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Bare Metal Stents for Treatment of Extracranial Internal Carotid Artery Aneurysms: Long-term Results

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Abstract

Purpose: To examine the long-term outcomes of bare metal stent placement for exclusion of extracranial internal carotid artery (ICA) aneurysms. **Methods:** From 2006 to 2011, 7 consecutive symptomatic patients (4 men; mean age 52 years) with surgically inaccessible extracranial ICA aneurysms were treated with a bare stent at a single center. Patients received clopidogrel for 3 months after the procedure and aspirin for life. Clinical follow-up with duplex ultrasound and/or computed tomographic angiography was performed at 3, 6, and 12 months and yearly thereafter. **Results:** All procedures were technically successful; no neurological complications occurred. After 6 months, there was complete thrombosis of the aneurysm in all except one case. In this asymptomatic patient, the residual active flow was successfully obliterated by additional coil embolization. Over a mean follow-up of 57±22 months, all patients were alive and free of local or central neurological symptoms. All stents were patent, and thrombosis of the aneurysms was complete. **Conclusion:** In this small series, treatment of extracranial ICA aneurysms with a bare stent seems technically feasible and safe. All treated extracranial ICA aneurysms were excluded by primary intervention or secondary coil embolization.

Keywords

aneurysm, internal carotid artery, bare metal stent, endovascular treatment, carotid artery stenting, extracranial carotid aneurysm

Introduction

Surgical treatment of an extracranial internal carotid artery (ICA) aneurysm is a rare intervention, compromising <2% of all arterial aneurysm repairs.[1] If left untreated, ICA aneurysm may lead to significant morbidity[2] and remain as a potential source of emboli to the brain.[3] A carotid aneurysm may also present as a pulsating cervical mass or cranial nerve dysfunction due to local compression. In symptomatic patients, complete aneurysm resection with arterial reconstruction is currently considered the treatment of choice.[4–6] However, no evidence-based guidelines exist for extracranial carotid aneurysm treatment, and numerous techniques for exclusion have been reported in literature.[4]

Extracranial ICA aneurysm at the base of the skull often can be approached surgically, but distal exposure and control may be hard to obtain.[6–9] Therefore, stent placement has been proposed as an alternative in these situations. The stent needs to bridge healthy to healthy artery and subsequently promote thrombosis in the excluded aneurysm with continuation of blood flow to the brain. In the scarce available literature, mostly covered stents have been applied in the treatment of extracranial ICA aneurysms.[10] Some investigators have shown that pressure reduction and exclusion of intracranial aneurysms is feasible using bare metal stents alone or combined with coil placement.[11,12] We report our preliminary experience with bare stent placement in patients with surgically difficult-to-access true extracranial ICA aneurysms.

Methods

Patients

Between 2006 and 2011, 38 patients with 43 extracranial ICA aneurysms were seen at our tertiary referral center. Of

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Table 1. Patient Data and Treatment Outcomes.

Sex/Age, y	Presenting Symptoms	Treatment Year	Type of Stent	Outcome at 30 Days	Follow-up, mo	Long-term Patency	Long-term Follow-up
1. M/55	Horner syndrome, headache	2006	Precise	Hematoma	72	Good[a]	Asymptomatic
2. F/33	Asymptomatic, ED type 4	2006	Neuroform (×2)	Asymptomatic	84	Good[a]	Transient weakness right arm interpreted as epilepsy
3. M/56	Mass	2006	Precise	Asymptomatic	67	Good[a]	Asymptomatic
4. F/43	Tinnitus left ear	2007	Protégé	Asymptomatic	68	Good[a]	Asymptomatic
5. F/73	Pulsating sensation	2007	Precise	Hematoma; temporary hypoglossal nerve dysfunction	51	Persistent sac flow (CE)	Asymptomatic
6. M/50	Stroke	2009	Precise	Hematoma; temporary facial nerve dysfunction	26	Good[a]	Asymptomatic
7. M/54	Asymptomatic	2011	Solitaire	Asymptomatic	28	Good[a]	Asymptomatic

Abbreviations: ED, Ehlers-Danlos; CE, coil embolization.
[a]Good: no stenosis, aneurysm excluded.

these, 24 aneurysms in 19 patients were treated conservatively, 11 patients underwent surgery, and 8 patients were treated with an endovascular intervention. In the endovascular subgroup, one aneurysm was excluded by coil embolization; the other 7 consecutive patients (4 men; mean age 52 years) with true ICA aneurysms were treated with a bare stent (Table 1) after providing informed consent. Etiology was dissection or trauma in 4 patients, Ehlers-Danlos type IV in 1, and unknown in the other 2, with no signs of dissection on imaging. Five patients were symptomatic; the other 2 had proven aneurysm growth. All patients underwent computed tomographic angiography (CTA). Indications for treatment were discussed within a multidisciplinary vascular panel. All aneurysms were located in the distal ICA and therefore not suitable for surgical resection. Patients were started on dual antiplatelet treatment (clopidogrel 75 mg/d and aspirin 100 mg/d) before treatment.

