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# Development and clinical application of grading and classification criteria of lumbar disc herniation

Ding-Jun Hao, MD[a], Kun Duan, MD[b], Tuan-Jiang Liu, MD[a], Ji-Jun Liu, MD[a], Wen-Tao Wang, MD, PhD[a,*]

**Abstract**

This study aimed to develop new grading and classification criteria for lumbar disc herniation (LDH). First, from January 1993 to January 2003, we collected the detailed information of 1127 patients with LDH and, based on that information, developed a new grading classification termed the 6-score-V-type criteria wherein conservative treatment is recommended for patients with type I, II, or IIIA, surgical treatment is recommended for type IIIC, IV, and V, and 3 months of conservative followed by surgery if no improvements are obtained during the conservative treatment period is recommended for type IIIBe. The distribution of types among the 1,127 patients was: type I (7.9%), type II (22.9%), type III (34.1%), type IV (22.2%), and type V (12.6%). Type III cases were subdivided into type IIIA (9.9%), type IIIB (13.3%), and IIIC (10.8%). Second, from February 2003 to December 2009, we treated a separate group of 1130 patients with LDH according to this 6-score-V-type classification rubric and monitored them for 24 months. Therapeutic efficacy was assessed in 1130 patients with a standard evaluation for leg pain. Overall, 85.3% of the patients in the first year and 84.1% in the second year had good or excellent response ratings. The inter-examiner reliability was 98%. Assignment of therapeutic protocols according to the 6-score-V-type classification yielded satisfactory outcomes, indicating that the 6-score-V-type criteria are straightforward and practical.

**Abbreviations:** CT = computer tomographic, LDH = lumbar disc herniation, MRI = magnetic resonance images, ODI = Oswestry Disability Index, SF-36 = Short-Form Health Survey.

**Keywords:** classification criteria, grading, lumbar disc herniation

## 1. Introduction

Lumbar disc herniation (LDH) is a primary cause of leg pain. Clinical manifestations can include dull or sharp pain in the waist or lower extremities, muscle spasm, sciatica, paresthesia, and muscle weakness in the lower extremities. In some cases, acute cauda equina syndrome can occur. Sneezing, coughing, or bending at the waist can exacerbate pain and have a negative impact on patients' conditions. Currently, treatments for LDH include conservative therapy and surgery.[1,2] Surgery can eliminate pressure caused by protruding lumbar discs; however, it can also cause severe trauma and carries some risk of the development of additional symptoms. Conservative treatment alone cannot achieve dramatic pain relief in some cases, and long-term disease can even lead to uroschesis or foot-drop.

Current classification systems are based on imaging and pathomorphism.[3,4] LDH can be classified into 3 types (central, paramedian, and foraminal) according to the part that protrudes. On the basis of protrusion degree, the injury can be further classified as bulge, protrusion, or extrusion. In addition, there are nonruptured, ruptured, and sequestered types based on surgical pathomorphism.

The above classifications are based either on imaging and surgical findings or on pathological changes. However, the severity of clinical symptoms and physical signs are affected by the size of the protrusion, the part protruded, the size of the spinal canal, nervous pressure, and inflammation. At present, there is no classification method that combines the imageological, pathological, and clinical manifestations to reflect LDH disease severity. The establishment of a standardized system based on symptoms and image-based grading for LDH can enable accurate assessment and assist doctors in making treatment plans.

## 2. Methods

The design of the present study was approved by the Ethics Committee of the Honghui Hospital, College of Medicine, Xi'an Jiaotong University. This work was supported by social development of science and technology research grants from the Department of Science and Technology of Shaanxi Province (2016SF-072, 2017SF-233). Written informed consent was obtained from each participant before commencing with participation in the trial.

In the present study, we analyzed 1127 outpatient cases of LDH from January 1993 to January 2003, and summarized clinical manifestations, including pain, nervous signs, computer

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*[a] Department of Spine Surgery, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, [b] Department of General Surgery, The 417th Hospital, China National Nuclear Corporation (CNNC), Xi'an, Shaanxi, China.*

*[*] Correspondence: Wen-Tao Wang, Department of Spine Surgery, Hong Hui Hospital, Xi'an Jiaotong University College of Medicine, Youyi Road No. 555, Xi'an 710054, Shaanxi, China (e-mail: 731624568@qq.com).*



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tomographic (CT) findings, and magnetic resonance imaging (MRI) findings. We graded the symptoms and imaging results and developed the 6-score-V-type criteria. From February 2003 to December 2009, we applied the criteria to 1130 patients with LDH. We classified these patients into different types and developed type-associated treatment plans.

