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Dural Tears in Adult Deformity Surgery: Incidence, Risk Factors, and Outcomes

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Abstract

Study Design: Retrospective cohort study.

Objectives: Describe the rate of dural tears (DTs) in adult spinal deformity (ASD) surgery. Describe the risk factors for DT and the impact of this complication on clinical outcomes.

Methods: Patients with ASD undergoing surgery between 2008 and 2014 were separated into DT and non-DT cohorts; demographics, operative details, radiographic, and clinical outcomes were compared. Statistical analysis included *t* tests or χ^2 tests as appropriate and a multivariate analysis.

Results: A total of 564 patients were identified. The rate of DT was 10.8% (n = 61). Patients with DT were older (61.1 vs 56.5 years, $P = .005$) and were more likely to have had prior spine surgery (odds ratio [OR] = 2.0, 95% confidence interval [CI] = 1.2-3.3, $P = .007$). DT patients had higher pelvic tilt, lower lumbar lordosis, and greater pelvic-incidence lumbar lordosis mismatch than non-DT patients ($P < .05$). DT patients had longer operative times (424 vs 375 minutes, $P = .008$), were more likely to undergo interbody fusions (OR = 2.0, 95% CI = 1.1-3.6, $P = .021$), osteotomies (OR = 2.2, 95% CI = 1.1-4.0, $P = .012$), and decompressions (OR = 2.3, 95% CI = 1.3-4.3, $P = .003$). In our multivariate analysis, only decompressions were associated with an increased risk of DT (OR = 3.2, 95% CI = 1.4-7.6, $P = .006$). There were no significant differences in patient outcomes at 2 years.

Conclusions: The rate of DT was 10.8% in an ASD cohort. This is similar to rates of DT reported following surgery for degenerative pathology. A history of prior spine surgery, decompression, interbody fusion, and osteotomies are all associated with an increased risk of DT, but decompression is the only independent risk factor for DT.

Keywords

dural tears, durotomy, incidental durotomy, adult spinal deformity, complications, osteotomy

Introduction

Dural tears (DTs) are a relatively common complication in spine surgery. A number of studies have examined the incidence of incidental durotomies in the lumbar spine in the setting of degenerative pathology.[1-3] Rates of incidental durotomy in the literature range from 2% to 20%.[2] Several risk factors for incidental durotomy have been identified, including prior lumbar surgery, older age, female sex, and spinal trauma.[2-6] Similar investigations have also been performed in the cervical spine.[7] Understanding these risk factors and anticipating and perhaps reducing the risk of durotomies is critical because

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these complications can have a substantial impact on cost and hospital resource utilization.[8]

The incidence of DT and the risk factors for DT have been well described for lumbar, degenerative cases. There is, however, a paucity of literature reporting similar data in an adult spinal deformity (ASD) patient cohort. The only existing references are surveys of the Scoliosis Research Society (SRS) morbidity and mortality database.[9,10] These studies report a rate of incidental durotomy of 2.9% to 3.4% in adult scoliosis surgery.[9,10] Shaw et al also noted that DTs were the most common complication in patients over age 50.[9] However, both of these studies were focused on all complications in scoliosis surgery and did not perform any analysis to determine risk factors for incidental durotomy. They were also limited by the fact that deidentified data was utilized and verification of the data could not be performed beyond the accuracy of SRS members' retrospective data entry.

In order to address these shortcomings, we chose to survey our prospectively gathered, multicenter ASD database. The specific aims of this study were to (1) identify the rate of DTs in patients undergoing ASD surgery, (2) identify risk factors for DTs in ASD, and (3) compare clinical outcomes in patients with and without DTs.

Methods

This study was a retrospective review of a prospectively collected multicenter ASD database maintained by the International Spine Study Group. Patients from 11 sites were enrolled if the following inclusion criteria were met: age $\geq$18 years and the presence of spinal deformity. Exclusion criteria included neuromuscular scoliosis, infection, and malignancy. Spinal deformity was defied as follows: scoliosis Cobb angle $\geq$20°, sagittal vertical axis $\geq$5 cm, pelvic tilt $\geq$25°, and/or thoracic kyphosis $\geq$60°. Institutional review board approval was obtained prior to enrollment at each study site.

