

Efficacy of automated percutaneous lumbar discectomy for lumbar disc herniation in young male soldiers

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Abstract

Lumbar disc herniation (LDH) often results in back pain and radicular pain and is frequently treated with minimally invasive non-surgical methods in Korean Armed Forces Hospitals. Automated percutaneous lumbar discectomy (APLD) has been reported to have good clinical outcomes with low complication rates; however, the clinical efficacy of APLD performed in young male soldiers is uncertain. In order to clarify the efficacy of APLD for the treatment of LDH in young male soldiers, we designed a retrospective case-control study to compare patients who received APLD with patients treated with epidural steroid injection (ESI) alone.

A total of 181 patients were enrolled and divided into the APLD (n=92) and ESI (n=89) groups according to the treatment modality. A simple logistic regression analysis was conducted to clarify the difference between the two. To optimize patient selection, APLD group was additionally divided for subgroup analysis into favorable (n=59) and unfavorable (n=33) groups based on satisfaction scales. A simple logistic analysis was also performed.

The differences between pre- and postoperative numerical rating scale of pain ($P=.0027$) and hospital-own satisfaction scale ($P=.0045$) of the APLD group were significantly better compared to those of the ESI group. In terms of subgroup analysis, single-level pathology ($P=0.244$) and protruded disc ($P=.0443$) were associated with favorable outcomes, whereas dual pathology and extruded disc were related with unfavorable outcomes.

APLD using Dekompressor, performed in young male soldiers with back and radicular pain owing to LDH, showed better clinical outcomes compared to the ESI only therapy. Additionally, a single-level pathology with protruded disc was associated with favorable outcomes and may be indicated for treatment.

Abbreviations: APLD = automated percutaneous lumbar discectomy, ESI = epidural steroid injection, LBP = Lower back pain, LDH = lumbar disc herniation, NRS = numerical rating scale, ROK = Republic of Korea.

Keywords: automated percutaneous lumbar discectomy, Dekompressor

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1. Introduction

Lumbar disc herniation (LDH) is one of the most common causes of back pain and radicular pain and results in great socioeconomic burden. The gold standard for treating LDH is still under debate, and both surgical and non-surgical treatments are considered as possible options. The Spine Patient Outcomes Research Trial^[1] demonstrated the favorable outcomes of surgical discectomy, but this technique depends on the training and expertise of the surgeon and also on the resources available.^[2] Furthermore, surgical discectomy is also associated with significant morbidity and perioperative complications depending on patient-associated factors.^[3] Concerns regarding these disadvantages associated with surgical intervention are not limited to elderly patients but also to young patients. Thus, multiple minimally invasive disc decompression techniques have been developed and increasingly used due to advantages such as smaller wounds, fewer complications, and short hospitalization days with favorable outcomes.^[4–7]

Automated percutaneous lumbar discectomy (APLD) is a minimally invasive treatment modality for LDH, and Dekompressor (Stryker, Kalamazoo, MI, USA), a utilized high revolutions-per-minute mechanical instrument, has been identified as a novel device for APLD. This technique has shown good clinical outcomes compared to conservative treatments by several previous reports and has shown low complication rates.^[8,9] Due to several of the merits of the device, APLD using Dekompressor

