Early postoperative magnetic resonance imaging in detecting radicular pain following lumbar decompression surgery: Retrospective study of the relationship between dural sac cross-sectional area and postoperative radicular pain

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ABSTRACT

Study design: A retrospective analysis.

Objective: To evaluate the association between early postoperative dural sac cross-sectional area (DCSA) and radicular pain.

Summary of Background Data: The correlation between postoperative magnetic resonance imaging (MRI) findings and postoperative neurologic symptoms following lumbar decompression surgery is controversial.

Methods: This study included 115 patients who underwent lumbar decompression surgery followed by MRI within 7 days postoperatively. There were 46 patients with early postoperative radicular pain, regardless of whether the pain was mild or similar to that before surgery. The intervertebral level with the smallest DCSA was identified on MRI and compared pre- and postoperatively. Risk factors for postoperative radicular pain were determined using univariate and multivariate analyses. Subanalysis according to absence/presence of a residual suction drain also was performed.

Results: Multivariate regression analysis showed that smaller postoperative DCSA was significantly associated with early postoperative radicular pain (per -10 mm^2; odds ratio, 1.26). The best cut-off value for radicular pain was early postoperative DCSA of 67.7 mm^2. Even with a cut-off value of <70 mm^2, sensitivity and specificity are 74.3% and 75.0%, respectively. Early postoperative DCSA was significantly larger before suction drain removal than after (119.7 ± 10.1 mm^2 vs. 93.9 ± 5.4 mm^2).

Conclusions: Smaller DCSA in the early postoperative period was associated with radicular pain after lumbar decompression surgery. The best cut-off value for postoperative radicular pain was 67.7 mm^2. Absence of a suction drain at the time of early postoperative MRI was related to smaller DCSA.

Keywords: magnetic resonance imaging, dural sac cross-sectional area, postoperative radicular pain, postoperative epidural hematoma, suction drain

Introduction

Magnetic resonance imaging (MRI) is used to assess neurologic symptoms following lumbar decompression surgery. However, interpretation of the findings of early postoperative MRI is difficult because of postsurgical changes[1, 2]; thus, the value of early postoperative MRI is uncertain. Some authors have reported early postoperative mass effects and dural sac compression in asymptomatic patients.[1, 3] In contrast, some studies comparing postoperative epidural hematomas in patients with severe symptoms (most of whom required revision surgery) and asymptomatic patients have shown a relationship between severe symptoms and dural sac cross-sectional area (DCSA).[4-6] The lack of consensus emphasizes the need for caution when interpreting early postoperative MRI because of the weak correlation between clinical symptoms and radiographic findings.

Scavarda et al.[7] described a characteristic postoperative progression of epidural hematoma from sharp peri-incisional pain to paresthesia, radicular pain, and bilateral neurologic deficits. Clinically, most patients experience peri-incisional pain and paresthesia after surgery, but radicular pain is experienced by fewer patients. Careful attention must be paid to all patients presenting with postoperative radicular pain. Radicular pain after surgery causes concerns regarding the surgical results. In such cases, it can be difficult to distinguish whether the patient is experiencing residual pain resulting from preoperative symptoms or new postoperative pain.

The objectives of this study were to evaluate the association between early postoperative DCSA and radicular pain. A subanalysis was also performed to evaluate the influence of presence/absence of a suction drain on early postoperative DCSA and radicular pain.

To our knowledge, there has been no published report comparing early postoperative DCSA before and after suction drain removal.

Materials and Methods

This study was approved by our hospital's Investigational Review Board. The study population included 115 patients (68 men, 47 women; mean age, 64.6 ± 16.4 years) who had undergone lumbar decompression surgery within the intraspinal zone, followed by lumbar MRI within 7 days postoperatively, between September 2007 and September 2011 (Table 1). MRI was performed at the discretion of the spine surgeon. The preoperative diagnosis included lumbar spinal stenosis (LSS) in 83 patients and lumbar disc herniation (LDH) in 32. All patients underwent spinal decompression. Spinal instrumentation was used in all patients who underwent posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), or posterolateral fusion (PLF) (n = 57). All surgeries were performed by the same group of spine surgeons (YM, JT, TF, and HO). All patients had a suction drain placed into the epidural space after surgery, which was removed when drainage was ≤50 mL/day (mean period to removal, 3.7 ± 2.2 days). Both intra- and postoperative blood loss significantly positively correlated with drainage removal timing (intraoperative: Spearman's rho, 0.26; p = 0.005; postoperative: Spearman's rho, 0.20; p = 0.029).