From January 1993 to January 2003, 1127 consecutive cases of LDH that met the diagnostic criteria proposed by McCulloch[5] were enrolled in the study. The inclusion criteria were radicular pain and evidence of nerve root compression with a positive nerve root tension sign (positive straight leg raise test or femoral tension sign). Alternatively, patients may have a reflex (asymmetric depressed reflex), sensory (asymmetric decreased sensation in a dermatomal distribution), or motor (asymmetric weakness in a myotomal distribution) deficit with associated radicular symptoms and positive nerve root tension signs. In addition, a confirmatory imaging study (MRI or CT) must indicate an intervertebral disc herniation at a location corresponding with the patient's radicular signs or symptoms. Patients with only a bulging disc are not eligible.[6] Data on the history of present illness, past medical history, and physical examination were recorded. In each case, CT or MRI images were available. Clinical manifestations included symptoms of pain, utility of analgesia, and nervous signs. Patients with spinal stenosis, lumbar spondylolisthesis, or spinal canal encroachment were excluded from the study.

We assigned each patient's symptoms and signs and each patient's imaging findings a score from 1 to 3, according to severity. The most severe scores were chosen from each of the categories and summed to get the final score (Table 1 and Fig. 1). Types I, II, III, IV, and V were assigned to patients with combined scores of 2, 3, 4, 5, and 6, respectively. Type III was subclassified into subclasses IIIA, IIIB, and IIIC. Clinical manifestation and imaging scores for type IIIA patients were 3 and 1, for type IIIB patients were 2 and 2, and for type IIIC patients were 1 and 3, respectively, Fig. 1. To test our classifications' reliability, a blind study was performed independently by 3 independent examiners using the new classification scheme. Classification differences among the examiners were discussed and assigned a final score by consensus.

### 2.1. Reliability and clinical application of the grading and classification criteria

From February 2003 to December 2009, we treated 1130 consecutive patients with LDH according to the 6-score-V-type classification. The exclusion criteria were age $< 20$ years or age $>$ 60 years; illness currently or within the prior 6 weeks; overall health that makes spine surgery too life threatening to be appropriate; infection; lumbar spine surgery; nonavailability for follow-up or inability to complete questionnaires. All patients were followed up by phone and/or outpatient. We made treatment decisions based on patients' scores and classifications. Patients were divided randomly into 2 series (series A and series B) and treated by 2 groups of surgeons in our hospital. Type I, II, and III A patients were treated conservatively. The conservative protocol was "usual care" recommended to include at least active physical therapy, education, and counseling with home exercise instruction, and nonsteroidal anti-inflammatory drugs if tolerated, analgesic is necessary. Conservative treatments were individualized for each patient and tracked prospectively. Type IIIC, IV, and V patients were treated by standard open diskectomy with examination of the involved nerve root.[7] Type IIIB patients were treated conservatively for 3 months. If no improvements were seen, then surgery was performed. All patients were monitored by phone appointments and outpatient follow-up.

**Table 1**

**Grading and classification criteria for lumbar disc herniation.**

| Type | Features | Score |
|---|---|---|
| Clinical manifestation | | |
| Pain symptoms | | |
| Pain | Slight lower limbs pain, without analgesic, tolerable for more than 6 wks >6 wks | 1 |
| | Heavy lower limbs pain, tolerable with analgesic >6 wks | 2 |
| | Severe lower limbs pain, intolerable with analgesic >6 wks | 3 |
| Nervous signs | | |
| Nervous function | Slight involvement of nerves (numbness in any nerve root between L4-S1) | 1 |
| | Involvement of nerves (strength decreasing 1–2 grade in digital extensor L4-S1) | 2 |
| | Muscle strength decreasing ≥3 grade, and dysfunction of sphincter (foot-drop or uroschesis) | 3 |
| Straight let raising test (SLRT) | ≤70° positive | 1 |
| | 30°–50° positive | 2 |
| | ≤30° degree positive | 3 |
| Imaging findings | | |
| CT or MRI cross-section | | |
| Central | Protrusion <30% of spinal sagittal diameter | 1 |
| | Protrusion 30–50% of spinal sagittal diameter | 2 |
| | Protrusion >50% of spinal sagittal diameter | 3 |
| Paramedian | Lateral recess stenosis by protrusion <30% | 1 |
| | Lateral recess stenosis by protrusion 30–50% | 2 |
| | Lateral recess stenosis by protrusion >50% | 3 |
| Foraminal | Intervertebral foramen stenosis by protrusion <30% | 1 |
| | Intervertebral foramen stenosis by protrusion <30–50% | 2 |
| | Intervertebral foramen stenosis by protrusion >50% | 3 |

