Watertight Dural Closure Constructed With DuraSeal™ for Bypass Surgery

—Technical Note—

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Abstract

Superficial temporal artery-middle cerebral artery (STA-MCA) anastomosis is a common procedure for the treatment of cerebral ischemia and is useful for cerebral aneurysms and tumors. The STA has to pass through the dura and the dura cannot be sutured tightly around the STA to prevent vessel narrowing, so subcutaneous cerebrospinal fluid (CSF) collection is common. This study analyzed the feasibility of using a synthetic dural sealant in the STA-MCA anastomosis to establish watertight closure. Twenty-four patients underwent STA-MCA anastomosis for cerebral ischemia or cerebral aneurysm. After creation of a standard STA-MCA anastomosis, the dura was reapproximated closely, leaving a small defect around the STA. Then, DuraSeal™ was sprayed over the dural defect, and a negative-pressure drain was positioned before closing the skin. Only two patients developed subcutaneous CSF collection, which was managed conservatively. The patency of the anastomosis was proven by magnetic resonance angiography in all cases, and no ischemic complication suggesting chemical spasm of the STA due to the sealant occurred. With DuraSeal™, watertight dural closure can be obtained easily and safely in bypass surgery.

Key words: DuraSeal, watertight closure, cerebrospinal fluid leak, pseudomeningocele, superficial temporal artery-middle cerebral artery anastomosis

Introduction

Superficial temporal artery-middle cerebral artery (STA-MCA) bypass is a common procedure for the treatment of cerebral ischemia or an adjuvant tool for complex aneurysms and brain tumors.²,⁵,⁹–¹²) Harvesting of the STAs, and the procedure for anastomosis are well established,⁵,⁷,¹¹,¹²) but there is little discussion about dural closure.³) After establishing the patency of the bypass, the dura is usually just loosely reapproximated so as not to compromise the STA.²,⁵,¹¹,¹²) Alternatively, a small strip of the temporal muscle or fascia is employed around the STA and sutured to the dura to minimize the extent of the dural defect around the STA. The bandage tends to be loose so as not to compress and occlude the STA.⁵) Consequently, cerebrospinal fluid (CSF) leakage and subcutaneous CSF collection are common, and could cause site infection or delayed healing and wound disruption because the skin is rather compromised after harvesting the STA. To avoid these complications, watertight closure seems desirable.⁴)

Here we describe the use of the DuraSeal™ (Covidien; Mansfield, Massachusetts, USA) dural sealant system to make the dural closure watertight and the epidural drainage more effective.

Patients and Methods

Twenty-four patients have been treated with STA-MCA anastomosis for symptomatic major artery stenosis or occlusion or for revascularization for large aneurysms since October 2010 (Table 1). Patients with cerebral ischemia were evaluated with magnetic resonance angiography (MRA) and/or digital subtraction angiography (DSA), and single-photon emission computed tomography with iodine-123 N-isopropyl-p-iodoamphetamine (IMP-SPECT). STA-MCA anastomosis was indicated for patients with failed perfusion, as determined by the analysis of IMP-SPECT. Patients with aneurysm were treated with STA-MCA anastomosis if prolonged temporary
Table 1  Patient characteristics

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<thead>
<tr>
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<th>DuraSeal cohort</th>
<th>Temporal muscle cohort</th>
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<tbody>
<tr>
<td></td>
<td>Male:female</td>
<td>Ischemia:aneurysm</td>
</tr>
<tr>
<td></td>
<td>16 (2): 8 (0)</td>
<td>22 (2): 2 (0)</td>
</tr>
<tr>
<td>Single:double</td>
<td>4 (0):20 (2)</td>
<td>3 (0):23 (2)</td>
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Numerals in parentheses indicate number of patients developing cerebrospinal fluid leak.

occlusion of the parent artery was expected.

The synthetic absorbable sealant of the DuraSeal™ system consists of two solutions: polyethylene glycol (PEG) ester solution and trilysine amine solution. When mixed together by spraying, the precursors cross-link immediately to form hydrogel sealant on the dura, which has sufficient tissue adherence and cohesive strength to withstand CSF pressures. The 100% synthetic PEG is absorbed in approximately 4 to 8 weeks, allowing sufficient time for the scar to heal.

In our institution, the antiplatelet therapy is continued in ischemic patients until the day of the operation. Usually, both branches of the STA are harvested under an operating microscope. After standard pterional craniotomy, the dura is opened, and the STA is anastomosed to the M2 or M4 portion of the MCA according to the region of ischemia or impaired vascular reserve on SPECT, and the similarity of the diameters of the donor and recipient arteries. After establishment of the patency of the bypass, or following management of the aneurysms, arachnoid plasty is performed with Gelfoam (Baxter, Hayward, California, USA) soaked with fibrin glue (Beriplast®; CSL Behring, King of Prussia, Pennsylvania, USA).

