Review Article | Journal of Clinical Orthopaedics | 2026 January-June; 11(1):-27-32

Intraoperative Dural Tears: Current Trends in Management

Pranav Shah[1], Gautam Zaveri[2]

Abstract

Background: Incidental durotomy is a common complication of spine surgery, with reported rates ranging from 2.7% to 17.2%. Although modern surgical techniques have reduced its occurrence, dural tears remain clinically significant due to their impact on cerebrospinal fluid (CSF) dynamics, perioperative morbidity and surgical outcome. Understanding risk factors, early intraoperative recognition, and current management strategies is essential for optimizing patient outcomes.

Discussion: Dural tears arise from a combination of surgeon-, patient-, and procedure-related risk factors, particularly in revision surgery, severe stenosis, and deformity correction. Disruption of CSF flow may lead to intracranial hypotension, pseudomeningocoele, CSF fistula, meningitis, and radicular symptoms. Intraoperative detection relies on visualization of CSF leakage, Valsalva manoeuvres, and selective use of ultrasonography. Management options include primary suture repair, autologous muscle or fascia grafts, collagen matrices, fibrin sealants, and hydrogel-based products which provide high rates of watertight closure and are especially useful for tears in challenging anatomical locations. Post-operative care utilizing head-low positioning, targeted drain management, CSF-reducing medications, and vigilant monitoring—is crucial to prevent persistent leaks and promote healing.

Conclusion: Although incidental durotomy may increase short-term complications, effective intraoperative repair and structured post-operative protocols generally result in outcomes comparable to uncomplicated cases. Meticulous technique, careful pre-operative planning, and prompt recognition remain central to minimizing the impact of dural tears in spine surgery.

Keywords: Dural tear, Durotomy, CSF leak, Management

Introduction

Dural tear, which is more aptly called an incidental durotomy, is one of the complications of spine surgery. It is typically a break in the dura mater with resultant leakage of the cerebrospinal fluid (CSF). A dural tear can be iatrogenic during surgery, post-traumatic with durotomy occurring at the time of energy dissipation during trauma, or rarely spontaneous secondary to an underlying connective tissue disorder. An incidental durotomy is a common complication during spine surgery, with incidence varying from 2.7% to 17.2% [1]. Many studies have assessed the prevalence of dural tears in their setting. A recent study from Amman found an overall prevalence rate of 14.1% from a total of 92 patients [1].

A dural tear has a significant bearing on the post-operative course and recovery of the patient following spine surgery. This makes its prevention and its prompt management paramount. Neglecting a dural tear can have serious consequences, which vary from persistent headache, CSF fistula, arachnoiditis, or meningitis. Dural tears are multifactorial but have a higher likelihood of occurring during revision spine surgery, multilevel decompression, or surgery for a severe spinal stenosis.

[1]Department of Orthopaedics, Namaha Hospital, Mumbai, Maharashtra, India, [2]Department of Orthopaedics, Jaslok Hospital and Research Centre, Mumbai, Maharashtra, India

Address of Correspondence
Dr. Gautam Zaveri,
Department of Orthopaedics, Jaslok Hospital and Research Centre, Mumbai, Maharashtra, India.

Etiology and Risk Factors

Surgeon-related risk factors:

- Training in spinal or neurosurgery
- Experience in the field
- Choice of procedure and expertise with the same (open, minimal invasive, and endoscopic).

Submitted Date: 15-01-2026, Review Date: 06-02-2026, Accepted Date: 01-03-2026 & Published Date: 10-05-2026

Journal of Clinical Orthopaedics | Available on www.jcorth.com | DOI: https://doi.org/10.13107/jcorth.2026.v11.i01.830

Patient-related risk factors

- Age (advancing age)
- Prior surgeries (scar tissue and adhesions)
- Previous corticosteroid spine injection (root blocks and caudal epidural injections)
- Degenerative changes
- Congenital anomalies or connective tissue disorders.

Procedure-related risk factors

- Revision surgeries
- Tumor or infection
- Deformity correction
- Minimally invasive techniques.

