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Evaluating the impact of platelet-rich plasma injection in spinal endoscopic nucleotomy on MRI pfirrmann grading and clinical outcomes in lumbar disc herniation

Hairu Qi[1*†], Zhimin Zhou[2†], Gaoxiang Li[1], Yonggen Huang[1], Shujin Chen[1] and Bao Liu[1*]

Abstract

Background This study investigates the clinical efficacy and safety of percutaneous endoscopic nucleotomy combined with platelet-rich plasma (PRP) injection in treating lumbar disc herniation (LDH) in young and middle-aged adults.

Methods From April 2022 to September 2023, 60 patients diagnosed with LDH were randomly divided into two groups ($n=30$/group). The observation group underwent percutaneous endoscopic nucleotomy combined with autologous PRP gel injection into the disc, while the control group underwent percutaneous endoscopic nucleotomy alone. Visual Analogue Scale (VAS) scores and Oswestry Disability Index (ODI) scores were recorded preoperatively and at three time points postoperatively: three days, three months, and six months. The modified Macnab criteria were employed to evaluate efficacy at the final follow-up. Additionally, MRI Pfirrmann grading of the operated disc segment and potential complications were assessed both preoperatively and at the final follow-up.

Results All patients were followed for a minimum of six months. VAS and ODI scores at all postoperative time points (three days, three months, and six months) exhibited significant differences compared to preoperative scores in both groups ($P<0.05$). Notably, a significant difference was observed in VAS and ODI scores between the two groups at three days postoperatively ($P<0.05$). Preoperative MRI Pfirrmann grading indicated no significant difference between groups ($P=0.669$). However, at the final follow-up, the observation group demonstrated superior recovery compared to the control group ($P=0.013$). The modified Macnab criteria revealed no significant difference in the rates of excellent and good outcomes between the observation group (96.67%) and the control group (93.33%) ($P>0.05$). Furthermore, no patients experienced complications such as dural tears, nerve root injury, infection, or hematoma.

[†]Hairu Qi and Zhimin Zhou contributed equally to this work.

*Correspondence:
Hairu Qi
qhr10363@163.com
Bao Liu
LB20100801@126.com

Full list of author information is available at the end of the article

Conclusion The combination of percutaneous endoscopic nucleotomy and PRP injection could be a safe and effective treatment for LDH in young and middle-aged adults to promote disc repair following endoscopic procedures.

Keywords Lumbar disc herniation, Platelet-rich plasma, Spinal endoscopy, Pain measurement, Quality of life, Disability evaluation, Microdiscectomy, Treatment outcomes

Background

Lumbar disc herniation (LDH) is a prevalent clinical condition that leads to low back and leg pain, with an increasing incidence observed among younger populations. Although most patients with LDH can achieve recovery through conservative treatment, those who do not respond adequately often require surgical intervention. With advancements in minimally invasive spinal techniques, percutaneous endoscopic lumbar discectomy has gained widespread acceptance as the preferred surgical method for uncomplicated LDH due to its significant advantages [1–3]. While this technique effectively decompresses nerves, it does not address the repair of degenerated discs. Platelet-rich plasma (PRP), which is rich in various growth factors, has demonstrated promising potential for enhancing disc repair [4, 5]. While the efficacy of PRP in promoting tissue repair and reducing inflammation has been established in various medical fields, its application in the context of low back pain and LDH treatment remains underexplored. For instance, although current clinical studies have demonstrated that PRP can significantly improve symptoms of low back pain and facilitate disc repair, little is known about its integration with minimally invasive surgical techniques.

Therefore, we conducted a randomized controlled study from April 2022 to September 2023 to evaluate the combined use of percutaneous endoscopic nucleotomy and intradiscal PRP injection for young and middle-aged patients with LDH. Overall, this study provides insights into the potential of PRP to enhance the effectiveness of spinal endoscopic procedures, offering a novel therapeutic option for patients suffering from LDH.

