The Pedicled Buccal Fat Pad: Anatomical Study of the New Flap for Skull Base Defect Reconstruction After Endoscopic Endonasal Transpterygoid Surgery

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J Neurol Surg B 2017;78:75–81.

Abstract

Objectives To evaluate the efficacy and safety of using a buccal fat pad for endoscopic skull base defect reconstruction.

Design Descriptive anatomical study with an illustrative case presentation.

Setting Anatomical study was performed on 12 fresh human cadaver specimens with injected arteries (24 sides). Internal carotid artery was exposed in the coronal plane via the endoscopic transpterygoid approach. The pedicled buccal fat pad was used for reconstruction.

Participants: 12 human cadaver head specimens; one patient operated using the proposed technique.

Main outcome measures: Proximity of the buccal fat pad flap to the defect, compliance of the flap, comfort and safety of harvesting procedure, and compatibility with the Hadad–Bassagasteguy nasoseptal flap.

Results: Harvesting procedure was performed using anterior transmaxillary corridor. The pedicled buccal fat pad flap can be used to pack the sphenoid sinus or cover the internal carotid artery from cavernous to upper parapharyngeal segment.

Conclusion The buccal fat pad can be safely harvested through the same approach without external incisions and is compliant enough to conform to the skull base defect. The proposed pedicled flap can replace free abdominal fat in central skull base reconstruction. The volume of the buccal fat pad allows obliteration of the sphenoid sinus or upper parapharyngeal space.

Keywords

- buccal fat pad
- endoscopic endonasal approach
- transpterygoid approach
- skull base defect
- skull base reconstruction

Introduction

Endoscopic endonasal transpterygoid approach (TPA) is a workhorse of skull base surgery. This approach was initially introduced for the closure of cerebrospinal fluid (CSF) leaks located in the lateral sphenoid recess.¹ Indications for TPA include lesions of the pterygopalatine fossa (PPF), infratemporal fossa (ITF), cavernous sinus, Meckel cave, petrous apex,

and parapharyngeal space, with exposure of intracavernous structures, Gasserian ganglion and its branches, and internal carotid artery (ICA).^{2–12}

Variety of pathologies treated using this approach includes benign and malignant lesions arising intra- or extracranially, such as meningioma, trigeminal schwannoma, invasive pituitary adenoma, cholesterol granuloma, paraganglioma,

received

January 28, 2016

accepted after revision

May 25, 2016

published online

July 11, 2016

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Stuttgart · New York

DOI <http://dx.doi.org/10.1055/s-0036-1584895>.
ISSN 2193-6331.

juvenile angiofibroma, chordoma, sarcoma, lymphoma, adenoid cystic carcinoma, and other tumors.^{3,5,7,13–15}

Indeed, application of advanced endoscopic endonasal approaches (EEAs) such as TPA could not be possible without the development of new flaps providing watertight skull base reconstruction. Hadad–Bassagasteguy nasoseptal flap (NSF) has made a revolution in endoscopic skull base surgery due to a decrease of the incidence of postoperative CSF leaks to 5%.¹⁶ The NSF is the mainstay of contemporary skull base reconstruction in advanced EEA. However, in certain situations, the NSF is not available. In addition, NSF alone has limited usage in space-occupying reconstruction. Most popular local pedicled flaps include pericranium and temporal fascia flaps. Different other local pedicled flaps were proposed with their advantages and limitations.^{17–21}

We introduce buccal fat pad (BFP) as a novel local pedicled flap for reconstruction of skull base defects in endoscopic skull base surgery. Cherekaev et al²² in 2012 published the new method of skull base defect closure using the BFP after tumor removal using the orbitozygomatic approach. They reported safe and cosmetically acceptable usage of harvesting of this flap. Initially, the BFP is commonly used in the practice of maxillofacial surgery for reconstruction of palatal defects.²³ If pedicled, it receives vascular supply from the branches of the maxillary artery. Due to lateral location of the vascular pedicle, the BFP is suitable to reach lateral and paramedian skull base defects. Aim of this study is to evaluate efficacy and safety of using the BFP for skull base defect reconstruction after endoscopic transnasal transmaxillary TPA.

