Single Versus Double Hadad-Bassagasteguy Flap in Expanded Endoscopic Skull-Base Surgery

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Title

Single vs double Hadad-Bassagasteguy flap in expanded endoscopic skull-base surgery

Running title: Flaps in expanded endoscopic skull-base surgery

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Abstract

Background: The reconstruction of dural defects, after endoscopic removal of skull-base lesions, remains challenging when a large defect or a high flow intraoperative cerebrospinal fluid (CSF) leak is observed. The aim of this study is to describe our preliminary experience with a double Hadad-Bassagasteguy (H-B) flap technique for skull-base repair, comparing its efficacy with the use of a single H-B flap in our series.

Methods: A retrospective chart review was conducted on patients who underwent exclusive endoscopic endonasal skull-base surgery at our Referral Skull Base Center from December 2014 to January 2018. Data on patient demographics, pathology, preoperative and postoperative imaging, intraoperative findings, surgical route, defect size, reconstruction techniques and repair materials, were analyzed. Patients were divided into double and single H-B flap groups.

Results: In the single and double H-B groups, the postoperative CSF leak rates were 37.5% (6 of 16 patients) and 4.5% (1 of 22 patients), respectively. The difference between the two groups was statistically significant ($p = 0.0470$). In patients with defects > 4 cm or high-flow intraoperative CSF leakage related to the opening of the third ventricle, the double H-B flap was successfully placed with no occurrence of postoperative CSF leakage.

Conclusions: The double H-B flap significantly reduced the postoperative CSF leakage rate after expanded transnasal skull-base surgery. Particularly in challenging cases, where a large skull-base defect or a high-flow intraoperative CSF leak was observed, this reconstructive method proved to be very effective, with no evidence of postoperative CSF fistulas.

Key words: expanded endoscopic approach, skull base reconstruction, Hadad-Bassagasteguy flap, pedicled nasoseptal flap, vascularized flap.

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Text

Introduction

Since its introduction in 2006[1], the Hadad-Bassagasteguy (H-B) flap has progressively established itself as an effective method for repairing dural defects following the endoscopic endonasal approach (EEA) to skull-base diseases and is actually considered the best reconstructive option in many centers[2–8]. Concurrent with the increasing success of this reconstructive technique, the scope of the EEA has progressively widened to multiple areas of the skull base, thus allowing the development of modular expanded approaches for the removal of more complex lesions, with resulting larger dural defects[9–15]. Furthermore, opening of the third ventricle or cerebral cisterns during intra-arachnoid dissection of deep invasive lesions leads to a high-flow intraoperative cerebrospinal fluid (CSF) leakage, increasing the risk of a postoperative fistula, regardless of the size of the skull-base defect[4,14–16]. In the setting of these challenging cases, the use of a single pedicled nasoseptal flap may be insufficient to achieve a watertight seal and a significant rate of postoperative CSF leakage is still observed[3,5,12,17–19]. In an effort to solve this problem, we describe our preliminary experience using a double H-B flap technique for skull-base reconstruction after expanded endonasal approaches. This method is compared to using a conventional single H-B flap in our series. Our results are also compared to those reported in the literature.

Materials and Methods

A retrospective chart review was conducted on patients who underwent exclusive endoscopic endonasal skull-base surgery at our Referral Skull Base Center from December 2014 to January 2018. Only cases presenting a bone defect size at least of 1 cm and a large dural defect reconstructed by a pedicled nasoseptal flap (H-B flap) after an expanded transnasal approach were included. Therefore, extradural lesions or pituitary adenomas without opening of the sellar diaphragm were excluded. Patients with a bone defect size and a dural defect smaller than 1 cm after resection of sinonasal tumors were not included. In the majority of these cases, we successfully managed the repair by positioning a single graft; hence, although the H-B flap was used when possible, we considered this method not significant for this kind of reconstruction. Patients treated for spontaneous or post-surgical CSF leakage were also excluded because the defect size observed in our experience was less than 1 cm in all cases and the reconstruction did not require a pedicle flap. Data were recorded about patient demographics, pathology, preoperative and postoperative imaging, intraoperative findings, surgical route, defect size and location, reconstruction techniques and repair materials. The defect size was assessed by measuring its major axis on the postoperative CT scan. In the most complex cases, intraoperative videos were reviewed to assess the features of the defect. An intraoperative high-flow CSF leak was defined as an intense flow of CSF spilling through an arachnoid defect creating a communication between sinonasal spaces and cerebral cisterns or ventricles. The presence of a postoperative CSF leakage was assessed by endoscopic evaluation and MRI examination. Data were collected in a Microsoft Excel spreadsheet (Microsoft Corp., Redmond, WA, USA) and updated periodically. Patients were divided into two groups: the single H-B flap group, including surgeries between December 2014 and March 2016, and the double H-B flap group, between April 2016 and January 2018. To clarify data analysis, each group was examined separately, and the data were compared. Statistical significance was assessed at the 0.05 α level using a two-tailed Fisher's exact test. All patients were examined until 31 January 2019, thus the minimum follow-up planned for each patient was at least 12 months.

