One-Piece Modified Gasket Seal Technique

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Abstract

Objectives Review the effectiveness of a modified gasket seal technique utilizing a porous high-density polyethylene plate/rectus sheath fascia construct without fat grafting for primary closure of anterior defects following endoscopic skull base surgery.

Design Retrospective review (2011–2012).

Setting Single academic medical center.

Methods A retrospective review of five patients who underwent expanded endoscopic endonasal surgery for various pathologies (two craniopharyngiomas, two tuberculoma meningiomas, and one planum meningioma) was performed. Skull base closure was performed using a one-piece modified gasket seal technique. Primary outcome measures included postoperative cerebrospinal fluid (CSF) leaks and donor site morbidity.

Results There were no postoperative CSF leaks. Two patients experienced aseptic meningitis treated with a 14-day course of steroids. Two patients experienced new postoperative chronic/recurrent sinusitis treated with oral antibiotics and topical nasal therapy. There was no donor site morbidity such as infection, hematoma, or hernias.

Conclusions The one-piece modified gasket-seal closure is a safe and effective method for reconstruction of endonasal defects of the anterior skull base. Rectus sheath fascia is an appropriate dural substitute for free tissue grafting with low donor site morbidity. The construction of the one-piece graft significantly decreases operative time and lowers the learning curve for multilayered closure.

Keywords

- CSF leak
- endoscopic
- skull base
- gasket seal

Introduction

Background

An array of surgical techniques have been established for reconstructing the skull base following endoscopic endonasal approaches.^{1–11} Many of these methods evolved from lessons learned from microscopic transsphenoidal approaches and incorporate a wide range of surgical materials, including autologous fascia, muscle, fat, and bone, as well as various synthetic materials and tissue

sealants for multilayered closure. The goal of reconstruction is to reduce the incidence of postoperative complications, such as infection and cerebrospinal fluid (CSF) leak. Despite the range of surgical techniques available, creating a watertight seal between the intracranial spaces and the sinonasal tract remains a challenge for endonasal approaches.

In 2008, Leng et al first described a “gasket seal” technique as a method for creating a watertight seal between the intracranial compartment and the sinonasal cavity.⁹ The

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gasket seal technique, as originally described, involves the use of a fascia lata onlay graft that is countersunk into the skull base defect with a rigid buttress to create a watertight seal against the bony margins of the defect. The gasket seal has proven to be an effective method for closure of cranial base defects, thereby reducing the incidence of postoperative CSF leaks and meningitis.^{9,12} In this report, we present our initial findings with a modification of the gasket seal technique utilizing a unitized porous high-density polyethylene plate/rectus sheath fascia construct without fat grafting for primary closure of defects following endoscopic skull base surgery.

Materials and Methods

Between August 2011 and November 2012, five patients underwent expanded endoscopic endonasal surgery for various pathologies (two craniopharyngiomas, two tuberculum meningiomas, and one planum meningioma). Skull base closure of high-flow defects (communicating with the basal cisterns or ventricular system) was performed using a one-piece modified gasket seal technique.

Surgical Technique

During initial endonasal approach to expanded parasellar pathology, we routinely harvest a nasoseptal mucosal flap (NSF) as previously described by Hadad et al.¹³ After completion of the resection, under endoscopic visualization, the skull base defect is sized using a small-cut plastic ruler or cottonoids as standard reference (0.5 in × 0.5 in). A porous high-density polyethylene plate (Medpor TSI Barrier, Stryker Inc., Kalamazoo, Michigan, USA) is cut to size, oversizing by 1 to 2 mm circumferentially. The plate must be cut to the exact shape of the defect and is often trialed in situ prior to final closure to achieve a good seal around the entire bony edge of the defect.

A piece of rectus fascia is harvested from the left lower quadrant. On the back table, the fascia graft is then secured directly to the underside of the plate with the inner surface of the fascia apposed to the inner (smooth) surface of the plate. The fascia is held tense over the plate and then secured with multiple small straight hemostatic clamps. The fascia should overlap the edge of the plate by at least 3 to 5 mm on all sides. It is then fastened to the plate by passing 4–6 braided nylon stitches (Neurodon, Ethicon Inc., Somerville, New Jersey, USA) on an RB-1 needle through the plate, fascia, and then back through the fascia and plate so the knot lies on the external surface (►Fig. 1). Three or four stitches are sufficient to hold the fascia in place.

