

Retrospective Study

Clinical Outcomes of Percutaneous Endoscopic Lumbar Discectomy Assisted With Sequential SNRB in Treating Lumbosacral Contiguous Double-Level Disc Herniation

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Background: For patients with lumbosacral contiguous double-level disc herniation, there has been no consensus on which level(s) should be treated. Selective nerve root block (SNRB) can identify the pain-generating nerve root; however, its diagnostic accuracy remains controversial due to potential spread of the injectate. Sequential SNRB from S1 to L5 may improve the diagnostic specificity.

Objectives: To examine the clinical and radiographic outcomes of percutaneous endoscopic lumbar discectomy (PELD) assisted with sequential SNRB from S1 to L5 in patients who had lumbosacral contiguous double-level disc herniation.

Study Design: A retrospective design was used.

Setting: This study was conducted in a university-affiliated tertiary hospital in Shanghai, China.

Methods: Fifty-eight consecutive patients with lumbosacral contiguous double-level disc herniation were included (January 2018 to January 2021). Sequential SNRB from S1 to L5 was performed to identify the symptomatic level(s), followed by PELD based on the results of sequential SNRB. Clinical outcomes were assessed by the Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and modified Macnab criteria. Pre- and post-operation radiologic and clinical parameters were evaluated. Demographics were retrieved from medical records.

Results: Patients were followed-up with an average duration of 18.6 months. Among the 58 patients, 21 received surgical treatment at L4/L5 level, 25 at L5/S1 level, and 12 at both levels based on the results of sequential SNRB from S1 to L5. Compared with preoperative values, mean VAS scores for leg and back pain, as well as the ODI score, improved significantly after the surgery. There were no significant differences in the clinical outcomes between patients receiving surgical treatment at L4/L5, L5/S1, or both levels. According to the Macnab criteria, 49 patients (84.5%) had excellent or good results.

Limitations: This study used a retrospective design with relatively small sample size and medium follow-up duration.

Conclusions: Sequential SNRB from S1 to L5 was an effective approach to guide PELD treatment for patients with lumbosacral contiguous double-level disc herniation. Health care providers may consider using this approach to facilitate future clinical practice.

Key words: Double-level disc herniation, selective nerve root block, percutaneous endoscopic lumbar discectomy, sequential nerve root block

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Lumbosacral contiguous double-level disc herniation (i.e., L4/L5 and L5/S1 levels) is not uncommon in clinical practice (1-3). Sciatica and low back pain are the main complaints of patients with this condition (4-6). Conservative treatment is the first option when patients have symptomatic disc herniations. Surgery is usually considered if conservative treatment fails or neurological symptoms deteriorate (4-6). Percutaneous endoscopic lumbar discectomy (PELD) is one of the most commonly used surgical approaches for lumbar disc herniation (LDH), with high efficacy and minimal damage (7). However, there has been no consensus on how to choose the surgical level(s) for patients with lumbosacral contiguous double-level disc herniation. Previous evidence (1,8,9) has demonstrated that one-stage PELD is effective for contiguous double-level LDH. Others reported that patients with multilevel disc herniations could also benefit from single-level PELD (10-12).

LDH is a common age-related disease, but not all herniations cause significant neurological symptoms (4,13-15). Approximately 30% of individuals with abnormality in the disc as indicated by magnetic resonance imaging (MRI) are asymptomatic (13,14). Treatment is typically recommended for the symptom-inducing disc (i.e., the responsible level) (5). Concerns have been raised that if only the responsible level was treated with discectomy for double- or multilevel LDH, the adjacent asymptomatic level may cause symptoms in the future, and thus needs a reoperation, with a rate of 4.7% (16). However, treating the asymptomatic level simultaneously may accelerate disc degeneration at the surgical level. Additionally, the compromised annulus after discectomy may also have a risk of recurrence, with a rate of 5% to 15% (17,18). Therefore, identifying the responsible level(s) is essential in treating patients with lumbosacral contiguous double-level LDH.

Diagnostic selective nerve root block (SNRB) has been widely used to determine the origin of pain in patients with cervical and lumbar radiculopathy (19,20). Previous studies (21-23) have demonstrated that diagnostic SNRB could help identify the pain-generating nerve root and improve the clinical outcomes of patients with an uncertain diagnosis or multilevel LDH. Despite the widespread use of SNRB, its diagnostic accuracy in determining the symptomatic level remains controversial due to concerns about the potential spread of the injectate from the injected level onto the adjacent nerve root (24). This phenomenon is particularly common in a L5 nerve root block, in which the injectate inadvertently

spread toward the S1 nerve root among over half of the patients (25), making it challenging to differentiate between L5 and S1 nerve root compression in patients with lumbosacral contiguous double-level disc herniation. In comparison, S1 nerve root injection via the first sacral foramen would be more reliable due to a lower likelihood of spreading toward the L5 nerve root. Moreover, the S1 nerve root block has been successfully used for therapeutic and diagnostic purposes in patients with S1 radiculopathy (20,26,27).

Based on the above evidence, we hypothesized that sequential SNRB from S1 to L5 could accurately and effectively determine the responsible level(s) for patients with L4/L5 and L5/S1 LDH, which could assist the surgeons in providing a tailored surgical regimen for the patients. In this retrospective study, our aim was to examine the clinical and radiographic outcomes of patients who had lumbosacral contiguous double-level disc herniation and were treated with PELD assisted with sequential SNRB from S1 to L5.