Results

Among a total of 92 patients who underwent an EEA for skull-base diseases at our Referral Skull Base Center in the period examined, based on inclusion and exclusion criteria, 38 were admitted to this study. Of these, 16 were included in the single H-B flap group and 22 in the double H-B flap group.

Patient demographics

In the single H-B group, there were 8 men and 8 women. Age at the time of surgery ranged from 32 to 75 years (median 51.6 years). The double H-B group consisted of 11 men and 11 women. Age ranged from 46 to 81 years (median 62.1 years).

Approach to skull base

In the single H-B group the following approaches were used: transcribriform approach in 3 patients (18,7%); transsellar approach in1 case (6,2%); transplanum transtuberculum approach in 10 cases (62,5%); finally, transclival approach in 2 cases (12,5%). The following approaches were performed in the double H-B group: transcribriform approach in 7 patients (31,8%); transsellar approach in2 cases (9,1%); transplanum transtuberculum approach in 9 cases (40,9%); transclival approach in 4 patients (18,2%).

Defect size

The defects were at least 1 cm and were categorized into three groups as follows: defect < 2 cm, defect between 2 and 3 cm, defect > 3 cm. In the single H-B group, the extent of the defect was < 2 cm in 5 cases, between 2 and 3 cm in 7 cases and > 3 cm in 4 cases. In the double H-B group, the defect size was < 2 cm in 4 cases, between 2 and 3 cm in 12 cases and > 3 cm in 6 cases. The defects between 2 and 3 cm represented the largest category in our series and were associated more often with a transplanum approach (5 patients in the single H-B group and 6 patients in the double H-B group), as outlined in Table (supplemental content) 1.

Degree of intraoperative CSF flow

Overall, high-flow and low-flow intraoperative CSF leakage occurred in 9 and 29 patients, respectively. All of the cases of high-flow CSF leakage were related to a transplanum transtuberculum approach leading to the opening of the third ventricle for the removal of a suprachiasmatic lesion. Single and double H-B flaps were placed in 5 and 4 of them, respectively. The characteristics of patients with a high-flow intraoperative CSF leakage are included in Table (supplemental content) 2.

Postoperative CSF leak

The overall postoperative CSF leakage rate in our series was 18.4% (7 of 38 cases). All patients who failed the first reconstruction underwent re-exploratory surgery with a second repair procedure without further complications. The average time to revision surgery was 22.8 days (range 9–61 days). In the single H-B group, the postoperative CSF leak rate was 37.5% (6 of 16 cases) while in the double H-B group, it was 4.5% (1 of 22 cases). The difference between the two groups was statistically significant ($p = 0.0470$). Considering the surgical approach, in the single H-B group, the CSF leakage rate was 50% with the transplanum transtuberculum approach (5 of 10 cases) and 50% with the transclival approach (1 of 2 cases), whereas no CSF leakage was observed with the transcribriform and transsellar approaches. In the double H-B group, only one postoperative CSF leakage occurred in a patient who underwent the transplanum approach, so the CSF leakage rate in this group was 11.1% (1 of 9 cases). The difference between the single and double H-B groups was not statistically significant for both transplanum ($p = 0.3449$) and transclival ($p = 0.4286$) approaches. We also analyzed the relationship between CSF leakage and defect size. In the single H-B group, CSF leakage occurred in 1 of 5 patients (20%) with a defect between 1 and 2 cm, in 4 of 7 patients (57.1%) with a defect between 2 and 3 cm, and in 1 of 4 patients (25%) with a defect larger than 3 cm. The only case of postoperative CSF leak encountered in the double H-B group was in a patient with a defect between 2 and 3 cm (1 of 12 cases, 8.3%). In all three size categories, the difference between the single and double H-B flap groups was not statistically significant (1–2 cm, $p = 1$; 2–3 cm, $p = 0.1421$; > 3 cm, $p = 0.4545$).