MRI was performed using a 1.5-T system (Signa EXCITE; GE, Tokyo, Japan) with a spine-phased array coil. DCSA was measured on T2-weighted axial imaging with a matrix of 256 × 320 and a field of view of 300 mm. Scans were performed at the facet joint level. The images were digitized, and the graphic files were transformed into vectorial files, from which the DCSA was calculated. In patients who underwent multilevel decompression, early postoperative DCSA was measured at the smallest transverse area because some authors have reported that the smallest DCSA correlates with symptoms.[4, 8] Preoperative and early postoperative DCSAs were measured at the same site. All measurements were performed by 2 spine surgeons from the same spine group (HO and TF), and each surgeon measured each parameter 3 times on separate occasions. The average of the 6 measurements was calculated. The measured intervertebral levels are noted in Table 1. The mean duration between surgery and MRI was 4.4 ± 2.0 days (range, 1–7 days). The dural sac quotient was estimated as early postoperative DCSA/preoperative DCSA.

Statistical analysis was performed using statistical package R version 3.0.3 (http://www.r-project.org). Univariate and multivariate regression analyses were used to assess the factors associated with radicular pain in the early postoperative period. Regression coefficients were converted to odds ratios (ORs) with 95% confidence intervals (CIs). Receiver operating characteristic (ROC) curves were used to determine the best early postoperative DCSA cut-off value for the occurrence of radicular pain. Subgroup analysis according to absence/presence of a residual drain also was performed. Differences in the values between groups were tested using Welch's *t* test or the Mann-Whitney *U* test. The difference in ratios was tested using Fisher's exact test. A *P* value of <0.05 was defined as statistically significant.

Results

Forty-six patients presented with radicular pain, including mild symptoms, during the early postoperative period. Two of these patients required revision surgery because of intercurrent symptoms (motor weakness that worsened postoperatively and postoperative urination disorder). Radicular pain improved within several weeks after surgery in all patients.

Factors for early postoperative radicular pain

Significant risk factors for postoperative radicular pain determined by univariate regression analyses were early postoperative DCSA (per -10 mm^2; OR, 1.26; $P < 0.001$) and dural sac quotient (OR, 1.53; $P = 0.018$). In other words, smaller postoperative DCSA and insufficient dural sac expansion led to postoperative radicular pain. Absence of a suction drain at time of MRI also was shown to be a risk factor, but not to a significant degree (OR, 2.31; $P = 0.053$) (Table 2).

In multiple regression analysis, factors analyzed using univariate analyses were adopted as explanatory variables. We selected variables for the best regression model using a stepwise procedure based on Akaike's Information Criterion. After the model comparison, 3 variables (early postoperative DCSA, time to early postoperative MRI, and history of long-term anticoagulation therapy) were selected for the best model. Consequently, smaller DCSA in the early postoperative period was the sole significant independent factor associated with postoperative radicular pain (OR, 1.26; 95% CI, 1.14–1.41) (Table 3).

Best early postoperative DCSA cut-off value for radicular pain

ROC analysis confirmed that the best cut-off value for radicular pain was early postoperative DCSA of 67.7 mm^2. This value had a sensitivity of 56.5%, specificity of 89.9%, and area under the curve of 0.772 (Figure 1). When patients with early postoperative DCSA of <70 mm^2 were classified as the abnormal group and those with early postoperative DCSA of ≥70 mm^2 were considered the normal group, the rate of occurrence of radicular pain in the abnormal group (n = 35) was 74.3%, which was significantly higher than that in the normal group (n = 80, 25.0%) (Fisher's exact test, $P < 0.001$) (Table 4). This cut-off value (<70 mm^2) had a sensitivity of 74.3% and specificity of 75.0%.

Residual drain at time of early postoperative MRI

Early postoperative DCSA values before (n = 37) and after (n = 78) drain removal were 119.7 ± 10.1 mm^2 and 93.9 ± 5.4 mm^2, respectively; the difference in these values was significant (Welch's *t* test, $P = 0.027$). The rate of occurrence of radicular pain tended to be lower in the group before drain removal (Fisher's exact test, $P = 0.067$) (Table 5).