The 6-score-V-type criteria: Type I = 2, type II = 3, type III = 4 (type IIIA: clinical manifestation 3 + imaging 1, type IIIB: clinical manifestation 2 + imaging 2, type IIIC: clinical manifestation 1 + imaging 3), type IV = 5, type V = 6.

CT = computer tomographic, MRI = magnetic resonance images, SLRT = straight let raising test.

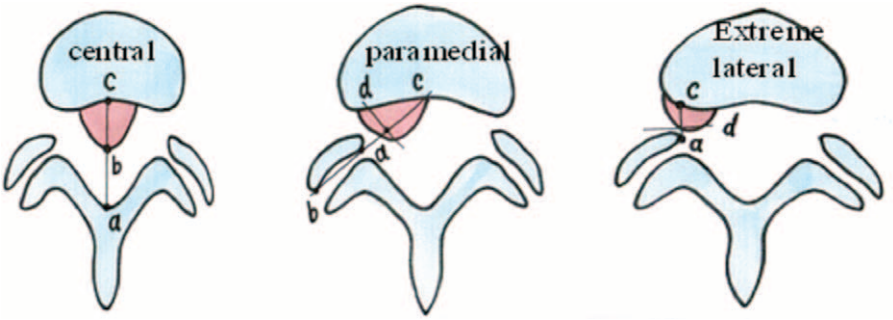


**Figure 1.** Schematic diagram of the imageological score criteria: (A) Central: Percentage of the vertical distance between the fixed point of the protrusion and the posterior vertebra from the sagittal diameter of the spinal canal; (B) Paramedian: Draw a line between the relief angle (point b) and the anterior angle (point a) on the zygopophysis. Extend the line and cross the posterior vertebra on point c. D is the midperpendicular of line ac; (C) Foraminal: draw a parallel line with the sagittal plane of the spinal canal that crosses the anterior angle (point a) on the zygopophysis. Extend the line and cross the posterior vertebra on point c. D is the mid-perpendicular of line ac.

### 2.2. Evaluation criteria

Primary end points were 2 scales of the Medical Outcomes Study Short-Form Health Survey (SF-36)—bodily pain scale and physical function scale[8] and the American Academy of Orthopaedic Surgeons MODEMS version of the Oswestry Disability Index (ODI)[9] as measured at 6 weeks, 3 months, 6 months, 1 year, and 2 years. Secondary outcomes included patient self-reported improvement, work status, satisfaction with current symptoms and care, and sciatica severity as measured by the Sciatica Bothersomeness Index.[10]

## 3. Results

### 3.1. Patient types

Included in the 1127 cases that were used to develop the criteria were 467 male (41.4%) and 660 female (58.6%) patients, ranging in age from 19 to 73 years (mean age, 40 ± 4.6 years). The herniation locus was L5–S1 in 59% of the patients, L4–5 in 37%, and L3–4 in only 4% of the patients. The 3 examiners classified acute herniated disc with a 98% agreement; after discussion, consensus was attained for the remaining 2%. There were 90 type I (7.9%), 259 type II (22.9%), 385 type III (34.1%), 251 type IV (22.2%), and 142 type V patients (12.6%). Among the type III patients, 112 were type IIIA (9.9%), 151 were type IIIB (13.3%), and 122 were type IV (10.8%), Fig. 2.

### 3.2. Patient outcomes

Patients were monitored for 24 months (Tables 2 and 3). The Oswestry Disability Index and SF36 were used to assess each patient's function at 6-week, 3-month, 6-month, 1-year, and 2-year follow-ups. Disability scores of ≤15%, 15% to 30%, and ≥30% were interpreted as good or excellent outcomes, fair outcomes, and poor outcomes, respectively.