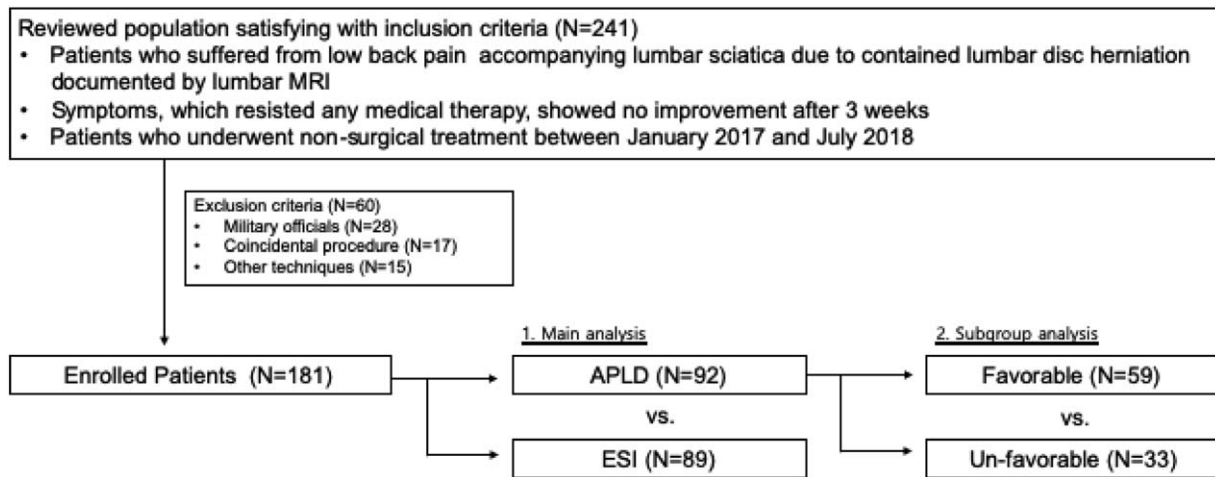


Figure 1. Flowchart of the patient enrollment and classification process.

is increasingly becoming a treatment option for LDH in the Republic of Korea's (ROK) Army, which is a unique environment, consisting mostly of a young male cohort. The ROK's army soldiers suffering from LDH tend to avoid surgery because military manuals indicate that service men who undergo surgery should go through deliberation and be discharged from the service. Additionally, even when the patients prefer surgical discectomy, the armed forces hospitals occasionally cannot provide these surgeries due to the limited medical resources, especially in the frontlines. Consequently, under the limited settings of military hospitals, APLD and epidural steroid injection (ESI) are the most commonly performed procedures for young male soldiers with LDH. In the present study, we attempted to determine the efficacy of APLD for LDH in young male soldiers by comparing the clinical and radiologic data of the APLD group with those of the ESI group. Furthermore, we analyzed the preoperative clinical and radiologic characteristics of the APLD group to determine which patients would be optimal candidates for this specific treatment method.

2. Methods

2.1. Patients

This study was approved by the Institutional Review Board of the Human Research Center of the institution, and requirement for informed consent was waived because of its retrospective design. We retrospectively reviewed 241 patients who had lower back pain (LBP) and radiating pain; were diagnosed with contained LDH documented by a lumbar magnetic resonance image (MRI); were resistant to medical therapy for 3 weeks; and received treatment using non-surgical procedures in the Armed Forces Yangju Hospital between January 2017 and July 2018.

Sixty patients, who were identified as military officials ($n=28$), and whom were coincidentally treated by both ESI and APLD at different levels ($n=17$) or by different-targeting steroid injection techniques other than the trans-foraminal ESI, including a median branch block, an inter-laminar block, or a caudal block ($n=15$), were excluded. Military officials were excluded because of the heterogeneity of their age and the amount of physical activity compared with the majority of the enrolled patients.

Coincidental operations and other injection techniques were not considered because the treatment outcome between the options was unclear. A total of 181 patients were enrolled, and the flowchart showing the enrollment process is shown in Figure 1.

The general demographics, including age, sex, initial symptoms and its duration, detailed diagnosis documented by MRI of the lumbar spine, treatment modality, hospitalization days, and outcomes, were retrospectively reviewed. Treatment outcomes were evaluated by assessing the differences between the preoperative and postoperative (1 day) numerical rating scales (NRS) of pain and the hospital-own satisfaction scale on the date of discharge (Table 1). The MRI features of the LDH were evaluated in terms of levels, locations, and morphologic variance based on the "Nomenclature and Classification of Lumbar Disc Pathology" (Fig. 2).^[10]

2.2. Operative techniques

All the enrolled patients, diagnosed with a contained LDH, underwent ESI or APLD. The treatment options were properly selected by the patients after understanding the pros and cons of each treatment modality.

In the transforaminal ESI procedure, the patients were placed in the prone position on a radiolucent operating table. A 23-gauge spinal needle was inserted into the target foramen using an oblique fluoroscopy image. The target nerve root and its epidural space were outlined by the contrast, ensuring epidural flow of the contrast with no intravascular, intradural, or subcutaneous infiltration. A mixture of 1 mL dexamethasone 5 mg, 2 mL ropivacaine 1%, and 2 mL lidocaine 1% was injected. Finally, the spinal needle was removed.