Patients were separated into 2 groups: (1) patients with DT and (2) patients without DT. Demographic data collected included patient age, gender, body mass index, American Society of Anesthesiologists (ASA) classification, history of previous infection, and previous spine surgery. Operative data collected included estimated blood loss, operative time, and intraoperative case details (such as osteotomy type, decompressions, interbody fusions, etc). Postoperative variables such as length of stay, intensive care unit stay, and complication data were also collected for all patients. Reporting of complication included the complication type (eg, neurologic, infectious, etc), the complication time (intraoperative vs postoperative), and complication severity (major vs minor). Complications were classified as major or minor similar to other studies in ASD.[11,12] A complication was classified as major if it prolonged hospitalization, required reoperation or an invasive intervention, caused prolonged or permanent morbidity, or resulted in death. For example, proximal junctional kyphosis requiring revision surgery was classified as a major complication, while proximal junctional kyphosis not requiring surgery was classified as a minor complication. The list of minor and major complications was similar to a consensus list prepared by ASD surgeons and presented by Christiansen et al.[11] Health-related quality-of-life (HRQOL) data collected at baseline, 6 weeks, and 2 years were analyzed; this included the Oswestry Disability Index (ODI), 36-item Short-Form Health Survey (SF-36; Physical Component Score and Mental Component Score), and the Scoliosis Research Society–22 questionnaire (SRS, subdomains: activity, pain, satisfaction, mental, appearance, and total).

Statistical Analysis

Statistical analysis was performed using an independent Student's t test for continuous variables. Categorical variables were compared using the χ^2 or Fisher exact test as appropriate; the P value derived from the Fisher exact test was used when cells had an expected count of less than 5. A $P < .05$ was considered significant. A binary logistic multivariate regression analysis was performed to identify preoperative and demographic risk factors, intraoperative techniques, and the risk of postoperative complications in patients with DTs. This regression analysis controlled for radiographic variables, age, gender, and ASA classification.

Results

Overview

In all 564 patients were identified. Two-year follow-up data was available for 270 patients out of 306 eligible (88.2%). The mean age was 57.02 years (range 18-68), with 21.3% male and 78.7% female patients. The rate of DT in this patient population was 10.8% (n = 61). Of 61 DTs, 58 (95.1%) were identified intraoperatively while the remaining 3 were identified in the perioperative or postoperative period. Most DTs (n = 58, 95.1%) were categorized as minor complications while 3 were classified as major complications.

Demographic and Radiographic Variables

Univariate analysis revealed that patients with DT were older (61.1 vs 56.5 years, $P = .005$) but with no differences in gender or body mass index (Table 1). A higher ASA grade was associated with an increased rate of DT ($P = .031$) as was a history of prior spine surgery (OR = 2.0, 95% CI = 1.2-3.3, $P = .007$). Radiographically, patients who sustained incidental durotomies had more severe preoperative deformity (Table 2). DT patients had a higher pelvic tilt (PT; $P = .012$), lower lumbar lordosis (LL; $P = .006$), greater pelvic incidence–lumbar lordosis (PI-LL) mismatch ($P = .007$), greater C7-S1 sagittal vertical axis (SVA; $P = .011$), and greater T1-pelvis angle (T1PA; $P = .003$). This difference was apparent even when patients were stratified based on Schwab classification; patients who sustained a DT were more likely to have higher Schwab modifiers for PT ($P = .011$) and SVA ($P = .04$; Table 3). There was no difference between groups with regard

Table 1. Patient Characteristics[a].