Finally, the degree of intraoperative CSF leakage was examined. Three postoperative CSF leaks were encountered in patients showing a low-flow intraoperative CSF leak, without a significant difference ($p= 0.5575$) between the single and double H-B groups. Among the 9 patients showing a high-flow intraoperative CSF leak, 4 had a postoperative CSF leak in the single H-B group (80%) whereas no cases of postoperative CSF leak were observed in the double H-B group. The difference was not statistically significant ($p= 0.2280$). In all cases, the high-flow intraoperative CSF leak was related to opening of the third ventricle through a transplanum transtuberculum approach with a defect size between 2 and 3 cm. The features of patients with a postoperative CSF leak are summarized in Table (supplemental content) 3.

Discussion

Watertight closure of dural defects after endoscopic transnasal removal of skull-base lesions is a crucial step to avoid potential complications of CSF rhinorrhea such as meningitis or cerebral abscess[2,5,20]. In many centers, the H-B flap, a vascular pedicled flap of the nasal septum mucoperiosteum and mucoperichondrium based on the nasoseptal artery, is considered to be the workhorse of skull-base reconstruction of large skull-base defects after the EEA[2–8,21]. Concurrently with the increasing success of this technique after its introduction in 2006, tremendous advancements have been made in neuronavigational system, surgical instrumentation and the understanding of endoscopic anatomy, thus allowing the development of multiple expanded approaches for resection of more complex and larger lesions. As a consequence, transnasal skull-base surgery frequently results in extensive skull-base defects or in a deep dissection leading to the opening of the third ventricle or cerebral cisterns[4,8–16]. In these cases, the reconstruction remains challenging, and the use of a single H-B flap can prove to be inadequate to prevent a postoperative CSF fistula[2,5,16–18].

To overcome this problem, new extended pedicled intranasal flaps including the lateral nasal wall mucosa, have been introduced in recent years[19,22]. The use of multiple intranasal vascular flaps is another feasible option. In the literature, Nyquist et al.[23] first reported a clinical experience using a bilateral nasoseptal flap called the "Janus flap", for the reconstruction of very large skull-base defects after an extended transsphenoidal surgical procedure. Compared to other methods which use a wide single pedicled intranasal flap, use of a double H-B flap has multiple advantages: 1) it ensures a larger coverage surface[23], 2) it takes less time to harvest because dissection of the thin mucosa of the middle and inferior turbinate is technically challenging[24,25]; 3) it is easier to set up, because handling a large single flap inside the narrow space of the nasal fossa is an additional challenge and requires a significant level of skill[19]. As reported by other authors[19,22], we acknowledge that there are also some potential disadvantages related to using the double nasoseptal flap. The major criticism concerns the lack of use of the contralateral septal mucosa for further revision procedures. In our opinion, the considerable reduction in CSF leakage rate we observed with the double H-B technique balances this downside. Among patients who underwent reconstruction by a double H-B flap in our series, the only case requiring a revision surgery for a CSF leak was managed by the addition of an inferior turbinate graft. We also believe that elevating a double H-B flap is preferable in all cases where the contralateral septal mucosa has to be sacrificed anyway, such as in transcribriform approaches or expanded transplanum approaches requiring enlargement of the posterior septectomy to widen the surgical corridor.

Our series is the first reported in the literature comparing the use of single and double Hadad-Bassagasteguy flaps. In the single H-B group, 6 postoperative CSF leaks were observed in 16 patients (37.5%) while in the double H-B group, there was 1 postoperative CSF leak in 22 patients (4.5%). The postoperative CSF leakage rate in the single H-B group was higher than that reported in previous large reviews. In their review of 38 studies with 609 patients, Harvey et al. observed a CSF leakage rate ranging from 6.7% for reconstructions achieved by vascularized intranasal or extranasal flaps, to 15.6 % for anterior skull-base (ASB) repairs realized with free grafts[2]. In the review by Soudry et al. including 22 studies and 673 patients, a reconstruction success rate from 67% to 100% was reported, with an overall postoperative CSF leakage rate of 8.5% (57 of 673 cases)[26]. However, a more detailed analysis reveals that these studies often included extradural lesions such as pituitary adenomas not extending beyond the sellar diaphragm, extradural clival chordomas or fibrous dysplasia, with a consequent overestimation of the reconstruction success. On this basis, the difference between the single and double H-B group in our series was statistically significant ($p = 0.0470$).

