Incidental durotomy during lumbar spine surgery: risk factors and anatomic locations

Clinical article

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Object. Incidental durotomy (dural tear) is a common complication of lumbar spine surgery. The purpose of this study was to clarify the anatomical location of and the specific causative factors for incidental durotomy during primary lumbar spine surgery.

Methods. The authors retrospectively reviewed 1014 consecutive cases involving patients (412 women and 602 men; mean age 57 years; age range 11–97 years) who underwent a surgical procedure for treatment of degenerative lumbar spinal disease at their institution between 2002 and 2008. In total, 1261 disc levels were treated surgically. Disease at the treated levels included 544 disc herniations, 453 instances of spinal canal stenosis without spondylolisthesis, 188 instances of lumbar spinal canal stenosis with spondylolisthesis (degenerative spondylolisthesis), 49 instances of combined stenosis (stenosis with disc herniation), and 22 juxtafacet cysts. In 5 of the treated levels, the condition was classified as “other” disease. Treatment included fenestration with discectomy in 547 levels, fenestration alone in 626, fenestration with resection of juxtafacet cysts in 22, unilateral recapping laminoplasty in 20, posterolateral spinal fusion or posterior lumbar interbody fusion in 17, microscopic discectomy with tubular retractor in 14, and “other” in 15.

Results. Unintended durotomy occurred in 4% of cases and in 3.3% of disc levels. The incidence of dural tear was significantly higher in women (5.6%) than in men (3%). The incidence of dural tear was 2% in disc levels with lumbar disc herniation, 1.8% with lumbar spinal canal stenosis without spondylolisthesis, 9% with degenerative spondylolisthesis, and 18.2% with juxtafacet cysts; the incidence was significantly higher in levels with degenerative spondylolisthesis or levels with juxtafacet cysts, than in those with other diseases. Incidental durotomy occurred in 4 critical anatomical zones, namely, the caudal margin of the cranial lamina, cranial margin of the caudal lamina, herniated disc level, and medial aspect of the facet joint adjacent to the insertion of the hypertrophic ligamentum flavum.

Conclusions. Risk factors for unintended durotomy were female sex, older age, degenerative spondylolisthesis, and juxtafacet cysts. In this study, the authors identified 4 high-risk anatomical zones that spine surgeons should be aware of to avoid dural tears.

Key Words • incidental durotomy • lumbar spine surgery • complication • juxtafacet cyst • degenerative spondylolisthesis • technique

Incidental durotomy is a common complication of spine surgery, and when managed inadequately, it can lead to CSF leakage or postoperative extradural arachnoid cyst development.5–7 Therefore, spine surgeons should exercise caution to avoid unintended durotomy. The incidence of unintended durotomy has been reported to be 0.5%–18%.2–4,7,12,14,16,17 Several studies also have reported postoperative complications and clinical results, but only a few have investigated the actual anatomical locations of dural tear or the causative maneuver and tool used at the time of durotomy. In 2010, Espiritu and colleagues7 reported that the risk factors for durotomy were the surgeon’s length of experience and the patient’s age. The purpose of this study was to clarify the anatomical location of and the specific causative factors for durotomy during primary lumbar spine surgery.

Abbreviation used in this paper: JOA = Japanese Orthopaedic Association.

Methods

We retrospectively reviewed 1014 consecutive cases involving patients who underwent a surgical procedure for the treatment of degenerative lumbar spinal disease at our institution between 2002 and 2008. These operations were performed by 5 surgeons. Each surgeon had more than 15 years of experience with degenerative lumbar spine surgery. After we excluded patients with spinal tumor or trauma, and those undergoing revision surgery, in which the dura mater may be incised intentionally, our sample included 412 women and 602 men with a mean age of 57 years (range 11–97 years) at the time of surgery. A total of 1261 disc levels were treated: 796 patients had 1 involved level, 190 patients had 2 involved levels, 27 patients had 3, and 1 patient had 4. Lumbar disc herniation was the reason for treatment in 544 levels, lumbar spinal canal stenosis without degenerative spondylolisthesis in 453, degenerative spondylolisthesis for 188, combined stenosis in 49, juxtafacet cysts in 22, isthmic
spondylolisthesis in 4, and spondylosis in 1 (Table 1). The diagnostic criteria for lumbar spinal stenosis were based on the classification introduced by Arnoldi and colleagues in 1976. The L1–2 disc level was treated in 5 cases, L2–3 in 63, L3–4 in 267, L4–5 in 659, L5–6 in 26, and L5–S1 in 241. The surgical procedures included fenestration with discectomy, fenestration alone, fenestration with resection of a juxtafacet cyst, unilateral recapping laminoplasty, posterolateral lumbar fusion, posterior lumbar interbody fusion, foraminotomy, laminctomy, lateral fenestration with herniotomy, and microscopic discectomy with a tubular retractor (Table 2).