	Non–Dural Tear (n = 503)	Dural Tear (n = 61)	Odds Ratio (95% CI)	*P* Value
Age*	56.5 ± 15.8	61.1 ± 11.0		.005
BMI	27.6 ± 9.3	28.6 ± 5.5		.401
Gender (n = 545)				.067
Male	98 (19.5%)	18 (29.5%)		
Female	388 (77.1%)	41 (67.2%)		
ASA (n = 522)*				.031
I	47 (9.3%)	2 (3.3%)		
II	235 (46.7%)	26 (42.6%)		
III	172 (34.2%)	30 (49.2%)		
IV	9 (1.8%)	1 (1.6%)		
History of prior spine surgery (n = 540)*	218 (43.3%)	37 (60.7%)	2.0 (1.2-3.3)	.007
History of deep infection (n = 270)	9 (1.8%)	2 (3.3%)	1.3 (0.4-4.6)	.663

Abbreviations: CI, confidence interval; BMI, body mass index; ASA, American Society for Anesthesiologists.
[a]For categorical variables, odds ratios are reported in addition to proportions. For some fields, data was not available for all patients analyzed. In these cases, the number of patients for whom valid data is available are listed. For example, data was available for ASA class on 522 patients.
*Significant differences noted ($P < .05$).

Table 2. Radiographic Characteristics of Patients With and Without Dural Tears[a].

	Preoperative			Two-Year Follow-up		
	Non-DT (n = 503)	DT (n = 61)	*P*	Non-DT (n = 231)	DT (n = 27)	*P*
SS	32.2 ± 12.1	29.2 ± 11.4	.075	34.2 ± 10.6	29.6 ± 11.6	.055
PT	22.9 ± 10.9	26.7 ± 10.5	.012	21.0 ± 10.2	23.4 ± 7.4	.228
PI	55.1 ± 12.6	55.9 ± 11.7	.644	55.2 ± 12.4	53.0 ± 11.2	.346
PI-LL	14.9 ± 21.1	22.9 ± 23.3	.007	3.3 ± 14.5	6.4 ± 15.8	.318
LL	40.3 ± 21.8	32.0 ± 22.8	.006	51.9 ± 13.9	46.9 ± 17.0	.090
TK	−35.4 ± 19.5	−3.4 ± 20.1	.469	−47.6 ± 17.6	−51.3 ± 19.0	.316
CL	9.3 ± 17.9	12.6 ± 16.3	.244	8.9 ± 15.4	10.5 ± 22.2	.742
T1PA	27.1 ± 14.3	21.9 ± 13.4	.009	17.1 ± 11.0	20.5 ± 9.9	.124
SVA	63.3 ± 75.8	90.5 ± 76.4	.011	29.6 ± 55.1	47.8 ± 64.4	.112

Abbreviations: DT, dural tear; non-DT, no dural tear; SS, sacral slope; PT, pelvic tilt; PI, pelvic incidence; PI-LL, pelvic incidence–lumbar lordosis mismatch; LL, lumbar lordosis; TK, thoracic kyphosis; T1PA, greater T1-pelvis angle; SVA, sagittal vertical axis.
[a]Patients who sustained a dural tear tended to have larger deformities and underwent larger corrections. There were no differences in radiographic characteristics between the 2 groups at 2-year follow-up.

to sacral slope (SS), pelvic incidence (PI), or thoracic kyphosis (TK). In our multivariate analysis, there were no independent preoperative demographic or radiographic risk factors that predisposed patients to DT.

Intraoperative Variables

Patients with DT had a longer operative time (424 vs 375 minutes, $P = .008$) and were more likely to undergo interbody fusions (IBF; OR = 2.0, 95% CI = 1.1-3.6, $P = .021$) and decompressions (OR = 2.3, 95% CI = 1.3-4.3, $P = .003$; Table 4). When individual types of IBF were examined, posterior lumbar interbody fusion (PLIF) was the only IBF type that had a significant relationship with DT (OR = 2.9, 95% CI = 1.1-7.5, $P = .021$). Anterior lumbar interbody fusions (ALIF), transforaminal lumbar interbody fusions (TLIF), and extreme lateral lumbar interbody fusions (XLIF) did not increase the odds of sustaining a DT. Patients undergoing osteotomies were more likely to sustain DT (OR = 2.2, 95% CI = 1.1-4.0, $P = .012$). When we examined individual types of osteotomies, Smith-Peterson osteotomies (SPO; $P = .088$) and vertebral column resection (VCR; $P = .759$) did not affect the risk of DT. Pedicle subtraction osteotomies (PSO), however, significantly increased the likelihood of DT (OR = 2.8, 95% CI = 1.7-4.6, $P < .001$). Estimated blood loss was higher (2116 mL vs 1658 mL, $P = .031$) in the DT group, and patients with DT had a longer length of stay (9.8 vs 7.9 days, $P = .039$). In our multivariate analysis, only decompressions were linked to an increased risk of DT (OR = 3.2, 95% CI = 1.4-7.6, $P = .006$). Unsurprisingly, cases with DT were associated with a longer operative time ($P = .035$) in the multivariate analysis as well.