While an assisting or cosurgeon drives a 0-degree endoscope in the right nostril for visualization, the operating surgeon holds the plate tab with a micrograsper in the right hand through the left nostril and a manipulating instrument (either an 8 Fr suction tip or a short blunt cervical nerve hook) in the left hand through the right nostril. The manipulating instrument is used to rotate the plate into position and apply controlled pressure to guide it into the epidural space while the grasper is used to provide countertension by gently pulling the plate outward. This method ensures that the plate

Fig. 1 Artist's rendition of technique for temporarily and permanently securing fascia free graft to the polyethylene plate for modified gasket seal reconstruction of the skull base.

does not sink too deeply and provides gratifying tactile feedback when the plate is properly countersunk. The final outcome of these surgical maneuvers is a unitized plate/fascia construct, which lies in the epidural space (►Fig. 2). We do not routinely pack the intracranial defect with free adipose graft. The defect is then covered directly with a nasoseptal flap, as described by Hadad et al.¹³ If a sealant is used, fibrin glue (Tisseel, Baxter, Deerfield, Illinois, USA) is preferred over hydrogel (DuraSeal, Covidien, Mansfield, Massachusetts, USA), as the hydrogel prevents the nasoseptal flap from adhering to the exposed edges of the fascial graft. Patients undergo continuous lumbar drainage at 5 to 10 mL/hr for 3 to 5 days postop.

Results

We have utilized this technique in five consecutive cases of expanded endonasal endoscopic approach for suprasellar pathology (two craniopharyngioma, two tuberculum meningiomas, and one planum meningioma). In each of these cases, the skull base defect was a minimum of 15 × 20 mm, up to 15 × 30 mm (right-left × cranio-caudal). Median length of follow-up was 10 months. There have been no postoperative CSF leaks. Two patients experienced aseptic meningitis treated with a 14-day course of steroids. Two patients experienced new postoperative chronic/recurrent sinusitis. There was no donor site morbidity such as infection, hematoma, or hernias (►Table 1).

Discussion

Expanded endoscopic endonasal approaches to the anterior skull base have become increasingly popular in recent years,

Fig. 2 (a) Artist's rendition of placement of the unitized plate and fascia graft in the defect. (b) Intraoperative photo demonstrating final placement prior to use of sealant and placement of the nasoseptal flap.

owing in part to advances in endoscopic technology. However, these approaches have been associated with a greater risk of postoperative CSF leak when compared with more traditional microscopic transsphenoidal or open transcranial approaches. A recent literature review of 88 studies found the CSF leak rates to be greater for endoscopic resection of craniopharyngiomas (18.6%) compared with microscopic transsphenoidal (9.0%) and open transcranial (2.6%) approaches.¹⁴ Similar results have been demonstrated for the resection of anterior midline skull base meningiomas via open (6% CSF leak rate) and endoscopic approaches (31.6% CSF leak rate).¹⁵ This brings into question the applicability of endoscopic methods, particularly for the resection of extensive skull base lesions such as meningiomas and craniopharyngiomas.

Current literature describes a wide range of CSF leak rates following the resection of midline skull base lesions. A recent review of 126 cases involving the transplanum, transtuberculum approach for resection of macroadenomas (51.6%), meningiomas (20.6%), and craniopharyngiomas (15.9%) demonstrated an overall CSF leak rate of 3.1%. However, CSF leak rates varied significantly depending on the reconstruction method utilized. Reconstruction with fat graft alone resulted in an 11% CSF leak rate, followed by the gasket seal only (4.2%), fat plus NSF (1.8%), and gasket seal plus NSF (0%).¹⁶ Many

other studies have demonstrated a wide range of CSF leak rates following resection of these lesions, as well, ranging from 9.5 to 58% with a variety of multilayered closure methods.^{2,17–21}

