Postoperative Thecal Sac Compression Induced by Hydrogel Dural Sealant after Spinal Schwannoma Removal

Hong Joon Han, Ju Ho Jeong, Jin Wook Kim, and Won Bae Seung

Department of Neurosurgery, Dongguk University Gyeongju Hospital, Dongguk University College of Medicine, Gyeongju, Korea

ABSTRACT

Cerebrospinal fluid (CSF) leak is a common complication of spinal and cranial surgery, and patients undergoing spinal tumor surgery are probably particularly predisposed due to the presence of an intradural tumor and many other factors. Furthermore, a meticulous dural closure technique does not always result in watertight closure. A number of adjunctive methods have been used to assist with dural closure. Synthetic, absorbable polyethylene glycol hydrogel dural sealants are widely used and have been approved for use as adjuncts for cranial applications requiring sutured dural closure. We report a case of thecal sac compression by DuraSeal® Dural Sealant used to repair the CSF leak after intentional durotomy during lumbar schwannoma extirpation.

Keywords: DuraSeal spinal sealant; Hydrogel; Spinal cord compression; Cerebrospinal fluid leak

INTRODUCTION

Cerebrospinal fluid (CSF) leaks are a known, frustrating complication in spinal and cranial surgery. In cases of intradural tumors, dura is opened intentionally, which exposes patients to the risk of CSF leakage, and postoperative CSF leaks can lead to complications, such as delayed healing, wound infection, pseudomeningocele, and meningitis. The risk of CSF leak has been reported to range from 1% to 21%, depending on the size and location of durotomy. Unintentional durotomy may lead to longer operation times, delayed postoperative mobilization, and nerve root injury or neurological deficit, but the majority of cases of incidental durotomy are identified and resolved during surgery without reoperation or further intervention. Patients undergoing surgical intervention for spinal tumors are particularly prone to postoperative CSF leaks due to many other factors. To address this problem, various agents have been introduced over the years to secure watertight dural repairs. In particular, the DuraSeal® Dural Sealant system is a synthetic, absorbable polyethylene glycol (PEG) hydrogel sealant that is widely used in spinal and cranial surgery as an adjunct to sutured dural closures. The authors report a patient that underwent thecal sac compression caused by DuraSeal® Dural Sealant used for management of intentional durotomy during lumbar schwannoma extirpation.
CASE REPORT

An 81-year-old woman presented with a one-month history of right lower extremity pain and hyperesthesia. Neurological examination on admission showed motor weakness of her right lower limb with 4/5 power and paresthesia below the L3 sensory level. Magnetic resonance imaging (MRI) of the lumbar spine revealed an intradural-extramedullary cystic mass lesion at the L1 level. Contrast-enhanced MRI depicted a well-enhanced cystic lesion appearing isointense on T1 and hypointense on T2 weighted images. The cystic mass had an intraspinal component that displaced and compressed the cauda equina. The cystic lesion had fluid-fluid level and the dependent portion was hypointense, suggesting the possibility of hemorrhage (FIGURE 1).

The patient underwent total laminectomy of L1, subtotal laminectomy of T12, and microsurgically assisted intradural exploration. A dural bulge was present and an extramedullary mass lesion was observed posteriorly that compressed and displaced the conus medullaris to the right and anteriorly. Dura mater was opened at the midline and tented laterally. The arachnoid was opened separately. A minimal incision was made on the surface of the lesion and the internal portion was then explored and an old blood clot evacuated. The arachnoid plane between the lesion and dural sac was obscure, and the lesion was attached to a dorsal nerve root. The involved nerve root was sacrificed and the lesion was removed en bloc. Dura was repaired using a continuous locking suture technique, and a standard applicator was used to apply the DuraSeal® Dural Sealant system at a total volume of 3 mL. Intra-operative neuromonitoring waves did not differ from baseline recording waves. Histopathological findings showed the lesion was positive for s-100 protein and vimentin and negative for epithelial membrane antigen, which is consistent with schwannoma.

One day after surgery, symptoms of the right lower extremity were relieved, but the patient reported paresthesia on the left lower extremity and motor strengths of 1/5 for hip flexion, 2/5 for ankle dorsiflexion and plantarflexion, and 2/5 for great toe extension. An MRI scan was performed and demonstrated an extradural high signal intensity lesion compressing the thecal sac (FIGURE 2). Revision surgery was performed for exploration and decompression. At the level of laminectomies, a large amount of clear yellow gel-like material was visualized.
Postoperatively, the severe paresthesia was resolved and motor function slightly improved to grade 3/5. The patient was transferred to our department of rehabilitation medicine. Manual muscle testing at discharge (up to 1 month later) showed motor function had improved to grade 4+/5.