Complications

Because most DTs were identified intraoperatively, DTs were associated with an increased rate of intraoperative complications ($P < .001$). However, DTs were also associated with an

Table 3. Baseline Radiographic Classification Based on Schwab Classification.

	DT (n = 503)	Non-DT (n = 61)	*P*
Curve type (n = 542)			.506
N (no coronal curve)	163 (32.4%)	19 (31.1%)	
T (thoracic only coronal curve)	31 (6.2%)	2 (3.3%)	
L (lumbar only coronal curve)	172 (34.2%)	19 (31.1%)	
D (thoracic and lumbar coronal curve	117 (23.3%)	19 (31.1%)	
PT modifier (n = 538)*			.011
Nonpathologic PT (PT < 20)	179 (35.6%)	15 (24.6%)	
Moderate deformity PT (20 < PT < 30)	187 (37.2%)	20 (32.8%)	
Marked deformity PT (PT > 30)	114 (22.7%)	23 (37.7%)	
SVA modifier (n = 533)*			.04
Nonpathologic global alignment (SVA < 4cm)	205 (40.8%)	16 (26.2%)	
Moderate deformity global alignment (4cm < SVA < 9.5cm)	124 (29.2%)	18 (29.5%)	
Marked deformity global alignment (SVA > 9.5cm)	147 (29.2%)	23 (37.7%)	
PI-LL modifier (n = 538)			.07
Nonpathologic deformity PI-LL (PI-LL < 10)	199 (39.6%)	18 (29.5%)	
Moderate PI-LL (10 < PI-LL < 20)	99 (19.7%)	11 (18.0%)	
Marked PI-LL (PI-LL > 20)	182 (36.2%)	29 (47.5%)	

Abbreviations: DT, dural tear; non-DT, no dural tear; PT, pelvic tilt; SVA, sagittal vertical axis; PI-LL, pelvic incidence–lumbar lordosis mismatch.
*Significant differences noted (*P* < .05).

Table 4. Case Details for the Dural Tear and Non–Dural Tear Cohorts[a].

	Non-DT (n = 503)	DT (n = 61)	OR (95%CI)	*P*
Operating room time (minutes)*	375 ± 132	424 ± 147		.008
EBL (mL)*	1658 ± 1551	2116 ± 1533		.031
Interbody fusion (n = 334)*	289 (57.5%)	45 (73.8%)	2.0 (1.1-3.6)	.021
ALIF (n = 128)	107 (21.3%)	21 (34.4%)	1.5 (0.8-2.8)	.230
PLIF (n = 24)*	17 (3.4%)	7 (11.5%)	2.9 (1.1-7.5)	.021
TLIF (n = 147)	127 (25.2%)	20 (32.8%)	1.0 (0.5-1.9)	.990
XLIF (n = 48)	43 (8.5%)	5 (8.2%)	0.7 (0.3-1.9)	.488
Decompression (n = 342)*	294 (58.4%)	48 (78.7%)	2.3 (1.3-4.3)	.003
Osteotomy (any) (n = 376)*	326 (64.8%)	50 (82.0%)	2.2 (1.1-4.0)	.012
VCR (n = 25)	21 (4.2%)	4 (6.6%)	1.2 (0.5-3.1)	.759
PSO (n = 93)*	69 (13.7%)	24 (39.3%)	2.8 (1.7-4.6)	<.001
SPO (n = 291)	257 (51.1%)	34 (55.7%)	0.6 (0.4-1.1)	.088
Length of stay (days)*	7.9 ± 4.9	9.8 ± 6.7		.039
SICU stay	324 (64.4%)	47 (77.0%)	1.5 (0.8-2.6)	.179