Pathophysiology

Dura mater extends from the foramen magnum to the S2 spinal segment. It encloses the spinal cord and cauda equina nerve roots, circumferentially enclosing within it the cerebrospinal fluid. The separation between the bony vertebral column and the dura mater is by epidural fat and venous plexus, which is irregular and unpredictable due to age or stenosis. It also extends around the nerve root as a sheath, and this becomes an occasional site of dural injury during pedicle screw instrumentation or lateral recess/foraminal decompression. Microscopically, dura mater has three distinct layers: the outer fibroelastic layer, the middle fibrous layer, and the inner cellular layer.

In 1898, Max Hofmann described epidural connections between the dura and the bony vertebral column. These are called the epidural ligaments of Hofmann. They are fibrous connective tissue bands that run ventero-laterally and are narrow, almost thread-like connections between the dura and the PLL present at most levels [2]. The relevance of these bands is the fact that during spinal surgery, one may inadvertently pull on the ligament, causing an avulsion of the dura, resulting in a dural injury. Mitigation techniques include using dissection with a wet neuro-patty or sharp dissection using a knife or bipolar diathermy rather than pulling, which can cause a dural tear.

CSF is produced in the lateral and the fourth ventricles at the rate of 0.6mL/min, and the total volume of CSF in an adult is approximately 140 to 270 mL. CSF pressure is about 100 to 180 mm of water. A dural tear disrupts the normal flow of the CSF and causes a decrease in the normal intracranial pressure, causing symptoms such as headache, nausea, vomiting, neck pain, hearing changes, or a sense of imbalance..

Intraoperative Recognition

There are various techniques that a surgeon may employ to detect a dural tear intraoperatively. The most common being visualization of leaking clear fluid, i.e., CSF. In an oozing wound, one may pick up CSF leak by the watery fluid, creating a dilutional effect on the blood. If the rent is large, it may be picked up by the naked eye. Tracing the source or upstream track of the fluid helps locate the tear if small. However, if the tear is along the nerve root sleeve or ventero-laterally, identifying the rent may sometimes not be possible. Good surgical lights and magnification in the form of a surgical microscope or surgical loupes aid in visualisation.

The Valsalva maneuver is a good surgical practice that may be employed by every spine surgeon during spinal surgery. It entails asking the anesthetist to manually increase the positive end-expiratory pressure to 40 mm Hg and the spine surgeon assessing the decompressed spinal canal to look for any leakage of CSF. In case of an arachnoid bleb on an insidious dural rent, the Valsalva pressure may help the surgeon pick up the injury. The maneuver is also used to assess the strength or take of a seal following dural repair.

Intraoperative ultrasonography can be used to assess the real-time integrity of the dura mater and any fluid collection around the spinal cord. Dyes such as Indocyanine Green are infrequently used to identify fistulous points in the dura.

Management Strategies

Any dural tear or incidental durotomy creates a challenge for the operating surgeon. As they are infrequent with the current technological advances and training levels, a dural tear does create a surprise when it occurs. The initial sequence of management should be the following:

- Visual confirmation of CSF leak and location of dural tear
- Applying a neuro-patty over the durotomy
- Placing the patient in a head-low position
- Completing the primary surgery as routinely planned
- Creating adequate bony decompression to safely address the dural tear
- Repairs can be undertaken using one of the following strategies:

Suture technique

When a dural tear is easily accessible, it is preferable to repair the same. In case the rent is a small puncture, one may extend it with a knife to create a durotomy with regular edges. Most surgeons prefer 5–0 or 6–0 monofilament suture material such as Prolene, while others prefer braided suture such as 5–0 Vicryl. The consensus is the usage of a round-bodied needle. Sutures may be interrupted or continuous, depending on the surgeon's preference or accessibility of the tear. Most surgeons prefer to augment the repair with an overlay of fat, fascia, or muscle. It is prudent to check the seal with a Valsalva maneuver.

Autologous graft

Use of autologous muscle, fat, or fascial graft along with an excellent water-tight soft tissue closure is also commonly

employed. This technique is preferable, especially if the dural rent is a small puncture or difficult to suture because of its location in the axilla or shoulder of the nerve root. Hereby, the graft material is locally harvested from the corners of the wound, thinned into a small section, and gently applied to the rent. Some prefer invaginating the graft into the rent to make an in-lay seal. However, care must be taken not to cause the rent to extend in the process of doing so.