Discussion

In our study, multivariate regression analysis showed that only early postoperative DCSA was associated with postoperative symptoms. ROC analysis confirmed that the best early postoperative DCSA cut-off value for symptoms was 67.7 mm^2. Early postoperative DCSA was significantly larger before suction drain removal than after.

A study of early postoperative MRI by Leonardi et al.[4] comparing asymptomatic and symptomatic patients with and without epidural hematoma reported median DCSA values at the site of maximal compression of the operated level of 128.5 mm^2 and 0 mm^2 in asymptomatic and symptomatic patients, respectively. In their study, all symptomatic patients required revision surgery.

Sokolowski et al.[6] reported a relationship between early postoperative MRI and clinical symptoms in 3 patient groups in a cohort that included an asymptomatic group (n = 57), a pain group with severe peri-incisional pain but without neurologic deficit (n = 12), and a group with cauda equina syndrome (CE) (n = 5). Revision surgery was required in 4 patients in the pain group and in all 5 patients in the CE group, indicating that 8 patients without revision surgery in the pain group had severe symptoms; patients with mild symptoms (i.e., those without severe postoperative pain or neurologic deficit) were included in the asymptomatic group. In their report, the critical ratio was the only measure that differed significantly among the 3 study populations. The "critical ratio" was defined as the smallest postoperative-to-preoperative DCSA ratio calculated at each disc space for each patient.

Asymptomatic epidural hematoma has been identified in 33%–100% of patients after lumbar spine surgery on computed tomography and MRI.[2-5, 9-11] In contrast, symptomatic epidural hematoma as an early complication after decompression in patients with LSS has a prevalence of only 0.1%–0.2%.[12-15] All the above-mentioned reports only included cases of epidural hematoma that required surgical intervention. However, clinically, many cases involve mild symptoms that resolve during the observation period, without requiring revision surgery.

According to Scavarda et al.[7], radicular pain is a more severe neurologic symptom than peri-incisional pain or paresthesia. In our study, most patients experienced peri-incisional pain or paresthesia, but radicular pain was rare. It can be difficult to distinguish whether the patient is experiencing residual pain of preoperative symptoms or new postoperative pain. However, we believe the distinction is not significant. We included all patients with radicular pain, regardless of whether the pain was mild or similar to that before surgery. This is a new point of view, which we believe is more clinically relevant than the findings of previous studies.

Oba et al.[16] reported that patients with preoperative DCSA of <60 mm^2 had a significantly smaller DCSA in the early and late postoperative phases, compared with patients with preoperative DCSA of ≥60 mm^2. They hypothesized that limitation in expansion capability influences dural sac expansion. After lumbar decompression, most of the decompressed space should be occupied by the enlarged dural sac and epidural hematoma, and the areas of each change to ensure pressure balance between them. Considering this viewpoint, the distinction between residual preoperative symptoms and new postoperative symptoms is not significant. They also reported that DCSA increased significantly between the early and late postoperative phases. In our study, early postoperative radicular pain in all patients improved within several weeks after surgery. Thus, it seems that radicular pain improves over time along with expansion of the dural sac.

Leonardi et al.[4] reported an absolute critical value of early postoperative DCSA, indicating that an area of 75 mm^2 in the early postoperative period probably represents a threshold that can help to differentiate patients at risk for developing new symptoms from those with uneventful outcomes. They got this idea from the value in preoperative images proposed by different authors to differentiate moderate from severe stenosis.[17] To our knowledge, our study is the first to confirm a cut-off value using ROC analysis. Our best cut-off point was approximately 70 mm^2 (sensitivity, 56.0%; specificity, 89.2%). The number of symptomatic patients was significantly larger when DCSA of 70 mm^2 was used as a cut-off. Patients with DCSA of <70 mm^2 reporting radicular pain need to be followed closely to avoid missing any exacerbation of neurologic symptoms.

When comparing patients with and without suction drains at the time of MRI, early postoperative DCSA was significantly larger in patients with drains. In addition, patients who underwent MRI after drain removal showed a higher rate of symptoms. Postoperative drainage after lumbar surgery remains controversial.[11, 12, 14, 18-20] In our study, all patients had drains placed; therefore, the efficacy of drain placement could not be determined comparatively. However, our results suggest that the beneficial effects of drain placement may include decreased epidural hematoma pressure and increased DCSA, and consequently, a reduction in early postoperative symptoms.