We compared the age and sex of the patients in whom unintended durotomy occurred with those in whom it did not occur using the Student t-test and chi-square test (with p < 0.05 considered significant). We also examined and compared the incidence of durotomy according to each diagnosis and surgical procedure; the Yates chi-square test was used for these statistical analyses (with p < 0.05 considered significant). The method of dural repair was retrospectively reviewed from medical records. The actual anatomical location of the dural tear and the intraoperative maneuver and tool used at the time of incidental durotomy were also reviewed. Immediately after the operation, the primary surgeon created an intraoperative record that included a figure. In our department, since 2002, it has been mandatory to draw a figure of the decompressed area, causative factors of compression (for example, articular processes, bony spurs, thickness of the ligamentum flavum, herniated discs, and cystic lesions), and any specific matters (for example, unintended dural tear or accidental damage to a nerve). The anatomical position of the incidental durotomy was reviewed using these operative records; in addition, the sites of rupture were recorded in a schematic diagram, with a separate document maintained for each disease. All of the diagrams showed the right side only, and left-side tears were recorded in the corresponding right-side locations. Clinical outcome was evaluated using the JOA scoring system for lumbar spinal disease.9

Results

Clinical Data

Of the 1014 patients, 41 (4%) had an incidental durotomy. Of these 41 patients, 23 were women and 18 were men. Their mean age at the time of surgery was 65 years. The mean age of the patients who did not have incidental durotomy was 57 years; this difference in age was significant (p < 0.05). There was also a significant difference in the incidence of durotomy based on sex, with unintended dural tears occurring in 23 (5.6%) of 412 female patients and 18 (3%) of 602 male patients (p < 0.05) (Table 3). Unintended dural tears occurred in 2 cases at the L2–3 level, 8 cases at L3–4, 27 cases at L4–5, and 4 cases at L5–S1 (Fig. 1). There was no significant difference in the incidence of durotomy based on disc level (p > 0.05). With respect to the conditions being treated, incidental durotomies occurred at 11 (2.0%) of 544 levels treated for disc herniation, 8 (1.8%) of 453 levels treated for stenosis without spondylolisthesis, 17 (9%) of 188 levels treated for degenerative spondylolisthesis, 1 (2%) of 49 levels treated for combined stenosis (stenosis and disc herniation), and 4 (18.2%) of 22 levels treated for juxtafacet cysts (Fig. 2). The number of incidental durotomies according to surgical procedure was as follows: 11 (2.0%) in patients who underwent fenestration with discectomy, 24 (3.8%) in those who underwent fenestration, 4 (18.2%) in those who underwent fenestration with resection of a juxtafacet cyst, and 2 (3.0%) in those who underwent other procedures (Fig. 3).

Management of Dural Tear and Complications

In 37 (89%) of the 41 cases of incidental dural tear, we performed primary repair with 6-0 nylon suture and covered the area with fibrin glue (Beriplast P, CSL Behring). In the other 4 cases, the tears were small, and fibrin glue was simply sprayed on, with no suturing performed. Cerebrospinal fluid leakage was recognized in only 1 patient, who underwent revision surgery 2 weeks later.

Nerve injury was found in 2 of the 41 patients; 1 of the 2 patients with nerve injury showed postoperative muscle weakness of the unilateral extensor hallucis longus. Seven patients (20%) experienced headaches after surgery (mean duration 2.6 days, range 1–5 days).