Despite this encouraging evidence, to improve the quality of the analysis, we focused our attention on three main factors affecting the outcome of the reconstruction: the defect size, the location of the skull-base defect, and the degree of intraoperative CSF flow. Regarding the defect size, the difference between the single and double H-B groups for all three categories examined (1–2 cm, 2–3 cm, >3 cm) was not statistically significant. Given this result, two observations are important. First, among the patients with a defect > 3 cm, all cases (4 patients) showing defects > 4 cm were successfully managed by a double H-B flap with no postoperative CSF leakage. Although aware of the limitations related to the retrospective design of this study and to the small sample size, we believe this result is indicative of the reliability of this kind of flap for closure of large defects. Second, the CSF leakage rate was higher in patients with a defect size between 2 and 3 cm (26,3%, 5 of 19 cases) than in those with a defect greater than 3 cm (11%, 1 of 9 cases). Furthermore, the difference between the single and double H-B groups, even though not statistically significant, appeared to be more pronounced for defects between 2 and 3 cm (4 CSF leaks in 7 patients in the single H-B group vs 1 CSF leak in 12 patients in the double H-B group) than in other categories. During the revision surgery, one of these patients who underwent reconstruction with a single H-B flap, showed a retraction of the flap, with a small gap between the mucosa and the underlying bone in the anterior portion of the defect. This confirms the importance of overestimating the size of the flap, as suggested by Hadad et al.[1]. In all of the remaining cases, the coverage area appeared to be adequate, thus suggesting the presence of other factors affecting the success of the reconstruction. In particular, we noticed that among the patients with a defect between 2 and 3 cm and showing postoperative CSF leakage, a transplanum approach had been performed in all cases. Therefore, we decided to carefully analyze the relationship between the postoperative CSF leak and the defect location. Among the 7 CSF leaks observed in the present series, 6 were related to a transplanum-transtuberculum approach and 1 to a transclival approach. In a patient with a clival defect, during revision surgery, we observed that fat placed to obliterate dead space was insufficient, thus reinforcing our opinion about the importance of this step during skull-base repair. Among transplanum approaches, the CSF leakage rate was 31.6% (6 of 19 cases). Even though 5 of these CSF leaks were observed in the single H-B group, the difference between the single and double H-B groups was not statistically significant ($p = 0.3449$).

Nevertheless, in the light of this preliminary report, we believe, as with other authors[16,27], that reconstruction in this particular area of the skull base remains challenging for several reasons, regardless of the defect size. Primarily, the placement of an inlay graft increases the risk of damaging the neurovascular structures running in a very close relationship with the boundaries of the transplanum-transtuberculum defect. This occurrence is more likely if a wide dural opening is made to dissect a tumor spreading into the optic canals or strictly adhering to the carotid arteries, such as a craniopharyngioma or meningioma. To minimize the risk of neurovascular damage, we suggest avoiding the placement of any rigid material, especially when a gasket-seal closure is planned.

Another drawback related to the transplanum-transtuberculum approach, as already reported in the literature[13,16,18], is the arachnoid dissection with opening of the suprasellar arachnoid cistern, which increases the risk of a postoperative CSF leak. Finally, the removal of suprachiasmatic tumors through this approach often leads to the opening of the third ventricle, with a resulting high-flow intraoperative CSF leak[15,16,18,27,28]. This condition is still related to a significant postoperative CSF leak rate[3,16,26,27,29,30] and constitutes a relevant hindrance to the success of the skull-base repair for two main reasons. First, in agreement with Hu et al.[27], we believe the

CSF leak derived from opening the third ventricle is greater than that related to opening of the cerebral cisterns. Second, packing material cannot be placed to obliterate the dead space because of the risk of its dislocation with a resulting obstruction of the Monro foramina[16,27]. In these cases, as the modified gasket-seal technique, we place a piece of autologous fat over the graft, instead of rigid material. Then Surgicel is wedged into the fat to maintain the graft in place. In this way, the central part of the graft is fastened subdurally and the edges remain in the sphenoid sinus and are draped around the bony defect, creating a watertight closure. Fibrin glue is finally sprayed along the edges of the graft to fasten the reconstruction. The H-B flap is rotated and gently positioned over the denuded bone surrounding the defect. If the double H-B technique has been planned, the second flap is rotated and overlapped over the first one. We believe this technique may play a role in these challenging defects, allowing the autologous fat to embed deeply into the intradural portion of the graft, in order to reduce dead space, serving as packing material. Moreover, the graft placed on the reconstruction floor acts as barrier, avoiding the fat migration into the ventricular system. This technique does not allow the entire elimination of the dead space, but, in our opinion, it contributes to prevent CSF buildup in the suprachiasmatic space. We also believe that the Surgicel placed as wedge into the fat, even though is not rigid material, ensures a reasonable stabilization of the intradural part of the reconstruction. In accordance with Eloy et al.[16], this step is crucial to convert a high-flow CSF leak to a low flow-CSF leak, lowering the risk of a post-operative CSF fistula.