Altogether, there were 1468 patients enrolled in the study, 338 (23%) patients were lost to follow-up by the final 2-year follow-up timepoint; the remaining 1130 patients were included in the statistical analysis. The average age of the final cohort of patients was 38 ± 4.6 years; 52% of the patients were male and 48% were female. Regarding disc herniation locus, 60% were L5–S1, 35% were L4–5, and only 5% were L3–4. Typical cases are shown in Fig. 3. There were 550 and 580 patients in series A and series B, respectively. Out of the total of 283 type I and II patients seen at 1-year follow-up, 84.4% of the patients in the first year and 86.5% in the second year were rated as good or excellent. The average treatment course was 45 days. There were 430 patients classified as type III, including 115 patients with a type IIIA classification who received conservative treatment. Good or excellent outcome rating was obtained for 76.5% of these patients in the first year and 72.1% of these patients in the second year. The average treatment course was 68 days. There were 170 patients classified as Type IIIB. Among them, 65 received conservative treatments, 105 received surgical treatments, and 89.4% of the patients in the first year and 87.6% in the second year were rated as good or excellent. A total of 145 patients were classified as type IIIC. All of them received surgical treatment, and 85.2% of the patients in the first year and 82.6% in the second year were rated as good or excellent. There were 417 cases classified as type IV or V. All of them received surgical treatment. Twenty-three (5.5%) of the patients had recurrent herniation; good or excellent outcomes rating were obtained from 86.1% of these patients in the first year and 85.1% in the second year. Overall, 85.3% of the patients in the first year and 84.1% in the second year were rated as good or excellent. The overall outcome results at 1 year and 2 years are summarized in Tables 2 and 3, and Fig. 4.

### 3.3. Surgical treatment and complications

The median surgical time was 80 minutes (63–120 minutes) with a median blood loss of 195 mL (150–280 mL). There were no

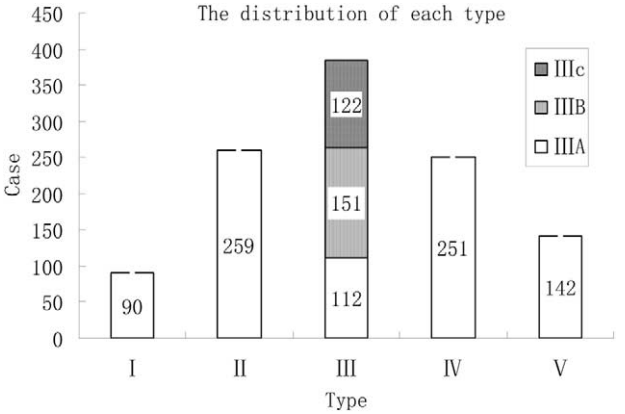


**Figure 2.** Distribution of each type determined by the 6-score-V-type criteria.

**Table 2**

**Outcomes of the 1130 patients treated at 1-y follow-up.**

| Type | Case | Treatment protocol | Effect | | | | |
|---|---|---|---|---|---|---|---|
| | | | Excellent | Good | Fair | Poor | Rate of excellent/good |
| I, II | 283 | Conservative | 99 | 140 | 31 | 13 | 239 (84.4%) |
| IIIA | 115 | Conservative | 42 | 46 | 15 | 12 | 88 (76.5%) |
| IIIB | 170 | Conservative first, surgery | 63 | 89 | 12 | 6 | 152 (89.4%) |
| IIIC | 145 | Surgery | 53 | 71 | 14 | 7 | 124 (85.5%) |
| IV, V | 417 | Surgery | 142 | 219 | 38 | 18 | 361 (86.6%) |
| Sum | 1130 | | 399 | 565 | 110 | 56 | 964 (85.3%) |

perioperative mortalities. The most common surgical complication was dural tear (1.5% of cases). Reoperation occurred in 1% of cases by 1 year and in 4% of cases by 2 years; more than half were recurrent herniations at the same level.

## 4. Discussion

Currently, there are 2 mechanisms proposed to explain how LDH causes leg pain.[11] The first theory involves machinery compression,[12] which is treated by surgical removal of the protruding nucleus pulposus and elimination of nervous compression. Typically, the pain lightens or is eliminated as soon as the surgery is completed, indicating that this mechanism plays an important role in the pain caused by LDH. The second theory involves aseptic inflammation and immunological responses.[13–15] Previous studies have found that slight LDH may cause sharp pain, and serious LDH may present mild clinical symptoms. In some cases, surgical removal of the oppression yields no significant effect, but anti-inflammatory treatment does.[16]

We also found that, in some cases, nerve root compression presented by imaging was not severe, but the patient complained of intolerable pain. On the contrary, in other cases, the compression was severe by imaging, but the patient reported only slight pain.[17] Thus, classification systems only based on pathological changes or protrusions do not reflect the severity of the illness accurately and do not provide evidence for subsequent therapeutic protocol selection.