METHODS

Patients

This study was approved by the Institutional Review Board at Naval Medical University (Shanghai, China). Written informed consent was obtained from all patients prior to the procedures. In this study, 58 consecutive patients with lumbosacral contiguous double-level disc herniation were enrolled from January 2018 to January 2021. The inclusion criteria were: (1) patients diagnosed with LDH at L4/L5 and L5/S1 based on imaging findings; (2) unilateral sciatica history with or without low back pain and failure to conservative treatments for over 6 weeks; (3) received sequential diagnostic SNRB starting from the S1 nerve root; (4) treated with PELD; and (5) aged between 18 to 70 years. The exclusion criteria included: (1) presence of 3 or more levels of disc herniation; (2) lumbar segmental instability or severe canal stenosis; (3) far lateral disc herniation at L4/L5 and/or L5/S1; (4) cauda equina syndrome or other severe spinal diseases; and (5) patients with missing data or follow-up < 12 months.

Block Logistics and Evaluation

All patients underwent SNRB following the procedures below. No analgesics were given within 24 hours before the procedure. Patients were asked to rate their leg pain on a Visual Analog Scale (VAS) 30 minutes before the SNRB. They also underwent provocation

with walking to assess leg pain. Five minutes after the SNRB, clinical assessments, including walking provocation and the VAS rating, were repeated. All SNRB procedures started from the S1 nerve root. 1) If the S1 block showed over 70% of pain reduction (28), the L5/S1 level was considered the responsible level, and PELD was then performed only at this level (Fig. 1). 2) If the S1 block showed no effect on pain reduction, the L5 block was then performed. If the L5 block showed over 70% of pain reduction, PELD was then performed at the L4/L5 level (Fig. 2). 3) If the S1 block showed some effects on pain reduction but the degree was < 70%, the L5 block was then scheduled on the next day. If the L5 block also reduced the pain (including pain in different areas), both levels were considered responsible levels. PELD was then performed at both levels (Fig. 3).

Block Technique

The block procedures were similar to previous ones (12,20). All procedures were performed by the same senior surgeon (GX). Patients were placed in a prone position on a radiolucent table in an x-ray suite. For the S1 nerve root block, a standard anteriorposterior (AP)

fluoroscopy image of the lumbosacral spine was obtained, and the first sacral foramen was marked on the skin. The injection site was prepared and draped. The skin was injected with 1% lidocaine using a 9-gauge, 100-mm needle. The needle was then advanced slowly toward the sacral foramen under fluoroscopic visualization. The correct position of the needle tip should be at the lateral zone of the sacral foramen in an AP view and go beyond the posterior border of the sacral vertebral body in a lateral view (Figs. 4a and 4b). Once the needle was in the correct position, 0.5 mL iohexol (contrast medium) (300 mg/mL, Omnipaque GE Healthcare Ireland, Cork, Ireland) was injected slowly under the fluoroscopic guidance to determine the distribution of the contrast medium. After confirming the absence of intravascular or intracanal diffusion, 0.5 mL 1% lidocaine was then injected. After the injection, patients were asked to rate their pain. For the L5 nerve root block, the entry point was located approximately 10-12 cm from the midline and parallel or a bit higher to the L5/S1 level based on the iliac crest position. The skin was anesthetized with 1% lidocaine and a 22-gauge, 180-mm needle was inserted from the entry point to