Materials and methods

Clinical data

General data

This study comprised a total of 60 patients diagnosed with LDH from April 2022 to September 2023 who underwent surgical intervention at the Orthopedics Department of Zhongshan Torch Development Zone People's Hospital. The trial protocol received approval from the hospital's Ethics Committee, and all participants provided written informed consent before their inclusion in the study. This study was approved by the Ethics Committee of Zhongshan Torch Development Zone People's Hospital on January 2022 (approval no.: (2022)-0001). All patient data were anonymized before analysis to ensure confidentiality. Pseudonymization was employed where required, in accordance with ethical guidelines. The principal investigator and the data management team were responsible for ensuring the secure handling and protection of all data. No personally identifiable information was used in the analysis or presentation of results.

Inclusion criteria

The inclusion criteria for participation in the study were as follows:

(1) Age 18–55 years; (2) Diagnosed with LDH, exhibiting significant radicular symptoms and a positive straight leg raise test, unresponsive to at least one month of conservative treatment; (3) Presence of a single segment identified as responsible for surgical intervention; (4) Participants belonged to a specific racial or ethnic group.

Exclusion criteria

Participants were excluded from the study based on the following criteria:

(1) Presence of lumbar infections, tumors, severe deformities, lumbar instability, or spondylolisthesis; (2) Blood system-related diseases; (3) History of use of nonsteroidal anti-inflammatory drugs (NSAIDs) or immunosuppressants for more than 3 consecutive months prior to surgery; (4) Significant calcification or bony stenosis of the affected lumbar disc; (5) Psychiatric disorders that hindered full cooperation with treatment protocols.

Grouping method

The patients were randomly allocated into observation and control groups using a random number table, with thirty patients assigned to each group. The observation group underwent percutaneous endoscopic nucleotomy combined with autologous PRP gel injection into the disc, while the control group received percutaneous endoscopic nucleotomy alone.

Treatment methods

PRP gel preparation

Routine disinfection and draping procedures were performed. A #12 scalp needle was used to puncture the median cubital vein, and a 20 mL syringe was utilized to draw 2 mL of sodium citrate (Sigma-Aldrich, St.Louis, USA), followed by 18 mL of the patient's whole blood. After removing the scalp needle, a metal stopper (Thermo Fisher Scientific, Waltham, USA) was secured

onto the syringe. The contents were gently mixed, and the plunger was removed. The syringe was then sealed with sterile film and placed in a medical high-speed centrifuge (Baiyang Medical BY400B, Jinan, China). An equal weight balance of water was symmetrically placed in the centrifuge. The blood was centrifuged at 40×10 g (1495 rpm) for 10 min. After allowing the tube to stand for 3 min, it was removed horizontally. The red blood cells at the bottom layer were separated, and the remaining plasma was subjected to a second centrifugation at 70×10 g (1978 rpm) for another 10 min. The upper layer of platelet-poor plasma was carefully removed, and 3 mL of PRP was collected from the lower layer and mixed. PRP preparation started 30 min before the anticipated conclusion of spinal endoscopic decompression. Next, routine platelet count testing was performed. To create the PRP gel, the PRP was mixed with 500 U/mL thrombin activator at a ratio of 10:1, and the gel was utilized immediately.

Percutaneous endoscopic nucleotomy

The surgical procedure was conducted using the transforaminal approach, with the interlaminar approach employed for the L5/S1 segment. General anesthesia combined with local anesthesia was administered. The patient was positioned prone, and fluoroscopy was used to identify the surgical intervertebral space. A skin puncture point was selected 8–10 cm lateral to the posterior midline. Under X-ray guidance, a puncture needle was inserted into the upper articular process bone, followed by a 0.8 cm skin incision. Sequential dilation was performed along the guide needle. After inserting the spinal endoscope (Karl Storz, Tuttlingen, Germany), a visual trephine was employed to partially remove and reshape the upper articular process bone and the hypertrophic yellow ligament at the lateral edge. The nucleus pulposus forceps were then used to excise the protruding nucleus pulposus tissue, and low-temperature plasma was utilized to shrink the annulus fibrosus. Once satisfactory nerve root decompression was achieved, thorough hemostasis was performed.