Anatomical Location of Dural Tear

The anatomical positions of the durotomy lesions according to the treated conditions are shown in Fig. 4. In patients with herniated discs, ruptures occurred mainly at the nerve root near the herniated disc level (Fig. 4A). In patients with degenerative spondylolisthesis, dural tears occurred primarily around the medial aspect of the facet joint attaching the hypertrophic ligamentum flavum, or at the cranial margin of the caudal lamina (Fig. 4B). In patients with stenosis without spondylolisthesis, dural tears occurred around the medial aspect of the facet joint attaching the hypertrophic ligamentum flavum, or at the cranial margin of the cranial lamina (Fig. 4C). Incidental dural tear in patients with juxtafacet cysts occurred where the adhesive lesions contacted the dura mater (Fig. 4D).

Maneuver and Device Used at the Time of Unintended Durotomy

Incidental durotomy occurred in 21 cases when a dissector was used to separate the dura from the ligamentum flavum, a disc herniation, a cystic lesion, or a bony frag-
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ment. Dural tear occurred because of a Kerrison rongeur in 8 cases, abrasion of the lamina or facet by an air drill in 4 cases, a chisel in 1 case, and retraction of the nerve root during posterior lumbar interbody fusion in 1 case. The causative factors were unknown in 6 cases.

Clinical Outcome in Cases of Unintended Durotomy

Clinical outcome was evaluated by JOA score at 1 year after surgery. The follow-up rate was 80.5% (33 of 41 patients). The mean preoperative JOA score for patients who had unintended durotomy was 12.0 points (total possible score 29 points); the mean JOA score increased to 20.4 points at the 1-year follow-up. The recovery rate was 51.2%, calculated by the Hirabayashi method. In the 33 patients who underwent follow-up MRI, the imaging studies showed no pseudomeningocele or CSF fistula.

Discussion

The incidence of unintended durotomy has been reported to range from 0.5% to 18%. Such a wide range is probably because in multicenter studies, the incidence rates have been estimated using questionnaires alone rather than prospective findings. Therefore, for a complication survey, a single-institution study is more precise. At our institution, the incidence of dural tear in primary lumbar spine surgery was 4% during the study period. In 2007, Epstein reported that patients without dural tear were younger than those with dural tear (average age 69 vs 74 years, respectively). We obtained similar results in our study (average age 57 vs 65 years, respectively). We also found that the incidence of dural tear in women (23 [5.6%] of 412 cases) was higher than that in men (18 [3%] of 612 cases). Thus, we can deduce that female sex and older age are risk factors for dural tear. Degenerative signs include narrowing of the spinal canal, thicker ligamentum flavum, and osteophyte formation; these factors probably affected the incidence of dural tear in the present study and in earlier studies. Therefore, we should carefully assess severe degenerative changes on preoperative radiographs, CT scans, and MR images to determine the risk factors for incidental dural tear.

In some cases, it is impossible to avoid dural tear because of an adhesive lesion; however, we encountered unintended durotomy in cases without severe adhesion. Few studies have reported the detailed rate of dural tear in different diseases. Wang et al. reported that in patients with stenosis without spondylolisthesis, the rate was 13%. Our study indicated that the rate of durotomy was significantly higher in patients with degenerative spondylolisthesis (12%) or juxtafacet cysts (18.2%) than in those with other diseases. In 2001, Salmon and colleagues reported that the rate in patients with juxtafacet cysts was 17%, which is similar to the data obtained in our series (18.2%). Therefore, we can conclude that degenerative spondylolisthesis and juxtafacet cyst are risk factors for unintended durotomy. This higher incidence is a result of severe degenerative and adhesive changes around the lesion.

It is important for spine surgeons to be aware of the anatomical locations that are most vulnerable to dural tears in specific diagnoses and procedures; however, no study has examined the actual anatomical locations of incidental dural tears. In this study, we identified 4 critical anatomical zones where incidental durotomy occurred (Fig. 5). Zones 1 and 4 are the cranial and caudal margins of fenestration; incidental tear while using an air drill or Kerrison rongeur occurred in these zones. Zone 2 is the medial aspect of the facet joint in the area of the insertion of the hypertrophic ligamentum flavum; dural tears occurred mainly in this zone in patients with stenosis.