In our series, high-flow intraoperative CSF leak was observed in 9 patients underwent a transplanum-transtuberculum approach. Among these cases presenting challenging defects, despite the modified gasket-seal technique adopted for reconstruction, four postoperative CSF leaks (44.4%) were observed. It is interesting to note that they all occurred in the single H-B group (4 of 5 patients) while no cases of postoperative fistula were observed in the double H-B group. Even though the difference between the groups was not statistically significant (p=

0.2280), in our opinion this preliminary result is encouraging for the future viability of the double H-B flap in these challenging cases.

As an argument for this, we believe the particular architecture of the double H-B flap increases the strength of the reconstruction. Indeed, the two flaps are overlapped over the reconstruction so that the borders are slightly staggered as in a brick wall structure. Some authors assume that the gap between the overlapping flaps might be the leak point after the reconstruction[19]; however, we believe this particular spatial arrangement is the selling point of this reconstructive method as it provides a proper barrier to the high CSF pressure resulting from opening of the third ventricle. The results of our data analysis were affected to some degree by its retrospective design and the reduced sample size. Therefore, our findings need to be verified by a study on a larger number of cases, and a randomized prospective trial would be advisable. Despite these limitations, we believe the results from the double H-B group are very promising, especially when the reconstruction has to take place in challenging cases with very large craniotomies or high-flow intraoperative CSF leakage.

Conclusions

This preliminary report comparing the use of single and double H-B flaps for reconstruction of the skull base after expanded endonasal approaches shows that the double flap technique seems to be an effective method that significantly reduces the postoperative CSF leakage rate. In particular, for repair of large defects, the double H-B flap proved to be a reliable reconstructive method with no evidence of postoperative CSF fistulas. Reconstruction of transplanum-transtuberculum defects, especially when the third ventricle has to be opened, remains a unique challenge for the surgeon, regardless of the defect size. In these cases, an atypical reconstruction has to be planned and the use of the double H-B flap gave a better outcome than the single H-B flap in our series, even though these results need to be validated by a study with a larger sample size.

References

[1] Hadad G, Bassagasteguy L, Carrau RL, et al. A novel reconstructive technique after endoscopic expanded endonasal approaches: Vascular pedicle nasoseptal flap. Laryngoscope 2006; 116: 1882-1886.

[2] Harvey RJ, Parmar P, Sacks R, Zanation AM. Endoscopic skull base reconstruction of large dural defects: a systematic review of published evidence. Laryngoscope 2012; 122: 452-459.

[3] Kassam AB, Thomas A, Carrau RL, et al. Endoscopic reconstruction of the cranial base using pedicled nasoseptal flap. Neurosurgery 2008; 63: ONS 44-32; discussion ONS 44-33.

[4] Zanation AM, Carrau RL, Snyderman CH, et al. Nasoseptal flap reconstruction of high flow intraoperative cerebrospinal fluid leaks during endoscopic skull base surgery. Am J Rhinol Allergy 2009; 23: 518-521.

[5] Thorp BD, Sreenath SB, Ebert CS, Zanation AM. Endoscopic skull base reconstruction: a review and clinical case series of 152 vascularized flaps used for surgical skull base defects in the setting of intraoperative cerebrospinal fluid leak. Neurosurg Focus 2014; 37(4): E4.

[6] Simal Julián JA, Miranda Lloret P, Cárdenas Ruiz-Valdepeñas E, Barges Coll J, Beltrán Giner A, Botella Asunción C. Middle turbinate vascularized flap for skull base reconstruction after an expanded endonasal approach. Acta Neurochir (Wien) 2011; 153(9): 1827-1832.

[7] Fortes FS, Carrau RL, Snyderman CH, et al. The posterior pedicle inferior turbinate flap: a new vascularized flap for skull base reconstruction. Laryngoscope 2007; 117(8): 1329-1332.

