Strategy of endoscopic skull base reconstruction in endoscopic transsphenoidal approaches

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Introduction

Endonasal endoscopic approaches gained acceptance in managing many benign skull base tumors. Cerebrospinal fluid (CSF) leak is a common and serious complication with high risk of morbidities or mortality. Identification and management of intraoperative CSF leak is a critical step in these approaches. Various methods and materials had been described for a skull base reconstruction. The size of arachnoid defect plays a crucial role in selecting the proper method of reconstruction.

Patients and methods

This is a prospective analytical study in which 67 patients with benign skull base lesions who were candidates for endoscopic transnasal transsphenoid surgery were included. All cases were subjected to detailed assessment protocol preoperatively and postoperatively. Intraoperative CSF leak was meticulously observed and graded according to the size of arachnoid defect, and then reconstruction was done according to grade of CSF leak by grafts or flaps or combination of them.

Results

This study included 67 patients with sellar–suprasellar tumors who were managed by endoscopic transsphenoid approach. Intraoperative CSF leak occurred in 23 (34.3%) cases. A total of nine (13.4%) cases had grade 1 CSF leak, and all cases were reconstructed with abdominal fat with success rate of 100%;six (8.9%) cases had grade 2 CSF leaks, and all cases were repaired with pedicled nasal flap with success rate (83%); and grade 3 CSF leak occurred in eight (11.9%) cases, and all were repaired with multilayer technique, with success rate of 75%. The incidence of postoperative CSF leak in this study was 4.5%, that is, three patients.

Conclusion

The strategy of skull base reconstruction depending on grade of intraoperative CSF leak according to size of arachnoid defect produces a promising result in decreasing the incidence of postoperative CSF leak and saving the need of unnecessary flaps.

Keywords:
arachnoid defect, reconstruction, sella, skull base

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Background

Endonasal transsphenoidal approach has been adopted as the standard surgical technique for treatment of sellar pathology since the 1960s and also for some of the suprasellar and clival lesions with the advances in fiberoptic endoscopes and skull base instruments [1].

However, one of its major drawbacks is cerebrospinal fluid (CSF) leakage. Its rate in literature ranged from 0.5 to 15% [2].

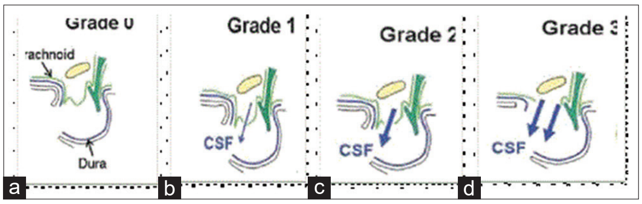
Intraoperative CSF leak can occur through one of three ways, either during removing tumor part that is guarding an already incompetent diaphragma, or as a result of traction on the tumor, leading to diaphragmatic tear, or as a result of a wide opening of the diaphragm or dural to access extrasellar extensions [3].

To describe a proper algorithm for skull base reconstruction, different classifications of intraoperative CSF leakage have been proposed. The most accepted classifications were based on size of the arachnoid defect or flow of the leaked fluid [4].

Classifications according to arachnoid defect had been modified several times. It entails grade 0, where there is no CSF leak; grade 1, in which there is a small ‘weeping’ leak without an obvious tear; grade 2, which entails a well-visualized small defect in the arachnoid or diaphragma sella; and grade 3, which is characterized by a large opening of the diaphragm or arachnoid or an opening of the dura of the tuberculum, or plannum or clivus as a part of an extended approach (Fig. 1) [4,5].

The cutoff point of arachnoid defect classification between grades 2 and 3 was resettled by many authors.

Figure 1



Schematic diagrams depicting the different grades of CSF leak. (a) No CSF leak and intact arachnoid. (b) Grade 1 CSF leak (minor leak with no obvious arachnoid defect). (c) Moderate grade 2 CSF leak, with a visible arachnoid defect. (d) Large grade 3 CSF leak, with large arachnoid [5]. CSF, cerebrospinal fluid.

The most accepted cutoff point is 5 mm [6] and 1 mm [3].

The ultimate goal of skull base reconstruction is to separate the cranial cavity completely from the sinonasal tract using different types of grafts, vascularized flaps, synthetic materials, or combination [7].

Skull base reconstruction can be classified according to the type of reconstructive material, position of reconstructive material, and layers of the reconstructive materials [8].