DISCUSSION

CSF leakage is a common complication after spinal and cranial surgery, though reported leakage rates vary widely and appear to depend on size, location, procedural complexity. A number of complications of CSF leaks have been reported. The more serious include delayed wound healing and/or infection, meningitis, intracranial hemorrhage, and neurological symptoms (e.g., radiculopathy, myelopathy, and cranial nerve palsies), though the most frequent presentation is postural headache associated with nausea, vomiting, and dizziness. Optimal management of CSF leaks occurring during spinal or cranial surgery remains controversial and currently no definitive algorithms have been proposed. Intra-operative identification of incidental durotomies and meticulous primary repair is preferred, and although primary repair has been widely used for dural tears, it still has a failure rate of 5–9%. Thus, a variety of dural repair materials and techniques have been introduced to assist closure.

DuraSeal® is a water soluble, synthetic, bioabsorbable hydrogel that was specifically developed for cranial and spinal dural repair. This 2-pack product transforms from a liquid to a solid, which contains >90% water, within 2 seconds of being sprayed onto tissue without generating detectable heat. Duraseal® is composed of water-soluble PEG and trilysin amino acid, which are combined in the supplied syringe applicator. The product also contains Food Drug and Cosmetic Blue No.1 dye, which is added to enable accurate estimations of coverage and thickness.

Several studies have demonstrated the safety and effectiveness of the DuraSeal® Sealant System. Kim et al. compared rates of successful intraoperative watertight closure, postoperative CSF leaks, infections, and wound healing between DuraSeal as an adjunct to sutured dural repair and standard care methods (sutures or sutures plus fibrin glue). They found successful watertight closure rates in DuraSeal® and standard care groups
were 91.2% and 63.6%, respectively. In a prospective study, Cosgrove et al. evaluated the safety and efficacy of DuraSeal® in patients undergoing elective cranial surgery with documented CSF leakage after sutured dural repair and concluded DuraSeal® used as an adjunct to sutured dural repair provided safe and effective watertight closure. Schiariit et al. reported a post-operative incisional CSF leak rate of 1.8%, but a rate in excess of 50% for supratentorial procedures. Boogaarts et al. prospectively treated 46 patients with DuraSeal® in combination with autologous materials, and over a 3-month follow-up period encountered one CSF leak after supratentorial craniotomy and one case of pseudomeningocele after posterior fossa surgery. No infections or other adverse events related to hydrogel use were observed. Of the 46 patients, 18 (39%) underwent posterior fossa surgery, and a CSF leak occurred in one patient (5.5%).

Because of its hydrophilic nature, DuraSeal® absorbs water and swells after application. Several reports of neurological complications due to mass effects have been reported after DuraSeal® Dural Sealant spinal applications, and thus, the original PEG hydrogel was modified to reduce swelling. This product was named DuraSeal® Exact Spine Sealant System (DESS) and it was approved by the FDA in 2009. Kim et al. recommended that DESS should be used instead of DuraSeal® Dural Sealant in the spine. However, DESS is not available in South Korea. The complication encountered in the present case was unexpected as we were unaware that the use of DuraSeal® is contraindicated in areas where nerves and spinal cord are confined, because it reportedly swells by up to 50%. According to the data provided by the manufacturer, DuraSeal® is resorbed after 4 to 8 weeks, which provides sufficient time for dura to heal adequately. In a canine craniotomy model, DuraSeal® was observed to swell between 3 and 14 days after implantation, and complete absorption was observed after 10 weeks. Blackburn and Smyth reported a case of hydrogel-induced cervicomедullary compression after posterior fossa decompression and dural augmentation for Chiari malformation Type I. In another study, DuralSeal® was used to seal a small CSF leak in a case of anterior cervical discectomy and fusion at C5–6, but the patient developed progressive quadriparesis at 3 hours after surgery. Lee et al. used DuraSeal® in intended durotomy during the treatment of intradural cervical meningioma, and 8 hours after surgery, the patient developed left-side motor weakness. In another report, a patient underwent laminotomy and discectomy at L4–5, but subsequently developed cauda equina compression caused by DuraSeal® migration.

Surgeons must take great care when using DuraSeal® and follow the manufacturer’s instructions. Gel thickness should be limited to 1–2 mm to avoid complications associated with swelling. Notably, the basic spray applicator provided in the DuraSeal® kit may not provide adequate control in terms of limiting thickness, and may result in larger than intended applications of the hydrogel. DuraSeal® should be applied using the Micromyst™ applicator, which allows precise application and very thin layer of the product to be applied.

