Perioperative Impact of Incidental Durotomy in Elderly Patients Undergoing Elective Spine Surgery: A Multicenter European Cohort Study

Ann. Ital. Chir., 2026 97, 11: 2000–2008
https://doi.org/10.62713/aic.4745

Ismail Zaed[1,2,3], Luca Ricciardi[2,4], Francesca Pasqua Mezzapesa[5], Leonardo Di Cosmo[3,6], Mario Ganau[7], Corrado Iaccarino[5,8,9], Salvatore Chibbaro[10], Julien Todeschi[11], Charles-Henry Mallereau[11], Andrea Cardia[1,†], Davide Milani[1,†]

[1]Department of Neurosurgery, Neurocenter of Southern Switzerland, Ente Ospedaliero Cantonale, 6900 Lugano, Switzerland
[2]Department of NESMOS, Sapienza University, 00118 Rome, Italy
[3]Neurosurgical Outcomes Research & Analytics (NORA) Laboratory, 6900 Lugano, Switzerland
[4]UOC di Neurochirurgia, Azienda Ospedaliera Universitaria Sant'Andrea, 00118 Rome, Italy
[5]Department of Biomedical, Metabolic and Neural Sciences, School of Neurosurgery, University of Modena and Reggio Emilia, 41124 Modena, Italy
[6]Department of Biomedical Sciences, Humanitas University, 20072 Milan, Italy
[7]Department of Neurosurgery, Oxford University Hospitals NHS Foundation Trust, OX3 9DU Oxford, UK
[8]Neurosurgery Division, University Hospital of Modena, 41124 Modena, Italy
[9]Neurosurgery Unit, AUSL RE IRCCS, 42123 Reggio Emilia, Italy
[10]Department of Neurosurgery, Department of Medical and Surgical Sciences and Neurosciences, University of Siena, 53100 Siena, Italy
[11]Department of Neurosurgery, Hautepierre Hospital, Strasbourg University Hospital, 67200 Strasbourg, France

AIM: Incidental durotomy is among the most frequent intraoperative complications in spine surgery, yet elderly patients may be especially vulnerable to its downstream consequences because of frailty, multimorbidity, delayed mobilization, and postoperative neurocognitive complications. The literature suggests that durotomy is associated with increased perioperative resource utilization, whereas long-term functional outcomes are not well reported.

METHODS: We performed a retrospective multicenter cohort study across five European academic neurosurgical centers. Consecutive patients aged 65 years or older who underwent elective spine surgery between 2019 and 2024 were reviewed. Patients with incidental durotomy during the index procedure were compared with those without durotomy. Outcomes of interest included length of stay, thromboembolic events, postoperative infection, delirium, readmission, revision surgery, postoperative intensive care use, and discharge disposition.

RESULTS: Among 723 included patients, 107 (14.8%) sustained an incidental durotomy. Operative time was longer in the durotomy cohort (median 178 vs 138 minutes; $p < 0.001$), as were length of stay (8 vs 5 days; $p < 0.001$), thromboembolic events (6.5% vs 1.8%; $p = 0.010$), and postoperative delirium (14.0% vs 5.2%; $p = 0.001$). In descriptive analyses of patients older than 75 years, median length of stay was 10 vs 6 days, delirium occurred in 17.7% vs 7.4%, and thromboembolic events occurred in 8.1% vs 2.2%. Postoperative infection, 30-day readmission, revision surgery, intensive care use, and discharge disposition were not significantly different between groups.

CONCLUSIONS: In elderly patients undergoing elective spine surgery, incidental durotomy was associated mainly with increased perioperative morbidity rather than clearly worse short-term post-discharge outcomes. The signals for prolonged stay, delirium, and thromboembolic complications—especially in patients older than 75 years—support age-sensitive perioperative pathways emphasizing meticulous repair, early mobilization when clinically appropriate, delirium prevention, and close medical surveillance.

Keywords: incidental durotomy; dural tear; elderly; geriatric; elective spine surgery; delirium; venous thromboembolism

Introduction

Incidental durotomy is one of the most common intraoperative complications encountered in spine surgery. Historical and contemporary series have reported incidence estimates ranging from roughly 1% to 17%, with important variation according to spinal region, diagnosis, surgical complexity, revision status, and the method used to identify durotomy [1,2,3,4].

Submitted: 7 May 2026 Revised: 19 August 2026 Accepted: 24 August 2026 Published: 10 November 2026
Correspondence to: Ismail Zaed, Department of Neurosurgery, Neurocenter of Southern Switzerland, Ente Ospedaliero Cantonale, 6900 Lugano, Switzerland; Department of NESMOS, Sapienza University, 00118 Rome, Italy; Neurosurgical Outcomes Research & Analytics (NORA) Laboratory, 6900 Lugano, Switzerland (e-mail: ismailzaed1@gmail.com).
[†]*These authors contributed equally.*
Editor: Roberto Gazzeri

The clinical significance of incidental durotomy lies not only in cerebrospinal fluid leakage itself, but also in the cascade of postoperative consequences that may follow: headache, wound-related problems, delayed mobilization, prolonged bed rest, venous thromboembolism, and higher hospital costs. Studies have shown that durotomy is associated with longer length of stay (LOS) and greater economic burden, while the effect on readmission, reoperation, and long-term patient-reported outcomes is less consistent [5,6,7].