Autologous grafts can be represented as fat harvested from the abdomen or thigh and fascia lata harvested from the thigh. It is biocompatible and free of charge. However, it needs a separate surgical incision [9].

Vascularized pedicled flaps such as nasoseptal flap, inferior turbinate flap, and middle turbinate flap became the preferred reconstructive technique for the defects resulting from endoscopic skull base surgery, especially large defects and recurrent cases [10]. These are endoscopically feasible and highly effective. However, they are not suitable for routine use because their need must be anticipated and prepared before tumor resection, especially in recurrent cases, so as not to interrupt their blood supply; moreover, they are technically demanding, requiring special training [11].

Aim

This study proposes an effective strategy for skull base reconstruction in endoscopic transsphenoid skull base approaches based mainly on the size of arachnoid defect.

Patients and methods

This is a prospective analytical study in which 67 patients presented to the neurosurgery or ENT Department in Kasr Alainy Hospital, Cairo University, with sellar or suprasellar benign tumors and were candidate for endoscopic endonasal transsphenoid skull base surgery during the period from July 2017 to December 2018. Patients with preoperative CSF leak were excluded from the study.

All procedures performed in this study were in accordance with the ethical standards of the institutional research committee.

A definitive protocol for evaluation was followed preoperatively in all patients, including detailed history taking, full otorhinolaryngology, radiological, neurosurgical, ophthalmological assessment, and endoscopic examination.

Informed written consent was taken after full explanation of the procedures and possible complications done for the study.

All procedures were done under general hypotensive anesthesia. The procedure is divided into four main stages; nasal, sphenoid, sellar stages, and reconstruction.

In cases presented with sellar lesions without lateral extension with adequate pneumatization of sphenoid, direct endonasal transsphenoid approach was used to reach sphenoid sinus ostium in most of the cases.

In lesions extending laterally to the cavernous sinus, wide exposure was done through complete ethmoidectomy and removal of lower two-thirds of middle turbinate in one side of the nose.

To decrease the incidence of intraoperative CSF leakage, dura is sharply incised in the midline in a linear or cruciate fashion, and the inferior and lateral components of the lesion were removed to prevent premature descend of suprasellar cistern into the operative field. At the end of surgery, Valsalva maneuver is performed, and 30° or 45° endoscope was then introduced into the sellar cavity to inspect the cavity to check and identify the presence of any intraoperative CSF leak and arachnoid defect and its grade.

Cases with no observable leak were considered as grade 0, and abdominal fat or surgicel and gelfoam were used for obliteration of sellar cavity. In grade 1 CSF leak (small ‘weeping’ leak without an obvious rent), fat was used in reconstruction, whereas in grade 2 CSF leak (well-visualized tear <2 mm), Hadad flap or middle turbinate flap was used. In grade 3 CSF leak (large deliberate diaphragmatic opening >2 mm), multilayer repairs with Hadad and fat were performed.

At the end of the procedure silicon sheets were used to prevent adhesion and to add support to reconstruction materials and were removed 10 days postoperatively. The nasal cavity was packed with merocell nasal pack, which was removed 2–5 days postoperatively according to presence of CSF leak.

During the postoperative period, the patients was kept on antibiotics, electrolytes were daily checked, 24 h urine was calculated, nasal blowing was avoided, and straining of all kinds was restricted (nasal blowing, weight lifting, bending, getting Mecca position, etc.). The patient was followed up every 2 weeks for 1.5 months.

Data were collected, tabulated, and statistically analyzed by using the program SPSS for Windows (version 11) to assess the efficacy of using CSF leakage grading system in mapping the strategy of sellar reconstruction (Scientific System LC-04R, manufactured in China). The independent samples Student *t* test was used for statistical analysis for all our parametric variables.

Results

This study was conducted on 67 patients. Their age ranged from 20 to 73 years, with a mean age of 42.5 years. A total of 31 (46.3%) patients were males, and 36 (53.7%) patients were females.

A total of 61 (91.2%) cases were pituitary adenomas, whereas two (2.9%) cases were meningioma, and four (5.9%) cases were craniopharyngioma.

Headache was encountered in 66 (98.5%) of 67 patients, with mean duration of 5 months. Hormonal disturbance was encountered in 15 (22.4%) of 67 in the form of acromegaly (11.9%), hyperprolactinemia (9%), and Cushing syndrome (1.5%). Overall, 14.9% of the cases had parasellar extension, and 34% of the cases had suprasellar extension. Pneumatization of sphenoid sinus was sellar in 46 (68.7%) cases and postsellar in 21 (31.3%) cases.