[8] Marchioni D, Gulino A, Sacchetto L, Pinna G, Musumeci A, Molteni G. Expanded endoscopic approach for anterior skull base tumors: Experience of a multidisciplinary skull base team. J Craniofac Surg 2019; 30(6): 1730-1733.

[9] Kassam A, Snyderman CH, Mintz A, Gardner P, Carrau RL. Expanded endonasal approach: fully endoscopic, completely transnasal approach to the middle third of the clivus, petrous bone, middle cranial fossa, and infratemporal fossa. Neurosurg Focus 2005; 19.

[10] Couldwell WT, Weiss MH, Rabb C, Liu JK, Apfelbaum RI, Fukushima T. Variations on the standard transsphenoidal approach to the sellar region, with emphasis on the extended approaches and parasellar approaches: surgical experience in 105 cases. Neurosurgery 2004; 55: 539-550.

[11] Schwartz TH, Fraser JF, Brown S, Tabaee A, Kacker A, Anand VK. Endoscopic endonasal cranial base surgery: classification of operative approaches. Neurosurgery 2008; 62: 991-1002.

[12] Greenfield JP, Anand VK, Kacker A, et al. Endoscopic endonasal transethmoidal transcribriform transfovea ethmoidalis approach to the anterior cranial fossa and skull base. Neurosurgery 2010; 66: 883-892.

[13] Gardner PA, Kassam AB, Thomas A, et al. Endoscopic endonasal resection of anterior cranial base meningiomas. Neurosurgery 2008; 63: 36-52.

[14] Liu JK, Christiano LD, Patel SK, Eloy JA. Surgical nuances for removal of retrochiasmatic craniopharyngioma via the endoscopic endonasal extended transsphenoidal transplanum transtuberculum approach. Neurosurg Focus 2011; 30: E14.

[15] Liu JK, Eloy JA. Endoscopic endonasal transplanum transtuberculum approach for resection of retrochiasmatic craniopharyngioma. J Neurosurg 2012; 32: E2.

[16] Eloy JA, Shukla PA, Choudhry OJ, Singh R, Liu JK. Challenges and surgical nuances in reconstruction of large planum sphenoidale tuberculum sellae defects after endoscopic endonasal resection of parasellar skull base tumors. Laryngoscope 2013; 123: 1353-1360.

[17] Pinheiro-Neto CD, Prevedello DM, Carrau RL, et al. Improving the design of the pedicled nasoseptal flap for skull base reconstruction: a radioanatomic study. Laryngoscope 2007; 117: 1560-1569.

[18] Jeon C, Hong SD, Seol HJ, et al. Reconstructive outcomes of intraoperative cerebrospinal fluid leak after endoscopic endonasal surgery for tumors involving skull base. J Clin Neurosci 2017; 45: 227-231.

[19] Moon JH, Kim EH, Kim SH. Various modifications of a vascularized nasoseptal flap for repair of extensive skull base dural defects. J Neurosurg 2019; 8: 1-9.
[20] Schmalbach CE, Webb DE, Weitzel EK. Anterior skull base reconstruction: a review of current techniques. Curr Opin Otolaryngol Head Neck Surg 2010; 18: 238-243.
[21] McCoul ED, Schwartz TH, Anand VK. Vascularized reconstructions of endoscopic skull base defects. Oper Tech Otolaryngol Head Neck Surg 2011; 22: 232-236.
[22] Boetto J, Labidi M, Watanabe K, et al. Combined nasoseptal and inferior turbinate flap for reconstruction of large skull base defect after expanded endonasal approach: operative technique. Oper Neurosurg 2019; 16(1): 45-52.
[23] Nyquist GG, Anand VK, Singh A, Schwartz TH. Janus flap: bilateral nasoseptal flaps for anterior skull base reconstruction. Otolaryngol Head Neck Surg 2010; 142: 327-331.
[24] Bhatyki AM, Pant H, Snyderman CH, et al. Reconstruction of the cranial base after endonasal skull base surgery: local tissue flaps. Oper Tech Otolaryngol Head Neck Surg 2010; 21: 74-82.
[25] Choby GW, Pinheiro-Neto CD, de Almeida JR, et al. Extended inferior turbinate flap for endoscopic reconstruction of skull base defects. J Neurol Surg B Skull Base 2014; 75: 225-230.
[26] Soudry E, Turner JH, Nayak JV, Hwang PH. Endoscopic reconstruction of surgically created skull base defects: a systematic review. Otolaryngology Head Neck Surg 2014; 150(5): 730-738.
[27] Hu F, Gu Y, Zhang X, et al. Combined use of a gasket seal closure and a vascularized pedicle nasoseptal flap multilayered reconstruction technique for high-flow cerebrospinal fluid leaks after endonasal endoscopic skull base surgery. World Neurosurg 2015; 83(2): 181-187.
[28] Xuejian W, Fan H, Xiaobiao Z, et al. Endonasal endoscopic skull base multilayer reconstruction surgery with nasal pedicled mucosal flap to manage high flow CSF leakage. Turk Neurosurg 2013; 23, n4: 439-445.

