



## Cranial Base Repair Using Suturing Technique Combined with a Mucosal Flap for Cerebrospinal Fluid Leakage During Endoscopic Endonasal Surgery

Takuma Hara<sup>1</sup>, Hiroyoshi Akutsu<sup>1</sup>, Tetsuya Yamamoto<sup>1</sup>, Shuho Tanaka<sup>2</sup>, Shingo Takano<sup>1</sup>, Eiichi Ishikawa<sup>1</sup>, Masahide Matsuda<sup>1</sup>, Akira Matsumura<sup>1</sup>

■ **OBJECTIVE:** To evaluate a cranial base repair method using the dural suturing technique in combination with a mucosal flap in the endoscopic endonasal approach.

■ **METHODS:** We analyzed 190 patients (mean age, 52.3 years; age range, 3–86 years) who underwent 194 endoscopic endonasal approaches. The degree of intraoperative cerebrospinal fluid (CSF) leakage was graded based on previously published criteria: grade 0, absent; grade 1, small; grade 2, moderate; and grade 3, large. Cranial base repair using the dural suturing technique was performed according to the grade of CSF leakage: grades 1 and 2, autologous fat graft anchored by dural suturing covered with a sphenoid sinus mucosal flap, and grade 3, multilayered, inlay sutured and onlay nonsutured fascial grafts covered with a nasoseptal flap.

■ **RESULTS:** Intraoperative CSF leakage was observed in 125 of 194 cases (64.4%). The degree of CSF leakage was grade 0 in 69 cases, grade 1 in 51 cases, grade 2 in 30 cases, and grade 3 in 44 cases. A postoperative CSF leak was encountered in 2 of 125 repaired cases (1.6%). Both cases with CSF leak involved grade 3 CSF leak (4.5%), and both were successfully treated with lumbar drainage.

■ **CONCLUSION:** Our graded cranial base repair method using the dural suturing technique is simple and reliable.

### INTRODUCTION

The indications for the endoscopic endonasal approach (EEA) for ventral skull base tumors have expanded in recent years and include pituitary adenomas, meningiomas,

chordomas, schwannomas, and craniopharyngiomas.<sup>1–4</sup> The EEA is superior to the conventional transcranial approach for properly selected patients with skull base tumors because it is less invasive and allows clear and panoramic visualization.<sup>5</sup> However, a disadvantage of the EEA is the higher risk of postoperative cerebrospinal fluid (CSF) leakage, especially in cases of extended EEA for skull base lesions because closure of the cranial base dura mater is technically challenging. The incidence of CSF leakage after surgery for tuberculum sellae meningioma or craniopharyngioma has been reported to be 4.6%–40%.<sup>3,6–10</sup> To date, a wide variety of closure methods for cranial base defects have been reported, including autologous fat graft, dural suturing, fascial patch graft, vascularized nasoseptal flap (NSF), and a hard buttress, alone or in combination.<sup>8,10–14</sup> However, the success rate varied among those reports, and a standard closure method still has not been established. In addition, the necessity of prophylactic use of spinal drainage is also controversial. A vascularized NSF has been proven to be among the most reliable methods and has contributed to dramatic improvement in the success rate of repair,<sup>14,15</sup> but a NSF alone is still insufficient for cases having high-flow CSF leaks during an extended EEA. Thus, multilayered closure using a fascial or fat graft or hard buttress covered with the NSF is recommended. Zanation et al.<sup>14</sup> reported a series of 70 consecutive patients with high-flow intraoperative CSF leaks and reconstruction with a non-sutured inlay graft and NSF. They reported a postoperative CSF leak rate of 5.7%. More recently, Garcia-Navarro et al.<sup>8</sup> reported a gasket seal closure method using a fascial graft bolstered by a hard buttress; the postoperative CSF leak rate for that method was 4.35% in 46 patients with a high-flow (with a large diaphragmatic or dural defect) CSF leak. However, they also used spinal drainage in more than 50% of the cases and a NSF in addition to the gasket seal closure in 50% of the cases. It was unclear which method had contributed to the excellent outcome. In addition, it is unclear whether all cases with high-flow CSF leaks were treated with this method. Furthermore, on the basis of our experience, and as

### Key words

- Cerebrospinal fluid leak
- Endoscopic endonasal surgery
- Postoperative complication
- Skull base repair

### Abbreviations and Acronyms

**CSF:** Cerebrospinal fluid  
**EEA:** Endoscopic endonasal approach  
**NSF:** Nasoseptal flap

<sup>1</sup>Department of Neurosurgery, University of Tsukuba, Tsukuba, Japan and <sup>2</sup>Department of Otolaryngology, University of Tsukuba, Tsukuba, Japan

To whom correspondence should be addressed: Hiroyoshi Akutsu, M.D., Ph.D.  
 [E-mail: akutsuh@md.tsukuba.ac.jp]

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Garcia-Navarro et al.<sup>8</sup> stated in their article, bolstering with a hard buttress is not always possible. Instead of using a hard buttress, we have used dural suturing to anchor the inserted autologous fat graft or fascial patch graft because this suturing technique is applicable to a wide variety of pathologic conditions, extremely large cranial base defects, or recurrent cases, without an increase in any risks if done by experienced hands. Since June 2012, we have standardized a closure method tailored according to the grade of intraoperative CSF leakage during the EEA using an autologous fat graft anchored with dural suturing covered with a sphenoid sinus mucosal flap for small-to-moderate CSF leaks and multilayered closure with sutured inlay and nonsutured onlay fascial graft covered with a NSF for large CSF leaks, without using a hard buttress or lumbar drainage. To suture the dura mater, we developed and reported the sliding-lock-knot method, which facilitates making knots in the deep operative field; we described the details of this method previously.<sup>16</sup> To date, the efficacy of cranial base repair using the dural suturing technique during standard or extended microscopic transsphenoidal surgery has been reported by several authors,<sup>13,17,18</sup> but a repair method using dural suturing during the EEA has not yet been evaluated in a clinical series. This article describes our standardized graded repair method using the dural suturing technique combined with an autologous graft and a mucosal flap in a group of consecutive patients whose clinical outcomes were analyzed.