We established new criteria for LDH grading and classification that combine the patients' symptom and signs and imageological results to reflect severity comprehensively. We developed the 6-score-V-type classification system based on an analysis of 1127 patients' clinical profiles, including their history of present illness, past medical history, physical examination, CT, MRI, and pain and nervous signs. LDH severity is affected by the size of the protrusion, the protruding part, spinal canal size, and nervous reaction to machinery oppression. On the basis of these criteria, we classified each illness as being of the central, paramedian, or foraminal type. In addition, by taking the percentage of the sagittal diameter of protrusion and the spinal canal or the nerve root canal as the measurement index, we standardized the classification. This classification was easy for doctors to use and for patients to understand. Our 1–3 scoring system for imaging signs is similar to the 1–2–3 score, A-B-C type Michigan State University classification system, but ours includes another score based on the patient's symptoms and signs and sums to get the final score, yielding the first full LDH classification system.[18]

To evaluate the new classification scheme, 1130 patients seen from February 2003 to December 2009 were treated according to our 6-score-V-type classification, the Oswestry Disability Index, and the SF36. The evaluation criteria included 4 outcomes: excellent, good, fair, and poor. The classification system was shown to be simple and suitable for clinical use. Patients with type I and II LDH, characterized by small protrusions and mild clinical symptoms, can reach high rates of excellent and good outcomes using conservative treatments. Patients with type IV and V LDH, characterized by serious clinical manifestations, can reach excellent and good outcomes with surgical intervention. In a study performed by Genevay et al,[19] clinical classification criteria were proposed to identify patients with radicular pain caused by LDH based on a 2-stage process. In stage 1, spine experts participated in a Delphi process to select symptoms and signs suggestive of radicular pain caused by LDH. In stage 2, clinical experts identified patients they were able to classify with confidence. The criteria showed good specificity (90.4%) and sensitivity (70.6%), and represented an important step in the field of spinal pain research.

Patients with type III LDH were divided into 3 subcategories, including type IIIA, which included patients with severe clinical manifestation scores of 3 and imageology scores of 1. In these cases, wherein oppression is mild and aseptic inflammation and

**Table 3**

**Outcomes of the 1130 patients treated at 2-y follow-up.**

| Type | Case | Treatment protocol | Effect | | | | |
|---|---|---|---|---|---|---|---|
| | | | Excellent | Good | Fair | Poor | Rate of excellent/good |
| I, II | 283 | Conservative | 100 | 145 | 29 | 9 | 245 (86.5%) |
| IIIA | 115 | Conservative | 40 | 43 | 18 | 14 | 83 (72.1%) |
| IIIB | 170 | Conservative first, surgery | 61 | 88 | 13 | 8 | 149 (87.6%) |
| IIIC | 145 | surgery | 50 | 69 | 16 | 10 | 119 (82.6%) |
| IV, V | 417 | surgery | 140 | 215 | 40 | 22 | 355 (86.6%) |
| Sum | 1130 | | 391 | 560 | 116 | 63 | 964 (84.1%) |