Stent Placement

Access to the ICA was obtained through a femoral approach in 2 (Figure 1A) or via a direct common carotid artery puncture after standard surgical exposure in 5 patients who had significant kinking in the ICA. In 3 of these patients, the carotid artery was manually straightened; in the other 2, the severely elongated ICA required surgical shortening to facilitate access of guidewires and positioning of a stent in the distal ICA (Figure 1B). When stent placement was combined with a surgical procedure, patients were operated on under general anesthesia with perioperative transcranial Doppler and electroencephalographic monitoring according to standard hospital protocol for carotid surgical procedures.[14,15] The percutaneous transfemoral procedures were performed under local anesthesia and sometimes light sedation.

After ICA access was obtained, a 0.014-inch guidewire (Choice PT; Boston Scientific, Natick, MA, USA) was introduced. After carefully maneuvering the guidewire cranially past the aneurysm, a self-expanding bare stent [Precise (Cordis, Bridgewater, NJ, USA), Protégé (Covidien, Mansfield, MA, USA), Solitaire (Covidien), or Neuroform (Boston Scientific)] was selected based on aneurysm characteristics, vascular anatomy, and diameter of the vessel. In aneurysms with difficult-to-access aneurysms because of loops or kinking, the Neuroform or Solitaire stent was chosen because of superior maneuverability. In one patient, the stent within a stent technique was used to increase the overall metal surface coverage and redirect blood flow.[13] ICAs with a >5-mm reference diameter were treated with a Protégé or Solitaire stent. All stents were deployed overlapping at least several millimeters of the proximal and distal disease-free carotid artery (Figure 1). Technical success, defined as correct stent position overlapping sufficient proximal and distal disease-free artery without compromising the vessel lumen, was assessed by control angiography immediately following stent placement.

Follow-up

Clinical surveillance was routinely performed with CTA or duplex ultrasound at 3, 6, and 12 months after the procedure and yearly thereafter. All patients continued to receive aspirin lifelong; clopidogrel was stopped 3 months after the procedure.

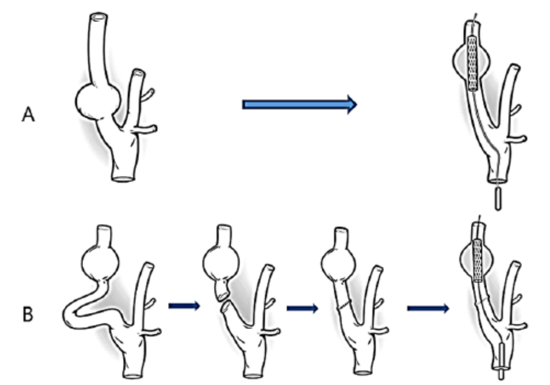

Figure 1. (A) An aneurysm located in the internal carotid artery (ICA) treated with stent placement over the extracranial carotid artery. The stent is deployed overlapping at least several millimeters of the disease-free artery. (B) Aneurysm located in the distal ICA. First the loop in the artery is resected followed by primary end-to-end anastomosis. The stent is deployed over the aneurysm as in figure A.

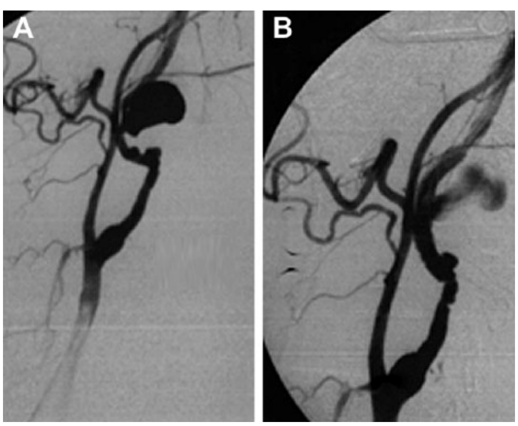

Figure 2. (A) An aneurysm located in the distal internal carotid artery (ICA) before stent placement. (B) Reduced filling of the aneurysm sac after stent placement.

Results

The stent was deployed at the predetermined position in all patients. Completion angiography showed reduced filling of the aneurysm sac in all patients (Figure 2). No emboli were registered by transcranial Doppler during the combined surgical and endovascular procedures, and electroencephalography did not indicate perioperative cerebral ischemia. No deaths or strokes occurred within 30 days of intervention. Two patients (numbers 5 and 6, Table 1) experienced temporary nerve palsy due to wound traction, with stretching of the auricular branch of the facial nerve; they fully recovered during follow-up.

Figure 3. (A) Residual flow in the internal carotid artery (ICA) aneurysm after plicature of the carotid artery and subsequent stent placement. (B, C) Coil placement in the aneurysm sac with total exclusion.

