

# Characteristics and Factors Associated With Spontaneous Regression of Extruded Lumbar Disc Herniation: A Retrospective Analysis of 31 Cases

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## Research Article

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# Abstract

## *Background*

Lumbar disc herniation (LDH) is a common condition leading to high individual, social, and economic impacts. Reported rates of spontaneous resorption of LDH vary from 35% to 100%; however, it remains unclear how spontaneous absorption, rather than re-protrusion, can be maximized.

## *Purpose*

The main objective of this study was to determine the characteristics and factors enabling for spontaneous regression of extruded LDH.

## *Design*

A retrospective single center case series.

## *Patient sample*

Inpatients (n = 33) with LDH who experienced spontaneous regression between September 2015 and June 2020.

## *Outcome measures*

Questionnaire responses and magnetic resonance imaging (MRI)-determined hernia regression.

## *Methods*

A questionnaire was distributed to patients to assess factors associated with hernia resorption, the volume of herniated intervertebral discs evaluated by MRI, and the absorption ratio calculated. Multiple linear regression was used to explore factors enabling spontaneous herniated disc regression.

## *Results*

A total of 31 patients received a mean of 5.90 conservative treatments during hospitalization, and 1.91 during rehabilitation. Of patients, 90.32% underwent bed-rest during the acute phase of the disease, and 61.29% did so during rehabilitation. Rehabilitation exercise was undertaken by 93.55% of patients, with a mean of 2.42 exercise methods per patient. Waist lumbosacral orthosis devices were worn by 80.65% of patients. Multiple linear regression showed that bed-rest days in the acute phase ( $X_1$ ), herniation type ( $X_2$ ), time wearing lumbosacral orthosis ( $X_3$ ), onset-treatment duration ( $X_4$ ), and days of bed-rest days in rehabilitation ( $X_5$ ) had significant effects on the spontaneous regression ratio ( $y$ ) of herniated discs (all  $P < 0.05$ ). The optimal linear regression equation was  $y = 0.616 + 0.497X_1 - 0.478X_2 + 0.384X_3 - 0.343X_4 - 0.241X_5$ .

## ***Conclusions***

Our findings support that patients with extruded or sequestered LDH should receive comprehensive treatment. Early treatment, early bed-rest, and lumbosacral orthosis protection promote the spontaneous regression of herniated discs; however, bed-rest during rehabilitation is a poor prognostic factor. Adherence to rehabilitation exercise will be beneficial to the recovery of patients with LDH.

## **Introduction**

Lumbar disc herniation (LDH) is a frequently-occurring disease that imposes a heavy burden on both individuals and society. First line treatment is nonoperative treatment [1], which includes drug therapy, such as oral medicine, epidural anesthesia, also includes non-drug therapy, such as physical therapy, acupuncture, and traction also good options [2] [3]. Since Guinto et al. reported the first case of spontaneous resorption of LDH in 1984 [4], an increasing number of cases of spontaneous regression have been described, with reported rates of spontaneous resorption varying from 35–100% [5]; for example, the incidence in the United Kingdom was 82.94%, while in Japan it was 62.58%. The overall incidence of spontaneous resorption after LDH, based on analysis of the findings from 11 cohort studies, was 66.66% [6].

The rate of spontaneous regression is influenced by numerous factors, including hernia type, hernia volume, age, optimal time of absorption, and other factors. Disc sequestration has the highest reabsorption rate, followed sequentially by extrusion, protrusion, and bulge [5]. The incidence of spontaneous absorption is highest in patients between 20 and 65 years old [6], and magnetic resonance imaging (MRI) showed that the fastest spontaneous absorption occurred within 2 months, and that absorption can still occur after one year [7]. The overall absorption rate was reported as 42.86% in one study [5], and 33.33% in another [8]. Factors including imaging modalities, inclusion criteria, follow-up time, classification of herniation, and regression criteria can impact the evaluation of spontaneous regression of LDHs; however, dynamic changes in herniated intervertebral discs should also be considered. Herniated lumbar discs are not always spontaneously absorbed, and both absorption and re-protrusion can occur simultaneously [9]. Family history, smoking, obesity, diabetes, taller height, and heavy work are important factors negatively influencing the absorption of LDH, while physical exercise and bed-rest are favorable [10, 11].

Spontaneous regression generally takes between 3 and 24 months [5] and how to ensure that herniated discs progress towards spontaneous absorption, rather than re-protrusion, is an unsolved problem of interest to both patients and clinicians. There are rare cases of spontaneous resorption of LDH, so a retrospective study was performed. The purpose of this study was to identify characteristics and factors enabling disc resorption by conducting a retrospective clinical analysis of 33 recovered patients with LDH.