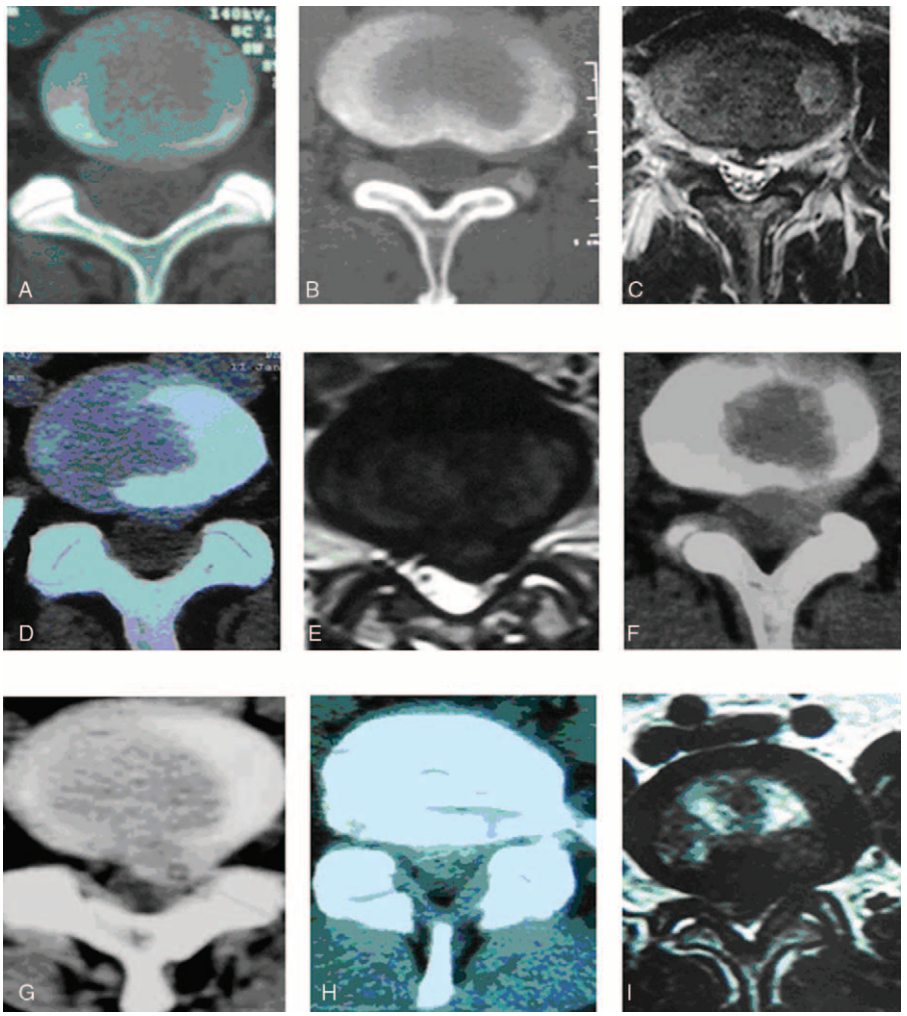


**Figure 3.** (A) grade 1, type I; bilateral lower extremity twitch was tolerable without analgesia,no nerve root involvement, SLRT of 60°, positive (score, 1); CT showed L4/5 central protrusion < 30% (score of 1). conservatively therapy. (B) grade 3, type II; left lower extremity twitch that was tolerable without analgesia,numbness on the back of the foot, an SLRT of 60°, positive (score of 1); CT showed L5/S1 lateral recess stenosis >50% (score of 2). conservative therapy. (C) grade 3, type II; waist and bilateral femoral pain tolerable with analgesia,numbness on the back of the foot, an SLRT of 60°, positive (score of 2); CT showed L4/5 central protrusion < 30% (score of 1). conservative therapy. (D) grade 3, type IIIA; waist pain was intolerable with analgesia and left lower extremity twitch,umbness on the back of the foot, an SLRT of 55°, positive (scores 3); CT showed L5/S1 lateral recess stenosis < 50% (score of 1). conservative therapy for 3 months, symptoms relieved significantly. (E) grade 4, type IIIB; waist pain that was relieved with analgesia and left lower extremity twitch,numbness on the back of the foot, an SLRT of 45°, positive (score of 2); MRI showed L5/S1 lateral recess stenosis >50% (score of 2). After ineffective 3-month conservative therapy protocol, a standard open diskectomy with examination of the involved nerve was performed. (F) grade 4, type IIIC; waist pain that was tolerable without analgesia and a twitch in the left lower extremity,numbness on the back of the foot, an SLRT of 50°, positive (score of 1). MRI showed L4/5 lateral recess filled by the protrusion (score of 3). The patient received a standard open diskectomy with examination of the involved nerve root. (G) (grade 5, type IV; waist pain relieved with analgesia and a twitch in left lower extremity, numbness on the back of the foot, an SLRT of 45°, positive (score of 2). CT showed complete block in vertebral foramen of L5/S1 (score of 3). Standard open diskectomy with examination of the involved nerve root was performed. (H) grade 5, type IV; waist pain relieved by analgesia, a twitch in the left lower extremity for 80 da,numbness in the perineal region (score of 3). MRI showed L4/5 central protrusion involving >30% of the spinal canal (score of 2). Standard open diskectomy with examination of the involved nerve root was performed, alleviating urinary symptoms. (I) grade 6, type V; waist pain relieved by analgesia, a twitch in left lower extremity for 80 days, and 2 days of uroschesis (score of 3). MRI showed L5/S1 protrusion filling the spinal canal (score of 3). treated with standard open diskectomy with examination of the involved nerve root, alleviating urinary symptoms.