Next, the irrigation fluid pathway was closed, and any residual irrigation fluid within the working channel was aspirated. An appropriate volume of gelatin sponge (Pfizer, New York, USA) was then inserted at the site of the disc annulus rupture using nucleus pulposus forceps. Subsequently, the prepared PRP gel was injected into the disc through a specialized long injection needle (Becton, Dickinson and Company, Franklin Lakes, USA) under endoscopic visualization, with 3 mL being administered at the rupture site. In the simple spinal endoscopy group, this step was omitted, with only the suturing of the skin incision performed.

For the L5/S1 segment, the interlaminar approach involved selecting a puncture point 1 cm lateral to the posterior midline of the affected side at the surgical segment. The puncture needle was inserted into the surface of the intervertebral ligament, and sequential dilation was performed along the guide needle before inserting the working cannula. After traversing the yellow ligament, access to the spinal canal was obtained, and the remaining steps followed the transforaminal approach protocol.

Evaluation of observation indicators

The observation indicators were assessed using several methodologies to evaluate treatment outcomes. Differences in Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) scores and MRI Pfirrmann grading were evaluated preoperatively and at three postoperative time points: 3 days, 3 months, and 6 months. For the VAS, participants rated their pain intensity on a scale from 0 to 10, where 0 represents no pain, and 10 indicates the worst pain imaginable. The ODI was utilized to assess the degree of disability and functional impairment. It comprises ten items related to daily activities, with each item scored from 0, indicating no disability, to 5, indicating maximum disability. The total ODI score was then calculated and expressed as a percentage of the maximum possible score. Additionally, the degeneration of the intervertebral disc was evaluated using the Pfirrmann grading system. This system classifies disc degeneration on a scale from I, representing normal conditions, to V, indicating severe degeneration, based on specific MRI characteristics.

Clinical efficacy was further evaluated using the modified MacNab criteria, which focused on determining the rates of excellent and good outcomes at the final follow-up. A comparison of lumbar MRI Pfirrmann grading was conducted preoperatively and at 6–9 months postoperatively. Additionally, the statistical incidence of complications during the follow-up period was recorded.

Statistical analysis

We conducted a priori power analysis to determine the necessary sample size for detecting differences in VAS and ODI scores between groups, based on prior studies [6, 7] evaluating the efficacy of PRP in treating lumbar disc herniation. Using a significance level of 0.05, a power of 0.80, and a medium effect size (Cohen's $d \approx 0.5$), we determined that a sample size of 30 patients per group would be sufficient to achieve statistical significance.

The statistical analysis was performed using SPSS version 13.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics were calculated for all outcome measures, and continuous variables are presented as mean ± standard deviation (SD). Comparisons between groups for

Table 1 Comparison of Baseline Data between the two groups

Groups		Observation Group ($n=30$)	Control Group ($n=30$)	χ^2/t-value	*P*-value
Sex (cases)	Male	16	18	0.271	0.602
	Female	14	12		
Age (years)		44.20 ± 7.32	43.30 ± 6.26	0.515	0.608
Height (cm)		167.43 ± 6.92	168.20 ± 6.30	-0.449	0.655
Weight (Kg)		72.53 ± 5.54	75.10 ± 6.19	-1.691	0.096
BMI (Kg/m^2)		25.89 ± 1.64	26.54 ± 1.73	-1.509	0.137
Duration of Disease (months)		5.98 ± 4.46	6.40 ± 5.21	-0.333	0.741
Surgical Segment	L3/4	5	4	0.315	0.854
	L4/5	14	13		
	L5/S1	11	13		

Table 2 Comparison of preoperative and postoperative VAS scores between the two groups

