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Clinical Study

Stent recanalization of carotid tonsillar loop dissection using the Enterprise vascular reconstruction device

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ABSTRACT

Although advances in endovascular techniques have permitted reconstruction of intimal dissections and related pseudoaneurysms of the extracranial cervical internal carotid artery, highly tortuous tonsillar loop anatomic variants still pose an obstacle to conventional extracranial self-expanding carotid stents. During a 12 year period, nine of 48 cases with cervical carotid dissections were associated with a tonsillar loop. Five patients required endovascular treatment, which was performed using a microcatheter-based technique with the low-profile Enterprise vascular reconstruction device (Codman Neurovascular, Raynham, MA, USA). Technical, radiographic, and clinical outcomes were analyzed for each patient. Dissection etiology was spontaneous in three patients, iatrogenic in one, and traumatic in one. Four near-occlusive tonsillar loop dissections were successfully recanalized during the acute phase. Dissection-related stenosis improved from 90 ± 22% to 31 ± 13%, with tandem stents needed in three instances to seal the inflow zone. There were no procedure-related transient ischemic attacks (TIA), minor/major strokes, or deaths. Angiographic follow-up for a mean of 28.0 ± 21.6 months showed all stents were patent, with average stenosis of 25.2 ± 12.2%. Focal ovalization and kinking of the closed-cell design was noted at the sharpest curve in one patient. Clinical outcome (follow-up of 28.1 ± 21.5 months) demonstrated overall improvement with no clinical worsening, new TIA, or stroke. Tonsillar loop-associated carotid dissections can be successfully and durably recanalized using the low-profile Enterprise stent with an excellent long-term patency rate and low procedural risk. The possibility of stent kinking and low radial force should be considered when planning reconstruction with this device.

1. Introduction

Internal carotid artery (ICA) dissection is a common cause of ischemic stroke, especially in young patients, and can lead to significant morbidity [1–3]. Carotid dissections have a poorly understood natural history and are classified as spontaneous, traumatic, or iatrogenic, with several risk factors identified [4,5]. Endovascular recanalization can provide significant benefits in a subset of patients, including hemodynamically significant stenosis with poor collaterals/isolated hemisphere, bilateral or multi-vessel dissection, development of enlarging dissecting pseudoaneurysm, or symptomatic failure of medical therapy [6,7].

Improvements in endovascular reconstruction techniques have enabled the recanalization of dissections involving the straight or gently curved cervical ICA, using large profile self-expanding biliary or carotid atherosclerosis stents [6,8–15]. Nonetheless, severe cervical ICA tortuosity remains a unique challenge for this treatment modality. Specifically, tonsillar loop anatomic variants of the ICA, which have been shown to confer an increased risk of traumatic dissection, remain a therapeutic conundrum [16–18]. The stiff extracranial self-expanding biliary or carotid stents are unable to navigate or be deployed across a tonsillar loop or >180° turn without iatrogenic injury [19,20].

In contrast, low-profile self-expanding stents intended for intracranial coil support are designed for navigating tortuous anatomy through low-profile microcatheters and are excellent for atraumatic passage through the tight bends encountered in cervical ICA tonsillar loops. We present a series of patients, demonstrating the endovascular management of cervical carotid dissection in the setting of tonsillar loop anatomy, employing the low-profile closed-cell design Enterprise nitinol self-expanding stent (Codman Neurovascular, Raynham, MA, USA).

2. Methods

2.1. Patient selection criteria

From June 2007 through June 2012, five patients underwent endovascular stent reconstruction of cervical ICA dissections

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involving tonsillar loop anatomy at our center. Patients were considered eligible for stent therapy only if they had failed optimal medical therapy, had hemodynamically significant flow-limiting stenosis, developed an intraprocedural iatrogenic flow-limiting dissection or progressively enlarging pseudoaneurysm, or were unable to undergo anticoagulation. Procedure details and clinical outcome at last follow-up are provided.

2.2. Procedure

In elective cases, patients were administered clopidogrel 75 mg/day (Bristol-Myers Squibb/Sanofi Pharmaceuticals, New York, NY, USA) and aspirin 325 mg/day (acetylsalicylic acid) a minimum of 3 days before intervention; in acute interventions, a bolus of 325 mg of aspirin and 600 mg of clopidogrel administered by gastric tube, and an intraprocedural bolus of weight-based intravenous eptifibatide (Merck, Whitehouse Station, NJ, USA) was administered followed by intravenous drip (1 mcg/kg/minute) for 24 hours with a continued oral regimen of aspirin and clopidogrel daily. Complete digital subtraction angiography (DSA) was performed of the entire cerebral circulation for evaluation of collateral flow pattern and caliber of the anterior/posterior communicating arteries. After femoral arterial access, a baseline activated clotting time was obtained, and a weight-based bolus of intravenous heparin (70 U/kg) was administered to achieve an activated clotting time of greater than 240 seconds; this was halted after administration of eptifibatide.