immunological responses play an important role in pathological processes, surgical removal of a nucleus pulposus that oppresses the nerve root may not eliminate the pain and surgical complications may even increase pain. In our study, conservative treatment produced excellent or good outcomes in 76.5% of patients. In type IIIC patients, with severe protrusion, imageology scores of 3, and mild clinical manifestation scores of 1, conservative treatment could improve symptoms and physical signs, but the compression remained and the uroschesis and foot drop signs were readily observed. Excellent and good outcomes were achieved in 85.5% of patients. In our previous studies,[20] conservative treatment for this type of injury relieved pain temporarily; however, the oppression persisted, which was difficult to cure, and sometimes resulted in dysfunction of the sphincter. Type IIIB cases, with clinical symptom and imageology scores of 2, were given surgery if conservative treatments for 3 months did not improve symptoms. Some patients achieved excellent results with conservative treatment, but many required surgical intervention. Chiu et al[21] found that spontaneous regression of herniated disc tissue can occur and then can resolve completely after conservative treatment. In our study, patients with disc extrusion and sequestration had a significantly higher

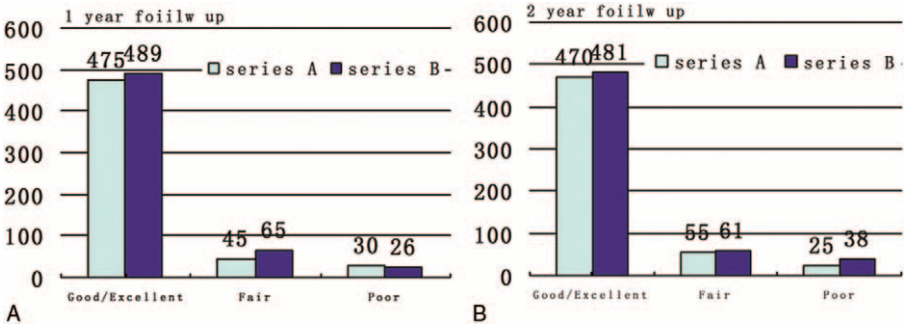


**Figure 4.** Outcomes of discectomy at (A) 1-year follow-up and (B) 2-year follow-up.

possibility of having spontaneous regression than did those with bulging or protruding discs. Disc sequestration had a significantly higher rate of complete regression than did disc extrusion. The type IIIB patients, who received conservative treatments for 3 months without symptom improvement, may experience spontaneous regression of herniated disc tissue.

The main advantage of our study was that our system was constructed over 10 years based on the clinical and imageology data of 1127 patients and employed to guide the treatment plans of 1130 patients over 8 years. The main goals of the classification scheme are convenience, reliability, and repeatability. It incorporates protrusion size as a reflection of the cause of the illness as well as inflammation, as evaluated by degree of pain and neurological involvement. We graded items from 1 to 3 and picked the highest scores in clinical manifestations and imageology, and then added them to get the final score. The classification was quantitative, easy to administer, and easy to compare across patients. In our study, we conducted an intraobserver analysis to validate its reliability. Both groups showed higher proportion of good to excellent outcomes with consistent results.

The limitations of this study include the sagittal plane angle and position of MRI. Also, CT does not provide an exact reflection of the size and location of the lumbar disc, which may influence measurements. In addition, it should be noted that Chinese people are generally reluctant to accept the surgical treatment immediately; therefore, initially, we performed a first-line conservative treatment. In the next trial, we will try to achieve timely surgical treatment for these patients through medical education.

The 6-score-V-type classification is easy to apply but does require doctors to do a careful analysis of medical history, physical examination, and imageology. By combining the most prominent clinical symptom score and the most severe imageology score, the doctor can classify the patient. This classification divides patients into different types and assigns appropriate treatment plans. This system has advantages compared with the Herron classification system.[22] Notably, the combination of practical applicability with quantitative and standardized analyses of protrusions is easier for doctors to use and for patients to understand. The treatment plans designated for each classification achieved high satisfactory outcome rates and a decreased rate of symptom recurrence.

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