[29] Luginbuhl AJ, Campbell PG, Evans J, Rosen M. Endoscopic repair of high-flow cranial base defects using a bilayer button. Laryngoscope 2010; 120: 876-880.

[30] Tabaee A, Anand VK, Brown SM, Lin JW, Schwartz TH. Algorithm for reconstruction after endoscopic pituitary and skull base surgery. Laryngoscope 2007; 117: 1133-1137.

Table 1: defect categorization basing on size and skull base approach

Skull base approach	*N° of patients*		
	1-2 cm	2-3 cm	> 3 cm
Single H-B group			
transcribriform	1	1	1
transplanum	2	5	3
transsellar	0	1	0
transclival	2	0	0
Double H-B group			
transcribriform	0	3	4
transplanum	1	6	2
transsellar	0	2	0
transclival	3	1	0
Total	8	19	10

Table 2: high-flow intraoperative CSF leak: patients' description

Patients, N°	Pathology	Defect site	Type of reconstruction	Type of flap	Graft material	Foley balloon
2	craniopharyngioma	transplanum	modified gasket-seal	pedicled, single H-B	tutopatch	0
6	pituitary adenoma	transplanum	modified gasket-seal	pedicled, single H-B	tutopatch	0
8	craniopharyngioma	transplanum	modified gasket-seal	pedicled, single H-B	tutopatch	0
14	pituitary adenoma	transplanum	modified gasket-seal	pedicled, single H-B	fascia lata	1
26	pituitary adenoma	transplanum	modified gasket-seal	pedicled, double H-B	fascia lata	1
27	craniopharyngioma	transplanum	modified gasket-seal	pedicled, double H-B	fascia lata	1
34	pituitary adenoma	transplanum	modified gasket-seal	pedicled, double H-B	tutopatch	1
35	craniopharyngioma	transplanum	modified gasket-seal	pedicled, double H-B	tutopatch	0
36	pituitary adenoma	transplanum	modified gasket-seal	pedicled, single H-B	fascia lata	0