Our study has several limitations. Retrospective studies are inherently problematic and subject to multiple biases. However, multivariate logistic regression analysis showed that smaller DCSA in the early postoperative period was the sole significant independent factor associated with postoperative clinical symptoms. The smallest DCSA might not have been in the intervertebral space in every case. However, we employed those data because the level could be recognized almost precisely for comparison with the preoperative status. Moreover, this study did not employ scores, such as the Japanese Orthopaedic Association score, Oswestry Disability Index, or Short Form-36. Furthermore, some postoperative radicular pain could have been caused by handling during surgery.

In conclusion, the sole significant independent risk factor for postoperative radicular pain was smaller early postoperative DCSA. Thus, smaller early postoperative DCSA (especially <70 mm^2) may relate to insufficient dural sac expansion, which leads to radicular pain. The best cut-off value for postoperative radicular pain was 67.7 mm^2. Absence of a suction drain at the time of early postoperative MRI may be related to smaller DCSA. Most early postoperative radicular pain can be improved with expansion of the dural sac over time; however, cautious follow-up by the patient and physician is warranted due to the possibility of severe neurologic symptoms. Therefore, the results of this study may help physicians to better explain postoperative radicular pain, which can cause anxiety in their patients.

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Figure Caption

Figure 1. Receiver operating characteristic curves of early postoperative dural sac cross-sectional area (DCSA) for the occurrence of postoperative radicular pain