Groups	Preoperative	Postoperative			Total	F-value	*P*-value
		3 d	3 months	6 months			
Observation Group ($n=30$)	7.07 ± 0.62	1.37 ± 0.62	0.77 ± 0.68	0.40 ± 0.56	2.40 ± 2.82	582.236	0.000
Control Group ($n=30$)	6.83 ± 0.95	1.93 ± 0.91	0.83 ± 0.75	0.37 ± 0.62	2.49 ± 2.70	511.785	0.000
Total	6.95 ± 0.96	1.65 ± 0.82	0.80 ± 0.71	0.38 ± 0.58	2.45 ± 2.76	1089.972#	0.000#
Test Statistics	0.936	-2.832	-0.362	0.219	$F=0.590$※	$F=3.396$★	
P-value	0.353	0.006	0.719	0.827	0.445※	0.019★	

#Time main effect F-value and *P*-value; ※Treatment main effect F-value and *P*-value; ★Interaction effect F-value and *P*-value

Table 3 Comparison of Preoperative and Postoperative ODI scores (%) between the two groups

Groups	Preoperative	Postoperative			Total	F-value	*P*-value
		3 d	3 months	6 months			
Observation Group ($n=30$)	50.70 ± 3.20	4.20 ± 0.71	3.93 ± 0.94	3.57 ± 0.93	15.60 ± 20.43	6159.923	0.000
Control Group ($n=30$)	50.80 ± 2.16	4.70 ± 0.75	4.00 ± 0.74	3.63 ± 0.72	15.78 ± 20.34	12911.658	0.000
Total	50.75 ± 2.70	4.45 ± 0.77	3.97 ± 0.84	3.60 ± 0.83	15.69 ± 20.34	16667.656#	0.000#
Test Statistics	-0.142	-2.645	-0.304	-0.310	$F=0.579$※	$F=0.342$★	
P-value	0.888	0.011	0.762	0.758	0.450※	0.795★	

#Time main effect F-value and *P*-value; ※Treatment main effect F-value and *P*-value; ★Interaction effect F-value and *P*-value

continuous variables, including VAS and ODI scores, were analyzed using two-sided Student's t-tests for normally distributed data or Mann-Whitney U tests for non-normally distributed data. Repeated measures analysis of variance (ANOVA) was applied to assess changes in VAS and ODI scores over time, followed by post hoc analysis with Tukey's test to determine differences at specific time points. The Chi-square test was utilized to compare categorical variables such as the modified MacNab criteria outcomes and MRI Pfirrmann grading. Statistical significance was established at an alpha level of 0.05.

Results

Baseline characteristics

The mean height of participants was 167.82 cm (±6.57), and the mean weight was 73.82 kg (±5.97). The body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared, yielding a mean BMI of 26.22 (±1.70). The general characteristics of the two groups are summarized in Table 1, which indicated no significant differences ($P>0.05$), thereby establishing comparability between the groups.

Follow-up duration VAS and ODI score analysis

All patients were followed up for a minimum of six months. Comparative analysis showed statistically significant differences in VAS and ODI scores at each postoperative observation point (3 days, 3 months, and 6 months) compared to preoperative scores in both groups, indicating a significant time effect ($P<0.05$). At 3 days postoperatively, a comparison of VAS and ODI scores between the two groups demonstrated statistical significance, revealing a group effect ($P<0.05$). However, no interaction effect was noted between time and group factors ($P>0.05$), as illustrated in Tables 2 and 3.

Table 4 Comparison of preoperative and postoperative MRI Pfirrmann Grading between the two groups

	Observation Group ($n=30$)	Control Group ($n=30$)	χ^2-value	*P*-value
Preoperative			0.183	0.669
I	0	0		
II	4	4		
III	17	15		
IV	9	11		
V	0	0		
Final Follow-up			6.105	0.013
I	0	0		
II	3	1		
III	20	13		
IV	7	15		
V	0	1		
χ^2-value	0.700	2.623		
P-value	0.791	0.105		

Table 5 Clinical efficacy evaluation using the Modified MacNab Criteria for the two groups

Groups	Sample Size	Excellent	Good	Fair	Poor
Observation Group	30	23	6	1	0
Control Group	30	21	7	2	0
χ^2-value	0.501				
P-value	0.778				

MRI Pfirrmann grading

The preoperative and final follow-up MRI Pfirrmann grading of the operated disc segment is presented in Table 4. No significant difference was found between the two groups preoperatively ($P=0.669$). However, at the final follow-up, the observation group exhibited better recovery compared to the control group ($P=0.013$).