Several risk factors have been described in the elective spine population, including increasing age, revision surgery, multilevel decompression, deformity surgery, fusion procedures, obesity, corticosteroid exposure, thrombocytopenia, ankylosing spondylitis, and, in some series, female sex [5,8,9,10]. Importantly, some of these factors cluster in elderly patients, who increasingly represent a large proportion of those undergoing surgery for degenerative spinal disease.

The geriatric population is uniquely susceptible to the secondary effects of incidental durotomy. Delayed mobilization may amplify the risk of venous thromboembolism, deconditioning, and pulmonary complications; meanwhile, pain, opioids, electrolyte shifts, sleep disruption, and prolonged hospitalization may precipitate postoperative delirium in older adults. In a dedicated cohort of patients aged 65 years or older, incidental durotomy was independently associated with delirium after spine surgery [11].

Against this background, the elderly elective spine population remains relatively under-characterized. The present multicenter study therefore aimed to evaluate the perioperative impact of incidental durotomy in patients aged 65 years or older undergoing elective spine surgery, with particular attention to hospital length of stay, thromboembolic events, postoperative infection, delirium, intensive care requirements, readmission, revision surgery, and discharge disposition.

Methods

Study Design and Setting

This retrospective multicenter cohort study was conducted at five European academic neurosurgical centers: the Neurocenter of Southern Switzerland (Switzerland), the Department of NESMOS at Sapienza University (Italy), the Department of Medical and Surgical Sciences and Neurosciences at the University of Siena (Italy), Strasbourg University Hospital (France), and the Oxford University Hospital (United Kingdom) The study was formally exempt from ethical review according to the requirements of each Ethical Committee (Comitato etico cantonale Ticino, Comitato Etico per la Ricerca Transdisciplinare (CERT), Comité d'éthique pour la recherche de l'Université de Strasbourg (CER-Unistra), Comitato Etico Regione Toscana, Oxford Research Ethics Committee). The need for individual informed consent was waived because of the retrospective design and use of de-identified data. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations for cohort studies.

Patient Population

We reviewed consecutive patients aged 65 years or older who underwent elective spine surgery between 1 January 2019 and 31 December 2024.

Patients were included if they were 65 years of age or older at the time of surgery, underwent elective spine surgery during the study period, had available perioperative clinical and operative records sufficient to define baseline characteristics, surgical procedure, revision status, and incidental durotomy status, and had at least 30 days of postoperative follow-up.

Patients were excluded if they were younger than 65 years, underwent emergency or trauma-related spine surgery, had follow-up shorter than 30 days, or had missing essential data required for the primary analysis. Missing essential data were defined as unavailable operative documentation preventing classification of incidental durotomy status, missing procedure type or revision status, missing primary postoperative outcome data including length of stay, delirium, thromboembolic events, or postoperative infection, or inability to ascertain 30-day readmission or revision surgery status.

The cohort was stratified into two prespecified age groups: 65–75 years and >75 years. The exposure of interest was incidental durotomy sustained during the index operation, as documented in the operative report and/or postoperative record. Patients with incidental durotomy were assigned to the durotomy group, and all remaining patients constituted the comparison group. Regarding durotomy management, primary suture repair was attempted whenever feasible, followed by patch and sealant application when primary closure alone was not possible or was considered insufficient.

Variables and Outcomes

Collected baseline variables included age, sex, body mass index, smoking status, alcohol use, preoperative neurological status, and available comorbidity data. Operative variables included procedure type, operative time, transfusion requirements, and postoperative intensive care use. The primary outcomes were hospital LOS, thromboembolic events (deep vein thrombosis or pulmonary embolism), postoperative infection, and delirium. Secondary outcomes included 30-day readmission, revision surgery, discharge disposition, and postoperative intensive care requirement.

All postoperative outcomes were assessed during the index hospitalization and within 30 days after surgery, unless otherwise specified. Postoperative infection included any clinically documented surgical site, wound, urinary tract, pulmonary, bloodstream, or other postoperative infection occurring within this observation window. Thromboembolic

events included symptomatic deep vein thrombosis or pulmonary embolism occurring within this observation window and confirmed by imaging when clinically suspected. Revision surgery was defined as any unplanned return to the operating room related to the index spinal procedure within 30 days after surgery.

Postoperative delirium was assessed during the index postoperative hospitalization using the Confusion Assessment Method (CAM) across the participating centers. Delirium was defined according to CAM criteria, requiring an acute onset and fluctuating course of mental status changes, inattention, and either disorganized thinking or an altered level of consciousness. Cases were recorded when CAM-positive delirium was documented in the medical, nursing, anesthesiology, geriatric, or surgical records during the postoperative inpatient stay. In positive patients, CAM-Assessment has been performed daily by trained nurses in all centers.

Perioperative venous thromboembolism prophylaxis followed institutional protocols across participating centers. Mechanical prophylaxis was routinely initiated in the immediate postoperative period and continued until patient mobilization. Pharmacological prophylaxis was routinely initiated on postoperative day 1, unless contraindicated, using subcutaneous low-molecular-weight heparin (LMWH), specifically enoxaparin at a dose of 4000 IU. Within each participating center, the same institutional prophylaxis protocol was generally applied to patients with and without incidental durotomy, including those in whom mobilization was delayed after dural repair.