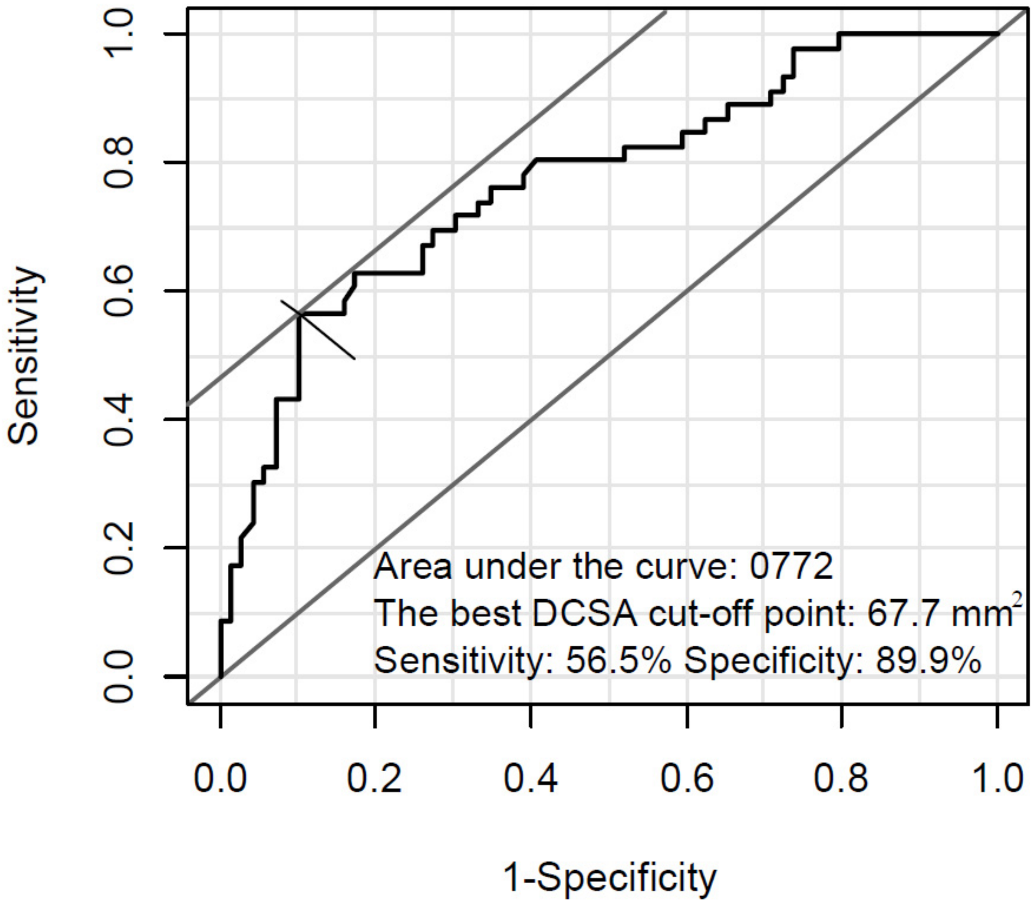

Table 1. Patient characteristics

Characteristic	Total
No. of patients	115
Age, mean ± SD, y	64.6 ± 16.4
Sex, male/female, n	68/47
Intervertebral level, n	
L1/2	1
L2/3	3
L3/4	15
L4/5	69
L5/S	27
Time to early postoperative MRI, mean ± SD, d	4.4 ± 2.0
Surgical procedure, n	
Without fusion	58
LOVE method/MED/laminectomy or fenestration/MEL	12/17/15/14
With fusion	57
PLIF or TLIF/PLF	52/5
Preoperative diagnosis, n	
LSS/LDH	83/32
Intraoperative blood loss, g	507 ± 534
Postoperative blood loss, g	510 ± 604
Time to postoperative suction drain removal, mean ± SD, d	3.7 ± 2.2

LDH, lumbar disc herniation; LSS, lumbar spinal stenosis; MED, microendoscopic discectomy; MEL, microendoscopic laminectomy; MRI, magnetic resonance imaging; PLF, posterolateral fusion; PLIF, posterior lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion

Table 2. Univariate regression analyses of potential risk factors for postoperative radicular pain

Factor	OR (95% CI)	*P* value
Age (+10 y)	0.97 (0.77–1.22)	0.817
Sex (female)	1.88 (0.88–4.04)	0.106
Intervertebral level		
(L3/4 or L4/5)	0.58 (0.07–5.07)	0.600
(L5/S1)	0.93 (0.10–8.68)	0.945
Time to early postoperative MRI (+1 d)	1.12 (0.93–1.36)	0.250
Spinal fusion (+)	1.03 (0.49–2.18)	0.939
Microendoscopic surgery (+)	1.34 (0.58–3.08)	0.493
Preoperative diagnosis (LDH)	1.24 (0.54–2.83)	0.611
Intraoperative blood loss (+100 g)	0.97 (0.89–1.04)	0.368
Postoperative blood loss (+100 g)	0.95 (0.88–1.01)	0.151
Time to postoperative suction drain removal (+1 d)	0.93 (0.78–1.10)	0.396
Drain at time of MRI (-)	2.31 (1.01–5.62)	0.053
Dural tear (+)	0.65 (0.23–1.69)	0.386
Preoperative DCSA (-10 mm^2)	1.05 (0.97–1.14)	0.246
Early postoperative DCSA (-10 mm^2)	1.26 (1.14–1.41)	<0.001*
Dural sac quotient (-1)	1.53 (1.12–2.26)	0.018*
Anticoagulation therapy (+)	0.15 (0.01–0.83)	0.075

*Significant difference

CI, confidence interval; DCSA, dural sac cross-sectional area; LDH, lumbar disc herniation; MRI, magnetic resonance imaging; OR, odds ratio

Table 3. Factors associated with postoperative radicular pain

Factor	OR	95% CI	*P* value
Early postoperative DCSA ($-10\ mm^2$)	1.26	1.14–1.41	<0.001[a]*
Time to early postoperative MRI (+1 d)	1.19	0.95–1.51	0.139[a]
History of long-term anticoagulation therapy	0.19	0.01–1.21	0.138[a]

*Significant difference

[a]Multiple logistic regression analysis with stepwise model comparison

CI, confidence interval; DCSA, dural sac cross-sectional area; MRI, magnetic resonance imaging; OR, odds ratio

Table 4. Ratio of patients with radicular pain according to early postoperative dural sac cross-sectional area cut-off value

Cut-off value	<70 mm^2 (n = 35)	≥70 mm^2 (n = 80)	*P* value
Ratio of patients with radicular pain, %	74.3	25.0	<0.001[a]*

*Significant difference

[a]Fisher's exact test

Table 5. Comparison of patients with and without suction drain at time of early postoperative magnetic resonance imaging

	Drain (+) (n = 37)	Drain (-) (n = 78)	*P* value
Ratio of patients with radicular pain, %	27.0	46.2	0.067[a]
Preoperative DCSA, mean ± SE, mm^2	65.7 ± 8.2	79.8 ± 5.7	0.159[b]
Early postoperative DCSA, mean ± SE, mm^2	119.7 ± 10.1	93.9 ± 5.4	0.027[b]*
Dural sac quotient, median	1.9	1.2	0.001[c]*

*Significant difference

[a]Fisher's exact test

[b]Welch's *t* test

[c]Mann-Whitney *U* test

DCSA, dural sac cross-sectional area