Materials and Methods

The cadaver study was performed on 12 fresh human cadaver specimens with injected arteries (24 sides). Each cadaveric dissection consisted of the same set of steps, including *nasal step* (approach to the paramedian skull base), *pterygopalatine step* (dissection of the contents of the PPF and exposure of the pterygoid process), *sphenoid step* (dissection of the cavernous sinus, V1 and V2), *pterygoid step* (pterygoidectomy and exposure of the Eustachian tube), *infratemporal step* (sacrifice of the Eustachian tube and exposure of the petrous and upper parapharyngeal ICA), and *reconstructive step* (harvesting of the BFP for closure of the skull base defect). The anatomical dissections were performed to expose the ICA in the coronal plane, elaborate the surgical technique of harvesting the BFP through anterior transmaxillary approach (TMA), and evaluate the properties of the BFP as a covering and space-occupying flap for defects of the central skull base and upper parapharyngeal space. Unilateral EEA was used to perform the entire dissection except for the final step, which required standard TMA. All manipulations were performed under the control of 4-mm 0-degree rigid telescope and high-definition (HD) video camera using basic set of instruments for paranasal sinus and skull base surgery (Karl Storz, Tuttlingen, Germany). Bone resection for better visualization and more accurate view was performed using chisel. All photo and video recordings were performed using a digital HD video recorder.

Results

Stepwise Cadaveric Dissection

1. *Nasal step*: The dissection started with unilateral middle turbinectomy, preparation of the contralateral NSF, unilateral infundibulotomy, wide medial maxillotomy, anterior and posterior ethmoidectomy, bilateral anterior sphenoidotomy, and resection of posterior one-third of the inferior nasal turbinate. Aim of this step was to expose key anatomical landmarks in the nasopharynx, sphenoid sinus, lateral nasal wall, and maxillary sinus.
2. *Pterygopalatine step*: TMA was performed using standard sublabial Caldwell–Luc anterior maxillary opening 10 to 12 mm wide. Further dissection was performed in the PPF. It consisted of opening of the sphenopalatine foramen, ligation of the sphenopalatine artery, and removal of the posterior maxillary wall medial to the infraorbital nerve. Palatovaginal and vidian neurovascular bundles were identified and sacrificed. Contents of the PPF were displaced laterally to expose the anterior surface of pterygoid process. Pterygoid muscles were subperiosteally dissected from pterygoid base to reach the foramen ovale and V3.
3. *Sphenoid step*: Aim of this stage was to remove the ipsilateral part of sphenoid body. We exposed the sella and ipsilateral parasellar space including the cavernous sinus with the ICA, III, IV, VI, and V1 nerves, and medial aspect of superior orbital fissure. Dura of the middle cranial fossa was denuded reaching the Meckel cave.
4. *Pterygoid step*: After detachment of lateral and medial pterygoid muscles and tensor veli palatini, pterygoidectomy was performed to facilitate further exposure of the petrosal and parapharyngeal ICA. Vidian canal was used as a landmark guiding to the foramen lacerum and the medial genu of ICA. Total pterygoidectomy was accomplished to allow wide exposure of the entire Eustachian tube and approach to the petrous and subcranial ICA.
5. *Infratemporal step*: Pharyngeal ostium of the Eustachian tube was circumferentially incised to mobilize the medial end. The tube was dissected gradually toward its lateral end. At the level of the foramen lacerum, dense fibrous tissue connections between the fibrocartilage and the tube were sharply transected. After mobilization and far lateral transection of the Eustachian tube, the inferior and anterior walls of the carotid canal were removed to expose the petrous segment and the lateral genu of the ICA. Fibrocartilage of the foramen lacerum was carefully resected. Final step of the ICA exposure was dissection in the poststyloid compartment of the upper parapharyngeal space. As a result, the ICA was exposed from its cavernous segment down to the upper parapharyngeal space (→ Fig. 1A).
6. *Reconstructive step*: Additional lateral resection of the posterior maxillary wall was performed to visualize the border between fat tissue and muscles of the ITF. This line served as the landmark for finding the BFP and the limitation of the posterolateral maxillotomy. Superior boundary of this resection was at the level of the inferior