Patch and seal techniques

The use of commercially available sealants such as DuraGen® and DuraSeal® has become increasingly prevalent in the management of incidental dural tears, particularly when primary suture repair is not feasible. These materials are especially advantageous in addressing tears located in anatomically challenging areas, such as ventrolateral dural defects or nerve root sleeve tears, where direct visualization and manipulation are limited.

DuraGen®, a resorbable collagen matrix derived from purified bovine Achilles tendon, functions as a dural substitute and scaffold for neodura formation. It is classified as a Type I collagen-based xenograft and is typically applied as an onlay graft. Studies have demonstrated that DuraGen facilitates rapid fibroblast infiltration and collagen deposition, promoting duraplasty without the need for sutures. The success rate of dural closure using DuraGen alone has been reported to be up to 95%, with low rates of post-operative CSF leakage.

The efficacy of this technique is enhanced when DuraGen is used in combination with DuraSeal®, a synthetic, absorbable polyethylene glycol hydrogel sealant. DuraSeal polymerizes upon contact with the surgical field, forming a watertight seal that conforms to the dural contour. It has been shown to withstand intrathecal pressures of up to 30 cm H2O, significantly reducing the risk of CSF egress during the critical early post-operative period. Moreover, DuraSeal has demonstrated a 99% success rate in achieving watertight closure.

Application technique is critical: the operative field must be dry and free of active bleeding to ensure adhesion and polymerization of the sealant. The matrix (DuraGen) is trimmed and placed gently over the dural defect and moistened with a few drops of sterile saline to allow it to mould to the contours of the dura. The hydrogel (DuraSeal) is then applied circumferentially to reinforce the patch. The dual mechanism – biological scaffold plus synthetic seal – promotes both mechanical sealing and biological integration through guided tissue regeneration.

Although the combination of DuraGen and DuraSeal adds cost, several cost-benefit analyses suggest it may be justified by reduced reoperation rates, shortened hospital stays, and lower incidence of post-operative pseudo-meningoceles or CSF fistulas, especially in complex or revision surgeries.

Fibrin glue and sealants

Fibrin glue is commonly employed as an adjunctive measure to enhance the integrity of dural closure, particularly when combined with primary suture repair or collagen-based grafts such as DuraGen®. It consists of two principal components: Fibrinogen and thrombin, which, when mixed at the application site, mimic the final step of the coagulation cascade, converting fibrinogen into fibrin. This leads to rapid formation of a fibrin clot, which adheres to tissues and creates a biologically active seal over the dural defect. The clot not only provides mechanical sealing of CSF leaks but also promotes hemostasis and tissue adhesion. Fibrin sealants have been found to achieve watertight closure rates of 90–98% when used in conjunction with other techniques. Moreover, they help reduce the operative time associated with complex dural repairs and offer a low-profile alternative when access to the tear is constrained.