## **Methods**

# Patients and methods

The subjects of this retrospective analysis study were 33 patients with LDH who received conservative treatment during hospitalization at Henan Provincial Luoyang Orthopedic-Traumatological Hospital (Henan Provincial Orthopedic Hospital) from September 2015 to June 2020. Their symptoms were relieved, and spontaneous resorption of the lumbar disc had occurred. Subjects participated in a questionnaire survey. The inclusion criteria for the study were: lumbar disc herniation, which was first identified by MRI, and follow-up MRI showing that the herniated disc was completely or partially absorbed, and that patients received nonoperative treatment, and their clinical symptoms improved significantly.

## Questionnaire

Attending physicians contacted patients via WeChat or telephone. After the patient consented, they received a paper or electronic version of the questionnaire. Subjects completed the questionnaire themselves, or with the help of family members, and returned it to their attending doctor. The questionnaire consists of closed and open-ended questions, for example, patients need to fill in time in bed each day and number of days spent in bed. The questionnaire had three sections: 1) social-demographic characteristics (e.g., age, sex, height, weight, education level, occupation, smoking, drinking alcohol); 2) treatment and rehabilitation (e.g., time of symptoms onset, complications, onset-to-treatment interval, received treatments, bed-rest, lumbosacral orthosis, rehabilitation exercise, relapse symptoms, inducements, employment, mood, family support, sequelae); 3) self-rated enabling factors, this is an open-ended question, patients describe factors that they believe are conducive to disc absorption.

The questionnaire defined and categorized 1) smoking, 2) alcohol consumption, 3) occupation type, 4) mood, and 5) family support as follows: 1) smoking and non-smoking, where smoking was defined as having smoked at least 1 cigarette per day for at least 1 year; 2) alcohol abuse and no addiction, where alcohol abuse was defined as the alcohol consumption > 20g per day, or drunkenness at least twice a month; 3) occupations were defined as physical workers, mental workers and others; 4) normal and emotional distress, self-evaluated depression, anxiety; and 5) support for nonoperative treatment, support for surgery, and disagreement.

## Hernia measurement

The volume, location, and type of herniated disc were assessed using a 3.0 T MRI scanner (Siemens MAGNETOM Skyra); 13 sections were scanned on T1 and T2 weighted sagittal planes, with layer thickness 3 mm and distance 3 mm. Herniated disc volume was calculated by two skilled radiologists, based on the methods previously described by Peng-Fei Yu et al. [12](Fig. 1). Resorption ratios were calculated as follows:

Resorption ratio = (pre-treatment herniated disc volume – post-treatment herniated disc volume/pre-treatment herniated disc volume) × 100%.

# Statistical analysis

Statistical analysis was performed using SPSS 20.0 software. Continuous data are expressed as mean  $\pm$  standard deviation (SD), count data are represented as constituent ratio(%). The independent samples t-test and one-way ANOVA were used to determine statistical significance ( $\alpha = 0.05$ ). Variables with significant differences and risk factors associated with LDH, based on published articles, were incorporated in multivariate regression analysis. Different categorical variables were treated as dummy variables and then included in regression analysis. The optimal regression equation was generated using multivariable linear regression models (by the backward method), and gradually eliminating non-significant independent variables.

## Results

### General patient characteristics

A total of 33 subjects received the questionnaire, of which 31 did and 2 did not complete it, respectively. Of the 31 included patients, 13 (41.94%) were male and 18 (58.06%) female. Mean  $\pm$  SD (range) age was  $36.97 \pm 9.48$  (22–65) years. Regarding education, 23 patients (74.19%) had college education or higher. Ten (32.26%) patients had emotional distress and 28 (90.32%) families supported conservative treatment. During the rehabilitation period, 29 patients (93.55%) received follow-up with a clinician or returned for follow-up visits (Table 1). Of 33 herniated lumbar discs from the 31 included patients, 31 were partly or completely reduced in size (Fig. 2). The majority of herniated discs occurred at the L4–L5 (32.26%) and L5–S1(61.29%) levels. The mean spontaneous absorption ratio was  $0.69 \pm 0.22$ .

Table 1  
Baseline characteristics of patients with spontaneous regression of  
herniated lumbar discs

Characteristic	n (%)	F/t	Sig
Sex			
Male	13 (41.94%)		
Female	18 (58.06%)	-0.72 <sup>a</sup>	0.48
Age (years)	36.97 ± 9.48	1.51 <sup>b</sup>	0.34
Education			
Illiterate	2 (6.25%)		
Primary/Junior	3 (9.38%)		
Senior /Technical Secondary School	3 (9.38%)		
College/ Undergraduate	18 (59.38%)		
Graduate	5 (15.63%)	1.79 <sup>b</sup>	0.16
Alcohol consumption			
No	30 (96.78%)		
Yes	1 (3.22%)	0.08 <sup>a</sup>	0.94
Smoking			
No	30 (96.78%)		
Yes	1 (3.22%)	0.32 <sup>a</sup>	0.75
Mood			
Normal	21 (67.74%)		
Emotional distress	10 (32.26%)	-0.93 <sup>a</sup>	0.36
Family support			
Yes	28 (90.32%)		
Disagreement	3 (9.68%)	0.39 <sup>a</sup>	0.70
Follow-up			