Modified MacNab criteria

The evaluation using the modified MacNab criteria indicated no significant difference in the rates of excellent and good outcomes between the endoscopic PRP group (96.67%) and the simple endoscopic group (93.33%) ($P>0.05$), as shown in Table 5.

Complications

No patients experienced complications such as dural tears, nerve root injuries, infections, or hematomas. A typical case is depicted in Fig. 1.

Discussion

LDH treatment methods primarily encompass conservative and surgical approaches. For patients who do not respond to conservative treatment, surgical intervention becomes necessary. Traditional open surgery presents several disadvantages, including long incisions, considerable tissue damage, and prolonged recovery times. However, advancements in minimally invasive spinal techniques have led to the widespread adoption of procedures such as percutaneous endoscopic nucleotomy and nerve decompression. These minimally invasive methods offer significant advantages over traditional open surgery, including reduced trauma and faster recovery. Studies have shown that these techniques can be as effective as classical posterior laminotomy and nucleotomy decompression in achieving nerve decompression [8]. Despite the benefits of minimally invasive endoscopic surgery [9], clinical practice has highlighted that these techniques may inadvertently damage the normal physiological structure of the disc during the decompression of protruding tissue [10]. Given that the intervertebral disc is avascular and possesses limited self-repair capacity in the annulus fibrosus, postoperative repair of the disc is often inadequate and can accelerate disc degeneration, decrease disc height, and potentially lead to spinal instability, adversely affecting overall surgical outcomes [11].

PRP is derived from centrifuged whole blood and is characterized by a concentration of platelets that is significantly higher than that found in baseline plasma [12]. Specifically, the platelet concentration in PRP can exceed three times that of whole blood. Upon activation, platelets release a variety of growth factors and active components that effectively promote tissue repair, facilitate reconstruction, and inhibit local inflammatory responses [13–15]. Due to its unique therapeutic effects, PRP has been widely used in various medical fields since its inception and has been shown to positively impact tendon, bone, cartilage, and wound healing [16–20]. Moreover, there is a growing body of research focusing on the role of PRP in addressing disc degeneration. The rich cytokine composition of PRP serves as a foundation for the repair of the annulus fibrosus [21]. Animal studies have shown that PRP can effectively inhibit inflammation mediated by inflammatory mediators and pro-degradative enzymes, thereby preventing further degeneration of the disc [22]. Additionally, PRP promotes angiogenesis