Postoperative mobilization after incidental durotomy was performed according to institutional practice and clinical judgment. In general, patients were mobilized with the assistance of a physiotherapist as soon as clinically appropriate after dural repair, taking into account neurological status, wound condition, symptoms suggestive of persistent cerebrospinal fluid leakage, and overall medical stability. Prolonged bed rest was not routinely mandated solely because of incidental durotomy.

Statistical Analysis

Continuous variables were assessed for normality using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Continuous variables with an approximately normal distribution were reported as mean ± standard deviation and compared using Welch's *t* test. Non-normally distributed continuous or ordinal variables were reported as median with interquartile range and compared using the Mann-Whitney U test. Categorical variables were reported as counts and percentages and compared using Pearson's chi-square test when expected cell counts were adequate; Fisher's exact test was used when any expected cell count was <5. All *p* values reported in Tables 1 and 2 were calculated using the prespecified statistical tests. Multivariable logistic regression models adjusted for age, sex, body mass index, comorbidity burden, revision status, procedure category, number of operated levels, operative time, and center. Firth penalized logistic regression was used for thromboembolic events because of the low event count. Prolonged length of stay was defined a priori as hospitalization longer than 7 days. Missing data were assessed for all baseline, operative, and outcome variables before model construction. Patients with missing essential exposure, operative classification, primary outcome, or 30-day follow-up data were excluded before analysis, as described above. For the remaining included patients, multivariable regression models were performed using complete-case analysis for the covariates included in each model; no multiple imputation was performed. No covariate data were missing, and no patients were excluded from the multivariable regression models because of missing data. The regression model is reported in Table 3. Because some postoperative outcomes were infrequent, the multivariable models were considered exploratory. Covariates were selected a priori based on clinical relevance and previously reported associations with incidental durotomy and postoperative morbidity. For low-event outcomes, estimates were interpreted cautiously, with emphasis on effect size direction and confidence interval width rather than statistical significance alone. A two-sided p value < 0.05 was considered statistically significant. Analyses were performed in R version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 723 elderly patients met the inclusion criteria. Patient age ranged from 65 to 87 years. Incidental durotomy occurred in 107 patients, corresponding to an overall incidence of 14.8%.

Baseline demographic and preoperative clinical characteristics are summarized in Table 1. Mean age was 74.6 ± 6.0 years in the non-durotomy cohort and 75.7 ± 6.3 years in the durotomy cohort ($p = 0.095$); patients older than 75 years represented 50.6% and 57.9% of the two groups, respectively ($p = 0.163$). Sex distribution, body mass index, smoking status, alcohol use, comorbidity burden, and baseline neurologic grade were similar between cohorts. By contrast, durotomy occurred more frequently in revision procedures (27.1% vs 16.9%; $p = 0.012$), fusion cases (59.8% vs 45.8%; $p = 0.007$), and operations involving more spinal levels (median 2 [2–4] vs 2 [1–3]; $p = 0.004$).

Operative time was significantly longer in patients who sustained a durotomy (median 178 [135–232] vs 138 [103–188] minutes; $p < 0.001$). Transfusion requirement, which is reported in Table 1, did not differ significantly between patients with and without incidental durotomy (10.3% vs 6.8%; $p = 0.205$). Likewise, postoperative intensive care use was comparable between groups (11.2% vs 8.8%; $p = 0.417$). Postoperative outcomes are summarized in Table 2. Incidental durotomy was associated with a longer hospital stay, with a median length of stay of 8 (6–12) days

Table 1. Baseline and operative characteristics by durotomy status.

Variable	No durotomy (n = 616)	Durotomy (n = 107)	*p* value
Age, years	74.6 ± 6.0	75.7 ± 6.3	0.095
Age >75 years, n (%)	312 (50.6)	62 (57.9)	0.163
Female sex, n (%)	302 (49.0)	58 (54.2)	0.323
Body mass index, kg/m^2	27.8 ± 4.5	28.1 ± 4.8	0.548
Current/former smoker, n (%)	123 (20.0)	25 (23.4)	0.421
Alcohol use, n (%)	71 (11.5)	14 (13.1)	0.644
Comorbidity burden (CCI), median (IQR)	4 (3–6)	5 (3–6)	0.110
Preoperative ASIA D/E, n (%)	592 (96.1)	100 (93.5)	0.202
Revision surgery, n (%)	104 (16.9)	29 (27.1)	0.012
Fusion procedure, n (%)	282 (45.8)	64 (59.8)	0.007
Operated levels, median (IQR)	2 (1–3)	2 (2–4)	0.004
Operative time, minutes, median (IQR)	138 (103–188)	178 (135–232)	<0.001
Transfusion requirement, n (%)	42 (6.8)	11 (10.3)	0.205

Values are shown as mean ± standard deviation, median (IQR), or n (%), as appropriate. CCI, Charlson Comorbidity Index; ASIA, American Spinal Injury Association Impairment Scale. Normality was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Pearson's chi-square test or Fisher's exact test was used for categorical variables, as prespecified; Welch's *t* test or the Mann-Whitney U test was used for continuous variables, as appropriate. *p* values are reported to three decimal places, except values <0.001.

Table 2. Postoperative outcomes.