APLD with Dekompressor was also performed under fluoroscopy (Fig. 3). The patient was placed in the prone position and the usual cutaneous sterilization was performed. After administering the local anesthetic along the trajectory of the extrapedicular disc access, a cannula with a stylet was introduced into the center of the disc. After confirming its radiological position within the disc using anteroposterior and lateral fluoroscopy views, the stylet was removed. The probe tip was then carefully advanced into the introducer cannula, and the discectomy procedure was initiated. The total activation time was

Table 1
Results of the simple logistic regression analysis between the ESI and APLD groups.

	ESI (n=89)	APLD (n=92)	Odds ratio (95% CI)	P
Age (years)	21.84 ± 1.40	21.85 ± 1.27	1.003 (0.81–1.25)	.9792
Symptoms			0.956 (0.49–1.85)	.8934
Unilateral	65 (73.03%)	68 (73.91%)		
Bilateral	24 (26.97%)	24 (26.09%)		
Duration (months)	7.51 ± 6.46	7.02 ± 5.86	0.99 (0.94–1.04)	.5965
Levels			0.72 (0.28–1.83)	.2072
L3/4	3 (3.37%)	2 (2.17%)		
L4/5	35 (39.33%)	50 (54.35%)		
L5/S1	39 (43.82%)	28 (30.43%)		
Dual pathology	12 (13.48%)	12 (13.04%)		
Hospitalization (days)	20.02 ± 10.20	24.28 ± 12.25	1.04 (1.01–1.06)	.0140*
NRS				
Preoperative NRS	3.03 ± 0.90	3.09 ± 1.10	1.03 (0.72–1.49)	.8633
Postoperative NRS	2.04 ± 0.77	1.57 ± 0.82	1.77 (1.28–2.46)	.0006*
ΔNRS (Pre-Post)	0.99 ± 0.98	1.52 ± 1.24	0.64 (0.48–0.86)	.0027*
Satisfaction scale			2.80 (0.51–15.43)	.0045*
1 Terrible	5 (5.62%)	2 (2.17%)		
2 Partially worsened	21 (23.60%)	9 (9.78%)		
3 No interval change	25 (28.09%)	22 (23.91%)		
4 Partially satisfied	33 (37.08%)	37 (40.22%)		
5 Satisfied	5 (5.62%)	22 (23.91%)		

APLD = automated percutaneous lumbar discectomy, CI = confidence interval, ESI = epidural steroid injection, NRS = numerical rating scale.
 *P < .05.

approximately 3 minutes, and the procedure ended when no more tissue was being removed or when the operator thought that the obtained materials were satisfactory. Then, the probe was replaced with the stylet, and the cannula was pulled out of the neuroforamen. After confirming the exact position with the contrast, the aforementioned mixture was also injected for this group. Perioperative antibiotics were given for 3 days.

Postoperatively, patients received conservative treatment including oral medication and minimal physical therapies for several days until they were ready to be back to the units and carry on their duties.

2.3. Statistical analysis

The enrolled populations were divided into the “ESI” and “APLD” groups according to their treatment modality. Continuous variables are reported as median values ± standard deviation, while categorical data are reported as frequencies and percentages. A simple logistic regression analysis was performed to identify the differences between the groups using a standard software (version 23.0, SPSS, IBM, Chicago, IL). Statistical significance was defined as a P-value < 0.05.

Subgroup analysis was also performed after dividing the APLD group into favorable (4 and 5 of satisfaction scale) and unfavorable (1–3 of satisfaction scale) outcome groups. A simple logistic regression analysis was also performed to identify the factors associated with favorable outcomes.