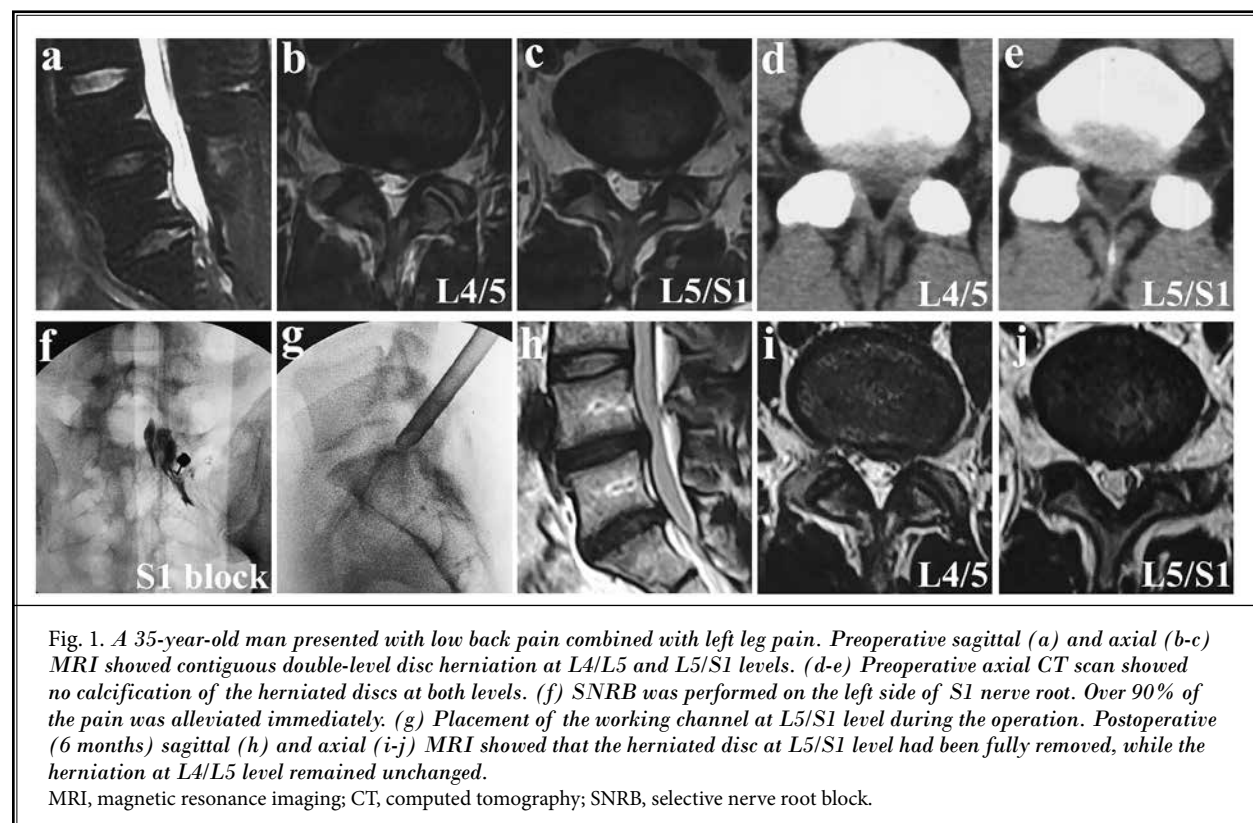
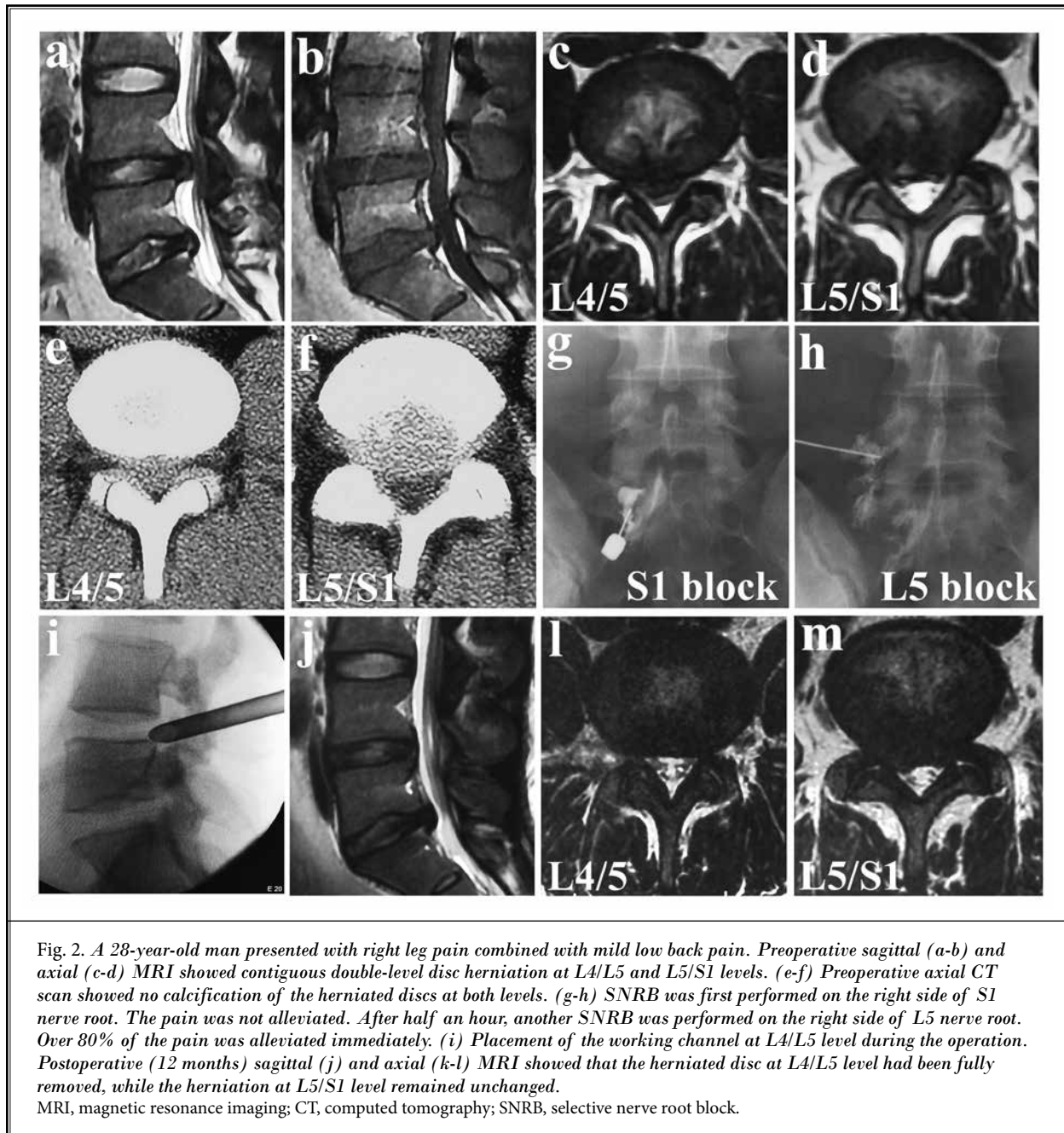


Fig. 1. A 35-year-old man presented with low back pain combined with left leg pain. Preoperative sagittal (a) and axial (b-c) MRI showed contiguous double-level disc herniation at L4/L5 and L5/S1 levels. (d-e) Preoperative axial CT scan showed no calcification of the herniated discs at both levels. (f) SNRB was performed on the left side of S1 nerve root. Over 90% of the pain was alleviated immediately. (g) Placement of the working channel at L5/S1 level during the operation. Postoperative (6 months) sagittal (h) and axial (i-j) MRI showed that the herniated disc at L5/S1 level had been fully removed, while the herniation at L4/L5 level remained unchanged.

MRI, magnetic resonance imaging; CT, computed tomography; SNRB, selective nerve root block.