Fig. 1 Skull base defect reconstruction and closure of the internal carotid artery (ICA) using the buccal fat pad (BFP), left side. (A) After completion of transpterygoid approach, the ICA is exposed in the coronal plane. Next, posterolateral maxillotomy and exposure of the BFP in the retromaxillary space is performed. (B) The body and buccal process of the BFP are mobilized. The pedicled BFP flap is used to cover the ICA at the level of either (C) upper parapharyngeal space or (D) skull base. (E) After elevation of the contralateral Hadad–Bassagasteguy nasoseptal flap (NSF), combined skull base reconstruction with both flaps is achieved. BFP, buccal fat pad; C1, subcranial segment of ICA; C2, petrous segment of ICA; C3, cavernous segment of ICA; CH, choana; CL, clivus; DTM, deep temporal muscle; MOW, medial orbital wall; NF, nasal floor; NS, nasal septum; NSF, Hadad–Bassagasteguy nasoseptal flap; OCR, opticocarotid recess; OF, orbital floor; ON, optic nerve; PG, pituitary gland; PMW, posterior maxillary wall; SOF, superior orbital fissure; SS, sphenoid sinus septum; V2, maxillary nerve; V3, mandibular nerve; VP, vascular pedicle of BFP flap.

orbital fissure, and inferior border was at the level of the maxillary sinus floor. Thin periosteal coverage of the ITF was opened, and the body of the BFP was exposed immediately behind it. The body and buccal process of the BFP were carefully pulled inside the maxillary sinus using angled grasping forceps and curved elevator (►Fig. 1B). To facilitate this, we applied special maneuver, a surgeon's index finger was introduced into the oral vestibule behind the molars to push the buccal process of the BFP upward. No sharp dissection was used to avoid mucosal perforation. Finally, the major volume of the BFP, including its body, buccal process, and sometimes partially temporal process, was available to be translocated into the skull base defect on the vascular pedicle containing feeding vessels from the MA in front of the lateral pterygoid muscle.

Our anatomical study has demonstrated that the BFP is characterized by sufficient plasticity to fill spaces of different shape and volume, for example, sphenoid sinus, infrapetrosal space, and pre- and poststyloid upper parapharyngeal space. The BFP was also able to provide protective coverage for the ICA in either of its segments: intracavernous, paraclival,

petrosal, and parapharyngeal (►Fig. 1C, D). Combined skull base reconstruction with addition of the NSF finalized the dissection (►Fig. 1E).

Illustrative Case

A 32-year-old woman presented with headaches and decreased hearing. Neurological examination revealed left V3 hypesthesia and conductive hypoacusis on the left side. Preoperative computed tomography (CT) discovered a lesion in the left ITF, which produced significant mass effect and wide erosion of cranial base around the foramen ovale with intracranial extension (►Fig. 2A). The patient was operated endoscopically using the transnasal transmaxillary TPA with additional palatal incision to control the inferior pole of the tumor. After complete removal of the tumor, the pedicled BFP flap was harvested and translocated into the middle skull base defect to isolate the exposed cavernous sinus and the Meckel cave from sinonasal cavity (►Fig. 2B). The flap was supported by a Foley catheter for 4 days. After removal of the balloon catheter, CT scans were obtained to confirm the correct placement of the BFP flap (►Fig. 2C). Histological examination diagnosed schwannoma, which obviously originated from V3. The patient was discharged on

Fig. 2 Illustrative case. A 32-year-old female patient with a large V3 schwannoma. (A) Preoperative computed tomography (CT) scan with contrast enhancement (site of intracranial extension is indicated by arrow). (B) The buccal fat pad (BFP) flap is positioned in the defect of cavernous sinus and the Meckel cave (0-degree endoscopic view). (C) CT scan obtained after removal balloon catheter on the fourth postoperative day indicating BFP in the skull base defect (asterisk). (D) Follow-up magnetic resonance imaging 3 months after surgery demonstrates presence of the BFP in the site of its placement (indicated by arrowheads). BFP, buccal fat pad; PMW, posterior maxillary wall; T, tumor.

the fifth postoperative day in satisfactory condition without any new neurological deficit. Her follow-up magnetic resonance imaging (MRI) demonstrated the presence of the BFP in the skull base defect (→Fig. 2D). The flap did not enhance as this fat normally does not on MRI in its anatomical bed. The patient had no cosmetic consequences associated with usage of this flap.