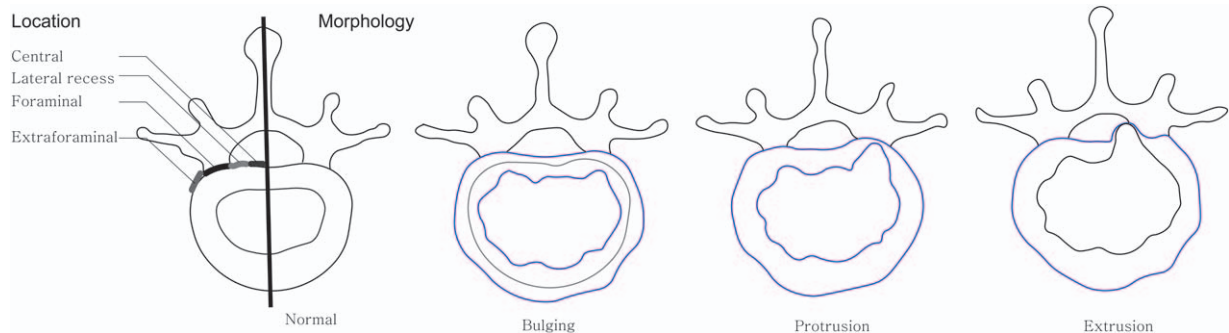


Figure 2. Classification of LDH according to morphology and location. (A) The location of the LDH was classified as “central”, “lateral recess”, “foraminal”, and “extraforaminal”. Additionally, “diffuse” was defined as a herniated disc compressing the thecal sac and root along 2 or more classified locations. (B) The morphology of LDH was classified as “bulging”, “protrusion”, and “extrusion”. LDH = lumbar disc herniation.

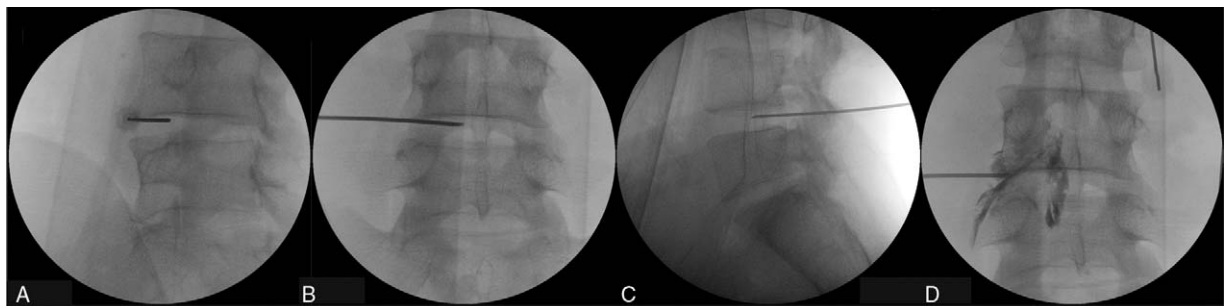


Figure 3. Fluoroscopic images during the APLD procedure. (A) Under an oblique view during fluoroscopy, the stylet and cannula of the Dekompessor were engaged in the herniated lumbar disc by passing through Kambin’s triangle. (B) Under the anterior–posterior view of fluoroscopy, the stylet and cannula were identically positioned at the center of the herniated disc. (C) Under the lateral view of fluoroscopy, the stylet and cannula were located at the half to posterior one third of the herniated disc space. (D) After percutaneous discectomy, the stylet and cannula were pulled out to the neuroforamen and the contrast was injected to confirm the exact position of the cannula in the epidural spaces before injection of the steroid mixture. APLD = automated percutaneous lumbar discectomy.

Table 2
The results of subgroup analysis between favorable and unfavorable groups of patients who received APLD.

	Favorable; Sat 4–5 (n=59)	Unfavorable; Sat 1–3 (n=33)	Odds ratio (95% CI)	P
Age	21.90 ± 1.34	21.76 ± 1.15	0.913 (0.645–1.292)	.6081
Symptom			1.1 (0.419–2.886)	.8464
Unilateral	44 (74.58%)	24 (72.73%)		
Bilateral	15 (25.42%)	9 (27.27%)		
Duration (months)	6.71 ± 5.47	7.58 ± 6.54	1.025 (0.954–1.102)	.4965
Hospitalization (days)	22.14 ± 9.69	28.12 ± 15.26	1.042 (1.004–1.082)	.0293*
Level			0.389 (0.023–6.654)	.1202
L3/4	1 (1.69%)	1 (3.03%)		
L4/5	36 (61.02%)	14 (42.42%)		
L5/S1	18 (30.51%)	10 (30.3%)		
Dual pathology	4 (6.78%)	8 (24.24%)	4.4 (1.211–15.984)	.0244*
Morphology			0.792 (0.281–2.226)	.0443*
Bulging	19 (32.2%)	9 (27.27%)		
Protrusion	32 (54.24%)	12 (36.36%)		
Extrusion	8 (13.56%)	12 (36.36%)		
Location			1.636 (0.482–5.561)	.8535
Central	11 (18.64%)	9 (27.27%)		
Lateral recess	18 (30.51%)	8 (24.24%)		
Foraminal	11 (18.64%)	7 (21.21%)		
Extraforaminal	3 (5.08%)	1 (3.03%)		
Diffuse	16 (27.12%)	8 (24.24%)		

APLD=automated percutaneous lumbar discectomy, CI=confidence interval, NRS=numerical rating scale, Sat=satisfying scale.