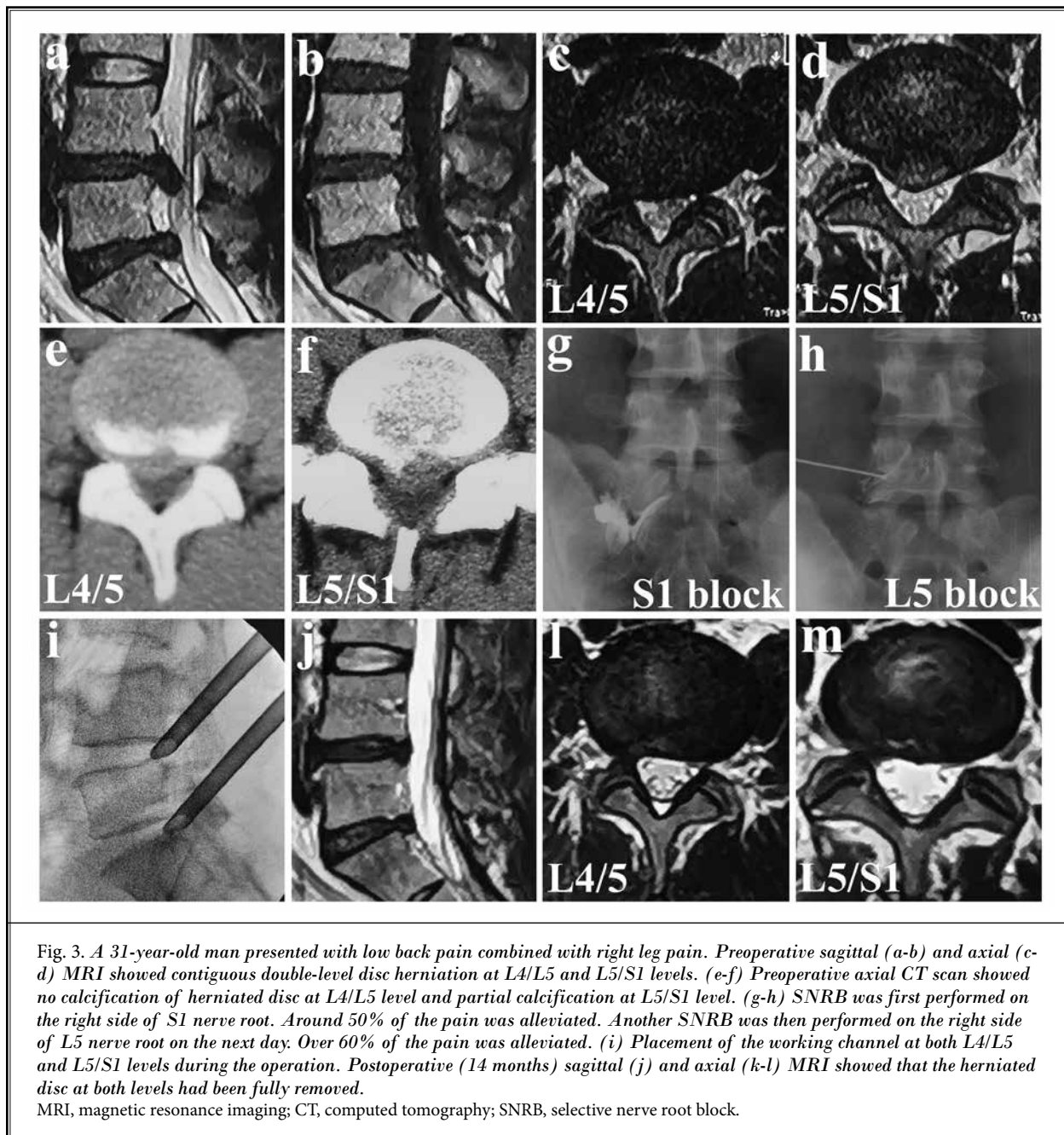


the L5/S1 intervertebral foramen under fluoroscopic visualization. The correct position of the needle tip should be directly below the L5 pedicle awl in an AP view, and also below the L5 pedicles, but not beyond the posterior border of the L5 vertebral body in a lateral view (Figs. 4c and 4d). Once the correct position was established, injection of the contrast medium and lidocaine was the same as the S1 block. After complet-

ing the block procedures, the entry point was sealed with a sterile dressing. The patients were asked to rate their pain after approximately 5 minutes.

Surgical Technique

The surgical process was followed the Transforaminal Endoscopic Spine System (TESSYS, Joimax, Karlsruhe, Germany) technique. Briefly, patients were



placed in the prone position on a radiolucent table under local anesthesia and sedation. The skin entry point was 8-11 cm lateral from the spinous process based on the surgical segment and body size of the patient, with the angle parallel to the direction of the intervertebral space. The needle was replaced by the guidewire once it touched the ventral side of the superior articular process without entering the intervertebral foramen. Se-

quential dilation was performed to spread the soft tissues to a 7.5 mm diameter. The Kirschner wire was then inserted to replace the guidewire and gently tapped to penetrate the ventral side of the superior articular process. After confirming the position, an 8.0-mm safety sleeve was inserted with the oblique opening to shield the exiting nerve root. A 7.5-mm trephine was used to remove the tip and ventral side of the superior