Abbreviations: DT, dural tear; non-DT, no dural tear; OR, odds ratio; CI, confidence interval; EBL, estimated blood loss; ALIF, anterior lumbar interbody fusion; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; XLIF, extreme lateral lumbar interbody fusion; VCR, vertebral column resection; PSO, pedicle subtraction osteotomy; SPO, Smith-Peterson osteotomy; SICU, surgical intensive care unit.
[a]Odds ratios are reported for categorical variables. For some fields, data was not available for all patients analyzed. In these cases, the number of patients for whom valid data is available are listed. For example, data was available for osteotomy versus no osteotomy on 556 patients.
*Significant differences noted (*P* < .05).

increased rate of perioperative ($P = .037$) and postoperative ($P = .019$) complications. Specifically, patients with DT were more likely to have minor ($P = .019$) postoperative complications but not major ($P = .367$) postoperative complications (Table 5). Patients with DT were not more likely to sustain infectious ($P = .055$), neurologic ($P = .066$), or wound ($P = .068$) complications. While infectious complications included pneumonia, urinary tract infections, and other infections, there was no difference in the rate of deep infections between the DT and non-DT cohorts ($P = .119$). There was no association between DT and perioperative and postoperative complications in our multivariate regression model.

Patient Outcomes

DT and non-DT patients had similar HRQOL scores at baseline. Follow-up HRQOL scores were collected at 6 weeks and 2 years. At both these time points, there were no differences between groups in ODI, SF-36, or SRS-22 total scores and in any subdomains (Table 6).

Discussion

This article represents the first report on the incidence, risk factors, and outcomes of DTs in ASD surgery. We report a

Table 5. The Incidence of Complications in Patients With a Dural Tear.

	Non-DT (n = 503)	DT (n = 61)	OR (95% CI)	*P*
Postoperative complications*[a]	134 (26.6%)	24 (40.0%)	1.8 (1.1-3.2)	.029
Major[a]	86 (17.1%)	14 (23.3%)	1.5 (0.8-2.8)	.232
Minor[a]	57 (11.3%)	12 (20.0%)	1.9 (1.0-3.9)	.053
Reoperation	78 (15.5%)	12 (19.7%)	1.3 (0.7-2.6)	.402
Neurologic complication	84 (16.7%)	16 (26.2%)	1.6 (1.0-2.8)	.066
Motor deficit	25 (5.0%)	4 (6.6%)	1.3 (0.5-3.3)	.541
Sensory deficit	12 (2.4%)	3 (4.9%)	1.9 (0.7-5.4)	.215
Radiculopathy	32 (6.4%)	5 (8.2%)	1.3 (0.5-3.0)	.582
Wound complications	11 (2.2%)	4 (6.6%)	2.6 (1.0-6.2)	.068
Dehiscence	8 (1.6%)	2 (3.3%)	1.9 (0.5-6.7)	.296
Infectious complication	38 (7.6%)	8 (13.3%)	1.9 (1.0-3.6)	.055
Deep infections	14 (2.8%)	3 (5.0%)	2.1 (0.9-5.2)	.119
Superficial infections	8 (1.6%)	0 (0%)		1

Abbreviations: DT, dural tear; non-DT, no dural tear; OR, odds ratio; CI, confidence interval.
[a]Dural tears themselves were counted as complications. However, 60/61 dural tears were classified as intra- or perioperative complications. The only patient with a dural tear classified as a postoperative complication was excluded from the analysis of postoperative complication rate. The remaining 60 patients still had a higher rate of all postoperative complications.
*Significant differences noted ($P < .05$).