<sup>a</sup>Independent-samples t-test; <sup>b</sup>One-way ANOVA

Characteristic	n (%)	F/t	Sig
No	2 (6.45%)		
Yes	29 (93.55%)	-0.46 <sup>a</sup>	0.65
Occupation			
Physical worker	5 (16.10%)		
Mental worker	18 (58.10%)		
Other	8 (25.80%)	1.40b	0.25
Hernia type			
Extrusion	20 (65.63%)		
Sequestration	11 (31.25%)	-2.72a	0.01
Exercise			
No	2 (6.45%)		
Yes	29 (93.55%)	-1.17a	0.25
Lumbosacral orthosis			
No	5 (16.13%)		
Yes	26 (83.87%)	0.12a	0.91
Treatment during rehabilitation			
No	9 (29.03%)		
Yes	22 (70.97%)	0.92a	0.37
Relapse during rehabilitation			
No	10 (32.26%)		
Yes	21 (67.74%)	-0.003a	1.00
Working during rehabilitation			
No	3 (9.68%)		
Yes	28 (90.32%)	0.56a	0.58
<sup>a</sup> Independent-samples t-test; <sup>b</sup> One-way ANOVA			

## Treatment methods, symptoms, and exercises

During hospitalization, all patients received numerous Traditional Chinese Medicine(TCM) therapies and modern medicine to relieve symptoms, with a mean number of therapies per person of 5.90. TCM fumigation, physiotherapy, traction, massage, and acupuncture were commonly used non-drug therapies, while, oral drugs and sacral anesthesia were commonly used drug therapies. During rehabilitation, the number of subjects receiving outpatient treatment reduced to 21 (67.74%), and the mean number of treatment methods reduced to 1.91 per patient; at this stage, plasters, oral drugs, and patented Chinese medicines became the most frequent treatment methods (Table 2).

Table 2  
Treatments and rehabilitation exercises

<b>Inpatient treatment</b>	<b>Frequency</b>	<b>Rehabilitation treatment</b>	<b>Frequency</b>	<b>Exercise</b>	<b>Frequency</b>
TCM fumigation	29	Plaster	12	Back Stretches	23
Oral drugs	27	Oral drugs	8	Hip lift training	16
Traction	27	TCM patented drug	5	Straight leg elevation	10
Plaster	17	Massage	4	Suspension	10
Physiotherapy	14	Traction	4	Reversal	6
Sacral Anesthesia	11	Physiotherapy	3	Swimming	4
Massage	10	Acupuncture	3	Sit-ups	2
Acupuncture	10	TCM fumigation	2	Radio calisthenics	1
Ozone injection	10	Moxibustion	1	Stretching	1
Osteopathy	8			Traditional Chinese Eight Brocade Exercise	1
Patented TCM drugs	8				
Moxibustion	7				
Nerve blockage	3				
Small needle-knife	2				
Total people	31	21			29
Mean per patient	5.90	1.91			2.42

During hospitalization, 21 patients (67.74%) experienced transient exacerbation of symptoms, for which predisposing factors obtained from patients themselves were prolonged sitting, cold, excessive weight bearing, or improper exercise. Further, 14 participants (45.16%) continued to have clinical symptoms after rehabilitation, including waist discomfort, discomfort of an affected limb, numbness of the affected shank, and sacrococcygeal discomfort. Prolonged walking, prolonged sitting, carrying heavy objects, and being cold were common predisposing factors.

All patients undertook rehabilitation exercises during the hospitalization period, 29 (93.55%) continued to exercise during rehabilitation, and the mean number of exercise methods was 2.42 per patient. Back stretches, bridge, straight leg elevation, and suspension, were commonly used exercise techniques, among others (Table 2).

## Factors influencing spine weight-bearing

Twenty-eight patients (90.32%) underwent bed-rest during the first month after hospitalisation; bed-rest times ranged from 2 to 16 h/d (not including 8 h at night; mean,  $12.32 \pm 4.36$  h/d) and bed-rest continued for 2 to 30 d (mean,  $22.46 \pm 9.39$  d). During rehabilitation, the number of patients continuing bed-rest decreased to 19 (61.29%), with bed-rest times ranging from 1 to 16 h/d (not including 8 h at night) (mean,  $10.84 \pm 4.79$  h/d), and durations from 7 to 360 d (mean,  $60.05 \pm 83.12$  d; mode, 30 d).

Lumbosacral orthosis devices were worn by 25 (80.65%) patients for between 1 and 16 h/d (mean,  $5.56 \pm 2.43$  h/d) and for durations of 1 to 8 months (mean, 2.46 months; mode, 1 month).