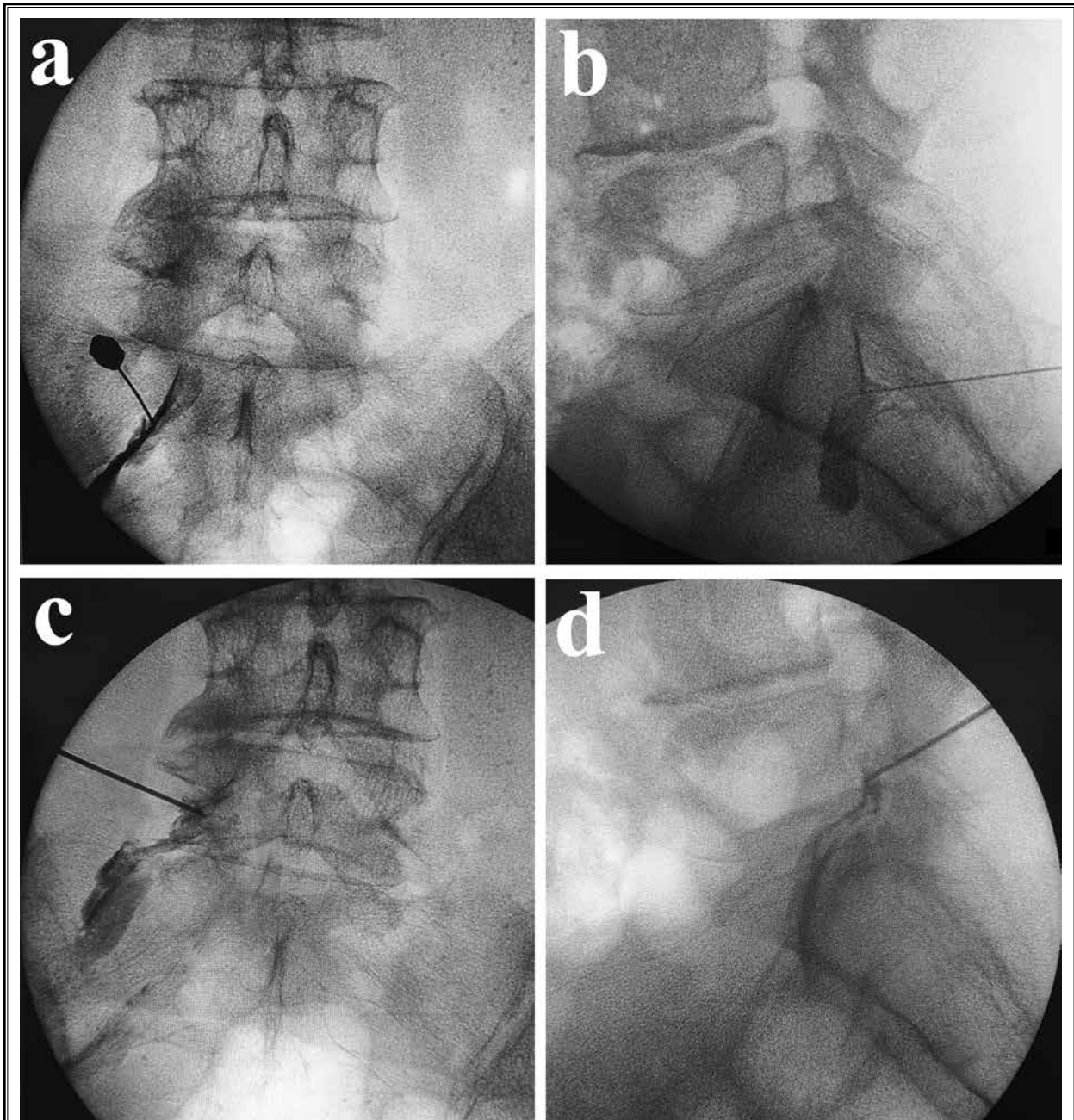


Fig. 4. Radiculogram of S1 and L5 selective nerve root block. (a) AP and (b) lateral radiograph showed the correct position of the needle tip for S1 nerve root block and the profile of S1 nerve root after injecting contrast. (c) AP and (d) lateral radiograph showed the correct position of the needle tip for L5 nerve root block and the profile of L5 nerve root after injecting contrast.

AP, anteroposterior.

articular process along the Kirschner wire. A tapered obturator was inserted to induce the insertion of the working channel. Endoscopic pituitaries were used to

remove the herniated disc. Complete decompression was achieved with adequate exposure of the dura and nerve root, mobilization, or pulsation of the neural tis-

sues. Bipolar probes were used to control active bleeding in the view. The endoscope and working channel were removed upon decompression and hemostasis. The skin was closed and no drainage was required.

Outcome Evaluation

Baseline demographics were collected, including age, gender, weight, height, and smoking status. We also obtained the duration of symptoms, surgical level(s), operation time, number of fluoroscopies and hospital stay, and comorbidities. Perioperative complications, including dysesthesia, nerve root injury, dural tear, postoperative hematoma, and infection, and postoperative complications, including recurrent symptoms and recurrent herniation, were also recorded. The recurrent symptom was defined as the recurrence of sciatica symptoms (i.e., tingling, numbness, and burning in the leg) after a pain-free period of over 6 months. Recurrent herniation was defined as the recurrence of disc herniation at the same surgical level after a pain-free period of over 6 months (Table 1).

All patients were followed-up at an outpatient clinic and assisted with telephone calls for a minimum of 12 months after the surgery. Pain was measured by the VAS for the back (back-VAS) and leg (leg-VAS) at pre-operation and 2-week, 3-month, 6-month, and

final follow-ups post-operation. Functional status was assessed by the Oswestry Disability Index (ODI) at pre-operation and 3-month, 6-month, and final follow-ups post-operation. Radiologic analysis was performed by x-ray, computed tomography scans, and MRI before the operation and at different time points of follow-ups after the operation or when patients had recurrent symptoms. The overall clinical outcome was assessed by the modified Macnab criteria at the final follow-up. Excellent and good outcomes were considered a clinical success, while fair and poor outcomes were considered a clinical failure (Table 2).