Outcome	No durotomy (n = 616)	Durotomy (n = 107)	*p* value
Length of stay, days, median (IQR)	5 (4–7)	8 (6–12)	<0.001
Delirium, n (%)	32 (5.2)	15 (14.0)	0.001
Any thromboembolic event, n (%)	11 (1.8)	7 (6.5)	0.010
Deep vein thrombosis, n (%)	7 (1.1)	5 (4.7)	0.022
Pulmonary embolism, n (%)	4 (0.6)	2 (1.9)	0.218
Postoperative infection, n (%)	21 (3.4)	7 (6.5)	0.167
30-day readmission, n (%)	34 (5.5)	9 (8.4)	0.243
Revision surgery, n (%)	28 (4.5)	8 (7.5)	0.198
Postoperative ICU use, n (%)	54 (8.8)	12 (11.2)	0.417
Discharge home, n (%)	426 (69.2)	67 (62.6)	0.180
Discharge to rehabilitation/SNF, n (%)	190 (30.8)	40 (37.4)	0.180

Values are shown as median (IQR) or n (%), as appropriate. ICU, intensive care unit; SNF, skilled nursing facility. Normality was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Pearson's chi-square test or Fisher's exact test was used for categorical variables, as prespecified; the Mann-Whitney U test was used for length of stay. *p* values are reported to three decimal places, except values <0.001.

compared with 5 (4–7) days in patients without durotomy ($p < 0.001$). In descriptive age-stratified analyses, the absolute difference in length of stay appeared numerically larger among patients older than 75 years, whose median length of stay was 10 (7–13) days after durotomy versus 6 (4–8) days without durotomy.

Thromboembolic events were significantly more frequent in the durotomy group (6.5% vs 1.8%; $p = 0.010$), driven mainly by deep vein thrombosis (4.7% vs 1.1%; $p = 0.022$). In descriptive age-stratified analyses, the absolute differences in length of stay, thromboembolic events, and postoperative delirium appeared numerically larger among patients older than 75 years. However, these subgroup findings were exploratory and were not supported by formal interaction testing. In particular, thromboembolic events occurred in 8.1% of patients with durotomy versus 2.2% of those without durotomy.

Postoperative delirium was also significantly more common after incidental durotomy (14.0% vs 5.2%; $p = 0.001$). The highest delirium rate was observed in patients older than 75 years, among whom delirium complicated 17.7% of durotomy cases compared with 7.4% of non-durotomy cases. In the 65–75-year subgroup, the same direction of association was present but less pronounced (8.9% vs 3.0%).

Postoperative infection (6.5% vs 3.4%; $p = 0.167$), 30-day readmission (8.4% vs 5.5%; $p = 0.243$), and revi-

Table 3. Adjusted association between incidental durotomy and postoperative outcomes.

Outcome	Adjusted effect for durotomy	*p* value
Prolonged length of stay >7 days	aOR 2.14 (95% CI 1.39–3.29)	<0.001
Postoperative delirium	aOR 2.21 (95% CI 1.15–4.24)	0.017
Any thromboembolic event	aOR 3.18 (95% CI 1.16–8.70)	0.024
Postoperative infection	aOR 1.67 (95% CI 0.68–4.11)	0.270
30-day readmission	aOR 1.42 (95% CI 0.63–3.21)	0.390
Revision surgery	aOR 1.51 (95% CI 0.63–3.60)	0.350

Models were adjusted for age, sex, body mass index, comorbidity burden, revision status, procedure category, number of operated levels, operative time, and center. Standard multivariable logistic regression was used for all outcomes except thromboembolic events, for which Firth penalized logistic regression was used because of the low event count. aOR, adjusted odds ratio; CI, confidence interval. *p* values are reported to three decimal places, except values <0.001.

sion surgery (7.5% vs 4.5%; $p = 0.198$) were numerically more frequent after durotomy, but these differences did not reach statistical significance. Similarly, discharge home was somewhat less common in the durotomy cohort (62.6% vs 69.2%; $p = 0.180$), although discharge disposition overall and postoperative intensive care use were not significantly different.

In multivariable models (Table 3), incidental durotomy remained independently associated with prolonged hospitalization greater than 7 days (adjusted odds ratio [aOR] 2.14, 95% confidence interval [CI] 1.39–3.29; $p < 0.001$), postoperative delirium (aOR 2.21, 95% CI 1.15–4.24; $p = 0.017$), and thromboembolic events (aOR 3.18, 95% CI 1.16–8.70; $p = 0.024$). No statistically significant adjusted association was observed for postoperative infection, 30-day readmission, or revision surgery; however, these low-frequency outcomes should be interpreted cautiously.

Discussion

This multicenter study suggests that incidental durotomy in elderly patients undergoing elective spine surgery is associated with a meaningful increase in perioperative morbidity. Compared with patients without durotomy, patients who sustained a durotomy had a longer median hospital stay (8 vs 5 days), a higher thromboembolic event rate (6.5% vs 1.8%), and a higher postoperative delirium rate (14.0% vs 5.2%). These associations persisted in adjusted models and were numerically more evident among patients older than 75 years, indicating that the consequences of durotomy are not uniform across the geriatric spectrum. Although the descriptive subgroup analysis suggested that the absolute perioperative burden associated with durotomy may be more evident in patients older than 75 years, this finding should be interpreted cautiously. The study was not powered for formal age-by-durotomy interaction testing, and no definitive conclusion can be drawn regarding effect modification by age group. These results should therefore be viewed as hypothesis-generating and warrant confirmation in larger prospective cohorts.

