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Skull Base Reconstruction Using Multilayer Method for Cerebrospinal Fluid Leakage During Endonasal Endoscopic Surgery for Tumor Removal

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Abstract

Objective: A tight skull base reconstruction is important for patients undergoing endonasal endoscopic surgery. We report here details of our skull base reconstruction procedure using a multilayer method for intraoperative cerebrospinal fluid (CSF) leakage occurring during endonasal endoscopic surgery for tumor removal.

Methods: To achieve a successful tight repair in cases with high-flow CSF leakage, we have adopted a multilayer method using inlay and onlay fascia, fat from abdomen, and rigid hard bone from nasal septal bone to stop CSF pulsation, as well as a nasoseptal flap to cover the skull base defect. Furthermore, a sinus balloon is inserted into the sphenoid sinus for a few days to secure the above listed materials keep them from falling.

Results: Of the 144 patients who underwent endonasal endoscopic surgery performed from November 2008 to March 2015 at our institution, 48 had CSF leakage. The mean age of those patients was 54.9 years old and 41 had a pituitary adenoma, 5 at Rathke's cleft cyst, 1 a chordoma, and 1 a malignant lymphoma. The mean tumor size was 29.1 mm. Esposito grade 1, 2, and 3 CSF leakage was seen in 18, 16, and 14 cases, respectively. Grade 3 cases had significantly larger tumors as compared to grade 1. There were no differences among the groups regarding the amount of gross total removal. Utilizing a multilayer method in 14 cases with high-flow CSF leakage during the operation, we were able to achieve a tight skull base reconstruction in all cases with no late CSF leakage.

Conclusion: Skull base reconstruction with a multilayer method was effective to achieve a tight repair and stop intraoperative high-flow CSF leakage.

Keywords: Cerebrospinal fluid leak; Endoscope; Nasoseptal flap; Multilayer method; Skull base reconstruction

Introduction

Endoscopic endonasal surgery is a powerful and effective tool for treatment of skull base tumors. Endoscopy provides a panoramic view, allowing for the potential to achieve complete removal of the tumor as compared to when viewing with a microscope [1]. However, with increased tumor volume removed, the risk of CSF leakage is also increased, thus it is important to perform a tight skull base reconstruction. Several different methods for skull base reconstruction have been reported [2-4], among which a vascularized nasoseptal flap has been repeatedly shown to be effective [5-7], though the risk of CSF leakage remains due to soft reconstruction in cases with a high level of CSF flow. In the present study, we examined the usefulness of our multilayer method for skull base reconstruction using inlay and onlay fascia, fat, and rigid hard bone to stop CSF pulsation, as well as a nasoseptal flap to prevent high-flow CSF leakage.

Materials and Methods

To achieve a successful tight repair in cases with high-flow CSF leakage, we have adopted a multilayer method using inlay and onlay fascia, fat from abdomen, and rigid hard bone from nasal septal bone to stop CSF pulsation, as well as a nasoseptal flap to cover the skull base defect. Furthermore, a sinus balloon is inserted into the sphenoid sinus for a few days to secure the above listed materials keep them from falling. No spinal drainage is utilized with our method, thus treated patients can freely ambulate following surgery. Informed consents were received from these patients for the use of findings in this report. Statistical analyses was performed using a t-test to compare groups, with a p value <0.05 considered to indicate significance.

Results

Of 144 cases of endonasal endoscopic surgery performed from November 2008 to March 2015, we encountered 48 with CSF leakage. Mean patient age in those cases was 54.9 years and 41 were treated for a pituitary adenoma, 5 for a Rathke's cleft cyst, and 1 each for a chordoma and malignant lymphoma. The mean tumor size was 29.1 mm. Skull base reconstruction with our multilayer method was performed in 14 cases with high-flow CSF leakage occurring during the operation.

Based on the Esposito CSF leak classification [8], 18 cases had grade 1, 16 cases had grade 2, and 14 cases had grade 3 leakage during surgery. The mean tumor size for grade 1 cases was 26.2 mm, while that for grade 2 and 3 was 29.2 and 32.7 mm, respectively, with grade 3 tumor size significantly larger as compared to grade 1 (P<0.01, Table 1).