Mean body mass index (BMI) before treatment was  $23.63 \pm 3.00$ , while that post treatment was  $23.38 \pm 3.22$ ; the difference was not significant ( $t = -0.95$ ,  $P = 0.35$ ). Further, there was no significant correlation between BMI and spontaneous absorption ratio ( $r = 0.02$ ,  $P = 0.94$ ). Among 31 patients, 15 with normal BMI had a mean absorption ratio of  $0.64 \pm 0.21$  and 13 who were overweight had a mean absorption ratio of  $0.73 \pm 0.25$ , which was not significantly different ( $t = -0.98$ ,  $P = 0.36$ ).

After 1 month from disease onset, 19 patients (61.29%) participated in work for between 1 and 12 h/d (mean,  $5.95 \pm 3.09$  h/d). There was no significant correlation between working hours and reabsorption ratio ( $r = -0.18$ ,  $P = 0.33$ ).

## Rehabilitation exercise

Rehabilitation exercises were undertaken by 29 (93.55%) patients with a mean of 2.42 methods of exercise per person. The most frequent exercises were back stretches, followed by hip lift training, straight leg elevation, and suspension, among others. Daily exercise times ranged from 0.25 to 5 h/d (mean,  $1.34 \pm 0.99$  h/d), while exercise continued for between 12 and 720 d (mean,  $135.46 \pm 153.09$  d; mode, 60 d).

## Self-rating of factors enabling rehabilitation

Adherence to rehabilitation exercise, early bed-rest, timely treatment, and proper rest were the top-ranking factors enabling recovery, according to patient self-rating. Confidence, positive attitude, and effective

doctor-patient communication were also considered necessary. Further, professional guidance from a physician and appropriate treatment were also considered to be facilitating factors (Table 3).

Table 3  
Self-evaluation of factors enabling spontaneous regression of herniated lumbar discs

Factor	Frequency
Rehabilitation adherence	12
Early bed-rest	11
Timely treatment	7
Proper Rest	6
Optimism	5
Effective doctor-patient communication	5
Professional guidance	5
Medicine	4
Hot compress	3
Osteopathy	2
Correct poses	2
Acupuncture	1
Physiotherapy	1
Young age	1
Lumbar lordosis	1
Family support	1
Weight loss	1

## Multivariate analysis of factors enabling reabsorption of herniated lumbar disc

Type of herniated disc, duration of wearing a lumbosacral orthosis device each day, number of days wearing a lumbosacral orthosis device, acute bed-rest per day, acute bed-rest duration, rehabilitation bed-rest per day, rehabilitation bed-rest duration, exercise per day, exercise duration, and amount of time working were included into multiple linear regression models, and non-significant independent variables gradually eliminated to determine the optimal regression equation model.

The mean reabsorption ratio was  $0.69 \pm 0.22$ , regression analysis could be performed, as the data followed a normal distribution ( $df = 31, < 50$ ; Shapiro–Wilk test,  $P = 0.08 (> 0.05)$ ). Adjusted  $R^2$  and F values indicated that the regression equation was very significant, and that the degree of fit between the independent and the dependent variables was good. The variance inflation factor values of the independent variables were all  $< 2$  (i.e.,  $<< 10$ ), indicating no collinearity between the independent variables in this model (Table 4).

Table 4  
Multiple linear regression analysis of lumbar disc herniation reabsorption ratio

Variable	Standardized coefficient	t	P	VIF
Constant	0.62	8.32	0.001	
Onset-to-treatment interval	-0.34	-2.97	0.007	1.48
Lumbosacral orthosis	0.38	3.65	0.001	1.22
Early bed-rest day	0.50	4.06	0.001	1.66
Rehabilitation bed-rest day	-0.24	-2.23	0.040	1.28
Hernia type	-0.48	-3.67	0.001	1.87
Adjusted $R^2 = 0.73$ ; Durbin-Watson = 2.47 ; F, 17.08. VIF, variance inflation factor				

The data presented in Table 4 demonstrate that the number of bed-rest days in the acute phase had the greatest impact on the herniated lumbar intervertebral disc reabsorption ratio (standard partial regression coefficient, 0.50), followed by herniated disc type (-0.48), time per day wearing a lumbosacral orthosis device (0.38), onset-to-treatment interval (-0.38), and days of bed-rest during rehabilitation (-0.24). The reabsorption ratio (y) was set as the dependent variable, with bed-rest days in the acute phase ( $X_1$ ), type of herniated disc ( $X_2$ ), time per day wearing a lumbosacral orthosis device ( $X_3$ ), onset-treatment interval ( $X_4$ ), and bed-rest days during rehabilitation ( $X_5$ ) set as independent variables. The optimal linear regression equation was  $y = 0.616 + 0.497X_1 - 0.478X_2 + 0.384X_3 - 0.343X_4 - 0.241X_5$ . If the number of bed-rest days during the acute phase ( $X_1$ ) increased by 1 day, while the other four independent variables remained unchanged, the reabsorption ratio of herniated disc increased by 0.50. When the other four independent variables were held constant, the reabsorption ratio of extruded discs decrease by 0.48 compared with that of sequestered discs. Similarly, if time per day wearing a lumbosacral orthosis device increased by 1 h/d, the reabsorption ratio increased by 0.38, while if bed-rest days during rehabilitation increased by 1 d, the reabsorption ratio decreased by 0.24.