* $P < .05$.

3. Results

The results of the simple logistic regression analysis between the ESI and APLD groups are shown in Table 1. There were no significant differences in age, symptoms, duration, pathologic levels, and preoperative NRS scores. However, the postoperative NRS score was significantly improved ($P=.0006$) and the satisfaction scale was significantly higher ($P=.0045$) in the APLD group. In addition, the hospitalization stay of the APLD group was also longer than that of the ESI group ($P=.0140$).

Table 2 shows the results of the subgroup analysis comparing the favorable and unfavorable outcome groups. The favorable group was significantly associated with a single-level pathology ($P=.0244$) and shorter hospitalization stays (.0293). Moreover, the morphology of the herniated disc was significantly different between the groups: a protruded disc was mostly observed in the favorable group, whereas an extruded disc was more frequently observed in the unfavorable group ($P=.0443$). The pathologic levels and location of the LDH showed no significant differences between the groups.

4. Discussion

According to our results, APLD performed in young male soldiers showed greater clinical efficacy and patient satisfaction compared to the ESI alone therapy. Additionally, a favorable outcome was achieved when the patients presented with a single-level of herniation with a protruded disc.

In order to evaluate the efficacy of APLD, we compared the clinical outcomes of the patients receiving APLD to those whom underwent ESI alone. As we reached the epidural space while approaching the intervertebral disc through the safe window delineated by Kambin's triangle, an additional ESI is routinely

performed without any need for additional punctures or invasive procedures during APLD as we previously stated in the methods. Therefore, comparing the clinical outcomes between 2 groups could clearly reflect the clinical efficacy of decompressed disc pressure, and greater improvement in APLD group might suggest the actual efficacy of APLD itself (not a steroidal effect). In terms of the clinical outcomes measured by the improvement in the NRS pain scale after the procedure, our results revealed that APLD showed significantly better results than did ESI alone. This result of APLD is compatible with previous studies which were conducted in general populations, suggesting that APLD can be equally effective for the young soldier cohort as well.^[11–15] Moreover, the subjective satisfaction scale indicated that the young male soldiers were satisfied with their pain relief after undergoing APLD for LDH. Unfortunately, APLD required, on average, 4 more days of hospitalization compared with ESI. This may be a confounding factor in the interpretation of the clinical significance of this treatment. However, 2 patients who presented with symptoms of root irritation postoperatively showed a longer hospitalization (more than 60 days). If these patients had been excluded, the result might have been different.

To maximize the clinical efficacy by figuring out which are the optimal candidates for APLD, we divided the soldiers assigned to the APLD group into 2 groups according to their clinical outcomes and conducted subgroup analyses. By comparing these 2 subgroups, we discovered that soldiers with certain characteristics responded better to APLD. Specifically, soldiers with a single-level pathology and protruded herniated discs showed favorable outcomes after receiving APLD, whereas those with extruded discs and dual-pathology LDHs had a larger possibility of lesser improvement postoperatively.

In terms of morphology of LDH, the mechanisms of APLD may be associated with the poor outcome of extrusion type and favor result of protrusion; the identical position of the cannula tip is at the center of the nucleus pulposus and that the decreased pressure might not be delivered effectively in extruded disc. In terms of unfavorable outcome of dual pathologic levels, patients diagnosed with multi-level LDHs may have symptoms consequent to multifactorial pain sources, and that could result in poor responses to the treatment. The results of the subgroup analysis are of interest as they may provide us with a clue regarding which patients might benefit by having this specific procedure.

LBP and lumbar sciatica are a significant public health problem that cost a significant amount of public funds and work days lost.^[16–18] Particularly, military service members are frequently exposed to strenuous physical activities, which might easily induce excessive loading to the spine and could result in LDH causing back pain with or without sciatica.^[19] These medical issues have a great impact on the activity and fitness of soldiers in service and on their overall mission readiness.^[20] Therefore, while LBP due to LDH is an issue among elderly people in general, the same disease is of great interest for young army soldiers as well in military hospitals. The armed forces hospitals of the ROK Army have obligations and duties to treat these young LDH patients effectively with limited resources and achieve a high rate of return of soldiers to their unit within shorter periods and with lower complication rates.