The dissection flap was analyzed to recognize true from false lumen. Next, a Synchro or Synchro-2 Soft microwire (Stryker Neurovascular, Fremont, CA, USA), selected for its low stiffness to avoid distorting the tonsillar loop anatomy, was used in conjunction with a Prowler Plus or Prowler Plus Select (Codman Neurovascular) to gently access and stay within the true lumen as the tonsillar loop was navigated. Once distal to the tonsillar loop, a run was performed to insure distal position within the true lumen. Contrast was administered to ensure diffusion within the entire lumen of the distal carotid artery rather than a focal false luminal pocket. The appropriate length Enterprise stent was then deployed to recanalize the dissected lumen. In cases where the inflow zone of the dissection was proximal to the tonsillar loop, an exchange length microwire was used to deliver either a Protégé extracranial carotid stent (ev3 Endovascular, Plymouth, MN, USA) or an Xpert biliary stent (Guidant, Indianapolis, IN, USA) of larger diameter to accommodate the greater caliber of the proximal ICA and tack down the proximal intimal flap. Stenosis was measured on two dimensional DSA using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) method [21] with Osirix digital imaging software (Osirix Foundation, Geneva, Switzerland).

3. Results

During the 12 year period from October 2001 through June 2012, 48 patients presented with cervical ICA dissection. Nine of these involved tonsillar loop anatomy, of whom five underwent endovascular therapy. All patients were women, aged 39–77 years with a mean age ± standard deviation (SD) of 52 ± 11.6 years. Patient demographics, presentation, etiology, and indications for treatment are displayed in Table 1. Three patients had spontaneous dissection, two were associated with trauma, and one patient had an iatrogenic dissection. Four patients (Patients 6 to 9) did not meet the criteria for endovascular recanalization and were treated medically. Procedural data are presented in Table 2. There were no procedural complications and all cases were technically successful. In three patients, one or two Enterprise stents were used alone. Two patients required additional placement of a proximal conventional biliary or carotid stent to tack down the inflow zone in the more proximal parent vessel. Patient 2 had a dissecting pseudoaneurysm that was treated with coil embolization using the jailing technique (see Section 4. Illustrative patients).

Clinical and radiographic follow-up data are summarized in Table 3. The four near-complete occlusions were recanalized and the dissecting pseudoaneurysm was occluded. The average ± SD dissection-related stenosis was 90 ± 22% prior to treatment and improved immediately post-treatment to 31 ± 13% ($p < 0.01$). Patients were followed radiographically with MRI and magnetic resonance angiography (MRA), computed tomography angiography and DSA, with an average ± SD angiographic follow-up of 28.0 ± 21.6 months. At the last follow-up, dissection-related stenosis improved or remained stable in all patients, with an average stenosis of 25.2 ± 12.2% (Fig. 1). Upon discharge, the clinical status of all patients had either improved or remained stable with a latest clinical follow-up mean of 28.1 ± 21.5 months (range, 10 days to 58 months).

4. Illustrative patients

4.1. Patient 2

A 47-year-old left-handed woman presented to a community hospital with acute onset of right-sided weakness and global aphasia, with a National Institutes of Health Stroke Scale (NIHSS) score of 23. She was administered intravenous tissue plasminogen activator (tPA), with an improvement of NIHSS score to 13. Further workup revealed a left ICA dissection. The following day her symptoms worsened. A CT scan demonstrated a dense left middle cerebral artery (MCA) sign, and the patient was transferred to our institution for endovascular intervention. Angiography revealed a left cervical ICA dissection without distal flow (Fig. 2A). After several attempts, the true lumen was accessed via a microcatheter, revealing a 360 degree tonsillar loop involved in the dissection (Fig. 2B). Intra-arterial tPA was administered in the distal lumen and an exchange wire was used to change the Excelsior SL-10 (Boston Scientific, Boston, MA, USA) to a Prowler Plus Select microcatheter. The distal ICA was catheterized, revealing the M1 occlusion (Fig. 2C). Thrombolytic therapy was administered to recanalize the MCA. Two Enterprise stents were deployed across the distal dissection flap in tandem within the tonsillar loop. Finally, a 5 mm × 40 mm Guidant Xpert stent was deployed concentrically within the proximal Enterprise stent across the proximal dissection flap, re-establishing flow through the left ICA (Fig. 2D). Cone beam computed tomography reconstruction demonstrated some kinking of the stent interstices at the apex of the curvature (Fig. 2E). Despite this kinking, the intimal flap was tacked down and the vessel caliber restored. Follow-up imaging 1 year later demonstrated patency of the stent construct and preserved distal flow (Fig. 2F).

4.2. Patient 3

A 60-year-old woman presented to an outside hospital with two episodes of headache and neck pain. CT scan demonstrated subarachnoid hemorrhage (SAH). A ruptured 4 × 10 mm wide-necked anterior communicating artery aneurysm and a right cervical ICA tonsillar loop were noted on DSA (Fig. 3A, left panel). The anterior communicating artery aneurysm was coiled endovascularly with complete occlusion (Fig. 3A, right panel). The left cervical ICA demonstrated a tonsillar loop associated with a dissecting pseudoaneurysm (Fig. 3B, top left). This was managed with systemic heparin. The patient underwent hyperdynamic treatment as well as intra-arterial verapamil for SAH-associated vasospasm. Two days after