

Risk Factors for Postoperative Cerebrospinal Fluid Leak in Pediatric Endoscopic Endonasal Skull Base Surgery

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Introduction

Endoscopic endonasal surgery (EES) provides access to the ventral skull base and is applicable to a wide variety of clinical conditions including benign and malignant neoplasms, and congenital, traumatic, and inflammatory disease¹. In two reviews of our experience with EES in the pediatric population, the most common conditions encountered included craniopharyngiomas, pituitary adenomas and Rathke's cleft cysts, angiofibromas, epidermoids/dermoids, chordomas/chondrosarcomas, congenital skull base defects, and fibro-osseous lesions^{2,3}.

Endonasal surgeries are classified into modules based on their orientation in sagittal and coronal planes⁴. Sagittal plane modules extend from the frontal sinus to the craniovertebral junction. Coronal plane modules correspond to the cranial fossae: anterior coronal plane modules provide access to the medial orbit and orbital roof; middle coronal plane modules provide access to the petrous apex, Meckel's cave, lateral cavernous sinus, and floor of the middle cranial fossa; posterior coronal plane modules provide access to the jugular tubercle, occipital condyle, and parapharyngeal space. The endonasal approaches are limited by surrounding neurovascular structures: optic nerves, carotid arteries, vertebralbasilar arteries, and other cranial nerves. The golden rule of EES is to avoid displacement of normal neural and vascular structures. Other tenets of EES include team surgery and improved visualization with the endoscope. Extensive experience with these procedures for more than two decades has demonstrated the safety and efficacy of EES, as well as its risks and limitations⁵.

One of the greatest challenges of EES is reconstruction of dural defects. Postoperative cerebrospinal fluid (CSF) leaks are a major source of morbidity and the primary source of postoperative infectious complications such as meningitis. There has been an evolution of techniques over the years with increased use of vascularized for tissue for reconstruction. The application of the nasoseptal flap to reconstruction of skull base defects has had a dramatic impact⁶ and is associated with superior results⁷. In our experience, the nasoseptal flap was the most common reconstructive technique, employed in over 40% of patients.

Pediatric patients appear to be at greater risk for postoperative CSF leak following EES. Challenges of EES in the pediatric population include the size of the nasal aperture and nasal cavity, undeveloped sinuses with lack of bony landmarks,

decreased blood volume, potential disruption of growth centers, and limited reconstructive options. The relative growth of the facial structures is delayed compared to the cranium and the nasoseptal flap is limited in size in younger patients⁶.

Surgical Technique

Techniques of dural repair vary depending on the location and size of the defect, reconstructive options, and age of the patient (**Table 1**). Smaller low-flow defects can be repaired with non-vascularized tissue (fascia, fat, mucosa) with good results. Larger defects require a multilayer reconstruction with vascularized tissue. For anterior skull base defects, we prefer an inlay (intradural) collagen graft (Duragen or fascia lata) with an extradural onlay graft of fascia lata (tucked in the epidural space). This is covered with a vascularized nasoseptal flap or extracranial pericranial scalp flap⁸. Sellar and suprasellar defects can be repaired with two layers: inlay (intradural) collagen graft (Duragen) and nasoseptal flap. Posterior fossa defects are repaired similarly to anterior cranial base defects with an inlay (intradural) collagen graft (Duragen or fascia lata) with an extradural onlay graft of fascia lata (tucked in the epidural space). The deep clival defect is then filled with adipose tissue to create a flat plane for coverage by a nasoseptal flap or lateral nasal wall (inferior turbinate) flap.

Table 1. Reconstruction Algorithm

Approach	Small/Low-Flow Defect	Large/High-Flow Defect	CSF Diversion (Lumbar Drain)
Anterior	2 layer: Non-vascular	3 layer: inlay fascia, onlay fascia vascular flap	Yes
Sellar/Suprasellar	2 layer: Non-vascular	3 layer: inlay fascia, onlay fascia, vascular flap	No
Posterior	2 layer: Non-vascular	4 layer: inlay fascia, onlay fascia, fat, vascular flap	Yes

Nasal packing consists of a Foley balloon catheter inflated with saline for sellar/suprasellar defects, or Merocel tampons for anterior and posterior fossa defects. Packing is generally removed at 5-7 days postoperative. Perioperative antibiotic prophylaxis continues as long as packing is in place.

CSF diversion with a lumbar spinal drain is used in high-risk patients: large defects, high-flow leaks, suspected increased intracranial pressure, or prior failure of repair.

Outcomes

We reviewed our experience with CSF leaks in pediatric patients with a diagnosis of craniopharyngioma, sellar pathology, and chordoma to identify risk factors for postoperative CSF leak (unpublished data, 2016). Among 47 patients with an intraoperative CSF leak, 11 patients (31%) developed a postoperative CSF leak; 7 of these 11 patients (64%) developed meningitis. There was no clear association with age or body mass index (BMI). Although not significant, postoperative CSF leak was associated with posterior fossa defects (transclival defects) and the use of a vascularized flap for reconstruction.