Discussion

Skull Base Reconstruction in Repair of Lateral Sphenoid Recess CSF Leaks

A variety of materials has been described for CSF leak closure.²⁴ Usually, a free fascia lata and free fat tissue are obtained from the right thigh.²⁵ Stabilization of reconstruction site may be established by packing of the sphenoid sinus with fat or fascia,¹ cartilage from the nasal septum or ear,²⁶ or septal bone.

We have investigated literature data on application of fat grafts in repair of lateral sphenoid recess CSF leaks. Forer and Sethi²⁴ suggested two-layer abdominal fat plasty with a free mucosal graft to create a “sandwich reconstruction” and a third piece of fat over the mucosal graft. Schmidt et al⁸ proposed to buttress the overlay mucosal graft with an autologous fat graft placed in the sphenoid sinus. Other authors reported using a free fat graft in certain cases for definitive closure of the recess. If mucosa can be completely extirpated from the lateral recess of the sphenoid sinus,

obliteration is performed by placing a free fat graft in the recess.²⁴

Consequently, the role of fat tissue in repair of lateral sphenoid recess CSF leaks may still be important. However, abdominal fat grafting requires additional incision, which, in our opinion, seems undesirable, especially when hip incision is mandatory to harvest fascial graft.

The Role of the Anterior Transmaxillary Corridor in the Endoscopic Endonasal TPA to the Skull Base

In TPA, the surgical corridor is narrow. Some difficulty in manipulation of the instruments becomes more problematic as dissection extends posteriorly. The smaller surgical window may also allow only piecemeal removal of a neoplasm.¹² Comfort of combined endoscopic transnasal transmaxillary approach in transpterygoid surgery is appreciated by many authors due to a wider operating angle and working space providing comfortable four-handed biportal manipulations with direct straight instruments under the control of a 0-degree endoscope.^{9,27–34} Bolger and Osenbach¹ advocate supplementation of transnasal approach to the lateral sphenoid recess with a limited endoscopic Caldwell–Luc sublabial port. However, creating an endonasal corridor than a trans-antral adds additional time to overall procedure.¹²

Exposure of the ICA in Endoscopic Endonasal TPA

EEAs provide access that extends from the cavernous to the parapharyngeal segments of the ICA,¹³ thus creating the possibility of extensive exposure of the ICA. Usually, there is no need for complete ICA skeletonization, which is only performed when there is direct disease encasement or in cases in which ICA mobilization or proximal control is required.³⁵ In addition, primary lesions from the PPF and ITF can extend around the ICA.¹³

It is important to apply the appropriate reconstructive techniques to obviate exposure of the ICA.¹² The vascularized mucosal reconstruction technique is ideal to cover the skull base defect and exposed ICA, preventing both CSF leak and ICA adventitia desiccation.³⁵ Although unroofing of the ICA is rare, the exposed vessel can be covered with fat or acellular dermis bolstered with a tissue glue or sealant. Another option is the NSF that can be harvested at the beginning of a case and then placed or sewn into place.^{3,12} These flaps can cover the ICA and prevent its exposure to nasopharyngeal secretions.⁴

Skull Base Defect Reconstruction in Extended EEA

A variety of free tissue grafts, vascularized local flaps, free microvascular flaps, and allografts are available for skull base reconstruction.³⁶ Among existing skull base reconstruction techniques, vascularized flaps appear advantageous and promote adequate and a rapid healing.^{4,17,36} In addition, pedicled flaps conform to irregular surfaces and are easier to mobilize into defects than rotation or advancement flaps.^{17,37} These benefits are critical for the reconstruction of very large defects and for defects in patients who have received preoperative radiotherapy or chemoradiotherapy. In addition, the complete and accelerated healing facilitated by the vascular flaps may allow for the earlier and safer delivery of postoperative radiation therapy.¹⁷