Table 6. Patient-Reported Outcomes at Baseline, 6 Weeks, and 2 Years for Patients With and Without Dural Tear.

	Baseline			6-Week Follow-up			2-Year Follow-up		
	Non-DT (n = 486)	DT (n = 60)	*P*	Non-DT (n = 365)	DT (n = 36)	*P*	Non-DT (n = 242)	DT (n = 28)	*P*
ODI	43.9 ± 18.6	47.4 ± 20.5	.170	46.6 ± 18.7	47.7 ± 18.6	.751	27.0 ± 20.8	27.0 ± 20.8	.642
SF-36 PCS	31.8 ± 10.0	30.6 ± 10.3	.429	30.1 ± 8.6	28.2 ± 7.3	.270	40.3 ± 11.3	40.3 ± 11.3	.994
SF-36 MCS	45.2 ± 13.6	45.1 ± 16.3	.962	46.7 ± 13.2	47.0 ± 13.0	.912	49.8 ± 12.6	49.8 ± 12.6	.871
SRS-22 Activity	2.9 ± 0.9	2.8 ± 0.9	.366	2.5 ± 0.7	2.6 ± 0.7	.702	3.5 ± 1.0	3.7 ± 1.0	.457
SRS-22 Pain	2.4 ± 0.9	2.3 ± 0.9	.551	2.4 ± 0.8	2.4 ± 0.8	.758	3.4 ± 1.1	3.7 ± 1.1	.236
SRS-22 Appearance	2.4 ± 0.8	2.3 ± 0.8	.405	3.4 ± 0.9	3.5 ± 0.9	.385	3.7 ± 0.9	3.4 ± 1.1	.162
SRS-22 Mental	3.4 ± 0.9	3.4 ± 1.0	.778	3.6 ± 0.8	3.6 ± 1.0	.825	3.8 ± 0.9	3.9 ± 0.9	.677
SRS-22 Satisfaction	2.8 ± 1.1	2.6 ± 1.1	.318	4.2 ± 0.9	4.1 ± 0.7	.766	4.2 ± 0.9	4.1 ± 1.1	.459
SRS-22 Total Score	2.8 ± 0.7	2.7 ± 0.8	.377	3.1 ± 0.6	3.1 ± 0.6	.609	3.7 ± 0.8	3.7 ± 0.9	.808

Abbreviations: DT, dural tear; non-DT, no dural tear; ODI, Oswestry Disability Index; SF-36, 36-item Short-Form Health Survey; PCS, Physical Component Score; MCS, Mental Component Score; SRS-22, Scoliosis Research Society–22 Questionnaire.

10.8% rate of DTs in ASD and identify several potential risk factors for DT that might help inform discussions between patients and surgeons. Our multivariate analysis revealed that decompression was the only independent risk factor for DT in ASD surgery. However, in addition to decompression, we identified several potential risk factors based on our univariate analysis. These include IBF, specifically, PLIF, and the use of PSOs. Other findings of note include the fact that patients with DT had larger preoperative deformity and were more likely to have undergone a prior spine procedure.

The rate of DT reported in this article is higher than the existing series of ASD patients.[9,10] Shaw et al surveyed the SRS M&M database and reported an overall rate of DT of about 3.4%. An earlier series by Sansur et al also queried the SRS M&M database and reported a rate of DTs of 2.9%.[10] There are several possible reasons for the discrepancy between the rates reported by these trials and our relatively higher rate of DT. First, Shaw et al reported data on a patient population with an average age that is slightly younger than our patient population (51.8 years vs 57.4 years).[9] Additionally, both studies utilize the SRS database. This database consists of de-identified, self-reported member data. This makes it impossible to validate the accuracy of the data and may lend itself to underreporting of complications. Ghobrial et al, for example, reported that the rate of durotomy reported in retrospective trials is significantly lower (4.32%) than the rate of durotomy in prospective trials (9.57%).[2] This discrepancy both highlights the plausibility of our retrospective data and outlines the importance of disciplined data collection and reporting in order to avoid misleading physicians and patients. Indeed, the rate of durotomy reported in this cohort is comparable to that reported by several authors in a degenerative setting.[4,13-16] The available data suggests that ASD surgery does not result in a substantially increased risk for DT compared to surgery for degenerative pathology in the lumbar spine.