The observed prolongation of length of stay is highly consistent with prior literature. Recent contemporary series and registry-based studies have repeatedly shown that durotomy increases hospitalization time even when reoperation is not required [4,6,12,13]. In the present study, the median difference was 3 days overall and 4 days in the subgroup older than 75 years, a magnitude that is both clinically and economically meaningful. This pattern likely reflects a combination of intraoperative complexity, postoperative monitoring, bed-rest traditions, concern for cerebrospinal fluid (CSF) leakage, and the slower recovery reserve typical of older adults.

Surgical approach may also influence both the occurrence and the downstream consequences of incidental durotomy. Minimally invasive spine surgery has been associated with reduced paraspinal muscle disruption, blood loss, postoperative pain, length of stay, and overall perioperative morbidity compared with conventional open approaches. Recent evidence supports the concept that less invasive techniques may reduce surgical trauma and postoperative complication burden [14].

Our finding regarding thromboembolic events is clinically important. Durotomy often leads to more cautious postoperative mobilization, whether because of surgeon preference or patient symptoms. That approach may be particularly harmful in elderly patients, for whom immobility rapidly translates into venous stasis, deconditioning, and medical complications. In the present study, thromboembolic events occurred in 6.5% of patients with durotomy compared with 1.8% of controls, and the adjusted association remained statistically significant. This interpretation is supported by modern observational data linking incidental durotomy with increased venous thromboembolic risk and by studies suggesting that prolonged bed rest after adequate repair offers little benefit [12,15,16]. Although patients

with incidental durotomy were mobilized with physiotherapist assistance once clinically appropriate, even short delays in mobilization may be clinically relevant in elderly patients with limited physiological reserve and may contribute to the observed association with longer hospitalization and thromboembolic events.

The delirium signal in our study is arguably the most original and clinically actionable finding. Kazarian and colleagues reported that, in patients aged 65 years and older, incidental durotomy was independently associated with postoperative delirium, with an adjusted odds ratio of approximately 1.9 [11]. Our results are directionally concordant and extend that concern to a multicenter European cohort: postoperative delirium occurred in 14.0% of the durotomy cohort versus 5.2% of controls overall, and in 17.7% versus 7.4% among patients older than 75 years. Mechanistically, the association is plausible: durotomy may increase postoperative pain, opioid exposure, immobilization, sleep disruption, and the duration of hospitalization, all of which are well-recognized delirium triggers in older surgical patients. The adjusted association observed in the present study therefore fits well within the geriatric perioperative literature [17,18].

Baseline clinical status is another important determinant of postoperative recovery in elderly spine patients. Although chronological age is an intuitive risk marker, it does not fully capture physiological reserve, functional independence, nutritional status, cognitive vulnerability, or the burden of chronic neurological impairment. In complex spinal cohorts, preoperative functional scores, baseline disability, neurological status, symptom duration, and frailty-related variables have been shown to influence postoperative recovery trajectories and the likelihood of achieving meaningful clinical improvement. In this context, incidental durotomy should not be interpreted in isolation, but rather as an intraoperative event whose clinical impact may be amplified in patients with limited baseline reserve.

This consideration is particularly relevant in older adults. Patients with prolonged symptom duration, worse preoperative mobility, more severe neurological impairment, or lower baseline functional scores may have less capacity to tolerate delayed mobilization, prolonged hospitalization, pain, sleep disruption, and postoperative medical complications. These factors may also increase susceptibility to delirium and thromboembolic events, which were among the main adverse outcomes observed in the present cohort. Therefore, baseline clinical characteristics may act as independent prognostic factors and potential effect modifiers when evaluating the consequences of incidental durotomy in elderly patients.

Importantly, the increased rate of thromboembolic events observed after incidental durotomy should be interpreted in the context of institutional thromboprophylaxis protocols that may have varied across participating centers. In our cohort, mechanical prophylaxis was initiated immediately after surgery and continued until mobilization, while pharmacological prophylaxis was routinely started on postoperative day 1. Within each center, prophylaxis protocols were generally not modified solely because of incidental durotomy. Therefore, the higher thromboembolic burden observed in the durotomy group is unlikely to be explained by systematic withholding of prophylaxis, but may instead reflect delayed mobilization, greater operative complexity, prolonged hospitalization, and the reduced physiological reserve of elderly patients.

By contrast, the absence of a clear difference in postoperative infection, readmission, revision surgery, intensive care use, or discharge disposition aligns with the broader literature indicating that incidental durotomy primarily worsens perioperative recovery while often sparing longer-term or post-discharge outcomes, provided it is recognized and managed appropriately [19,20]. In the present cohort, these events all trended numerically upward after durotomy but remained statistically non-significant, suggesting either a more modest true effect or limited power for relatively infrequent outcomes. Earlier series reported favorable longer-term outcomes after prompt repair [1,2,3,4], and a recent systematic review including more than 80,000 patients concluded that incidental dural tears generally do not produce clinically meaningful deterioration in long-term patient-reported outcomes after elective spine surgery [21].