Previously, autologous free grafts including fat, muscle, fascia lata, and nasal septal bone/cartilage have served as viable options for skull base reconstruction following endoscopic endonasal surgery. Kaptain et al encountered a 2.3% postoperative CSF leak rate among 257 patients with intrasellar pathologies who were reconstructed with autologous tissues after endoscopic surgery.²² However, the use of autologous free grafts alone has not been as successful for expanded endonasal approaches.^{2,23} Fortunately, the Hadad-Bassegasteguy vascularized nasoseptal flap has served as a valuable addition to multilayered reconstruction, reducing the risk of CSF leaks to that of traditional transcranial approaches.¹³ One recent study demonstrated no significant difference in CSF leak rates following endoscopic transsellar or expanded endonasal approaches with the use of a NSF in multilayered closure.²⁴ Nonetheless, various case series have demonstrated exceptionally high rates of CSF leak following expanded endonasal approaches despite the incorporation of a vascularized NSF.^{17,18} This underscores the importance of utilizing a sound multilayered reconstruction technique. Additionally, alternative methods for closure must be

Table 1 Clinical characteristics of five patients who underwent expanded endoscopic endonasal surgery^a

Case No.	Age	Gender	Pathology	Length of Lumbar Drainage	Post-Op CSF Leak	Other Morbidity	Length of Follow-Up
1	63	M	Craniopharyngioma	5 days	None	None	12 months
2	67	F	Tuberculum meningioma	3 days	None	Chronic sphenoid sinusitis	10 months
3	47	M	Tuberculum meningioma	5 days	None	Aseptic meningitis & recurrent sinusitis	10 months
4	59	M	Craniopharyngioma	5 days	None	None	9 months
5	50	F	Planum meningioma	5 days	None	Aseptic meningitis	8 months

Abbreviation: CSF, cerebrospinal fluid.

^aSkullbase closure was performed using a one-piece modified gasket seal technique.

available in the event that a NSF cannot be harvested due to tumor invasion. As displayed in the literature, numerous options for skull base reconstruction after endoscopic endonasal surgery, including both autologous and synthetic materials, have been described to date.^{1–11}

The primary goal of skull base reconstruction, regardless of surgical technique, includes watertight separation of the intracranial and sinonasal cavities. Failure to achieve these reconstructive goals can result in life-threatening complications such as CSF leak, meningitis, or tension pneumocephalus.^{25,26} In 2008, Leng et al first described the gasket seal technique, a novel method to reconstruct skull base defects after endoscopic endonasal surgery. This technique, as originally described, involved the obliteration of intracranial dead space with autologous fat, followed by autologous fascia lata onlay graft countersunk into the skull base defect with a rigid buttress to form a watertight seal around the dura.^{9,12}

Recent studies indicate that the gasket seal is an effective watertight method for closure of the endonasal skull base defects and long-term prevention of postoperative CSF leaks.^{9,12} Garcia-Navarro and colleagues recently published a prospective review of 46 consecutive patients undergoing endoscopic skull base surgery for a variety of pathologies. The authors reported a postoperative CSF leak incidence of 4.3% using the gasket seal closure with a mean follow-up period of 28 months.¹² These results were comparable to the postoperative CSF leak incidence after standard transsphenoidal or open transcranial approaches,^{2,27–29} and lower than various other endoscopic closure methods.^{3–5,10} Other groups have demonstrated reproducible results with the gasket seal technique.^{30,31}

Despite its advantages, the gasket seal technique poses some technical difficulties for the surgeon. Manipulating two independent graft materials into place within the skull base defect may require multiple attempts, thus increasing the operative time, before the fascia graft and buttress are properly situated within the epidural space. Traditionally, autologous intracranial fat graft has been utilized in the gasket seal technique, serving as temporary support for the fascia graft while the surgeon prepares the overlying rigid

buttress. Although autologous fat graft has historically been used for prevention of iatrogenic CSF leak following transsphenoidal surgery, this technique carries with it a particular set of risks, such as donor site morbidities, fat graft necrosis, and sinusitis.³² Excessive sellar packing with fat can also obscure postoperative imaging³³ and result in postoperative visual deterioration due to chiasmal compression.³⁴ The drawbacks of the original gasket seal method, including prolonged operative time, and the disadvantage of intracranial fat grafting led to our development of the modified one-piece gasket seal technique.