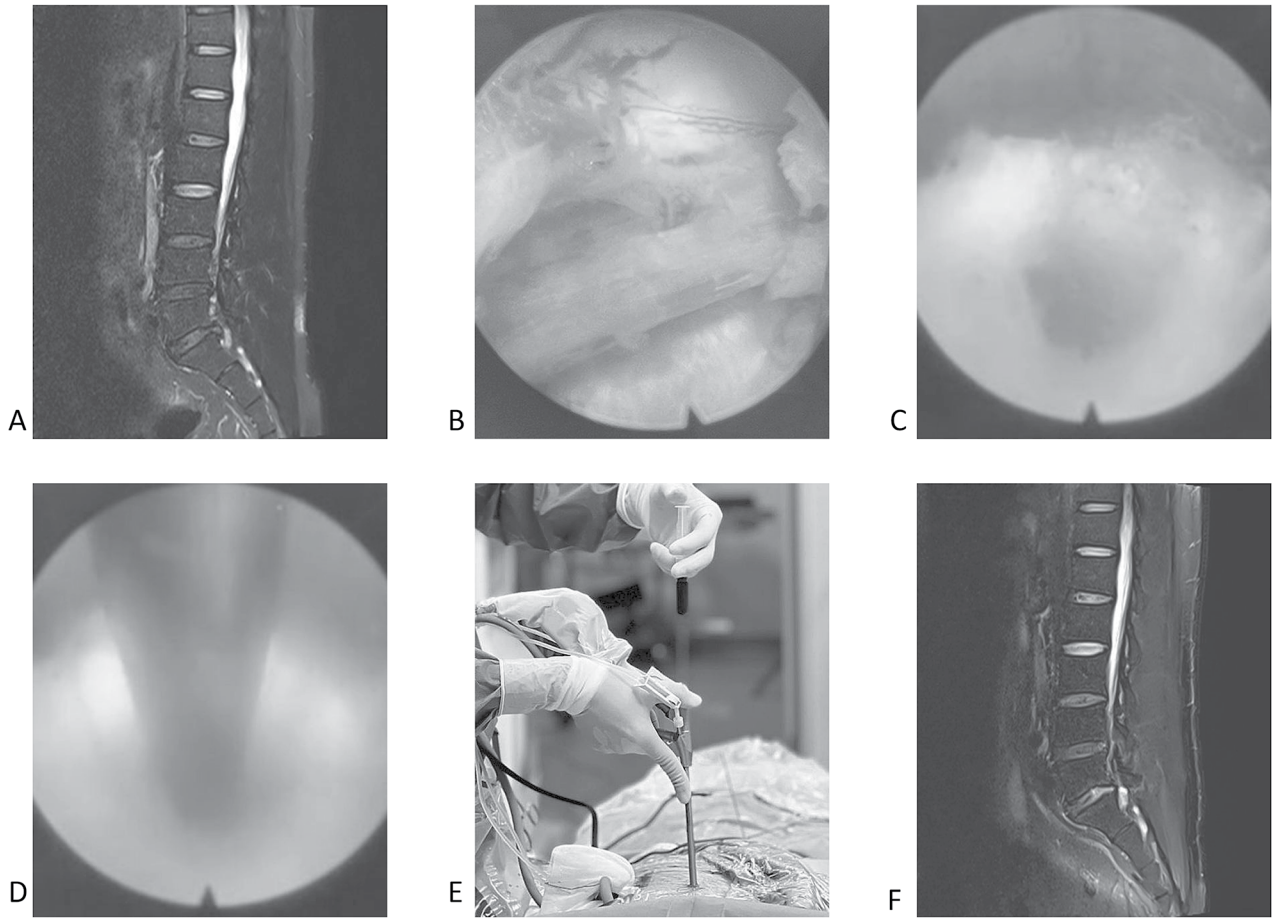

Fig. 1 Images of Posterior Endoscopic Nucleotomy Combined with PRP Gel Injection into the Disc. (**A**) Preoperative MRI. (**B**) Intraoperative Endoscopic View of Nerve Root. (**C**) Gelatin Sponge at Annulus Fibrosus Rupture Site. (**D**) Injection Needle Entering the Disc. (**E**) PRP Injection. (**F**) MRI 9 Months Postoperatively

and stimulates the proliferation of inner annulus fibrosus chondrocytes, supporting the repair of the annulus fibrosus and regeneration of the nucleus pulposus. Clinical studies have confirmed that intradiscal injection of PRP for the treatment of low back pain can lead to significant symptom improvement, marked reductions in pain scores, and is considered both safe and effective [22, 23].

Currently, some scholars have explored the combination of spinal endoscopy and PRP therapy for treating patients with LDH. However, reports on this approach remain limited. For instance, Bhatia reported a study involving ten patients with lumbar diseases exhibiting radicular symptoms. In this study, 5 mL of PRP was injected into the compressed nerve root within the epidural space via the interlaminar approach, assisted by endoscopy. This intervention resulted in varying degrees of pain relief within three months, with no reported complications [24]. Other studies have also demonstrated that combining endoscopic techniques with PRP injection for LDH treatment is safe and effective, as this approach appears to delay disc degeneration and promote disc repair [7]. In our study, we observed significant improvements in VAS and ODI scores at all postoperative observation points (3 days, 3 months, and 6 months) when compared to preoperative scores. These results confirmed good clinical efficacy in both the observation and control groups. Notably, at 3 days postoperatively, VAS and ODI scores exhibited statistically significant differences between the two groups. However, no significant differences were observed at the 3-month and 6-month follow-ups, suggesting that the PRP injection may provide a short-term inhibitory effect on local inflammation. The final follow-up assessment using the modified MacNab criteria showed no significant difference in clinical efficacy between the groups. However, MRI Pfirrmann grading at the 6–9 month follow-up indicated that the observation group outperformed the control group. This finding suggests that PRP may play a significant role in promoting disc repair following endoscopic procedures. Additionally, throughout the follow-up period,

