlusion testing may result in a false negative finding.[12–14] Carotid sacrifice also limits future treatment strategies should the patient develop pathology in the remaining extracranial arteries. This is particularly relevant as

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FIG. 3

Computed tomography angiograms of patient two following repair of right internal carotid artery aneurysm, showing: (a) coronal view of the repair and (b) a three-dimensional reconstruction.

these patients may have an underlying predisposition to develop vascular disease, as seen in patients one and three. Therefore, carotid occlusion is not a preferred treatment option.

Surgical repair remains the most definitive strategy in the management of these lesions. Considerations include the anatomical exposure required, the potential for cerebral ischaemia during arterial clamping, conduit requirements and the pathology being treated.

The options for surgical repair of the aneurysm include: aneurysm resection and end-to-end anastomosis; aneurysmorrhaphy and patch angioplasty; or bypass grafting.[15] Good results can be expected with surgical repair, with long-term stroke-free rates of 87 per cent reported at 20 years' follow up.[16]

The need to obtain adequate access to the ICA beyond the aneurysm can present a significant challenge (such as in patient two). For distal ICA aneurysms, a standard neck dissection will not allow adequate arterial exposure and alternative approaches are required. Since the description of infratemporal fossa exposure by Fisch *et al.*, in 1984,[7] many approaches have been identified, each with various advantages and disadvantages.[4] Our exposure is based on Fisch and colleague's lateral skull base approach.[7]

The disadvantages of the lateral skull base approach include the obligatory conductive hearing loss in the affected ear due to blind sac closure, which can be addressed by the use of a BAHA. More serious risks include temporary or permanent cranial nerve deficits. Malikov *et al*. reported on a series of 13 patients who all had a partial facial nerve palsy which was transient only.[6] Lower cranial nerve palsy affecting speech and swallowing is often due to neuropraxia, as the lower cranial nerves may be adherent to the wall of the sac. Facial nerve palsy may occur if transposition is required, but this is often transient. If the nerve is divided, repair is required. In this case, the best expected outcome is House–Brackmann grade III palsy.[17] Trauma to the nerve is most likely to occur with the retraction required to facilitate distal arterial exposure.

In regards to defining the potential for intra-operative cerebral ischaemia, balloon occlusion testing has a role. Immediate severe cerebral ischaemia is uncommon with ICA clamping.[18] If balloon occlusion of the ICA does cause significant cerebral ischaemia, this

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increases the complexity of the surgical repair. Shunt insertion may not be possible for distal ICA aneurysms. Use of cerebral protection strategies is a potential option. Additionally, extracranial-intracranial bypass combined with carotid occlusion can be considered.[19]

Management options may be limited by pathology, such as a mycotic aneurysm (patient one), requiring excision and surgical reconstruction with autogenous conduit. Mycotic aneurysms[20–22] treated non-surgically have high rates of rupture or thromboembolism, with mortality reaching 70–90 per cent.[2] Prior to 1980, ligation was considered standard treatment,[23] and had a mortality of 40 per cent and post-operative stroke incidence of 50–60 per cent.[2,23,24] More recent publications have advocated reconstruction using autogenous conduit, with non-septic mortality reported to have reduced to 4 per cent.[2,23,24] Mycotic aneurysms compound complexity and mortality in an already uncommon pathology. Prompt and aggressive surgical care is essential for optimal management of these lesions.

Autogenous conduit is the preferred option for carotid aneurysm reconstruction. Long saphenous vein is often well size-matched. For non-infected cases, prosthetic conduit can be used safely if autogenous conduit is not available.[25]

Endovascular repair results in less peri-operative morbidity than surgery.[26] Furthermore, it avoids concerns regarding anatomical exposure, ICA clamping and conduit availability. Endovascular repair is not ideal for infected cases; however, it can be used as a temporising strategy, for example, to treat haemorrhage. In some cases, endovascular stents combined with antibiotic therapy can achieve successful long-term outcomes for infected aneurysms.

The options for endovascular repair include bare-metal stent placement with transstent coiling, or the use of stent grafts.[27] The limitations of endovascular repair include the requirement to obtain stable access to the target vessel and the availability of appropriate stents. Access to the target artery may be complicated by aortic arch and common carotid artery tortuosity and disease. In some cases, it may be possible to introduce the sheath through the common carotid artery in the neck rather than through the femoral artery, thus bypassing problems encountered in the aortic arch.

The ideal stent for distal ICA aneurysm repair would have a low profile, be compatible with 0.36 mm (0.014 inch) guide wire, have good trackability and have a monorail delivery system. Balloon expandable stent grafts can achieve good results; however, long and tortuous aneurysms may not respond well. Furthermore, stents may not be available to treat ICAs with large diameters or significant diameter changes between proximal and distal landing zones.

Future advances in stent design may overcome these problems. Despite these limitations, for suitable lesions, such as in patient three, endovascular repair is an attractive option and can yield good results.[5,28] Successful graft patency rates of 93.2 per cent at 15 months, stroke rates of 1.8 per cent and endoleak rates of 8.1 per cent have been reported.[5]

- **Extracranial internal carotid artery aneurysms are rare, life-threatening lesions, with a high risk of thromboembolic sequelae and haemorrhage**
- **Treatment options include occlusion, surgical repair or bypass, or endovascular repair**
- **Surgical repair is a well-established, definitive management strategy for these lesions, despite some risk of long-term morbidity**
- **Endovascular stenting is a new, less invasive treatment modality for the appropriate patient, with good results**
- **Long-term results of endovascular stenting are lacking, and successes and failures should continue to be reported**

In summary, the optimal treatment strategy for distal ICA aneurysms involves careful consideration of factors that are critical to each approach. In many cases, a preferred option will become evident. In equivocal cases, endovascular repair has short-term morbidity advantages; however, the long-term results are not known.

## Conclusion

Future treatment of these rare and complex lesions will involve the complimentary use of surgical and endovascular techniques. To enable a better understanding of the strengths, limitations and outcomes of these techniques, it is essential that both successes and failures continue to be reported in the literature.

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