These findings have practical management implications. First, meticulous intraoperative recognition and repair remain essential. Primary closure is still regarded as the preferred strategy, while systematic review data suggest that adding a patch or graft may reduce postoperative CSF leakage compared with some alternative approaches [22,23]. Second, postoperative management should be adapted to the biology of the elderly patient rather than driven by reflexive immobilization. A randomized trial found no benefit for prolonged bed rest after adequately repaired lumbar durotomy, and meta-analytic evidence suggests that earlier mobilization is associated with fewer minor complications and shorter hospitalization without higher reoperation rates [24,25]. Third, once a durotomy occurs in an older patient, the care team should proactively address delirium and venous thromboembolism prevention rather than viewing the event as a purely technical issue.

Beyond postoperative management, the present findings also highlight the importance of intraoperative prevention strategies in elderly spine surgery. Older patients may present with reduced tissue elasticity, adhesions, ossified or hypertrophic ligamentum flavum, severe stenosis, revision scarring, and fragile dural tissue, all of which may increase the risk of incidental durotomy during decompression or fusion procedures. In this context, durotomy prevention should be considered an age-sensitive surgical objective, particularly because even a successfully repaired

tear may trigger delayed mobilization, prolonged hospitalization, delirium, and thromboembolic complications.

Several technical principles may help reduce this risk. These include careful preoperative review of Magnetic Resonance Imaging (MRI) and computerized tomography (CT) imaging to identify severe stenosis, ossified ligamentum flavum, synovial cysts, adhesions, prior laminectomy defects, or areas of dural thinning; the use of magnification and adequate illumination; meticulous layer-by-layer decompression; cautious use of Kerrison rongeurs in areas of absent epidural fat or adherent ligament; early conversion from sharp to blunt microdissection when adhesions are encountered; and avoidance of excessive traction on neural elements in patients with frail dura. In selected high-risk cases, adjuncts such as intraoperative microscopy or exoscopy, ultrasonic bone-cutting devices, endoscopic or minimally invasive approaches when appropriate, navigation-assisted bony decompression, and readily available dural repair materials may further support safer surgery.

The strengths of this study include its multicenter design, clinically relevant geriatric focus, and the deliberate separation of younger-old and older-old patients. That age stratification adds nuance, because a patient aged 67 years does not carry the same perioperative risk profile as one aged 82 years. From a clinical counseling perspective, this is a valuable contribution.

Future Directions

Future work should move in two directions. Methodologically, prospective or registry-based studies should incorporate standardized durotomy definitions, repair techniques, mobilization protocols, and geriatric complication screening. Clinically, the most promising next step is the development of a standardized elderly durotomy pathway combining watertight repair when feasible, early mobilization when safe, structured delirium prevention, and risk-adapted thromboprophylaxis.

Study Limitations

Several limitations should be acknowledged. First, the retrospective design introduces unavoidable risks of residual confounding and documentation bias. Second, center-specific differences in case mix, repair technique, drain use, mobilization protocol, thromboprophylaxis strategy, and delirium detection may have influenced the results. In addition, postoperative infections were identified based on clinically documented diagnoses in the medical records, and independent adjudication of these outcomes was not reported. Therefore, variations in diagnostic practices and documentation across participating centers may have resulted in outcome misclassification. Although postoperative delirium was assessed daily using the Confusion Assessment Method (CAM) by trained nurses across all centers, the retrospective design limited our ability to verify whether the assessment procedures were implemented and documented uniformly across centers. Third, the available outcomes are predominantly perioperative and 30-day metrics rather than true long-term endpoints such as 12-month patient-reported outcomes, late reoperation, or delayed cerebrospinal fluid-related complications. Finally, although multivariable adjustment was performed, the number of thromboembolic events was limited, and the corresponding estimates should be interpreted cautiously.

Another limitation is that detailed baseline prognostic variables, including symptom duration, granular preoperative functional scores, formal frailty indices, cognitive status, nutritional markers, and patient-reported outcome measures, were not uniformly available across centers. Although the models adjusted for available baseline and operative variables, the absence of these measures limits our ability to determine how preoperative functional reserve modifies the relationship between incidental durotomy and postoperative recovery [26]. Future prospective studies should incorporate standardized frailty assessment, symptom duration, baseline functional scores, and longitudinal patient-reported outcomes to better characterize recovery trajectories after incidental durotomy in elderly spine patients.

Finally, the outcomes evaluated in this study were restricted to the perioperative period and to 30-day postoperative events. Therefore, our data do not allow us to determine whether incidental durotomy has an impact on long-term functional recovery, pain, disability, or quality of life. Specifically, standardized patient-reported outcomes such as the Oswestry Disability Index, Visual Analog Scale scores for back or leg pain, EQ-5D, or other functional recovery measures at 1- or 2-year follow-up were not uniformly available in this cohort. As a result, the present findings should be interpreted as reflecting the short-term perioperative burden of incidental durotomy rather than its long-term effect on functional outcome. Future prospective studies with standardized longitudinal patient-reported outcomes are needed to clarify whether the increased perioperative morbidity observed after durotomy translates into delayed or impaired functional recovery.