Using our multilayer method, we were able to achieve a tight skull base reconstruction with no CSF leakage later in all cases. Gross total removal was performed in 11 (61%) of the grade 1, 8 (50%) of the grade 2, and 8 (57%) of the grade 3 cases, with no significant differences among the groups (Table 2).

Representative case

A 51-year-old male visited an ophthalmologist complaining of visual disturbance and an ophthalmological examination revealed bitemporal hemianopsia, for which he was referred to our department. Brain MRI with gadolinium (Gd) showed a well enhanced intra- and suprasellar mass compressing the optic apparatus (Figure 1 and Table 3).

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Grades	No	Mean tumour size (mm)
Grade 1	18	26.2
Grade 2	16	29.2
Grade 3	14	32.7*
Total	48	29.1

Table 1: Number of cases of intraoperative CSF leakage according to Esposito classification. Grade 3 cases had significantly larger sized tumors (*P<0.01). Statistical analysis was performed using a t-test to compare the groups, with p<0.05 considered to indicate significance.

Grades	No	GTR
Grade 1	18	11 (61%)
Grade 2	16	8 (50%)
Grade 3	14	8 (57%)
Total	48	27 (56%)

Table 2: Number and percentage of gross total removal in each group. There were no significant differences among the groups.

None	Small	Medium	Large
Gelfoam Bone Fibrin glue	Fat Graft Bone Fibrin glue	Fascia lata Fat Graft Bone Fibrin glue	Fascia lata Fat Graft Bone NS flap Fibrin glue Balloon

Table 3: Closure algorithm for intraoperative CSF leak.

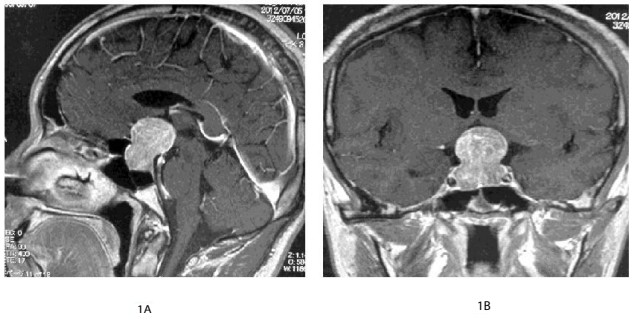

Figure 1: (A and B) A 51-year-old man with non-functioning pituitary adenoma. MRI with Gd showed intra and suprasellar tumour compressing the optic apparatus.

We performed an endonasal endoscopic surgical procedure for tumor removal, during which the tumor was found to be slightly elastic hard and there was high-flow CSF leakage (Figures 2A-2D). We employed our multilayer method with inlay and only fascia, fat, and rigid hard bone used to stop CSF pulsation, and a nasoseptal flap to cover the skull base defect. Next, a sinus balloon was inserted into the sphenoid sinus for a few days to hold the materials and prevent their falling. There was no evidence of CSF leakage thereafter. Postoperative MRI with Gd revealed total tumor removal. At 6 months after the operation, the nasoseptal flap was nicely enhanced by MRI as compared to 1 month, suggesting that it remained vital (Figures 3A and 3B). Visual disturbance was improved after surgery.

Discussion

A tight skull base reconstruction as part of endonasal endoscopic surgery is important for patients with skull base tumors, as reconstruction failure may lead to critical meningitis or encephalitis. Several different methods for repair of CSF leakage during endonasal endoscopic surgery for skull base tumors have been reported [2-4], of which use of a nasoseptal flap has been shown to be effective [5,6].