Our study is also in agreement with several risk factors already identified in the literature focusing on DT in patients with degenerative pathology. As in our study, multiple authors

have identified revision surgery (prior spine surgery) as a possible risk factor for incidental durotomy.[4-6,13] Unfortunately, we were unable to ascertain if the patients' prior surgeries were at the same levels as their current procedure. However, because these patients all underwent long fusions for ASD, it is likely that the location of the prior surgery was encountered during our procedures. Similarly, other authors have identified TLIF[5] and PLIF[17] as risk factors for incidental durotomy. Perhaps not coincidentally, these series report a much higher rate of durotomy ($\sim$14%) compared to other series in the literature. Our findings corroborate these results. We showed that interbody fusion and PLIF, in particular, results in an increased risk of DT. Patients with DT had a longer length of stay in our study, which is also similar to other series in the literature.[1,16,18,19]

In addition to corroborating the data from existing literature, we provide specific insights that might be of particular interest for deformity surgeons. For instance, we show that patients undergoing osteotomies were at higher risk for DT. When subgroup analysis was performed, we showed that PSOs increased the risk of DT. Surprisingly, VCRs were not found to increase the risk of DT. However, this finding must be interpreted with caution given the small number of VCRs performed our series ($n = 25$). The fact that techniques such as PSO are associated with a higher risk of DT is in line with our finding that patients with DT have larger sagittal deformities preoperatively. Our study also showed that decompressions were an independent risk factors for DT in ASD patients. In this context, the value of our study is particularly apparent as surgeons who anticipate performing a decompression can guide patients about the increased risk for DTs.

Finally, we showed that DT had no impact on functional outcomes. In our series, patients with DT had no difference in early (6 week) or late (2 year) functional outcomes. While we were not surprised by the fact that DT did not affect late outcomes, it was reassuring to learn that DT had no impact on early functional outcomes in adult patients despite an increased incidence of complications and a longer length of stay in this patient cohort. In that regard, our data allows us to reassure adult patients who have sustained a DT that their long-term outcome is not likely to be affected by this complication.

There are some important limitations to acknowledge. Perhaps the most significant limitation of our study is that we do not have data on how the DT in these patients were repaired. Different strategies for repair such as primary repair, dural patches, and/or the presence of irreparable tears could conceivably have a large impact on both the length of stay and the likelihood of other complications (return to the operating room or lumbar drainage, for example). Unfortunately, the retrospective nature of this database and the time frame over which cases were collected (2008-2014) preclude us from performing a detailed review of the DT repair strategies and the resultant complications. In general, however, the senior authors attempt to perform a primary repair of DT in all cases and augment the repair with dural patches or sealant if necessary. In cases of irreparable tears, dural sealant is used over the spinal canal to prevent cerebrospinal fluid leakage.

The retrospective design of this trail also prevents us from inferring causation and leads to the possibility of underreporting complications. However, the rate of DT reported by this study is similar to other prospective studies, which supports the validity of the auditing methods used by our database. While the ability to study granular questions (such as the impact of specific techniques such as PSO, VCR, etc) in a deformity surgery setting is a unique strength of this study, it is important to note that certain subgroups are necessarily small and limits the statistical power of this investigation. It is possible, for instance, that some trends noted in this article (gender-related changes, for example) would be significant if more patients can be examined. Despite that limitation, to our knowledge, this is the largest series of deformity patients that can examine questions that pertain to preoperative, intraoperative, and postoperative variables in the detailed manner presented above.

In summary, we report an overall rate of DTs of 10.8% in an ASD cohort. We report several risk factors that are in line with currently reported literature but also highlight specific techniques relevant to deformity surgeons (PSO) that might increase the risk of DT. Decompression performed in the setting of deformity surgery was an independent risk factor for DT.

Declaration of Conflicting Interests

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