## Discussion

The main mechanism underlying spontaneous resorption of LDH has been confirmed as contact of the nucleus pulposus perforate posterior longitudinal ligament with blood, which elicits an immune response

[9]. Resorption of LDH takes 3–12 months [5]. Patient experience of pain, mood, and family support are important factors that influence whether a treatment plan can be implemented[13]. The treatments patients receive, as well as their lifestyle, type of work, and rehabilitation exercises, can also affect the disease course[14]. Methods to promote absorption of the herniated disc and shorten the disease course warrant exploration. Because most of LDH patients were treated with surgery, prospective research on resorption of LDH is difficult; therefore, we conducted a retrospective analysis of patients with spontaneous absorption of LDH.

#### Physical and mental health parameters in patients undergoing conservative treatment

Although surgery has advantages in relieving early or mid-term pain and promoting early recovery in patients with LDH, its long-term efficacy does not differ from that of conservative treatment [15–17]. The main purpose of conservative treatment is to alleviate pain, increase motor function, improve quality of life, and provide adequate time for reabsorption to occur. Intensive conservative treatment can reduce the number of surgeries required for patients with non-contained LDH within 1 month of onset [18]. During hospitalization, patients in this study received a mean of 5.90 treatment methods each. Most patients (67.74%) also received intensive treatment during the rehabilitation period, with a mean of 1.91 outpatient treatments per patient. In this study, the majority of patients agreed that timely treatment, oral medicine, and hot compress were factors that enabled spontaneous absorption.

Early physical therapy can improve pain relief efficacy, function, and disability indices of patients with low back pain [19]. Acute pain management of non-specific chronic low back pain is conducive to recovery and return to work, and also reduces costs [19, 20]. Our data show that early treatment is beneficial to herniated disc absorption in patients with extrusion or sequestration.

For patients with chronic diseases, especially chronic low back pain, a good doctor-patient relationship is essential to treatment adherence [21]. The impact of the doctor-patient relationship is more obvious in the medium term (6 months after recovery) than in the short term [22]. A good doctor-patient relationship is conducive to recovery via spontaneous absorption in patients with LDH [23]. In this study, doctors and patients could communicate to ensure effective treatment according to patient symptoms during hospitalization, and during rehabilitation, 29 (93.55%) patients received subsequent visit(s) and follow-up by phone or WeChat. Patients also considered effective doctor-patient communication a favorable factor for recovery.

Anxiety or depression are common in patients with chronic low back pain; in one study, 56 (61.5%) such patients were reported to suffer from anxiety or depression before surgery [24]. Further, the prevalence rates of mood change and anxiety in 149 patients with LDH were 16.6% and 35.8%, respectively[25]. The most common specific diagnoses were major depression (16.9%) and generalized anxiety disorder (12.8%) [25]. Higher pain intensity and longer disease duration are independent risk factors for depression [26]. The use of microsurgery to remove the intervertebral disc can relieve pain, while also reducing physical anxiety and depression [27].

Family support for patients with chronic pain is also an important factor affecting mood. Patients with family support reported significantly lower pain intensity, drug dependence, and higher physical activity levels than those without [28]; for example, patients with knee arthritis who have strong family and spousal support had significantly fewer depression symptoms, and pain levels decreased with increasing family support [29]. In this study, although only 9.68% of patient family members did not agree with long-time conservative treatment, none firmly opposed this therapy option. Ten patients (32.26%) in this study experienced emotional distress, which is a lower rate than that in previous report[25]. This may be related to the fact that patients were hospitalized and received daily professional help from a physician. A good doctor-patient relationship has an important impact on rehabilitation [30], and 29 (93.55%) patients received follow-up visits via telephone or WeChat during rehabilitation; thus, they had access to professional help.