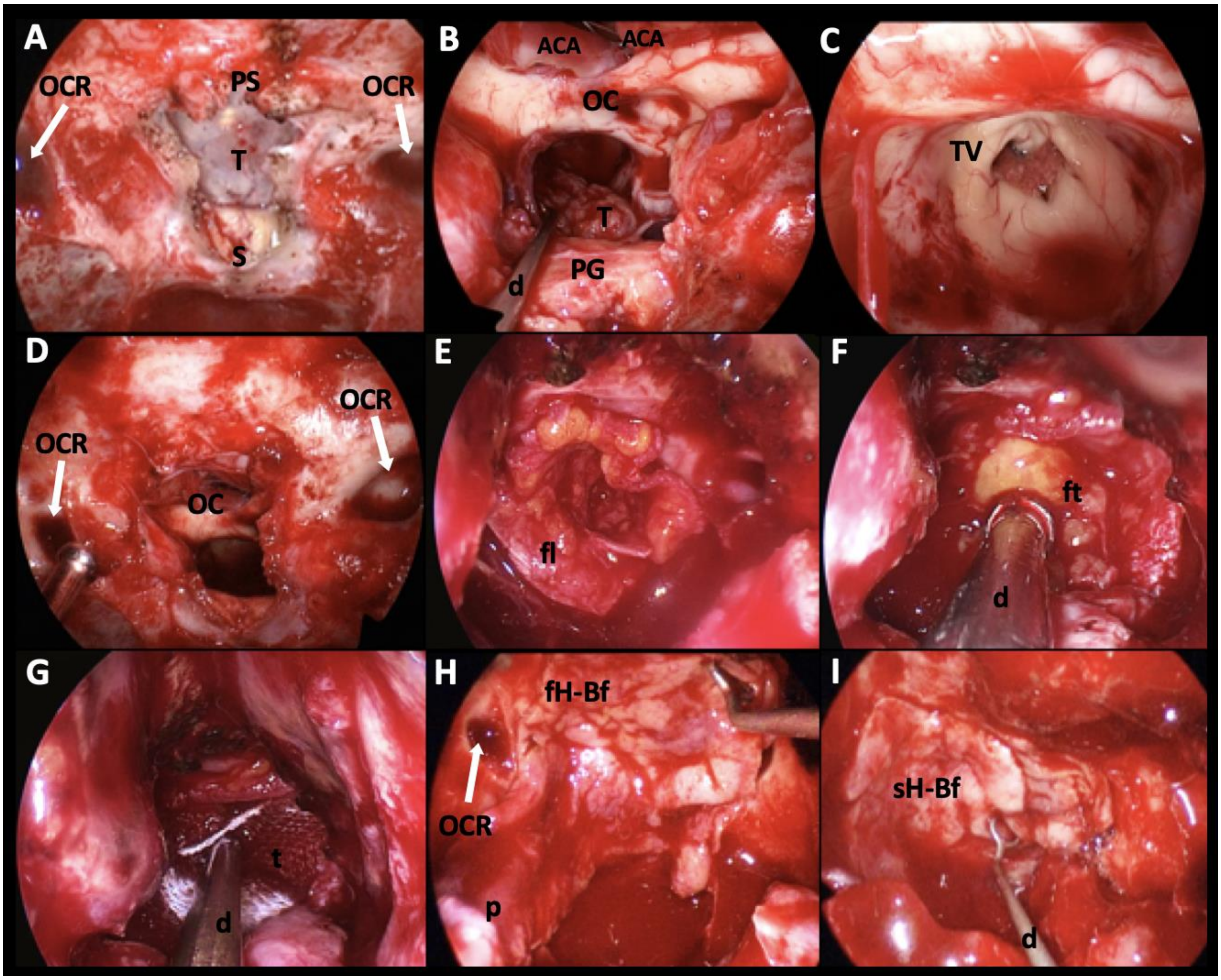
Table 3: Postoperative CSF leak occurrence: patients' description

Patients, N°	Pathology	Defect site	Intra-operative CSF leak degree	Defect size (cm)	Type of reconstruction	Type of flap	Graft material	Foley balloon	Data of CFS leak (days)
2	craniopharyngioma	transplanum	high	2-3 cm	modified gasket-seal	pedicled, single H-B	Lyoplant	yes	9
4	chondrosarcoma	transclival	low	1-2 cm	multilayer	pedicled, single H-B	Lyoplant	no	21
6	pituitary adenoma	transplanum	high	2-3 cm	modified gasket-seal	pedicled, single H-B	Lyoplant	no	21
9	meningioma	transplanum	low	2-3 cm	multilayer	pedicled, single H-B	fascia lata	yes	61
14	pituitary adenoma	transplanum	high	> 3 cm	modified gasket-seal	pedicled, single H-B	fascia lata	yes	10
23	pituitary adenoma	transplanum	low	2-3 cm	multilayer	pedicled, double H-B	fascia lata	yes	28
36	pituitary adenoma	transplanum	high	2-3 cm	modified gasket-seal	pedicled, single H-B	fascia lata	yes	10

Figure 1: Modified gasket-seal technique for reconstruction of transplanum defects.

Once the endoscopic craniotomy is performed through the planum sphenoidale, the tumor is identified in the suprasellar region (A). The tumoral tissue is gently dissected from the surrounding structure in the infrachiasmatic and suprachiasmatic space (B). Magnification of third ventricle at the end of the dissection (C). A bone defect extending from the planum sphenoidale to the sellar region is visible after the extirpative phase (D). To reconstruct the defect a piece of fascia lata is first centered over the defect (E). A piece of autologous fat is placed over the graft and is gently pushed into the fascia. (F). Surgicel is wedged into the fat to hold the graft on the floor of the reconstruction, creating a watertight seal (G). The first H-B flap is then rotated over the defect (H). The second flap is finally overlapped over the first one, maintaining the borders of the two flaps slightly staggered as in a brick wall structure. The dissector rests on the point of connection between the two flaps.

PS: planum sphenoidale; OCR: optico-carotid recess; T: tumour; OC: optic chiasm; PG: pituitary gland; ACA: anterior cerebral artery; TV: third ventricle; fl: fascia lata; ft: fat tissue; d: dissector; t: tabotamp; fH-Bf: first Hadad-Bassagasteguy flap; sH-Bf: second Hadad-Bassagasteguy flap.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