Our modified technique utilizes a unitized construct consisting of high-density polyethylene plate/rectus sheath fascia. As Leng et al originally described, they prefer vomer as a rigid buttress for the gasket seal closure.⁹ Similarly, others have used titanium mini-plates for the buttress. However, we find the high-density dual layer polyethylene plate to be a superior alternative. The plate is easily cut to size with Mayo scissors and can be passed through the nares to access the skull base. With its elastic properties, the plate flexes and restores when wedged into the skull base defect, creating a tight fit against the nonuniform bony edges of the defect. The porosity of the high-density polyethylene plate promotes fibrovascular ingrowth to the graft to stimulate wound healing and provide a stable reconstruction with biologically inert materials, lessening the incidence of postoperative infection related to the plate itself.^{35–38}

The polyethylene plate in itself makes the one-piece modified gasket seal technique possible, allowing the surgeon to easily mattress suture the fascia graft to the plate to create a construct that may be positioned in a single pass. The formation of a unitized construct provides the surgeon with easier manipulation of graft materials and allows for facile placement of the construct within the skull base, requiring fewer attempts to properly position graft materials over the epidural space. Although we have no formal record of operative time during this preliminary study, we propose that the one-piece modified gasket seal technique is more efficient than the original gasket seal method, among other techniques for multilayered closure. This technique may not be

Fig. 3 (a) Preoperative midsagittal T1SE postcontrast magnetic resonance imaging (MRI) and (b) Postoperative midsagittal T1SE postcontrast (non-fat saturated) MRI demonstrating lack of obscuration at the operative site for immediate evaluation of extent of resection and extent of decompression of the suprasellar structures.

significantly faster than an experienced surgeon who is proficient in skull base reconstruction, yet it has the potential to both reduce operative time and shorten the learning curve for multilayered closure of the anterior skull base. Suturing the fascia to the plate also eliminates the possibility of inward herniation, obviating the need for intradural fat packing. This results in easier interpretation of postoperative imaging,³³ as demonstrated in **Fig. 3**. There is also reduced risk of postoperative visual deterioration,³⁴ nausea, and vomiting³⁹ due to overpacking the suprasellar space.

Historically, fascia lata has been utilized in reconstruction of the skull base, noted for its ease of exposure, sturdiness, and pliability. However, we find rectus sheath fascia to be superior to fascia lata. Rectus fascia is thinner and more malleable and can readily conform to the nonuniform bony edges of the skull base defect, creating a tight, impermeable, seal of the dura. It is also easily harvested from the abdomen with reduced postoperative donor site morbidity.^{40–42}

Ultimately, the nasoseptal flap was added as an exterior layer to supplement the reconstruction, given its proven benefit of reducing postoperative CSF leak. The vascularized nasoseptal flap provides a blood supply to the reconstruction to promote rapid wound healing and prevent potential postoperative wound complications.¹³ With this in mind, the edges of the nasoseptal flap must extend beyond the outer margin of the rectus sheath fascia graft to ensure that the fascia remains tightly apposed to the dura so that an adequate seal is maintained. Additionally, the sealant should be applied over the nasoseptal flap and must not permeate underneath the flap itself. If sealant seeps between the edges of the nasoseptal flap and fascia/skull base, it may prevent the flap from adhering to the underlying fascia and bone, ultimately resulting in a failed reconstruction.¹² For this very reason, we prefer the use of fibrin glue (Tisseel, Baxter) over polyethylene glycol (PEG) hydrogel (DuraSeal, Covidien). Fibrin-based products are favorable because of their biocompatibility with normal stages of wound healing.⁴³ In contrast, PEG hydrogel is a synthetic agent that breaks down by encapsulation and hydrolysis over a 4-to-8-week period. If placed underneath the nasoseptal flap, the PEG may impair healing and produce an inadequate seal around the reconstruction.¹² Fibrin-based sealant, on the other hand, has been shown to significantly reduce the incidence of postoperative CSF leak⁴⁴ and is associated with enhanced biomechanical strength of skull base repair.⁴⁵

Conclusion

The one-piece modified gasket seal closure is a safe and effective method for reconstruction of expanded endonasal defects of the anterior skull base. Rectus sheath fascia is an appropriate dural substitute for free tissue grafting with low donor site morbidity. The construction of the one-piece graft saves a significant amount of operative time and lowers the learning curve for multilayered closure. In this initial series, we have experienced no postoperative CSF fistulae or donor site graft complications. Future study is required to further evaluate the efficacy of this technique.

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