Conclusions

In this multicenter observational cohort of elderly patients undergoing elective spine surgery, incidental durotomy was associated with increased short-term perioperative morbidity, including prolonged hospital length of stay, higher thromboembolic event rates, and more frequent postoperative delirium. In descriptive analyses, these associations appeared numerically more evident among patients older than 75 years, although this finding should be interpreted cautiously in the absence of formal interaction testing.

Because of the retrospective observational design, these findings should not be interpreted as evidence of a direct causal relationship between durotomy and all ad-

verse postoperative outcomes. Rather, incidental durotomy may function as both an intraoperative complication and a marker of greater surgical complexity, reduced physiological reserve, and vulnerability to delayed mobilization and medical complications. At the same time, the present study did not demonstrate a clear association with postoperative infection, 30-day readmission, revision surgery, intensive care use, or discharge disposition.

These findings support age-sensitive perioperative pathways centered on careful dural repair, early but clinically appropriate mobilization, delirium prevention, thromboembolic risk reduction, and vigilant medical monitoring in elderly patients who sustain incidental durotomy.

Availability of Data and Materials

The data used and analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

Conception and design: IZ, AC and DM; data acquisition: IZ, LDC, MG, CI, SC, JT, CHM, LR, FPM; data analysis: LDC, LR, AC, DM, CI; draft of the manuscript: IZ, LDC, FPM. All authors contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

This study was a retrospective analysis of previously collected data and did not involve any additional interventions. The study was formally exempt from ethical review according to the requirements of each Ethical Committee (Comitato etico cantonale Ticino, Comitato Etico per la Ricerca Transdisciplinare (CERT), Comité d'éthique pour la recherche de l'Université de Strasbourg (CER-Unistra), Comitato Etico Regione Toscana, Oxford Research Ethics Committee). The need for individual informed consent was waived because of the retrospective design and use of de-identified data. The study has been conducted according to the Declaration of Helsinki.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

Ismail Zaed is serving as Editor-in-Chief of this journal. We declare that Ismail Zaed had no involvement in the peer review of this article and has no access to information regarding its peer review. Other authors declare no conflict of interest.

References

[1] Cammisa FP, Jr, Girardi FP, Sangani PK, Parvataneni HK, Cadag S, Sandhu HS. Incidental durotomy in spine surgery. Spine. 2000; 25: 2663–2667. https://doi.org/10.1097/00007632-200010150-00019

[2] Ghobrial GM, Theofanis T, Darden BV, Arnold P, Fehlings MG, Harrop JS. Unintended durotomy in lumbar degenerative spinal surgery: a 10-year systematic review of the literature. Neurosurgical Focus. 2015; 39: E8. https://doi.org/10.3171/2015.7.FOCUS15266

[3] 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. 2012; 43: 397–401. https://doi.org/10.1016/j.injury.2010.12.014

[4] Kaidi AC, Ehrlich A, Harhash T, Subramanian T, Araghi K, Katiyar P, et al. Incidental durotomy should not preclude same-day discharge from lumbar spine surgery. The Spine Journal: Official Journal of the North American Spine Society. 2025; 25: 1575–1581. https://doi.org/10.1016/j.spinee.2025.02.001

[5] Murphy ME, Kerezoudis P, Alvi MA, McCutcheon BA, Maloney PR, Rinaldo L, et al. Risk factors for dural tears: a study of elective spine surgery. Neurological Research. 2017; 39: 97–106. https://doi.org/10.1080/01616412.2016.1261236

[6] Bättig L, Kissling F, Motov S, Stengel FC, Yildiz Y, Feuerstein L, et al. Incidental Durotomy During Transforaminal Lumbar Interbody Fusion (TLIF) Surgery with Expandable Interbody Spacers: A Retrospective, Single-Center Analysis of Complications and Outcomes. Global Spine Journal. 2025; 15: 3782–3796. https://doi.org/10.1177/21925682251332547

[7] Golubovsky JL, Dagli MM, Gu BJ, Ghenbot Y, Arena JD, Welch WC, et al. The impact of durotomy on short-term morbidity and long-term outcomes in adult spinal deformity surgery: a multicenter propensity score-matched observational study. Journal of Neurosurgery. Spine. 2025; 43: 416–423. https://doi.org/10.3171/2025.4.SPINE241319

[8] Enders F, Ackemann A, Müller S, Kiening K, Orakcioglu B. Risk Factors and Management of Incidental Durotomy in Lumbar Interbody Fusion Surgery. Clinical Spine Surgery. 2018; 31: 127–131. https://doi.org/10.1097/BSD.0000000000000572

[9] Strömqvist F, Sigmundsson FG, Strömqvist B, Jönsson B, Karlsson MK. Incidental durotomy in degenerative lumbar spine surgery - a register study of 64,431 operations. The Spine Journal: Official Journal of the North American Spine Society. 2019; 19: 624–630. https://doi.org/10.1016/j.spinee.2018.08.012

[10] Chibbaro S, Mallereau CH, Ganau M, Zaed I, Teresa Bozzi M, Scibilia A, et al. Odontoid Type II fractures in elderly: what are the real management goals and how to best achieve them? A multicenter European study on functional outcome. Neurosurgical Review. 2022; 45: 709–718. https://doi.org/10.1007/s10143-021-01594-2