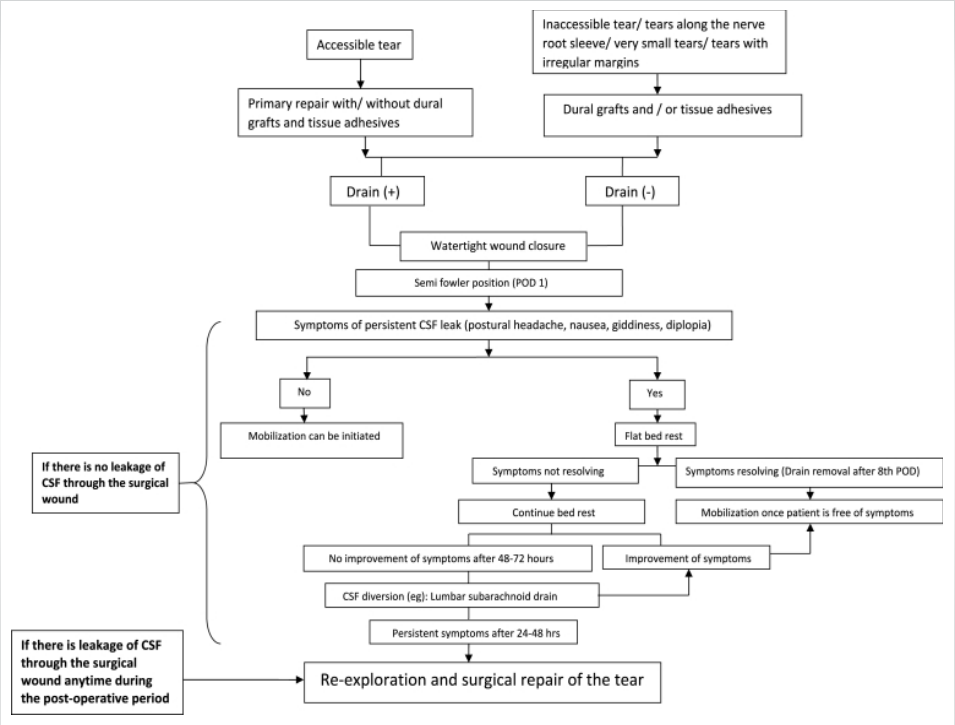

Figure 1: Algorithm for management of incidental dural tear in spine surgery. Courtesy Milton et al., Reproduced with permission [3].

Commercially available fibrin sealants, such as Tisseel® or Evicel®, are typically applied using a dual syringe system that allows simultaneous mixing of the two components at the tip of the applicator. For optimal results, the application field must be dry, and the fibrin clot should be allowed to polymerize undisturbed for 2–3 min. This ensures firm adhesion and reduces the risk of early dislodgement by CSF pulsations. Fibrin glue is sometimes layered over a dural patch (e.g., DuraGen) to reinforce the closure, creating a composite seal that combines the mechanical properties of a scaffold with the biological sealing of fibrin. In some cases, a thin layer of glue is also applied under the edges of the patch to promote adhesion to the dura and minimize dead space.

Despite its benefits, fibrin glue has limitations: It lacks tensile strength, is prone to mechanical disruption, and may be less effective in high-flow CSF leaks unless used in tandem with structural closure. In addition, concerns exist regarding the risk of viral transmission from human-derived components, although current manufacturing processes have largely reduced this risk. Nevertheless, fibrin sealants remain an important tool in the spine surgeon's arsenal, especially for sealing microleaks and enhancing the efficacy of primary repair strategies.

Conservative intraoperative management

Irrespective of the techniques used to seal the leaking spinal fluid, there are some intraoperative measures that are highly beneficial. A good water-tight closure in layers involving muscle closure, double-breasted closure of the fascia, subcutaneous, and cutaneous closure is not only effective in managing a dural tear but also reduces the chance of subsequent infection. Skin is closed with vertical mattress sutures with the skin in eversion to provide a good contact surface between the edges and act as another layer in closure. Wound management in the form of drains is an important measure. The authors recommend the use of two drains, one deeper to the fascia, which is not under suction, and one above the fascia kept under a suction effect. The drains must be tunnelled suprafascially and exit cephalad and at a distance from the surgical wound. Purse string sutures are taken around the drain at the site of the drain exit through the skin. These are tied at the time of drain removal. A well-padded compression dressing is given. Milton et al. [3] devised a treatment algorithm to manage an incidental durotomy based on the site of the tear and consideration of various techniques that a surgeon may employ (Fig. 1).

Dural and soft-tissue healing

The healing of tissues following an incidental durotomy follows an initial inflammatory response whereby cellular infiltration causes the release of inflammatory cytokines, causing tissue breakdown and removal of debris. This is followed by the formation of granulation tissue with neovascularisation, fibroblast proliferation, and laying down of a connective tissue matrix. Finally, scar tissue forms with fibrosis, providing structural support to the rent. The entire process of dural healing can take a few weeks to months. However, there is no clarity on the exact duration of the healing process.