Large defects comparable in size to a craniofacial resection have traditionally been repaired using regional vascularized flaps (pericranial, galeal, and temporoparietal flaps). With the advent of EEA, however, these flaps require a separate external approach and add to the morbidity of the procedure. Introduction of the pedicled mucoperiosteal NSF has made a revolution in endoscopic endonasal skull base surgery having lowered the incidence of postoperative CSF leaks to approximately 5%.¹⁶ The vascularized mucosal reconstruction technique is ideal to cover the skull base defect.³⁸

However, in patients who have undergone previous EEAs that included a posterior septectomy or in patients with tumors involving the posterior septum, rostrum of the sphenoid sinus, or PPF, the blood supply to the NSF has been compromised; therefore, this option is not available.¹⁷ Even contralateral NSF may not reach a laterally situated skull base defect.

Different alternatives have been proposed to reconstruct the skull base after EEA, for example, temporoparietal fascial flap, subgaleal fascia flap, inferior turbinate flap, pedicled buccinator myofascial flap, and palate myocoperiosteum.^{17,20,21,37,39} Except for temporoparietal fascial flap and inferior turbinate flap, these flaps require complicated harvesting procedure and significantly extended exposure.

Finally, the donor site may be compromised by tumor or prior surgery, and, occasionally, the size of the defect may require multiple flaps or even a hybrid technique.¹⁶

Perspectives of Using the Pedicled BFP for Skull Base Reconstruction in TPA

The BFP is a separate mass of fat located in the masticatory space of the ITF. Its body is medial to the ramus of mandible and immediately behind the posterior maxillary wall. Four processes extend to the adjacent regions: buccal, temporal, pterygoid, and pterygopalatine (►Figs. 3 and 4).⁴⁰ Vascular

supply of the BFP is provided by the branches of MA and facial artery (for the buccal process).⁴¹

Mean volume of the BFP is 10 cm³. Three-dimensional CT studies did not reveal any significant differences between sides and genders. The BFP enlarges with age, leading to almost doubling of its volume in adult age. Moderate decrease of volume after age of 50 is observed.⁴²

Initially, the BFP flap was introduced by maxillofacial surgeons for reconstruction of palatal defects.²³ First description of skull base reconstruction using the BFP was published by Cherekaev et al.²² It was demonstrated that the BFP with pterygopalatine process as a vascular pedicle was effective for closure of middle skull base defects from the superior orbital fissure to the petrous bone, without additional postoperative morbidity related to harvesting procedure. We have reported in 2013 the first case of skull base closure with the BFP in EEA in a patient with juvenile angiofibroma.⁴³

Discussing the possible advantages of the BFP in endoscopic endonasal skull base reconstruction, we should appreciate the role of fat tissue in EEA. Fat not only provides a biological dressing, promoting vascularization and healing, but also applies pressure, reducing the risk of migration of the underlying grafts. Although before the development of the NSF free abdominal fat was very popular, today fat graft is reserved for the obliteration of bone cavities such as the sphenoid sinus or its lateral recess.³⁸

Possible applications of the BFP in endoscopic endonasal surgery are as follows: (1) obliteration of lateral sphenoid recess in CSF leak repair, (2) flap for obliteration of the dead space in superior TPA (at the level of skull base) or inferior TPA (at the level of upper parapharyngeal space), (3) part of multilayer skull base reconstruction as a replacement for free abdominal fat, and (4) isolation of the ICA from sinonasal cavity with or without NSF. We have demonstrated that the pedicled BFP flap may be used at any level of the ICA, from paraclinoid to upper parapharyngeal.

Being a stable flap, the vascularized BFP is superior to abdominal fat due to several reasons including presence of vascular pedicle, proximity to the surgical site in TPA, no need for additional incision of the abdominal wall, faster healing and minimal risk of failure due to preserved vascular supply, and minimal risk of complications associated with harvesting procedure. In comparison with temporoparietal fascial flap, the BFP does not require external incisions and is harvested in a significantly easier and faster way. Unlike the NSF, the BFP flap is very compliant and can be rotated and reshaped to conform to the configuration of skull base defect.