Operative time ranged from 2 to 5 h. Pack was removed after time interval of 2–5 days. Postoperative hospital stay ranged from 4 to 15 days. A total of 16 patients required postoperative ICU admission, with duration range of 1–11 days. Dural opening intraoperatively was relatively wide (from cavernous to cavernous sinus, and from superior to inferior intercavernous connections) in 62 (91%) cases and small in five (9%) cases. Gross total tumor removal was achieved in 61 (91%) cases.

No intraoperative CSF leak (grade 0) was found in 44 (65%) cases; all cases were pituitary adenoma. However, fat was used in obliteration of sellar cavity in 20 cases, whereas in the remaining 24 cases, surgicel and gelfoam were used, with no postoperative CSF leak.

Intraoperative CSF leak was encountered in 23 (34.3%) cases.

Grade 1 CSF leak was present in nine (13.4%) cases. All of them were pituitary adenomas. Fat was used in repair in all the nine cases, with 100% success rate.

Grade 2 CSF leak was present in six (8.9%) cases. All of them were pituitary adenomas. Pedicled flap was used in their reconstruction, where Haddad flap was used in five cases and middle turbinate flap in one case, with success rate of 83%. One failed case was managed conservatively.

Grade 3 leak was encountered in eight (11.9%) cases. A total of four cases were craniopharyngiomas, two were meningiomas, and two macroadenomas. All cases were repaired using multilayer repair technique, using fat together with Haddad flap, with 75% success rate. The two failure cases were craniopharyngiomas: one of them required revision with multilayered repair in the form of fat, fascia lata, and nasoseptal flap, and the other required lumbar drain (Fig. 2).

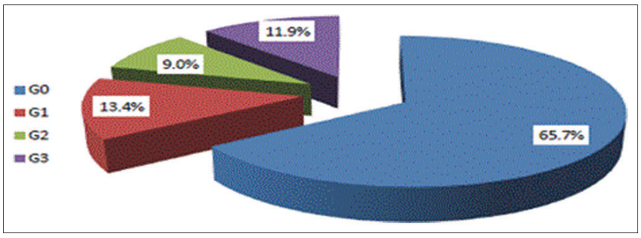
The incidence of postoperative CSF leak in this study was 4.5%, representing three of 67 patients. Of them, one was grade 2 and the other two cases were grade 3 intraoperative CSF leak. After 2 weeks, no cases had CSF leakage.

Regarding other postoperative complications, pneumocephalus occurred in one (1.5%) case and was evident with postoperative follow-up computed tomography. Intracranial hematoma developed in one (1.5%) patient, and 10 (15%) cases developed transient postoperative diabetes insipidus. All those cases were managed conservatively without long-term morbidity or mortality. Cases reconstructed with local nasal flap had more nasal crustations, and two cases of them had mild nasal bleeding after pack removal, which stopped with local vasoconstrictors.

Discussion

CSF leak remained the most experienced complication after endoscopic skull base surgery in the literature. Its

Figure 2



A pie chart showing different grades of intraoperative CSF leak. CSF, cerebrospinal fluid.

rate in literature ranged from 0.5 to 15% [2]. This rate is consistent with this study, which showed a rate of 4.5%.

The rate of detection of intraoperative CSF leak ranges from 18.1 to 53.2%. In this study, a nearly similar value (34.3%) was reported.

Reconstruction of sellar, plannum, and clival defects had always been a challenging issue. This is because the complex three-dimensional anatomy of this area, the antigravity characteristics of defects in this area, and deficiency of supporting structures for the reconstructive materials.

Several factors increase the incidence of postoperative leak, like presence of intraoperative leak, specific tumor type, size and extension of tumor, defect size, and recurrent cases.

Shiley *et al.* [2], showed that the incidence of postoperative leakage is six times more in patients in whom intraoperative CSF leakage was identified. Moreover, Couldwell *et al.* [12], reported no incidence of postoperative CSF rhinorrhea if there was no intraoperative leak during transsphenoidal surgery [3].

This previously mentioned strong correlation between postoperative and intraoperative CSF leakage raised the importance of accurate detection and grading of intraoperative CSF leakage and to repair according to this grading. Accurate detection of intraoperative CSF leakage can be done by meticulous inspection of tumor bed after gross total tumor removal using different types of angled endoscope (0, 30, or 45, or even 70) and with the assistance of valsalva maneuver, or intrathecal fluorescein injection [3,13].