Clinical follow-up was available for all patients with a mean duration of 57±22 months (range 26–84). All patients were alive and without any local or central neurological symptoms during follow-up, which included 17 CTAs and 18 duplex examinations in total. After 6 months, all aneurysms were thrombosed except one (Table 1). In this asymptomatic patient (number 5), scheduled CTA revealed active flow in the aneurysm sac. In addition to clopidogrel, the patient had also been using acenocoumarol for several years after a myocardial infarction. This leakage of contrast through the stent struts was successfully treated by placing coils through the meshwork of the stent until total exclusion of the sac was achieved (Figure 3). Duplex at 3 months after the coil procedure showed no evidence of residual flow in the aneurysm, which had reduced in size. None of the other 6 patients underwent any additional vascular procedure during follow-up. At the most recent examination, the stent was fully patent and thrombosis of the aneurysm sac was complete in all 7 patients.

Discussion

Accessing an extracranial carotid artery aneurysm can be difficult when it is located distal in the ICA or there is proximal vessel elongation. In our limited series, we showed successful exclusion of the sac using bare stents with the option to place coils at a later stage in case of incomplete thrombosis. The procedure has provided good clinical and technical results in all patients, the majority followed for >5 years.

When we began this study, we anticipated that additional interventions, such as coil placement, would be necessary in perhaps half of the patients. Heretofore, exclusion of aneurysms with bare stents had been demonstrated primarily in intracranial aneurysms with coronary stents (15% metal surface coverage). Angiographic follow-up after 1 year showed more than three-quarters of the patients had complete aneurysm occlusion after initial stent placement.[16] A complete obliteration rate of 66% was also demonstrated after placement of the Neuroform stent (6.5% to 9.5% metal coverage) in intracranial aneurysms.[11] The 86% complete initial obliteration rate in our series was higher than expected.

If stent placement is not sufficient to achieve complete thrombosis of the aneurysm, several additional treatments are available. When there are no clinical symptoms and no aneurysm growth, a wait and see policy can be applied. Carotid aneurysms are considered to have a low risk for rupture, and thrombosis of the aneurysm induced by stent placement will probably prevent thromboembolic events.[17] If continued aneurysm perfusion produces symptoms or induces aneurysm growth, coil embolization through the stent meshwork is possible, as demonstrated in our patient.[18–21]

The mechanism of aneurysm treatment by uncovered stents is probably multifactorial. First of all, it is based on the hemodynamics in the aneurysm sac. For an aneurysm without collaterals, blood flowing into the sac generates vortices. The turbulence becomes stronger until they reach the aneurysm outlet. These continuous movements induce stress in the arterial wall.[22] A postulated mechanism of aneurysm exclusion by an uncovered stent is inflow alteration by the stent skeleton. The stent redirects the blood flow from a vortex into laminar flow, leading to stasis of blood in the sac that promotes thrombosis.[23–26] Although theoretically every stent will have a certain effect on the inflow of the aneurysm, unfortunately there is no scientific evidence regarding the degree of blood flow redirection of the different stents. Furthermore, stent placement will change (straighten) the geometry of the vessel, which influences inflow and promotes stasis and thrombosis within the aneurysm. Another factor adding to aneurysm exclusion could be endothelialization and fibroblastic infiltration of the stent from the adjacent vascular wall or circulating myofibroblasts.[23,24,26]

It must be noted we used these stents in a non-branching artery and probably dissecting aneurysms. In arterial branching, a monolayer stent will decrease the vortex but it will persist, while a multilayer stent will laminate the flow.[22]

The superior flexibility of bare stents compared to covered stents is very useful in guiding through the often tortuous carotid arteries.[27] The superior flexibility of the bare stents compared with the covered stent might also result in less stent-induced kinking because the bare stent is more prone to adjust to the shape of the vessel. Besides flexibility, bare stents have another advantage: covered stents are more prone to in-stent stenosis and thrombosis at short- and long-term follow-up.[28,29]

In 2006, when we started using bare stents in ICA aneurysms, flow-diverting stents (FDS; 30% to 35% metal coverage) were just coming to market. They had been developed after promising outcomes of bare stent monotherapy in intracranial aneurysms (obliteration rates of 86% to 93%[30,31]). In our study, we demonstrated an obliteration rate of 86%; even taking into account the additional intervention in one patient, this method would still have been less expensive than if we had used an FDS. Even today, with the wide availability of FDS, bare stent placement in extracranial ICA aneurysms could be more economical.

Limitations

The single-center experience and small number of patients in our study as a result of the low incidence of ICA aneurysm are shortcomings of this study. Because of different morphology of the aneurysms and anomalies of surrounding anatomy, different type of stents and access modes had to be used. Nonetheless, we were able to achieve durable aneurysm exclusion with only one reintervention in our cohort.

Conclusion

Bare stent treatment is technically feasible and safe in a non-branching aneurysm of the extracranial ICA. Our limited experience in this small series has produced excellent medium and even long-term outcomes.

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Declaration of Conflicting Interests

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