We propose the BFP as a valuable and promising flap for either external or endoscopic skull base surgery.

Possible disadvantages of the proposed technique are due to TMA. Anterior maxillotomy may carry the risk of typical postoperative complications such as injury to the infraorbital nerve branches or the superior alveolar nerves and arteries.³ However, if the lesion infiltrates V2, sacrifice of its alveolar branches will not worsen the situation. Wide posterolateral maxillotomy and communication of the masticatory space with the sinonasal cavity also should be considered. In addition, the BFP has spatial limitations. Due to its laterally

Fig. 3 Scheme demonstrating relations between the buccal fat pad (BFP; yellow) and skull structures. B, body; BP, buccal process; TP, temporal process (all structures related to the BFP).

Fig. 4 Computed tomography anatomy of the buccal fat pad (BFP) in relationship with surrounding structures. The BFP is situated immediately behind the posterior maxillary wall in the masticatory space of the infratemporal fossa. (A) Axial scan at the level of inferior turbinates. (B) Axial scan at the level of inferior orbital fissure. (C) Coronal scan at the level of the orbital apex. (D) Sagittal scan at the level of junction between the body and the ramus of mandible. B, body of BFP; BM, buccinator muscle; BP, buccal process of BFP; LPM, lateral pterygoid muscle; LSR, lateral sphenoid recess; MM, masseter muscle; MS, maxillary sinus; OP, orbital process of BFP; PP, pterygoid process of BFP; PPP, pterygopalatine process of BFP; TM, temporal muscle; TP, temporal process of BFP; ZA, zygomatic arch.

situated vascular pedicle, its usage is limited for reconstruction of midline skull base defects such as sella, planum sphenoidale, or clivus. However, we have a single unreported experience of transcranial closure of posterior ethmoid defect.

Conclusion

The BFP as an adjunct to TPA provides an excellent vascularized fat tissue, which can be harvested using the same approach without external incisions and has sufficient plasticity to be rotated and reshaped according to the configuration of skull base defect. No morbidity related to donor site is reported. The BFP can cover any segment of the ICA from supraclinoid to parapharyngeal to isolate it from the sino-nasal tract. It can replace free abdominal fat in any type of skull base closure (single layer of multilayer) and may be used in combination with the NSF or substitute it in case of compromised blood supply of the NSF (e.g., after previous surgeries). The volume of the BFP is large enough to obliterate the sphenoid sinus or upper parapharyngeal space. Disad-

vantage of the BFP application is associated with the risks of anterior maxillotomy, which is beneficial for flap harvesting.

References

- 1 Bolger W, Osenbach R. Endoscopic transpterygoid approach to the lateral sphenoid recess. *ENT J* 1999;78:36–46
- 2 Battaglia P, Turri-Zanoni M, Dallan I, et al. Endoscopic endonasal transpterygoid transmaxillary approach to the infratemporal and upper parapharyngeal tumors. *Otolaryngol Head Neck Surg* 2014; 150(4):696–702
- 3 Hofstetter CP, Singh A, Anand VK, et al. The endoscopic, endonasal, transmaxillary transpterygoid approach to the pterygopalatine fossa, infratemporal fossa, petrous apex, and the Meckel cave. *J Neurosurg* 2010;113(5):967–974
- 4 Hosseini S, Razfar A, Carrau R, et al. Endonasal transpterygoid approach to the infratemporal fossa: correlation of endoscopic and multiplanar CT anatomy. *Head Neck* 2012;34:313–320
- 5 Jiang W-H, Tang Q-P, Xie Z-H, et al. Endoscopic surgery of cavernous sinus tumors originating from the extradura. *J Craniofac Surg* 2012;23(6):1699–1702
- 6 Komatsu F, Komatsu M, Di Ieva A, et al. Endoscopic approaches to the trigeminal nerve and clinical consideration for trigeminal