## **Symptoms and associated factors**

Fourteen subjects (45.16%) were sensitive to factors such as prolonged walking, prolonged sitting, excessive weight bearing, and cold, which provoked waist discomfort, affected limb discomfort, numbness of the affected shank, and sacrococcygeal discomfort. Although patients with LDH exhibit a degree of fear avoidance [31], such beliefs are more common among patients with chronic low back pain than those with acute low back pain [31]; however, fear avoidance cannot explain patient sensitivity to factors such as prolonged sitting, fatigue, and cold. Inflammatory mediators released at the herniated disc can alter the expression of sodium, potassium, and calcium ion channels on the surface of the dorsal root nerve, causing ectopic and continuous discharge [32], which is related to sensitization of spinal dorsal horn cells and consequent hyperalgesia [33]. Simultaneously, spinal dorsal horn microglia are activated, and the expression of phosphorylated SRC family kinases up-regulated [34]. Long term nociceptive signals input caused by the herniated disc alters the morphology and/or cell structure of the anterograde projection area [35]. Functional MRI shows that the right dorsolateral prefrontal cortex and left anterior cingulate cortex of the pain-related area are activated in patients with chronic low back pain [36]. Further, patients with chronic low back pain have central sensitization, with sensitivity to noxious stimulus [37], as well as innocuous stimuli [38]. Lower than normal pressure levels can produce mild and severe pain in patients with chronic low back pain [36]. Further, patients with chronic low back pain have lower cold pain thresholds at the waist and in distal body parts [39]. Nevertheless, changes in weather temperature do not increase the risk of low back pain [40]. Since the autoimmune responses to herniated disc exceed 3 months, prolonged painful stimulation can cause central sensitization. Patient sensitivity to fatigue and cold may also be related to central sensitization.

## **Factors favorable for herniated disc absorption**

Hernia type is an important factor affecting the occurrence of spontaneous resorption. Sequestered herniations have the highest proportion of spontaneous resorption, followed by transligamentous, with the lowest rates for subligamentous[8]. Further, the probability of sequestered discs being fully resorbed is higher than that of extruded discs [5, 41]. Three hypotheses, including retraction, absorption, and

dehydration, have been proposed to explain the resorption of herniated discs. Matrix metalloproteinases (MMPs) are the main metabolic enzymes involved in the process of apoptosis and self-absorption of intervertebral disc protrusions. Numerous mononuclear macrophages and MMP-3 have been detected in the herniated nucleus pulposus [42]. Levels of MMP-1, 3, and 13 in sequestered discs are significantly higher than those in contained discs [43]. In our study, the spontaneous resorption ratio of sequestration type hernia was significantly higher than that of extrusion type, confirming that the type of herniation is an important factor in spontaneous absorption.

The ruptured annulus fibrosus has reduced ability to fix the nucleus pulposus, and bed-rest can alleviate the load on spine intervertebral discs, thereby reducing the chance of further nucleus pulposus protrusion [44, 45]. When resting in bed, the height and area of the intervertebral disc increase significantly; however, the water signal intensity does not alter [46]. A meta-analysis showed that bed-rest is effective in reducing pain and improving lumbar function in patients with acute low back pain [47]. In self-evaluation, patients recommended bed-rest during the acute period as a favorable factor. Further, our regression analysis supported early bed-rest for patients with sequestration or extrusion disc herniation. Although the optimal duration of bed-rest remains uncertain, it has been recommended that patients with LDH remain in bed for < 1 week [48], and 2 weeks has also been suggested [49]. Based on the mean bed-rest day of the 31 patients in this study, we advise that patients with sequestration or extrusion disc herniation should remain in bed for approximately 3 weeks, to alleviate the load on ruptured intervertebral discs. However, long-term bed-rest during the early stages of pain is associated with higher levels of long-term disability [50]. Moderate quality evidence suggests that there is little difference between patients with sciatica who undergo bed-rest and those who stay active, in terms of pain reduction and function improvement [47]. Another study also found that bed-rest does not improve sciatica [51] because radicular pain is caused by various factors, including mechanical compression, inflammatory stimulation, and autoimmunity [35]. Therefore, active symptomatic treatment, such as medication, nerve block, acupuncture, and moxibustion, is necessary [52].

For patients with non-specific low back pain, prolonged bed-rest during the initial stages of symptoms is associated with higher levels of long-term disability [50], and can cause major cardiovascular, respiratory, musculoskeletal, and neuropsychological changes, as well as bone loss, which may delay or prevent recovery from critical illnesses, including disuse muscle atrophy, joint contractures, thromboembolic disease, and insulin resistance [53] [54] [55]. In this study, regression analysis showed that prolonged bed-rest duration in rehabilitation was negatively correlated with the reabsorption ratio; hence, prolonged bed-rest should be avoided during the rehabilitation period.