These results are not surprising. Posterior fossa defects, in particular, are difficult to reconstruct and are situated more inferiorly in pediatric patients. A nasoseptal flap may not provide adequate coverage for large transclival defects and it can be difficult to place packing effectively in this area.

Although we lack data on the efficacy of CSF diversion in pediatric EES patients, extrapolation of results from the adult population provides guidance. In a randomized trial of CSF diversion in adult EES patients, patient groups that benefited included large anterior and posterior fossa defects (unpublished data, 2016). Sellar/suprasellar defects did not benefit from lumbar CSF drainage.

Management of CSF Leaks

Postoperative CSF leaks can be difficult to diagnose in pediatric patients due to decreased communication, limited examination, and posterior drainage pathway to the pharynx. In particular, posterior fossa defects may drain into the pharynx and patients may not report the drainage; frequent coughing or aspiration may be the primary symptom. A CSF leak may not be apparent until after nasal packing is removed. In small patients, removal of packing under anesthesia in the operating theater provides an opportunity to inspect the surgical site and reinforce the repair if necessary.

CSF leaks should be managed promptly to prevent infectious complications. Suspicious drainage can be confirmed with beta-2-transferrin testing. CSF diversion with a lumbar spinal drain should not be used as the primary treatment of a CSF leak, since it delays repair and increases the risk of meningitis. Ideally, patients should be returned to the operating room within 24 hours of diagnosis. In most cases, the flap can be repositioned or supplemented with fascia or fat to seal the leak. A lumbar drain is placed at that time and continued for 3-5 days. Other surgical options when a nasoseptal flap is not available include multilayer fascia lata and fat grafts, inferior turbinate (lateral nasal wall) flap, temporoparietal fascial flap, or pericranial scalp flap.

Conclusions

CSF leaks remain a major source of morbidity in pediatric patients undergoing EES. Pediatric patients appear to have an increased risk of postoperative CSF leak and reconstruction of dural defects is challenging. Risk factors may include posterior fossa defects and complex reconstructions requiring the use of a nasoseptal flap. Ideal management includes multilayer reconstruction with vascularized tissue, and CSF diversion with lumbar spinal drainage in high-risk patients. Prompt recognition and treatment can prevent infectious complications.

References

1. Rastatter JC, Snyderman CH, Gardner PA, Alden TD, Tyler-Kabara E. Endoscopic endonasal surgery for sinonasal and skull base lesions in the pediatric population. *Otolaryngol Clin North Am*. 2015 Feb;48(1):79-99.
2. Kassam A, Thomas AJ, Snyderman C, Carrau R, Gardner P, Mintz A, Kanaan H, Horowitz M, Pollack IF. Fully endoscopic expanded endonasal approach treating skull base lesions in pediatric patients. *J Neurosurg*. 2007 Feb;106(2 Suppl):75-86.

3. Chivukula S, Koutourosiou M, Snyderman CH, Fernandez-Miranda JC, Gardner PA, Tyler-Kabara EC. Endoscopic endonasal skull base surgery in the pediatric population. *J Neurosurg Pediatr.* 2013 Mar;11(3):227-41.
4. Snyderman CH, Pant H, Carrau RL, Prevedello DM, Gardner PA, Kassam AB. Classification of endonasal approaches to the ventral skull base. Pp. 83-91. In Stamm AC (ed): *Transnasal Endoscopic Skull Base and Brain Surgery.* Thieme, New York, 2011.
5. Snyderman CH, Pant H, Gardner PA, Carrau RL, Prevedello DM, Kassam AB. Management of complications of endonasal cranial base surgery. Pp. 182-90. In Kassam AB, Gardner PA (eds): *Endoscopic Approaches to the Skull Base. Progress in Neurological Surgery, Volume 26.* Karger, Basel, 2012.
6. Shah RN, Surowitz JB, Patel MR, Huang BY, Snyderman CH, Carrau RL, Kassam AB, Germanwala AV, Zanation AM. Endoscopic pedicled nasoseptal flap reconstruction for pediatric skull base defects. *Laryngoscope.* 2009 Jun;119(6):1067-75.
7. Harvey RJ, Parmar P, Sacks R, Zanation AM. Endoscopic skull base reconstruction of large dural defects: a systematic review of published evidence. *Laryngoscope.* 2012 Feb;122(2):452-9.
8. Patel MR, Shah RN, Snyderman CH, Carrau RL, Germanwala AV, Kassam AB, Zanation AM. Pericranial flap for endoscopic anterior skull-base reconstruction: clinical outcomes and radioanatomic analysis of preoperative planning. *Neurosurgery.* 2010 Mar;66(3):506-12; discussion 512.