- schwannomas: a cadaveric study. *J Neurosurg* 2012;117(4):690–696
- 7 Pinheiro-Neto CD, Fernandez-Miranda JC, Prevedello DM, et al. Transposition of the pterygopalatine fossa during endoscopic endonasal transpterygoid approaches. *J Neurol Surg B Skull Base* 2013;74(5):266–270
 - 8 Schmidt RF, Choudhry OJ, Raviv J, et al. Surgical nuances for the endoscopic endonasal transpterygoid approach to lateral sphenoid sinus encephaloceles. *Neurosurg Focus* 2012;32(6):E5
 - 9 Singh A, Anand V, Schwartz T. Endoscopic approaches to the pterygopalatine and infratemporal fossae. In: Kennedy D, Hwang P, eds. *Rhinology. Diseases of the Nose, Sinuses, and Skull Base*. New York, NY: Thieme; 2012:653–658
 - 10 Taniguchi M, Kohmura E. Endoscopic transnasal transmaxillary transpterygoid approach to the parapharyngeal space: an anatomic study. *Minim Invasive Neurosurg* 2010;53(5–6):255–260
 - 11 Van Rompaey J, Bush C, Khabbaz E, et al. What is the best route to the Meckel cave? Anatomical comparison between the endoscopic endonasal approach and a lateral approach. *J Neurol Surg B Skull Base* 2013;74(6):331–336
 - 12 Van Rompaey J, Suruliraj A, Carrau R, et al. Access to the parapharyngeal space: an anatomical study comparing the endoscopic and open approaches. *Laryngoscope* 2013;123(10):2378–2382
 - 13 Fortes FSG, Pinheiro-Neto CD, Carrau RL, et al. Endonasal endoscopic exposure of the internal carotid artery: an anatomical study. *Laryngoscope* 2012;122(2):445–451
 - 14 Kassam A, Prevedello D, Carrau R, et al. The front door to Meckel's cave: an anteromedial corridor via expanded endoscopic endonasal approach - technical considerations and clinical series. *Neurosurgery* 2009;64(3, Suppl):ons71–ons82
 - 15 Kassam AB, Gardner P, Snyderman C, et al. 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(1):E6
 - 16 Hadad G, Bassagasteguy L, Carrau RL, et al. A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. *Laryngoscope* 2006;116(October):1882–1886
 - 17 Fortes FSG, Carrau RL, Snyderman CH, et al. Transpterygoid transposition of a temporoparietal fascia flap: a new method for skull base reconstruction after endoscopic expanded endonasal approaches. *Laryngoscope* 2007;117(6):970–976
 - 18 Fortes FSG, 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
 - 19 Hadad G, Rivera-Serrano CM, Bassagaisteguy LH, et al. Anterior pedicle lateral nasal wall flap: a novel technique for the reconstruction of anterior skull base defects. *Laryngoscope* 2011;121(8):1606–1610
 - 20 Oliver CL, Hackman TG, Carrau RL, et al. Palatal flap modifications allow pedicled reconstruction of the skull base. *Laryngoscope* 2008;118(12):2102–2106
 - 21 Rivera-Serrano CM, Oliver CL, Sok J, et al. Pedicled facial buccinator (FAB) flap: a new flap for reconstruction of skull base defects. *Laryngoscope* 2010;120(10):1922–1930
 - 22 Cherekaev V, Golbin D, Belov A. Translocated pedicled buccal fat pad: closure of anterior and middle skull base defects after tumor resection. *J Craniofac Surg* 2012;23(1):98–104
 - 23 Hudson JW, Anderson JG, Russell RM, et al. Use of pedicled fat pad graft as an adjunct in the reconstruction of palatal cleft defects. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;80(1):24–27
 - 24 Forer B, Sethi DS. Endoscopic repair of cerebrospinal fluid leaks in the lateral sphenoid sinus recess. *J Neurosurg* 2010;112(2):444–448