Statistical Analysis

The SPSS Version 20.0 (IBM Corporation, Armonk, NY) was used for statistical analyses. Continuous variables were presented as mean (standard deviation). Categorical variables were presented as frequency (%). Group difference in demographics was examined by one-way analysis of variance (ANOVA) and chi-square (or Fisher's exact) tests. Between-group differences in the clinical outcomes were analyzed using one-way ANOVA. Within-group differences in the clinical outcomes were analyzed using repeated measure ANOVA. The statistical significance level was set at $P < 0.05$.

Table 1. Demographic, diagnosis, and surgical outcomes of the patients.

Variables	Total (n = 58)	L4/5 Level (n = 21)	L5/S1 Level (n = 25)	Both Levels (n = 12)	P value
Age (y)	38.2 (12.0)	37.1 (13.2)	39.2 (10.9)	37.7 (13.0)	0.84
Gender (men)	34 (58.6%)	11 (52.4%)	15 (60.0%)	8 (66.7%)	0.71
BMI (kg/m ²)	24.0 (2.6)	23.8 (2.8)	24.5 (2.8)	23.6 (2.1)	0.54
Smoking	11 (19.0%)	4 (19.0%)	5 (20.0%)	2 (16.7%)	1.00#
Comorbidities					
Hypertension	8 (13.8%)	3 (14.3%)	3 (12.0%)	2 (16.7%)	1.00#
Diabetes	6 (10.8%)	2 (9.5%)	2 (8.0%)	2 (16.7%)	0.74#
Duration of Symptoms (mo)	7.6 (4.7)	7.2 (3.8)	8.2 (5.7)	6.8 (4.0)	0.69
Operation Time (min)	88.2 (31.7)	69.2 (11.6)	76.7 (10.9)	145.3 (12.9)	< 0.01
Number of Fluoroscopy (times)	20.6 (8.0)	15.1 (2.4)	18.5 (3.0)	34.7 (3.7)	< 0.01
Hospital Stay (d)	2.2 (0.8)	2.1 (0.7)	2.1 (0.8)	2.6 (0.7)	0.20
Follow-up Duration (mo)	18.6 (7.3)	19.3 (7.4)	17.8 (7.6)	19.1 (7.0)	0.69
Complications					
Dysesthesia	4 (6.9%)	1 (4.8%)	2 (8.0%)	1 (8.3%)	
Dural Tear	2 (3.4%)	1 (4.8%)	0 (0%)	1 (8.3%)	
Recurrent Symptom	6 (10.3%)	2 (9.6%)	3 (12.0%)	1 (8.3%)	
Recurrent Herniation	2 (3.4%)	0 (0%)	1 (4.0%)	1 (8.3%)	

Notes. Continuous variables are presented as mean (SD); categorical variables are presented as n (%); both levels mean L4/L5 and L5/S1 levels; BMI, body mass index; SD, standard deviation.

#Fisher's exact were used.

Table 2. Clinical outcomes of the patients.

Parameters		Total (n = 58)	L4/L5 Level (n = 21)	L5/S1 Level (n = 25)	Both Levels (n = 12)	One-way ANOVA (P)
VAS-Leg	Pre-op	6.9 (1.6)	6.8 (1.7)	6.7 (1.6)	7.5 (1.6)	0.38
	2-week post-op	2.5 (1.4)**	2.6 (1.2)**	2.4 (1.3)**	2.3 (1.8)**	0.89
	3-month post-op	1.9 (1.2)**	1.8 (1.1)**	2.0 (1.3)**	1.7 (1.4)**	0.74
	6-month post-op	1.8 (1.2)**	1.7 (0.9)**	2.0 (1.3)**	1.7 (1.4)**	0.70
	Final follow-up	1.4 (1.2)**	1.4 (1.1)**	1.4 (1.4)**	1.3 (1.1)**	0.91
Repeated measure ANOVA (p)		< 0.01	< 0.01	< 0.01	< 0.01	
VAS-Back	Pre-op	4.4 (1.2)**	4.3 (1.4)**	4.3 (1.1)**	4.8 (1.0)**	0.47
	2-week post-op	2.5 (0.9)**	2.5 (1.1)**	2.4 (0.8)**	2.7 (0.9)**	0.58
	3-month post-op	1.9 (0.8)**	1.9 (0.8)**	2.0 (0.8)**	1.8 (0.7)**	0.89
	6-month post-op	1.9 (0.8)**	1.9 (0.8)**	1.8 (0.8)**	2.0 (0.9)**	0.86
	Final follow-up	1.6 (1.1)**	1.6 (1.1)**	1.6 (1.2)**	1.7 (1.2)**	0.97
Repeated measure ANOVA (p)		< 0.01	< 0.01	< 0.01	< 0.01	
ODI (%)	Pre-op	53.9 (18.2)**	54.4 (17.5)**	52.0 (19.8)**	57.1 (16.8)**	0.73
	3-month post-op	20.3 (8.5)**	20.0 (7.4)**	21.8 (8.9)**	17.5 (9.1)**	0.34
	6-month post-op	18.6 (8.1)**	18.4 (7.5)**	19.5 (8.0)**	17.3 (9.7)**	0.75
	Final follow-up	16.3 (7.9)**	16.2 (6.2)**	17.0 (9.4)**	15.1 (7.5)**	0.81
Repeated measure ANOVA (p)		< 0.01	< 0.01	< 0.01	< 0.01	
Macnab Criteria†	Excellent	17 (29.3%)	6 (28.6%)	8 (32.0%)	3 (25.0%)	0.95
	Good	32 (55.2%)	12 (57.1%)	13 (52.0%)	7 (58.4%)	
	Fair	7 (12.1%)	3 (14.3%)	3 (12.0%)	1 (8.3%)	
	Poor	2 (3.4%)	0 (0%)	1 (4.0%)	1 (8.3%)	

Notes. VAS, visual analog scale; ODI, Oswestry disability index; ANOVA, analysis of variance; SD, standard deviation; pre-op, pre-operation; post-op, post-operation; continuous variables are presented as mean (SD); categorical variables are presented as n (%); both levels mean L4/L5 and L5/S1 levels.