no infections or complications were reported in patients treated with intradiscal PRP injections, further confirming the safety of this treatment. Several important points should be noted in this study: First, during endoscopic disc nucleotomy, it is essential to limit and protect the area of annulus fibrosus rupture to facilitate subsequent disc repair. Second, thorough hemostasis must be achieved prior to PRP injection, ensuring that no significant bleeding points are present under endoscopic visualization. Third, after thermal coagulation and shaping of the annulus fibrosus rupture, it is advisable to fill the area with an appropriate volume of gelatin sponge before injecting PRP gel, as this step helps prevent the loss of active PRP components. Finally, selecting young and middle-aged patients with relatively mild disc degeneration and high moisture content in the nucleus pulposus tissue may enhance the reparative effects of PRP [6].

Despite the interesting findings described, several limitations should be clarified. First, the sample size was relatively small, which may limit the generalizability of the findings. Future studies should involve larger cohorts to validate these results across diverse populations. Second, the follow-up duration of six months may not be sufficient to assess the long-term effects and potential complications of the treatment, such as re-herniation or disc degeneration in the treated segments. Longer follow-up periods, ideally 12 months or more, are recommended to evaluate the sustainability of clinical outcomes and the long-term impact of PRP on disc repair and degeneration. Additionally, the lack of a control group receiving PRP alone limits the ability to fully assess the additive benefits of PRP in this context. Thus, future research could explore the underlying mechanisms of PRP and consider stratifying patients based on specific characteristics, such as age and severity of degeneration, to optimize treatment protocols. Lastly, this study did not account for potential variability in PRP composition between patients, as preparation methods and growth factor concentrations can vary significantly. Standardizing PRP composition or measuring the concentration of key growth factors may enhance the study's credibility in attributing observed effects specifically to PRP treatment.

Conclusion

This study demonstrates that the combination of spinal endoscopic nucleotomy with intradiscal PRP injection could be a safe treatment strategy for young and middle-aged patients with LDH. Although the MRI Pfirrmann grading indicated improved disc repair in the observation group at the final follow-up, clinical outcomes assessed by the modified MacNab criteria showed no significant differences between the groups. These findings suggest that while PRP may enhance radiological indicators of disc repair post-endoscopy, its impact on clinical outcomes remains to be established. Further research is warranted to elucidate the potential benefits of PRP in clinical practice.

Abbreviations

PRP	Platelet-rich plasma
LDH	Lumbar disc herniation
VAS	Visual Analogue Scale
ODI	Oswestry Disability Index

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None.

Author contributions

Conceptualization, H.Q. and B.L.; methodology, H.Q.; software, B.L.; validation, H.Q., G.L. and Y.H.; formal analysis, S.L.; investigation, Z.Z.; resources, H.Q.; data curation, Z.Z.; writing—original draft preparation, B.L. and Z.Z.; writing—review and editing, H.Q.; visualization, G.L.; supervision, Y.H.; project administration, H.Q.; funding acquisition, Z.Z. All authors have read and agreed to the published version of the manuscript.

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Data availability

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

Declarations

Ethics approval and consent to participate

The trial protocol was reviewed and approved by the Ethics Committee of Zhongshan Torch Development Zone People's Hospital, and all participants voluntarily signed informed consent forms.

Competing interests

The authors declare no competing interests.

Consent of publication

All authors have read and agreed to the published version of the manuscript.

Author details

[1]Department of Orthopaedics, Zhongshan Torch Development Zone People's Hospital, Zhongshan 528437, Guangdong, China
[2]Department of General surgery, Zhongshan Torch Development Zone People's Hospital, Zhongshan 528437, Guangdong, China

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