**CONCLUSION**

The propensity of DuraSeal® to swell postoperatively and cause neurological complications due to neural compression should be recognized and considered by surgeons if there are any neurological symptoms and/or signs. Spine surgeons should use modified reduced-swelling PEG hydrogel sealants and special applicators to control applied sealant volumes and thicknesses and prevent the complications caused by hydrogel swelling.
REFERENCES

1. Barber SM, Fridley JS, Konakondla S, Nakhla J, Oyelese AA, Telfeian AE, et al. Cerebrospinal fluid leaks after spine tumor resection: avoidance, recognition and management. Ann Transl Med 7:217, 2019

2. Blackburn SL, Smyth MD. Hydrogel-induced cervicomedullary compression after posterior fossa decompression for Chiari malformation. J Neurosurg 106:302-304, 2007

3. Blackburn SL, Smyth MD. Hydrogel-induced cervicomedullary compression after posterior fossa decompression for Chiari malformation. J Neurosurg 106:302-304, 2007

4. Boogaarts JD, Grotenhuis JA, Bartels RH, Beems T. Use of a novel absorbable hydrogel for augmentation of dural repair: results of a preliminary clinical study. Neurosurgery 57:146-151, 2005

5. Chauvet D, Tran V, Mutlu G, George B, Allain JM. Study of dural suture watertightness: an in vitro comparison of different sealants. Acta Neurochir (Wien) 153:2465-2472, 2011

6. Cosgrove GR, Delashaw JB, Grotenhuis JA, Tew JM, Van Loveren H, Spetzler RF, et al. Safety and efficacy of a novel polyethylene glycol hydrogel sealant for watertight dural repair. J Neurosurg 106:52-58, 2007

7. Fang Z, Tian R, Jia YT, Xu TT, Liu Y. Treatment of cerebrospinal fluid leak after spine surgery. Chin J Traumatol 20:81-83, 2017

8. Guerin P, El Fegoun AB, Obeid I, Gille O, Lelong L, Luc S, et al. Incidental durotomy during spine surgery: incidence, management and complications. A retrospective review. Injury 43:397-401, 2012

9. Hawk MW, Kim KD. Review of spinal pseudomeningoceles and cerebrospinal fluid fistulas. Neurosurg Focus 9:e5, 2000

10. Kacher DF, Frerichs K, Pettit J, Campbell PK, Meunch T, Norbash AM. DuraSeal magnetic resonance and computed tomography imaging: evaluation in a canine craniotomy model. Neurosurgery 58:ONS140-ONS147, 2006

11. Kim KD, Wright NM. Polyethylene glycol hydrogel spinal sealant (DuraSeal Spinal Sealant) as an adjunct to sutured dural repair in the spine: results of a prospective, multicenter, randomized controlled study. Spine 36:1906-1912, 2011

12. Kim KD, Ramanathan D, Highsmith J, Lavelle W, Gerszen P, Vale F, et al. Duraseal exact is a safe adjunctive treatment for durotomy in spine: postapproval study. Global Spine J 9:272-278, 2019

13. Lee SH, Park CW, Lee SG, Kim WK. Postoperative cervical cord compression induced by hydrogel dural sealant (Duraseal®). Korean J Spine 10:44-46, 2013

14. Menon SK, Onyia CU. A short review on a complication of lumbar spine surgery: CSF leak. Clin Neurol Neurosurg 139:248-251, 2015

15. Mulder M, Crosier J, Dunn R. Cauda equina compression by hydrogel dural sealant after a laminotomy and discectomy: case report. Spine 34:E144-E148, 2009

16. Neuman BJ, Radcliff K, Rihn J. Cauda equina syndrome after a TLIF resulting from postoperative expansion of a hydrogel dural sealant. Clin Orthop Relat Res 470:1640-1645, 2012

17. Oshun JW, Ellenhogen RG, Chesnut RM, Chin LS, Connolly PJ, Cosgrove GR, et al. A multicenter, single-blind, prospective randomized trial to evaluate the safety of a polyethylene glycol hydrogel (Duraseal Dural Sealant System) as a dural seal in cranial surgery. World Neurosurg 78:498-504, 2012

18. Schiariiti M, Acerbi F, Broggi M, Tingali G, Raggi A, Broggi G, et al. Two alternative dural sealing techniques in posterior fossa surgery: (Polylactide-co-glycolide) self-adhesive resorbable membrane versus polyethylene glycol hydrogel. Surg Neurol Int 5:171-171, 2014
19. Thavarajah D, De Lacy P, Hussain R, Redfern R.M. Postoperative cervical cord compression induced by hydrogel (DuraSeal): a possible complication. *Spine* 35:E25-E26, 2010
   [PUBMED](https://pubmed.ncbi.nlm.nih.gov/20590982/) | [CROSSREF](https://doi.org/10.1097/BRS.0b013e3181e25aaf)

20. Tseng WL, Xiao F. Duraseal thecal sac compression after lumbar discectomy causing radiculopathy. *Spine J* 15:1892-1893, 2015
   [PUBMED](https://pubmed.ncbi.nlm.nih.gov/25474943/) | [CROSSREF](https://doi.org/10.1016/j.sij.2015.05.003)

21. Wang MC, Chan L, Maiman DJ, Kreuter W, Deyo RA. Complications and mortality associated with cervical spine surgery for degenerative disease in the United States. *Spine* 32:342-347, 2007
   [PUBMED](https://pubmed.ncbi.nlm.nih.gov/17985943/) | [CROSSREF](https://doi.org/10.1097/BRS.0b013e3181b09c29)