Even though there are some controversies about the best treatment modality among the surgical or non-surgical techniques, minimally invasive techniques are frequently chosen by the physicians and the patients owing to the advantages of smaller wounds, fewer complications, short hospitalization stays, and

favorable outcomes.^[4–7] These advantages meet the needs of military services. Due to the aforementioned benefits and along with the potential of being discharged from military services after surgical discectomies, young soldiers frequently choose non-surgical options for the treatment of their LDHs. Among various minimally invasive techniques, APLD has the following advantages: (1) the largest instrument is 1.5 mm in diameter, and this minimally-sized diameter lowers the risk of injuring the normal spinal structures, including the posterior common vertebral ligaments and the annulus fibrosus; (2) removing a few cubic centimeters of the disc results in a significant decrease in the intradiscal pressure and therefore decreases the disco-radicular related pain; (3) the procedure induces minimal injury to the tissues, which suggests that the disc height might be maintained, or that it subsides more slowly, thus allowing the body itself some time to adapt to this change; (4) the device is easy to operate, and therefore even young surgeons, even those with minimal experience, could easily learn this technique and perform the operation. Most of the neurosurgeons in Korea serve as medical officers in the early years of their careers, and this might be a great advantage in the military medical perspective; (5) the device is a single-use disposable probe that can be easily equipped and supervised, which requires minimal human resources.^[13,14] Considering the benign nature of the procedure and its cost, it appears that APLD can be recommended for a highly select group of young male soldiers meeting the right inclusion criteria.

To our knowledge, numerous investigations have been conducted to prove the efficacy of APLD and its superiority to other discal therapies.^[12–15] In spite of these efforts, the true effectiveness of APLD may be less than that reported and also raises questions. The early studies showed the greatest outcomes, but these were sponsored by the device manufacturer and involved the inventor of the device.^[13,14] The later studies reported favorable outcomes at both the short and long-term follow-ups.^[21] However, they failed to prove better outcomes compared with other discal therapies or surgery.^[11,12,22] Recent review articles concluded that percutaneous disc decompression by any of the modalities may still be an attractive option for patients with LDHs even though there is limited evidence.^[8,23,24] Our study is novel since it is the only study to investigate the effects of APLD in a young male soldier population, which is a very unique “healthy” cohort that enables us to evaluate the true efficacy of APLD by excluding other degenerative spinal disorders. Our results show that, by adding another minimally invasive percutaneous procedure, namely APLD, we can achieve maximal relief of pain without further risks of complications and meet the need of soldiers as well as the ROK army. Furthermore, by dividing the cohort into 2 groups according to the clinical outcomes (favorable outcome group vs unfavorable outcome group), we discovered additional information suggesting that APLD had even better outcomes for specific LDH types, that is, single-level pathology and protruded disc.

There are certain limitations in our study. First of all, the long-term efficacy of APLD was not proven in the present study. The time frame of our study is set up at “postoperative 1 day” and “discharging date”, which are far different from the previous long-term observational studies. We choose these time frames due to the special environment of the entire cohort: (1) long-term follow-up is limited with soldiers because they would not visit the military hospital if they are improved or have only tolerable complaints, (2) the soldiers could only discharge if they are able to carry on their duties in the military units, so the evaluation on

discharging date would reflect the latest physical status of the soldiers, and (3) both ESI and APLD were performed to relieve the currently existing pains, not for the long-term efficacy of 3 or 6 months follow-up. Secondly, the results of our study are limited to be generalized because of the retrospective design and special cohort of young male soldiers. APLD performed in young male soldiers was certainly effective, however, it should be carefully considered when performed in aged with multifactorial sources of pains.

5. Conclusion

APLD using Dekompressor, performed in young male soldiers diagnosed with LDH and presenting with back and radicular pain, showed significantly better outcomes based on the differences between the pre- and postoperative (NRS) ($P=.0027$) and the hospital-own satisfaction scale ($P=.0045$) compared with the ESI alone therapy. Furthermore, single-level pathology ($P=.0244$) and protruded disc ($P=.0443$) were significantly associated with favorable outcomes and can be indicated for treatment with better outcomes.

Author contributions

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