MRI analysis showed that the cross-sectional area of the iliopsoas muscle was reduced on the 14th day of strict bed-rest, while the sartorius muscle was reduced on the 42nd day [56]. After living in space weightlessness for 6 months, lumbar lordosis was reduced by an average of 11%, when astronauts were supine, and the functional cross-sectional area of the multifidus muscle and erector spinae were reduced by 20%, with the cross-sectional area reduced 8–9%. These data suggest that prolonged bed-rest causes lumbar muscle atrophy and a decline in spinal stability [57]. Trunk extensor strength is beneficial in

increasing spinal stability and improving its function [58]. Early functional exercises, including passive and autonomous activities, can improve patient physiological function following percutaneous transforaminal endoscopic discectomy for LDH, as well as improving emotional function, mental health, and quality of life [59]. Dynamic lumbar stabilization training can relieve pain, reduce functional disabilities, and decrease patient fear avoidance behavior following lumbar microdiscectomy [60]. Early strengthening exercises include Williams flexion exercises and/or McKenzie extension exercises, which can increase spine compression by 12–18% and stability by 34–64% [61]. Eight weeks of core stability training improves the static endurance of the trunk muscles of patients with LDH to a normal level [62]. Rehabilitation exercise was the enabling factor rated highest in patient self-evaluation in this study. Active improvement of trunk extensor strength can help to prevent adverse reactions to prolonged bed-rest, enhance patient mood, and improve and maintain spinal function.

Lumbosacral orthosis is widely used to relieve low back pain. Moderate evidence shows that lumbosacral orthosis is more effective in preventing low back pain and improving pain and function than lack of intervention and training [63] [64]. Home care workers who wore lumbosacral orthosis devices had a reduced number of days of pain, but no reduction in sick days [65]; however, another study showed that lumbosacral orthosis did not reduce the incidence of low back pain in workers [66]. Hence, lumbosacral orthosis is effective in improving pain, but ineffective as primary prevention [63]. Rupture of the annulus fibrosus and decreased pressure on the intervertebral disc increases spinal flexion and rotation instability [67]. Lumbosacral orthosis improves the stiffness and stability of the spine by increasing abdominal pressure. The results of this study suggest that lumbosacral orthosis is beneficial for the absorption of herniated discs that break through ligaments and prolapse. Wearing a lumbosacral orthosis device during the acute phase of LDH is a favorable factor, which may be related to increased spine stability and reduced pressure on the intervertebral disc. Nevertheless, lumbosacral orthoses may reduce back muscle activity, leading to a concern that long-term wear may cause trunk muscle weakness; however, wearing lumbosacral orthoses for 6-months does not cause weakening of the paravertebral muscles in patients with chronic low back pain [68]. Further, there is no scientific evidence that prolonged wearing of lumbosacral orthosis devices results in trunk muscle weakness [69].

BMI is positively correlated with pain and the Roland-Morris Disability and Oswestry Disability indices, and logistic regression analysis demonstrated that higher BMI is a risk factor for LDH recurrence [11]. Here, we did not identify a relationship between BMI and spontaneous regression ratio; however, this does not mean that weight loss is not beneficial for herniated disc regression.

Our survey had several limitations, as follows: first, there was selection bias, as all subjects included in the study were hospitalized patients from Henan Provincial Luoyang Orthopedic-Traumatological Hospital (Henan Provincial Orthopedic Hospital) who had severe symptoms, hence they are not representative of patients with mild or moderate symptoms; second, this is a retrospective study, spanning a period of 4 years 3 months, hence patients will have exhibited memory bias; third, due to the wide application of spinal surgery techniques, most patients with severe LDH received surgeries, meaning that the number of collected cases was small, leading to potential data bias; fourth, few of the included

patients were underweight or overweight, making it difficult to determine the effect of weight on reabsorption; finally, as patients were hospitalized in a Chinese medicine hospital, they received more TCM treatment techniques, which may have resulted in a bias toward Chinese medicine culture and treatment techniques.

## Conclusions

To improve the spontaneous absorption ratio, pain management used for lumbar disc sequestration or extrusion should be applied in multiple ways. In the acute phase, patients require early bed-rest and should wear lumbosacral orthosis devices, while the duration of bed-rest days should be reduced during the recovery period. Symptomatic treatments are crucial to symptom relief during the acute and convalescent phases. Further, rehabilitation exercises are beneficial throughout the entire treatment period and family support and effective doctor-patient communication assists the implementation of conservative treatment in alleviating the adverse emotions of patients.

## Abbreviations

LDH Lumbar disc herniation

SD Standard deviation

BMI Body mass index

MRI Magnetic resonance imaging

MMPs Matrix metalloproteinases

TCM Traditional Chinese medicine

## Declarations

### Ethics approval and consent to participate

The clinical trial has been approved by the Institutional Review Board of Henan Provincial Luoyang Orthopedic-Traumatological Hospital (Henan Provincial Orthopedic Hospital). This study is to be conducted in accordance with the principles of the Declaration of Helsinki. All participants provided informed consent.

### Consent for publication

The authors have received written consent from participants to publish individual images.

### Availability of data and materials

The datasets supporting the conclusions of this article are included within the article. Raw data can be requested from the corresponding author.

### **Competing interests**

The authors declared that they have no conflicts of interest to this work.

