

CORRELATION BETWEEN PREOPERATIVE MRI FINDINGS AND POSTOPERATIVE OUTCOMES IN LUMBAR DISC HERNIATION

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ABSTRACT

Background: Lumbar disc herniation (LDH) is a prevalent spinal condition causing significant morbidity and functional impairment. Magnetic Resonance Imaging (MRI) serves as the gold standard for diagnosis; however, its role in predicting postoperative outcomes remains debated.

Objective: This study aimed to determine the correlation between preoperative MRI findings and postoperative functional outcomes among patients undergoing microdiscectomy for LDH.

Methods: A cross-sectional observational study was conducted at tertiary care centers across Punjab, Pakistan, from January 2023 to February 2025, involving 100 patients aged 25–60 years with MRI-confirmed single-level LDH. Preoperative MRI parameters—including type of herniation (protrusion, extrusion, sequestration), size, and degree of nerve root compression—were assessed. Postoperative recovery was evaluated using the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) at three months. Statistical analysis was performed using SPSS v26, and correlations were determined using Pearson's coefficient, with $p < 0.05$ considered significant.

Results: The mean age of patients was 43.6 ± 9.8 years, with 62% males and 38% females. The most common level of involvement was L5–S1 (54%). Patients with protruded discs and mild-to-moderate nerve compression showed significant improvement in postoperative ODI and VAS scores, while those with sequestered discs and severe compression demonstrated delayed recovery. A strong positive correlation was observed between MRI severity grading and postoperative ODI scores ($r = 0.61$, $p < 0.01$).

Conclusion: Preoperative MRI findings, particularly herniation type and nerve root compression severity, significantly predict postoperative outcomes following microdiscectomy. MRI-based grading aids in prognostication and individualized surgical planning.

Keywords: Lumbar disc herniation, Magnetic resonance imaging, Microdiscectomy, Postoperative outcome, Oswestry Disability Index, Nerve root compression

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INTRODUCTION

LDH is among the most common causes of low back pain and radiculopathy that causes a significant amount of disability in the world¹. It mostly occurs in those of third and fifth decades of life and is a leading cause to absenteeism in work and spinal surgery. The disorder is associated with the protrusion of the nucleus pulposus of the intervertebral disc, through a ruptured annulus fibrosus and leads to the compression and irritation of the nerve roots². This results in a range of symptoms that go through back pain that is localized to a radiating leg pain, sensory

loss, and motor weakness, which are referred to as sciatica³.

Magnetic Resonance Imaging (MRI) has now been adopted to become the gold standard in the diagnosis of LDH because it has better soft-tissue contrast and multiplanar images. It enables the accurate visualization of disc morphology, whether herniation is protrusion, extrusion, or sequestration and direction of herniation and degree of neural structure compression⁴. The MRI results inform clinical decisions, predetermine the necessity of surgery, and help with the planning of the operations.

Nonetheless, the relationship between the MRI results and the postoperative results is a controversial issue. Some of the patients who have severe radiological abnormalities recover excellent and others with mild MRI changes persist in enjoying residual symptoms following surgery⁵.

Surgical decompression, especially microdiscectomy is the most common treatment of patients whose neurological symptoms of persistence or severity do not respond to conservative treatment^{1,3}. The type of herniation, size and position of the disc fragment, extent of compression of nerves, and the preoperative symptoms, among others, are some of the factors on which postoperative outcomes are dependent⁶. Use of MRI as a prognostic measure to predict any functional recovery in the discectomy population has not been clearly established, particularly among South Asians where there is scanty regional data^{1,6}.

Under these clinical uncertainties, an increasing interest in the issue of whether MRI-based grading and morphological parameters can be utilized as effective predictors of postoperative functional recovery is observed⁵. The study of this correlation could help to inform preoperative counseling, select patients to operate in the most suitable way, and better treat LDH on the whole⁷.