 - 25 Bachmann-Harildstad G, Kloster R, Bajic R. Transpterygoid trans-sphenoid approach to the lateral extension of the sphenoid sinus to repair a spontaneous CSF leak. *Skull Base* 2006;16(4):207–212
 - 26 Alexander NS, Riley KO, Woodworth BA. Treatment strategies for lateral sphenoid sinus recess cerebrospinal fluid leaks. *Laryngoscope* 2011;121(Suppl 4):471–478
 - 27 Alimohamadi M, Hajiabadi M, Gerganov V, et al. Combined endonasal and sublabial endoscopic transmaxillary approach to the pterygopalatine fossa and orbital apex. *Acta Neurochir (Wien)* 2015;157(6):919–929
 - 28 Caseido E, Herrera A, Carrau R, et al. How to manage lateral sphenoid cerebrospinal fluid leaks. In: Stamm A, ed. *Transnasal Endoscopic Skull Base and Brain Surgery: Tips and Pearls*. New York, NY: Thieme; 2011:332–336
 - 29 Har-El G. Combined endoscopic transmaxillary-transnasal approach to the pterygoid region, lateral sphenoid sinus, and retrobulbar orbit. *Ann Otol Rhinol Laryngol* 2005;114(6):439–442
 - 30 Little AS, Nakaji P, Milligan J. Endoscopic endonasal transmaxillary approach and endoscopic sublabial transmaxillary approach: surgical decision-making and implications of the nasolacrimal duct. *World Neurosurg* 2013;80(5):583–590
 - 31 Schwartz TH, Fraser JF, Brown S, et al. Endoscopic cranial base surgery: classification of operative approaches. *Neurosurgery* 2008;62(5):991–1002, discussion 1002–1005
 - 32 Singhal D, Douglas R, Robinson S, et al. The incidence of complications using new landmarks and a modified technique of canine fossa puncture. *Am J Rhinol* 2015;21(3):316–319
 - 33 Tewfik M, Wormald P. Pterygopalatine and infratemporal fossae. In: Stamm A, ed. *Transnasal Endoscopic Skull Base and Brain Surgery: Tips and Pearls*. New York, NY: Thieme; 2011:293–300
 - 34 Tosun F, Carrau R, Snyderman C, et al. Endonasal endoscopic repair of cerebrospinal fluid leaks of the sphenoid sinus. *Arch Otolaryngol Head Neck Surg* 2003;129:576–580
 - 35 Prevedello DM, Ditzel Filho LFS, Solari D, et al. Expanded endonasal approaches to middle cranial fossa and posterior fossa tumors. *Neurosurg Clin N Am* 2010;21(4):621–635
 - 36 Kassam A, Carrau RL, Snyderman CH, et al. Evolution of reconstructive techniques following endoscopic expanded endonasal approaches. *Neurosurg Focus* 2005;19(1):E8
 - 37 Patel MR, Shah RN, Snyderman CH, et al. Pericranial flap for endoscopic anterior skull-base reconstruction. *Neurosurgery* 2010;66(3):506–512
 - 38 Fortes FSG, Sennes LU, Carrau RL, et al. Endoscopic anatomy of the pterygopalatine fossa and the transpterygoid approach: development of a surgical instruction model. *Laryngoscope* 2008;118(1):44–49
 - 39 Casoli V, Dauphin N, Taki C, et al. Anatomy and blood supply of the subgaleal fascia flap. *Clin Anat* 2004;17(5):392–399
 - 40 Zhang H-M, Yan Y-P, Qi K-M, et al. Anatomical structure of the buccal fat pad and its clinical adaptations. *Plast Reconstr Surg* 2002;109:2509–2518
 - 41 Kahn J. Vascularization of the adipose body of the cheek. *Arch Anat Histol Embryol* 1990;73:3–20
 - 42 Xiao H, Bayramiçli M, Jackson IT. Volumetric analysis of the buccal fat pad. *Eur J Plast Surg* 1999;22(4):177–181
 - 43 Golbin DA, Lasunin NV. The first experience of skull base defect reconstruction using pedicled buccal fat pad after endoscopic endonasal resection of a craniofacial tumor [in Russian]. *Vopr Neurokhir* 2013;77(2):44–49