Minimally invasive surgery

Minimal invasive techniques, such as the use of a tubular retractor system, have certain advantages with respect to dural tear. With better illumination and magnification, it reduces the chances of an incidental durotomy. However, in the eventuality of a CSF leak, the minimal tissue dissection provides a more anatomical water-tight closure to tackle a dural tear. However, repairing a tear is invariably challenging due to the narrow working channel. In cases where the operating surgeon feels it necessary to repair or seal the dural defect, primary repair with sutures may not always be possible, and one may have to rely on patches and seals to address the same. In case a primary repair is deemed necessary, converting the minimal access to open is a feasible option.

Endoscopic spine surgery

Like minimal invasive spine surgery, the chances of dural tears in endoscopic spine surgery are less compared to open surgery. Often, an incidental durotomy is a puncture. An autologous muscle or fat graft in combination with fibrin glue or a fibrin-sealed collagen sponge is a good and safe method for the management of dural tear in lumbar endoscopic spine surgery [4]. Undertaking a primary repair with the suture technique is challenging.

Cervical spine surgery

Incidental durotomies can be encountered in cervical spine surgery, especially with a tight stenosis, ossified posterior longitudinal ligament, and revision spine surgery. In a posterior approach, it may be possible to deal with a dural tear with primary repair. However, in an anterior approach, this may not be possible. Such a dural tear may be addressed with sealant or muscle, fat, or fascia graft. Due to the cephalad location, cervical dural tears are relatively forgiving. Wounds closed over drains, such patients are mobilised sooner and usually remain asymptomatic with the pressure of the spinal fluid travelling down and allowing the dura to heal satisfactorily.

Post-operative care and monitoring

Although debated, most surgeons prefer to keep patients with lower thoracic and lumbar dural tears flat, prone, or in a head low position. This is done to lower the hydrostatic pressure of the CSF in the dural sac. Nursing in such a decubitus for 48–72 h allows time for the seal to take and/or a fibrin clot to form at the durotomy site. As an adjunct to this nursing protocol, some

surgeons prefer to use oral Acetazolamide, a carbonic anhydrase inhibitor, in a dose of 250–500 mg 2 or 3 times a day. The rationale for its use is to reduce the production of CSF and hence the intracranial pressure to allow for a more favorable internal milieu for the durotomy to heal or the seal to take. Ensuring adequate hydration, mechanical thromboprophylaxis, and antibiotic cover are other essential care aspects that should be appropriately addressed.

The authors prefer to remove the deep drain within 48–72 h, as soon as the quantity of blood within the drain reduces. The superficial drain is left in situ for a longer period, usually for 5–7 days, and occasionally longer. The superficial drain is only removed if the patient is asymptomatic upon verticalization and after adequate skin healing. By preventing the collection of CSF within the wound, the drains allow time for tissue healing. In these cases, successful treatment of the dural tear is the formation of an asymptomatic pseudo-meningocele. A retrospective study conducted by Zhai et al. explored the management of CSF leak with the prolonged use of subfascial drain [5]. They found that retaining the drain for 7–10 days postoperatively under antibiotic cover helped prevent CSF leakage through the wound, comparable to CSF leaks treated with conventional techniques, allowing the wound to develop sufficient resistance to withstand subarachnoid pressure, thereby preventing persistent CSF leak and without increasing the risk of infection. The duration of post-operative antibiotics is debated. The authors prefer to provide antibiotic cover until the drains are in situ.

Signs of persistent CSF leak comprise symptoms of low CSF pressure, such as headache and dizziness. No reduction in drain volume over days or a soaking wound dressing are other indicators. Rarely, patients report a lot of post-operative nerve pain or wound site pain.

Imaging in the form of a contrast MRI or a CT myelogram may be undertaken to assess the formation of a pseudo-meningocele or a fistula. Rarely, a secondary post-operative incidental durotomy may develop from a bony spicule from the decompression window impinging on the dural sac. Imaging holds special value in diagnosing a CSF collection in such cases.

Complications

- CSF fistula
- Pseudomeningocele
- Headaches, nausea, dizziness
- Meningitis and infection risk
- Neurological deterioration
- Radicular pain if a nerve root is entrapped in the dural defect.