![Fig. 1. Incidence of dural tear stratified by disc level. There was no significant difference between disc levels.](image-url)
without spondylolisthesis or juxtafacet cysts. Salmon and colleagues\textsuperscript{14} reported that adhesive changes in juxtafacet cysts with dural membranes were recognized in 30\% of cases of juxtafacet cysts. When operating in Zones 2 and 3, careful management is necessary for separation of the adhesive lesion, especially in juxtafacet cyst cases. Zone 3 is the intervertebral disc level, and tears in patients with disc herniation occurred mainly in this zone because of the adhesion of the dura to the disc or the herniation. Recently, endoscopic procedures have become common for lumbar decompression and/or disc surgery. In 2010, Sairyo et al.\textsuperscript{13} reported that the incidence of dural tear was 8.1\% during endoscopic lumbar disc surgery. For the above reasons, spine surgeons should know the possible anatomical zones for dural tear and should exercise caution when operating in these areas.

Some reports have indicated that the ruptured dural membrane should be sutured and that fibrin glue should be used.\textsuperscript{4,11} In the current study, we sutured the ruptured dural membrane and sprayed the lesion with fibrin glue, except in tears smaller than 2 mm without fluid leakage; for these smaller tears, fibrin glue was used without sutures. There were no serious postoperative complications using this management approach. Some studies have reported that dural tear led to fluid leakage or extradural arachnoid cyst formation.\textsuperscript{5,6} Fortunately, there was no case of pseudomeningocele or CSF fistula in our study. With regard to clinical outcome, the literature is controversial. Cammisa et al.\textsuperscript{3} and Wang et al.\textsuperscript{17} found no long-term sequelae in patients with unintended durotomy. On the other hand, Saxler and colleagues\textsuperscript{15} found poorer outcomes in cases with incidental dural tears than in control cases without dural tears. In this study, the mean JOA score increased at the 1-year follow-up, and the recovery rate was 51.2\%, which is similar to previously reported rates.\textsuperscript{8,10} Although clinical outcome after 1 year was not affected by unintended durotomy, continued follow-up is necessary in these cases.

\textbf{Fig. 2.} Incidence of dural tear stratified by disease or condition being treated. The incidence of dural tear in levels with juxtafacet cysts or degenerative spondylolisthesis was significantly higher than that in levels with other diseases. LDH = lumbar disc herniation; LCS = degenerative spinal stenosis without spondylolisthesis; DS = degenerative spondylolisthesis; CS = combined stenosis (stenosis with disc herniation); Cyst = juxtafacet cyst. *p < 0.05.

\textbf{Fig. 3.} Incidence of dural tear stratified by surgical procedure. The incidence of dural tear during fenestration with resection of juxtafacet cysts was significantly higher than that during other operations. F = fenestration; F+Cyst = fenestration with resection of juxtafacet cyst. *p < 0.05.

\textbf{Fig. 4.} Schematic drawings showing the anatomical location of dural tears (indicated by X) according to the condition being treated. A: In patients with lumbar disc herniation, tears occurred mainly near the herniated disc. B: In patients with degenerative spondylolisthesis, dural tears occurred primarily around the medial aspect of the facet joint. C: In patients with lumbar spinal canal stenosis (without spondylolisthesis), dural tears occurred around the medial aspect of the facet joint. D: In patients with juxtafacet cysts, dural tears occurred where adhesive lesions contacted the dura mater. D = disc; FJ = facet joint; LF = ligamentum flavum.
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**Fig. 5.** Critical zones of unintended durotomy. There are 4 critical anatomical zones in lumbar fenestration where dural tears can occur: Zone 1, cranial margin of fenestration; Zone 2, medial aspect of the facet joint; Zone 3, intervertebral disc; and Zone 4, caudal margin of fenestration.

**Conclusions**

Risk factors for unintended durotomy were female sex, older age, degenerative spondylolisthesis, and the presence of a juxtafacet cyst. This study reinforces the notion that surgeons must exercise caution to avoid incidental dural tear during surgical treatment of degenerative spondylolisthesis and juxtafacet cysts. We identified 4 high-risk anatomical zones (cranial and caudal margins of fenestration, medial aspect of the facet joint, and intervertebral disc level) that spine surgeons should be aware of in order to avoid dural tears.

**Disclosure**

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Takahashi.

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