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### **Author’s contributions**

Prof. Yi-Kai Li is the designer of the article, Dr Qing-Guang Qin is responsible for data analysis and article writing and edited the article for revision. Jia Liu, Li-Jing Zhao, Shuai Yuan, Fang Feng, Hong-Zhou Xu, Ya-Fei Jing, Lei Chen, Kui Zhu and Shuai Wang are responsible for the questionnaire distributed and collected and MRI images consolidation, Dr Bing-Qing Zhang, and Fang-Le Zhang calculates the absorption rate, All authors read and approved the final manuscript.

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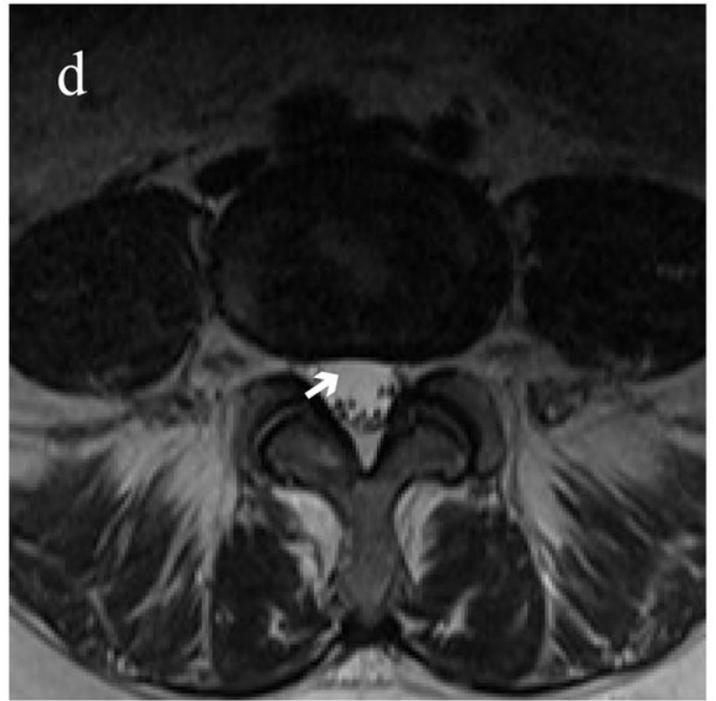
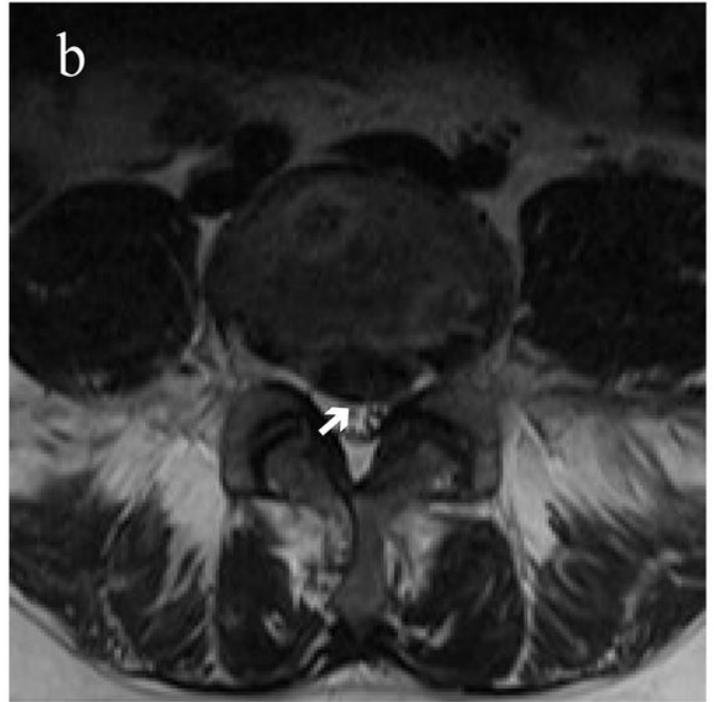
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## Figures



**Figure 1**

Sagittal T2 weighted MRI showing measurement of a lumbar herniated disc. a) Inferior-posterior edge of the superior vertebral body. b) Superior-posterior edge of the inferior vertebral body. The white arc is the trailing edge of the protruding disc. MRI 3.0 T, sagittal T2-weighted MR imaging, layer thickness 3 mm, layer distance 3 mm, 13 sections. Herniated disc volume (mm<sup>3</sup>) = (interlayer spacing + layer thickness) (mm) ×  $\Sigma$  area of each layer (mm<sup>2</sup>).



**Figure 2**

Images from a 47 year-old-woman participant showing a large sequestered disc (white arrows) at the L4/5 level. T2-weighted sagittal (a) and axial (b) images. Four months later, complete resorption of the sequestration was observed on sagittal (c) and axial (d) images.