Most studies recommend sellar repair in all cases of detected intraoperative leakage [1]; however, different protocols were followed in such studies, as each study recommends repair method to be tailored according to the grade of CSF leak [5]. Some studies recommend repair method to be according the severity of its flow [14], whereas others depend more on the size of arachnoid defect [6,15].

In this study, intraoperative CSF leak was graded according to the size of arachnoid defect. Reconstruction protocol was to use abdominal fat alone in grade 1 CSF leak, whereas vascularized pedicled flap was used in grade 2 leak, and both together were used in grade 3 leak. The usage of vascularized flap in high grades of CSF (grades 2 and 3) was based on efficacy results documented in the literature. In this study, the incidence of postoperative CSF leak was 4.5%.

In 2001, Kelly *et al.* [14] showed their experience of sellar reconstruction of 62 cases after transsphenoidal approach. They applied only collagen sponge in case of small 'weeping' CSF leak and abdominal fat for relatively large arachnoid defects. They reinforced sellar floor using titanium. They reported an overall postoperative CSF leak of 3.2%, which was comparable to our results.

In 2007, Esposito *et al.* [4] reported the incidence of postoperative CSF leak (2.6%) in a series of 668 cases. They used collagen sponge and titanium mesh in grade 1 CSF leak, and added fat packing of sella and sphenoid in grade 2 (moderate leak), whereas in grade 3 (large diaphragmatic or dural defect), they used CSF diversion methods.

In 2011, Kong *et al.* [5] studied 124 cases of endonasal transsphenoidal surgeries. They adopted reconstruction with free tissue graft (fat or mucosa or both) with or without pedicled flap in arachnoid defect less than 5 mm (grade 2), and gasket-seal method in defect more than 5 mm (grade 3). They had a rate of postoperative leakage of 4.8%. They concluded no significant value of using gasket-seal method over fat in low-grade CSF leakage in cases with small arachnoid defect.

Strickland *et al.* [13] used free graft (fat or fascia or both) in cases of detected intraoperative leakage in pituitary surgery and reported a postoperative leakage of 2.6% in a large series of 1002 case of pituitary adenomas.

In 2017, Zhang *et al.* [3] achieved 2.7% postoperative rate after their strategy of repair of 485 transsphenoidal procedure. They used surgicel and fibrin glue in low CSF leakage with small defect. In high CSF leakage with large defect, they used fat and fibrin glue for closure of defect and reconstructed the sellar floor using septal cartilage and artificial cerebral dural patch. They used lumbar drain in all cases.

Kuan *et al.* [16], presented a retrospective study for 300 cases that underwent endoscopic transsphenoidal approach. They proposed evidence-based algorithm for sellar reconstruction according to the grade of CSF leak: free mucosal grafts for no CSF leak (grade 0), fat graft with free mucosal grafts ± rigid fixation for low-grade leaks, and fat graft + nasoseptal graft ± rigid fixation for high-grade leaks. They reported intraoperative CSF leak in 30.7% of all cases: 15% grade 1, 10.7% grade 2, and 5% grade 3 CSF leaks. Postoperative CSF leaks occurred in 2.3%.

In the current study, the incidence of postoperative CSF leak is a little bit higher at 4.5%, because of the small sample size, inclusion of other intra-arachnoid surgeries in the study, and not using tissue fixator (glue) or lumbar drains.

Jalessi *et al*. [6] adopted multilayered reconstruction in high-grade CSF leaks without using rigid buttress, but they recommended using of nasoseptal flap.

In the reconstruction of a large skull base defect, a significant variation in success rate between vascularized flaps and free grafts was found in many studies [11].

Cappabianca *et al*. [17], adopted a policy to reconstruct the sella in endoscopic transsphenoidal pituitary approach according to other factors, such as the prolapse of the suprasellar cistern, bleeding from medial wall of the cavernous sinus, injury of the carotid artery, and invasive adenoma.

Conclusion

In transsphenoidal skull base surgery, postoperative leak did show a strong correlation to identified intraoperative leak. The strategy of skull base reconstruction based on grading of arachnoid defect seemed to be reasonable and effective in decreasing the incidence of postoperative leak after such procedures. In small defects, free grafts showed high efficacy in managing the leak, whereas adding pedicled flap is mandatory in large defects (high-grade leak).

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Conflicts of interest

There are no conflicts of interest.

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