Repeated measure ANOVA was used for within-group comparison: $P < 0.01$, compared to pre-operation within the same group.

One-way ANOVA was used for between-group comparison at the same time point.

†Modified Macnab criteria at final follow-up.

RESULTS

General Results

The demographics and surgical data of the patients are shown in Table 1. In this study, a total of 58 patients were included with an average follow-up period of 18.6 (12-44) months. Their average age was 38.2 (20-68) years, and 58.6% were men. The mean duration of symptoms was 7.6 (2-21) months. Among the 58 patients, 21 received surgical treatment at the L4/L5 level (L4/5 group), 25 received treatment at the L5/S1 level (L5/S1 group), and 12 received treatment at both levels (2-level group) based on the results of sequential SNRB from S1 to L5. The 3 groups were comparable in demographics, such as age, gender, body mass index, smoking, and comorbidities. The mean operation time and the number of fluoroscopies were 88.2 (50-168) minutes and 20.6 (12-42) times, respectively. There

were significant group differences in those 2 outcomes. Patients receiving the 2-level treatment had longer operation time and more fluoroscopies than those receiving the one-level treatment ($P < 0.01$). The 3 groups were comparable in hospital stay and follow-up duration.

Clinical Outcomes

The clinical outcomes of the patients are shown in Table 2. Within-group analysis showed that in the whole sample, VAS-leg, VAS-back, and ODI all improved significantly during each follow-up compared to pre-operation ($P < 0.01$). Similar results were found when data were analyzed separately for each group ($P < 0.01$). Between-group analysis revealed no significant differences in VAS and ODI between the 3 groups ($P > 0.05$). Based on the modified Macnab criteria, clinical success was achieved in 49 patients (84.5%) at the

final follow-up, including 17 excellent and 32 good outcomes. No difference was found between these 3 groups in the overall clinical outcome.

Complications

All patients had complete decompression of the surgical level(s) based on postoperative imaging. Four cases experienced postoperative dysesthesia, with one in the L4/L5 group, 2 in the L5/S1 group, and one in the 2-level group. Symptoms of dysesthesia among these 4 patients were relieved within 3 weeks with steroid treatment. There were 2 cases (one in the L4/L5 group and one in the 2-level group) of dural tear during the operation. No incarceration of cauda equina nerve roots or postoperative cerebrospinal fluid leak was observed. Six cases experienced postoperative recurrent symptoms, with 2 in the L4/L5 group, 3 in the L5/S1 group, and one in the 2-level group. Among them, recurrent symptoms were due to the asymptomatic nonsurgical level in the L4/L5 group (n = 2) and L5/S1 group (n = 2). Two patients (one in the L5/S1 group and one in the 2-level group) with recurrent symptoms had recurrent herniation at the surgical level. These patients received conservative treatments and the symptoms were relieved. No patients experienced reoperation during the follow-up (Table 1).

DISCUSSION

In this study, we included 58 patients with lumbosacral contiguous double-level disc herniation (i.e., L4/L5 and L5/S1). Sequential SNRB from S1 to L5 nerve roots was used to identify the responsible level(s) prior to the surgery. After confirming the responsible level(s), PELD was used to treat the pathology at the L4/L5 level in 21 patients, the L5/S1 level in 25 patients, and both levels in 12 patients. All surgeries were performed successfully without major complications. After a minimum of a 12-month follow-up, the clinical outcomes of the patients including pain, functional status, and global outcomes were significantly improved, suggesting that PELD assisted with sequential nerve root blocks from S1 to L5 was an effective way for the treatment of lumbosacral contiguous double-level disc herniation.

LDH, affecting 2% to 3% of the population, is one of the most common pathologies among lumbar degenerative diseases (4-6). Approximately 95% of LDH occurs at the L4/L5 or L5/S1 level (6). Some patients even have multilevel disc herniations (2,3). It is worth mentioning that abnormal MRI findings of the lumbar spine may not correlate well with clinical symptoms. For instance, among healthy patients without any symptoms, around 28% to

33% had degenerative changes (e.g., disc herniation and disc extrusion) on MRI images (13-15). A slightly higher rate (31% to 39%) was found in healthy, asymptomatic tennis players (29,30). Janardhana et al (31) examined the correlation between clinical symptoms and MRI findings in LDH. It was found that 80 of the 169 levels of herniated discs were asymptomatic (47.3%), slightly higher than the one found in our study with 46 of the 116 levels of herniated discs asymptomatic (39.6%).

The treatment of multilevel LDH is complicated. Particularly, whether the asymptomatic disc herniation at the adjacent segment needs to be treated remains controversial. On the one hand, if the asymptomatic level was treated simultaneously with the symptomatic level, the surgery per se would inevitably injure the ligamentum flavum, the posterior longitudinal ligament, and the posterior lumbar disc structure, which may put the lumbar spine at risk of instability (32). Relatedly, discectomy could accelerate degeneration of the disc and compromise the annulus, thus increasing the likelihood of backward herniation reoccurrence (17,18,33). Previous studies (17,18) reported a recurrence rate of 5% to 15% after discectomy. In this study, we also observed that 3.4% of the patients had recurrent herniation. Additionally, one-stage operation of 2-level LDH also prolonged the operation time, increased radiation exposure, and impaired patient tolerance. On the other hand, if left untreated, the asymptomatic disc herniation may cause clinical symptoms over time, and thus needs further treatment in the future. For instance, Wu et al (16) found that 4.7% (5/107) of the patients needed reoperation approximately 2 years after the PELD surgery due to deterioration of the adjacent asymptomatic level. In our study, 4 patients (6.9%) experienced clinical symptoms caused by the asymptomatic disc herniation during the follow-up. However, their symptoms were relieved with conservative treatments, and no one needed a reoperation. A longer follow-up may help to unveil whether leaving the symptomatic level untreated is superior to having it treated simultaneously with the symptomatic level.