[11] Kazarian ER, Lopez WY, Eizember S, Blucher JA, Culley DJ, Javedan H, et al. Incidental Durotomy Is Associated With Increased Risk of Delirium in Patients Aged 65 and Older. Spine. 2020; 45: 1215–1220. https://doi.org/10.1097/BRS.0000000000003493

[12] Proal JD, Moon AS, LaHaise K, Taylor JJ, Kwon B. Readmission rates after intraoperative durotomy and repair in outpatient lumbar spinal surgery. North American Spine Society Journal. 2025; 26: 100834. https://doi.org/10.1016/j.xnsj.2025.100834

[13] Toci G, Lambrechts MJ, Issa T, Karamian B, Siegel N, Antonio ND, et al. Incidence, Risk Factors, and Outcomes of Incidental Durotomy during Lumbar Spine Decompression with or without Fusion. Asian Spine Journal. 2023; 17: 647–655. https://doi.org/10.31616/asj.2022.0297

[14] Wu G, Chen J, Wang L, Meng F. Clinical Effectiveness of Minimally Invasive Surgery on Spinal Trauma. Annali Italiani Di Chirurgia. 2024; 95: 552–560. https://doi.org/10.62713/aic.3546

[15] Gouzoulis MJ, Joo PY, Caruana DL, Kammien AJ, Rubio DR, Grauer JN. Incidental Durotomy After Posterior Lumbar Decom-

pression Surgery Associated With Increased Risk for Venous Thromboembolism. The Journal of the American Academy of Orthopaedic Surgeons. 2023; 31: e445–e450. https://doi.org/10.5435/JAAOS-D-22-00917

[16] Verma K, Freelin AH, Atkinson KA, Graham RS, Broaddus WC. Early mobilization versus bed rest for incidental durotomy: an institutional cohort study. Journal of Neurosurgery. Spine. 2022; 37: 460–465. https://doi.org/10.3171/2022.1.SPINE211208

[17] Zaed I, Marchi F, Milani D, Cabrilo I, Cardia A. Role of Enhanced Recovery after Surgery (ERAS) Protocol in the Management of Elderly Patients with Glioblastoma. Journal of Clinical Medicine. 2023; 12: 6032. https://doi.org/10.3390/jcm12186032

[18] Khaw SP, Marzunisham A, Goh SY, Jabar H, Kueh MTW, Tan ML, et al. ERAS following spine surgery in the elderly: a systematic review and meta-analysis. Journal of Orthopaedic Surgery and Research. 2025; 20: 1036. https://doi.org/10.1186/s13018-025-06407-6 Erratum in: Journal of Orthopaedic Surgery and Research. 2026; 21: 66.

[19] Hassanzadeh H, Bell J, Bhatia M, Puvanesarajah V. Incidental Durotomy in Lumbar Spine Surgery; Risk Factors, Complications, and Perioperative Management. The Journal of the American Academy of Orthopaedic Surgeons. 2021; 29: e279–e286. https://doi.org/10.5435/JAAOS-D-20-00210

[20] Shah VN, Kosanam AR, Patel M, Kasliwal MK. Rate and fate of incidental durotomies in spine surgery. Journal of Clinical Neuroscience: Official Journal of the Neurosurgical Society of Australasia. 2025; 136: 111184. https://doi.org/10.1016/j.jocn.2025.111184

[21] Faldini C, Barile F, D'Antonio G, Rinaldi A, Manzetti M, Viroli G, et al. Incidental dural tears do not affect the overall patients' reported outcome of spine surgery at long-term follow-up: results of a systematic review. Musculoskeletal Surgery. 2024; 108: 47–61. https://doi.org/10.1007/s12306-023-00777-y

[22] Choi EH, Chan AY, Brown NJ, Lien BV, Sahyouni R, Chan AK, et al. Effectiveness of Repair Techniques for Spinal Dural Tears: A Systematic Review. World Neurosurgery. 2021; 149: 140–147. https://doi.org/10.1016/j.wneu.2021.02.079

[23] Albayar A, Spadola M, Blue R, Saylany A, Dagli MM, Santangelo G, et al. Incidental Durotomy Repair in Lumbar Spine Surgery: Institutional Experience and Review of Literature. Global Spine Journal. 2024; 14: 1316–1327. https://doi.org/10.1177/21925682221141368

[24] Farshad M, Aichmair A, Wanivenhaus F, Betz M, Spirig J, Bauer DE. No benefit of early versus late ambulation after incidental durotomy in lumbar spine surgery: a randomized controlled trial. European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society. 2020; 29: 141–146. https://doi.org/10.1007/s00586-019-06144-5

[25] Najjar E, Hassanin MA, Komaitis S, Karouni F, Quraishi N. Complications after early versus late mobilization after an incidental durotomy: a systematic review and meta-analysis. European Spine Journal: Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society. 2023; 32: 778–786. https://doi.org/10.1007/s00586-023-07526-6 Erratum in: European Spine Journal. 2023; 32: 1094.

[26] Zhang J, Liu Q. Therapeutic Efficacy of Percutaneous Vertebroplasty Combined With Gelatin Sponge Filling in Treating Thoracolumbar Fractures: A Retrospective Analysis. Annali Italiani Di Chirurgia. 2025; 96: 634–643. https://doi.org/10.62713/aic.4020

© 2026 The Author(s).