## MATERIALS AND METHODS

### Patients and Grade of Intraoperative CSF Leak

Prospectively collected clinical data of consecutive patients who underwent the EEA performed by the senior author (H.A.) at our institution from June 2012 to May 2015 were analyzed. During this period, 190 patients (88 male patients; mean age, 52.3 years; age range, 3–86 years) underwent 194 EEAs. During the study period, 1 patient with craniopharyngioma and 1 patient with a Rathke cleft cyst underwent 2 operations, and 1 patient with a nonfunctioning pituitary adenoma underwent 3 operations for 2 recurrences. In all operations, a high-definition endoscope (KARL STORZ, Tuttlingen, Germany) was used. In all surgeries, the 2-surgeon, binostrial, 4-hand technique was used by a collaborating team of a neurosurgeon and an otolaryngologist, as advocated by Kassam et al.<sup>19</sup> The otolaryngologist was responsible for surgery from the nasal cavity to the sphenoid sinus, making and placing the mucosal flap, and nasal packing as well as maneuvering the endoscope while the neurosurgeon performed the surgery. The neurosurgeon was responsible for opening the sella floor, anterior or middle skull base, or clivus and then removing the tumor and reconstructing the skull base, including placing the graft material and dural suturing.

Intraoperative CSF leakage was classified into 4 grades, according to a previous report: grade 0, absence of a CSF leak, confirmed by the Valsalva maneuver; grade 1, small “weeping” leak, confirmed by the Valsalva maneuver, without obvious or with only a small diaphragmatic defect; grade 2, moderate CSF leak, with an obvious diaphragmatic defect; and grade 3, large CSF leak, typically created as part of the extended EEA through the diaphragma sellae, clival dura mater, or middle fossa dura

mater for tumor access.<sup>7</sup> Extended EEA was defined as a procedure with additional basal bony resection except for the sellar floor.

### Method of Cranial Base Repair and Postoperative Treatment Strategy

Since June 2012, we have standardized the method of graded cranial base repair according to the degree of intraoperative CSF leak: grades 1–2, autologous fat graft anchored by dural suturing covered with a sphenoid sinus mucosal flap, and grade 3, multilayered, inlay sutured and onlay nonsutured fascial grafts covered with NSF. In cases of grades 1 and 2, if the leak point is found, a small piece of Gelfoam (Pfizer Inc, New York, New York, USA) is placed on the leak point and fixed with fibrin glue. An autologous abdominal fat graft is then placed in the sellar space or other part of the dural defect and anchored with dural suturing. The sutured dura mater and bony surface are covered with a pedicled sphenoid sinus mucosal flap, and the flap is fixed with fibrin glue (Figure 1A–F). The sphenoid sinus mucosal flap is prepared before opening of the sellar floor; after opening the anterior wall of the sphenoid sinus, the septum of the sphenoid sinus is drilled out. Then the mucosa on the posterior wall of the sphenoid sinus is peeled off the sellar floor or other area of the cranial base opening. The peeling of the mucosa is generally started from the area of the septum in the sphenoid sinus. Incision of the mucosa is not required. At least some part of the mucosa should be kept in contact with the bone outside the cranial base opening to maintain the vascular supply (Figure 1A). To prevent the preserved mucosa from hindering the subsequent procedures, Surgicel is placed on it to fix it in place. In the cases of sellar lesions, the dural incision is H-shaped, which facilitates dural suturing; sutures are placed at 2 points (right and left sides) with 3 stitches for each side (upper, lower, and side of the H-shaped incised dura mater), as shown in Figure 1C. In cases of grade 3 CSF leakage, an inlay fascial patch graft harvested from the thigh is anchored with approximately 4–6 point sutures (e.g., for the transplanum approach covered with another onlay fascial graft without suturing). The graft and bony surface are then covered with a pedicled NSF (Figure 2). The NSF should contact the bone surface around the onlay fascial graft and not be on the sphenoid sinus mucosa. Each layer is fixed with fibrin glue. DuraSeal (Covidien, Mansfield, Massachusetts, USA) is not used.

For suturing, an exclusive, long and monoshaft needle holder (Fujita Medical Instruments Co., Ltd., Tokyo, Japan) and 6-0 nylon (PROLENE; Ethicon, Inc., Somerville, New Jersey, USA) are used. For knotting, the sliding-lock-knot technique, in which a knot is made outside the nasal cavity and then slid in by pulling 1 string,<sup>16</sup> is used. A hard buttress is not used. After completing the reconstruction, fibrin glue is applied, and Surgicel (Ethicon, Inc., Somerville, New Jersey, USA) is placed on the sphenoid sinus mucosal flap or NSF for reinforcement. At the end of the operation, the mucosal flap is gently buttressed by packing the sphenoid sinus with Beschitin-F sponge with gauze (Unitika Co., Ltd., Osaka, Japan) (Figure 1E). This packing is removed 3–7 days after surgery. A sinus balloon is not used in any case. Unless postoperative CSF leakage is encountered, lumbar drainage is not performed during or after surgery. However, in the last 2

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