Determining which nerve root(s) is responsible for the pain is particularly challenging for patients with multilevel LDH. In clinical practice, SNRB has been commonly used to identify the pain-generating nerve root (19,24). Based on previous evidence (10,20), surgeries based on SNRB results could help to improve clinical outcomes. SNRB could also provide important prognostic information and has demonstrated predictive value (22,23). Although current evidence supports the clinical value of SNRB, its diagnostic accuracy varied from

31% to 100% (24). The unstable accuracy of SNRB is mainly due to the potential epidural spread of the local injectate (e.g., anesthetic) onto adjacent nerve root(s), resulting in a false-positive result (21,24,34). Thus, a minimal volume of injectate has been recommended to optimize specificity (24,35). In the present study, we injected 0.5 mL lidocaine (1%) into the target area, in line with the dose suggested by Furman et al (35). Spread of the injectate based on the anatomic structure of the lumbar. The target point for SNRB lies at the dorsal root ganglion of the exiting nerve root, which is typically located within the superolateral portion of the lumbar intervertebral foramen. Based on the anatomy of the lumbar spine, no barriers of the bone structure were present between the dorsal root ganglion and dura sac at the level of the foramen. Thus, the injectates tend to spread onto the medial epidural space. In the lower lumbar region, the medial spread would affect the adjacent traversing nerve root below the injected nerve root as it usually exits the dura above the disc level, meaning that the exiting nerve root and the adjacent traversing nerve root are very close to each other in the lower lumbar intervertebral foramen (25,36). Based on the study by Vassiliev (25), the injectate spread onto L5 nerve roots in 46.1% of the patients during SNRB at L4, and the injectates spread onto S1 nerve roots in 57.7% of the patients during SNRB at L5. In comparison, the injectate has a low tendency to spread onto nerve roots above the injected nerve root. Based on the above evidence, sequential SNRB starting from the distal level should be used for multilevel contiguous LDH. For lumbosacral contiguous double-level disc herniations, SNRB starting from the distal level (i.e., S1 nerve root) has another advantage. That is, the S1 nerve root exits from the first sacral foramen (27), which is surrounded by bone structures, making the injectate less likely to spread onto other nerve roots, especially the upper-level nerve root (i.e., L5 nerve root). The diagnosis of lumbosacral double-level contiguous disc herniations lies in L5 and S1 radiculopathy. For this type of herniation, SNRB at S1 should be performed first, which tends to block the pain from the S1 nerve root but may not relieve pain originating from L5. If subsequent SNRB at L5 relieved the pain (despite a high probability of anesthetic spreading onto the S1 nerve root), it would suggest L5 radiculopathy.

In this study, sequential SNRB from S1 to L5 was used to identify the responsible level(s) of lumbosacral contiguous double-level disc herniation. One-level (n = 46) or 2-level (n = 12) PELD was then performed

based on results from the sequential SNRB. The clinical outcomes improved significantly after a minimum of a 12-month follow-up, supported by decreased VAS and lumbar ODI scores. The success rate achieved 80%, higher than the one found in previous studies (approximately 70%) (10,11). In those studies, only one level of the multilevel LDH was treated without the assistance of SNRB. It is possible that some responsible level might have been missed, thus impairing the efficacy. Our success rate was comparable to the one reported by previous studies (10,11) where one-stage 2-level PELD was performed. Specifically, Zhou et al (1) used PELD via the transforaminal approach combined with the interlaminar approach to treat the L4/L5 and L5/S1 2-level LDH, and 89.47% of the patients achieved excellent or good recovery. Similarly, Hur et al (8) found an overall success rate of 83.8% at the final follow-up for the 2-level contiguous LDH. Mao et al (9) reported a success rate of 93.7% among adolescents with 2-level contiguous LDH. Compared with those studies, we used sequential SNRB to tailor the treatment regimen. This approach has the advantages of decreasing injuries, operation time, and radiation dose, as suggested by our results. Collectively, the above evidence suggests that PELD assisted with sequential SNRB could achieve high efficacy without inadvertently compromising the asymptomatic level.

This study was among the first that used sequential SNRB from S1 to L5 to assist PELD in treating lumbosacral contiguous double-level disc herniation. However, our findings should be interpreted in light of the limitations below. Although data were collected prospectively, this study was retrospective in design, limiting our ability to detect the causality. The sample size was not determined a priori and was relatively small. Thus, some of the group differences might have been missed. Additionally, the follow-up was not long enough, precluding us from observing the long-term effects of the treatment (e.g., reoperation rate due to the progression of the asymptomatic level and reoperation rate due to reherniation of the surgical level). Prospective studies with a larger sample size and longer duration of follow-up are warranted to confirm findings from this study.

CONCLUSIONS

In clinical practice, it is challenging to determine which level(s) is responsible for the symptoms in patients with lumbosacral contiguous double-level disc herniation. Sequential SNRB from S1 to L5 was an effective approach to identify the symptomatic level(s) among

patients who had L4/L5 and L5/S1 disc herniation. PELD based on the results of sequential SNRB demonstrated efficacy of improving clinical outcomes of the patients. In future practice, surgeons may consider using sequen-

tial SNRB from S1 to L5 to guide their selection of the surgical regimen for patients with lumbosacral contiguous double-level disc herniation.

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