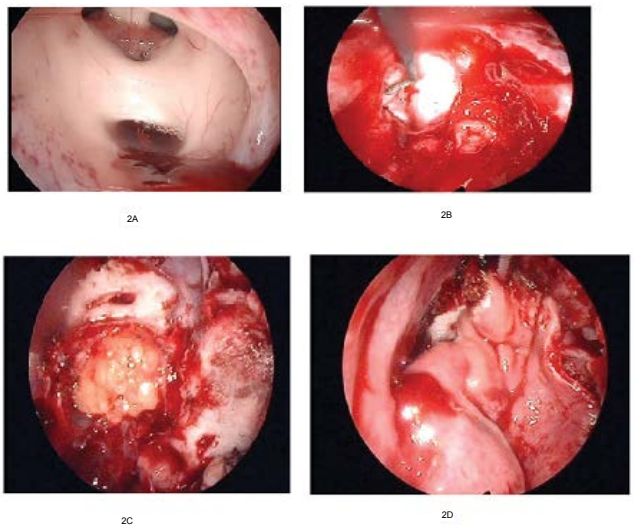

Figure 2: Shown is a representative intraoperative image of the endoscopic endonasal surgical procedure. **(A)** A third ventricle and foramen of Monro were exposed after tumour removal. High-flow CSF leakage occurred. **(B)** Abdominal fascia was inserted into the subdural space in an inlay manner: C. Abdominal fat tissue was implanted into the sella turcica. D. A nasoseptal flap was used to cover the skull base.

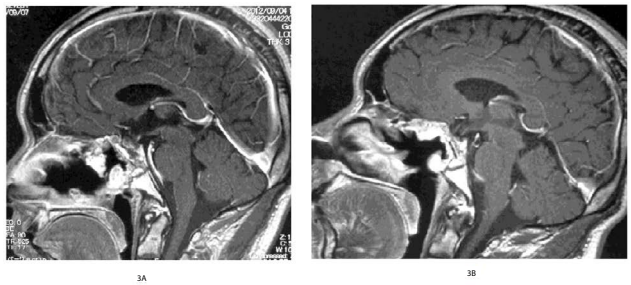

Figure 3: (A) MRI with Gd was performed at 1 month after the operation, which revealed tumor disappearance and no CSF leakage. **(B)** MRI with Gd was performed a 6 month after the operation, which showed that the nasoseptal flap (white arrows) was nicely enhanced, especially as compared to after 1 month, suggesting that it remained in a vital condition.

Schwartz et al. presented their algorithm for harvesting a nasoseptal flap for large tumors with suprasellar extension, which takes into consideration extradural, intradural intrasellar, and intradural non-sellar pathologies [7]. According to their protocol, if intraoperative CSF leakage occurs with a large defect, a nasoseptal flap is used for repair along with a multilayer method, with good results reported. We have also obtained good results with our original protocol for skull base reconstruction (Table 3). With our multilayer method, inlay and onlay fascia, fat, and rigid hard bone are used to stop CSF pulsation, as well as a nasoseptal flap to prevent high-flow CSF leakage. We only use this technique for cases with high-flow CSF leakage rated Esposito grade 3, because of its invasiveness. Furthermore, utilization of a nasoseptal flap may lead to such complications as nasal bleeding, olfaction disturbance, and crust formation. To avoid those, we take care to coagulate the nasal mucosa to stop bleeding and produce the flap without cutting the upper region of the nasal cavity, where olfactory nerves exist. Nevertheless, with such a nasoseptal flap, the rare complication of nasoseptal flap necrosis may occur [9]. For low-flow CSF leakage rated as Esposito

grade 1, only fat tissue and bone are used to repair the defect (Table 3), while for moderate CSF leakage rated as grade 2, fascia, fat, and bone are used for the repair (Table 3). The occurrence of intraoperative CSF leakage is dependent on tumor size, shape, and consistency. Among our 144 cases, we noted 48 (33.3%) with CSF leakage, a rate like previous reports. With our method, spinal drainage is not used because the patient becomes bedridden, which may cause deep thrombosis, decubitus, and/or muscle weakness.

Conclusion

Skull base reconstruction with the present multilayer method was found useful to achieve a tight repair for intraoperative high-flow CSF leakage. Nevertheless, we only recommend it for cases with high-flow leakage because of invasiveness.

Disclosure

The authors have no personal financial or institutional interest regarding any of the drugs, materials, or devices described in this article.

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