Prevention Strategies

- Education and training
- Pre-operative planning and imaging. Identifying high-risk cases for dural tears
- Use of magnification and illumination
- Surgical technique refinement
- Meticulous hemostasis
- Preferably, finish instrumenting the spine before spinal decompression
- Careful use of high-speed drills, harmonic scalpel, and osteotomes
- Dissection between the bone and dura with a dissector and cotton patties
- Use Kerrison punches under vision. They should be used perpendicular to the dura. In the central canal within the lumbar spine, bone excision proceeds from caudal to cephalad. In the lateral canal, decompression is performed from cephalad downwards along the nerve root
- Disc punch should be opened up only within the disc space and perpendicular to the dura
- Always protect exposed dura when using sharp instruments and performing other surgical steps.

Outcomes and Prognosis

A multicenter observational study assessed 2146 patients undergoing lumbar spine surgery. Incidental durotomies were noted in 166 patients (7.7%). No significant difference was found in post-operative pain or dysesthesia of the lower back, buttock, leg, and plantar area between patients who sustained an incidental durotomy as compared to those who did not [6]. Patients with dural tears show nearly equivalent post-operative outcomes at 1 year following cervical spine surgery compared to those without dural tears. However, the incidence of perioperative complications is often higher, emphasizing the need for careful management [7].

Conclusion

Dural tears, though incidental, remain a significant complication in spine surgery that demands meticulous attention from both the surgeon and the care team. If not identified and managed appropriately, their occurrence can lead to a range of post-operative complications. Advances in surgical techniques, improved intraoperative visualization, and the availability of diverse repair methods, including sutures, autologous grafts, and sealants, have greatly enhanced the ability to address these tears effectively.

Nonetheless, prevention through careful pre-operative planning, precise surgical technique, and gentle tissue handling remains paramount. When managed appropriately, most dural tears do not significantly affect long-term outcomes, although they may increase perioperative risks. A structured post-operative care regimen, including flat bed rest, drainage strategies, and vigilant monitoring, ensures better healing and reduces the likelihood of persistent cerebrospinal fluid leaks or

infections. Ultimately, awareness, prompt recognition, and skilled management are key to minimizing the impact of dural tears and achieving favorable outcomes in spine surgery.

–

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

References

1. Alessa M, Ababneh F, Al Taimeh F, Haddad S, Al Rabadi J, Hjazeen A. Incidental Dural tears during lumbar spine surgery: Prevalence and evaluation of management outcomes. Cureus 2024;16:e54212.
2. Tardieu GG, Fisahn C, Loukas M, Moisi M, Chapman J, Oskouian RJ, et al. The epidural ligaments (of Hofmann): A comprehensive review of the literature. Cureus 2016;8:e779.
3. Milton R, Kalanjiyam GP, Rajasekaran S, Shetty AP, Kanna RM. Dural injury following elective spine surgery - a prospective analysis of risk factors, management and complications. J Clin Orthop Trauma 2023;41:102172.
4. Müller SJ, Burkhardt BW, Oertel JM. Management of Dural tears in endoscopic lumbar spinal surgery: A review of the literature. World Neurosurg 2018;119:494-9.
5. Zhai J, Guo S, He D, Zhao Y. Treatment of cerebrospinal fluid leakage with prolonged use of subfascial epidural drain and antibiotics in patients of thoracic myelopathy after posterior decompression surgery. Front Surg 2023;10:1302816.
6. Nakajima K, Nakamoto H, Kato S, Doi T, Matsubayashi Y, Taniguchi Y, et al. Influence of unintended Dural tears on postoperative outcomes in lumbar surgery patients: A multicenter observational study with propensity scoring. Spine J 2020;20:1968-75.
7. Oshima Y, Nakamoto H, Doi T, Miyahara J, Sato Y, Tonosu J, et al. Impact of incidental Dural tears on postoperative outcomes in patients undergoing cervical spine surgery: A multicenter retrospective cohort study. Spine J 2025;25:91-8.

Conflict of Interest: NIL
Source of Support: NIL

How to Cite this Article

Shah P, Zaveri G. Intraoperative Dural Tears: Current Trends in Management. Journal of Clinical Orthopaedics. January-June 2026;11(1):27-32.