During closing of the dura, a small vertical incision is added to the dural edge by the STA to prevent compression of the vessel (Fig. 1A). The posterior half of the dura, except around the STA, is reapproximated with 4–0 Nurolon (Ethicon, Somerville, New Jersey, USA). DuraSeal™ is applied around the STA after relieving the vasospasm with papaverine chloride (Fig. 1B). Because the backside of the STA becomes the dead angle, this region should be sprayed first. The subdural space is filled with saline to wet the surface of the brain (Fig. 1C). The remaining anterior half is sutured in the usual fashion, and the remaining DuraSeal™ is sprayed onto that part (Fig. 1D). Care should be taken to prevent the DuraSeal™ from being sprayed over the cut edge of muscles and skin as subsequent retention there will disturb the wound healing.

The bone flap is then repositioned after making enough space for the STA to pass through it. An
epidural or subcutaneous drain is then placed with mild negative pressure using a J-VAC Suction Reservoir (Johnson & Johnson, New Brunswick, New Jersey, USA), and the temporal muscle and skin are sutured as dictated by the anatomy. The drainage is maintained until the amount of the drainage becomes less than 10 ml/day, which is usually by 1 or 2 days after the operation.

Twenty-six STA-MCA anastomosis procedures were performed over 12 months using a vascularized temporal muscle strip for the dural closure to patch the gap around the STA and was sutured loosely to the dura before fibrin glue was sprayed over. Statistical analysis was performed by comparing the occurrence rate of CSF collection or infection with Fischer’s exact test. A p-value of 0.05 was considered statistically significant.

Results

Two patients had temporary CSF collection in the ischemic group treated by the DuraSeal technique, whereas one patient in each of the ischemic and aneurysm groups of the former temporary muscle strip cohort developed CSF collection (p > 0.99). In each case, the CSF collection disappeared after compression with a bandage in around 2 weeks. No surgical site infection was documented. Patency of the bypass was examined in each patient by MRA or DSA approximately 1 week after the operation, and no acute occlusion of the STA was detected. All patients were followed up at our institution (155 patient-years), and the STA was palpable in each case. One patient with a large internal carotid-posterior communicating artery aneurysm required reoperation 10 days later because of postoperative parent artery occlusion, adherence of the DuraSealTM was confirmed, and the STA was adequately patent to prevent cerebral infarction (Fig. 2).

Discussion

Pericranium, temporal fascia, temporal muscle, and gelatin foam discs have been placed around the STA to reduce the space around the STA, to prevent CSF leakage after bypass surgery, but this approach is not necessarily reliable. In the present study, the occurrence of CSF leakage did not differ with the use of hydrogel sealant from the temporal muscle cohort. However, the DuraSealTM can seal a gap of up to 1 mm, so can be used to cover the small defect around the STA. By spraying the DuraSealTM onto the posterior part of the exposed dura first, we can maintain much of the brain surface in the wet state because it is soaked in saline up to the suturing point, which is also important for brain compromised by ischemia. Attention should be paid before spraying the DuraSealTM to avoid vasospasm of the STA due to mechanical manipulation or drying; the synthetic PEG is elastic and rather hard, and could prevent indigenous release of STA vasospasm. In addition, because the dura is reapproximated in a watertight fashion, gentle negative pressure can be applied to the epidural or subcutaneous drain, which would reduce the dead space and the risk of postoperative epidural or subcutaneous hematoma.

The most pressing concern related to this application is that hydrogel sealant might cause chemical spasm of the STA, because the safety of use around arteries has not been evaluated. DuraSealTM is said to expand after application, so could constrict the STA and reduce the bypass flow. However, we have never experienced this issue. Moreover, one patient with an aneurysm and delayed occlusion of the internal carotid artery showed that patency of the STA-MCA anastomosis was not compromised on the 10th postoperative day. In addition, follow-up MRA of some patients who were treated early in the course of this study, so the PEG would have degraded by the time of the follow up, demonstrated patency of the STA.

We recommend the use of DuraSealTM to obtain watertight dural closure easily and safely, even in bypass surgery.

References


12) Yasargil MG: *Anastomosis Between Superficial Temporal Artery and a Branch of Middle Cerebral Artery*. Stuttgart, Thieme-Verlag, 1969

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