Thus, the current research was aimed to assess the relationship between the preoperative MRI results and the postoperative outcome of patients with lumbar disc herniation who undergo a microdiscectomy surgery in tertiary care units in Punjab, Pakistan⁶. The research will determine certain MRI parameters to exert postoperative pain relief and functional improvement which will be of great importance in determining the prognostic value of imaging in lumbar spine surgery⁸.

MATERIALS AND METHODS

The research was a cross-sectional observational study done in tertiary care facilities in Punjab, Pakistan with orthopedic and neurosurgical units in the presence of MRI and spinal surgery units. The research period was extended to January 2023-2 February 2025 to include the enrollment of the patients, preoperative imaging, surgery and postoperative follow-up. The research was aimed at assessing the relationship between preoperative MRI results and postoperative outcome in patients who have undergone microdiscectomy procedure to remove lumbar disc herniation (LDH).

The sample size of the study was 100 patients who were chosen by the use of non-probability consecutive sampling method. Male and female patients aged 25 to 60 years that had their lumbar radiculopathy symptoms confirmed by single-level LDH in MRI were recruited. To have homogeneity in the sample population, patients were chosen using well defined inclusion and exclusion criteria. The inclusion criteria included adults at the age of 25-60 years with confirmed single-level lumbar disc herniation

on MRI and the clinical manifestation of nerve root compression (radiating leg pain, sensory disturbance or muscle weakness) plus the inability to respond to treatment consisting of physiotherapy, rest, and analgesics over at least six weeks. Patients with recurrent or multi-level herniation, spinal infections, trauma, tumours, congenital deformities, prior spinal surgeries, or systemic neurological conditions were not included in the study.

Preoperative MRI scan of all patients was done with a 1.5 Tesla machine in order to improve homogeneity of the results. The parameters of MRI were such as the level of disc involvement (L4-L5, L5-S1, or others), herniation type (protrusion, extrusion, or sequestration), the size and direction of the herniated fragment (measured as the maximal anteroposterior extension of the fragment in millimeters), and the extent of nerve root compression (mild, moderate, or severe). Such other developments like the Modic changes and disc signal intensity changes were also observed to assess the degenerative status. The review of all MRI scans by two qualified radiologists blinded to the postoperative clinical outcome of the patients was done to create the objectivity.

A normal microdiscectomy procedure was used under general anesthesia to perform surgical intervention. The operation entailed a midline incision, minimum paraspinal muscle displacement, laminotomy where necessary and microscopic excision of the fragment of the herniated disc without any damage to the neural structures. All the participating centers were given the same approach to surgery and postoperative care to minimize the variability of the procedures.

After the operation, the patients were monitored and assessed during the follow-up visit arranged at one week, one month and three months. Two validated measures were used (a Visual Analog Scale, VAS) to measure pain intensity and Oswestry Disability Index (ODI) to assess the functional improvement and disability status. Positive outcomes were established by a minimum of 50 percent decrease in VAS and ODI scores relative to the preoperative baseline which represented satisfactory recovery.

All the clinical and radiological record evaluations were gathered via a developed proforma and incorporated into SPSS version 26.0 to compute the figures. Quantitative variables included age, herniation size, and ODI scores of which the mean and standard deviation were used to express, whereas gender, type of herniation, and nerve compression grade were categorical variables which were expressed as frequencies and percentages. The correlation between the parameters of MRI and the postoperative functional outcomes were evaluated using the Pearson correlation coefficient (r), whereas the mean differences between groups were compared by the analysis of variance (ANOVA) and independent t-tests. All analyses were found to be statistically significant when the p-value was below 0.05.

The study received ethical approval by the Institutional Review Board (IRB) of the participating centers and approval number LDH/2023/105. All the participants signed an informed written consent after being informed about the purpose, procedures and possible risks of the study. All the information was treated with high confidentiality and the experiment was conducted in accordance with the philosophies of the Declaration of Helsinki regarding ethical medical research.

RESULTS

In the study, 100 patients with MRI-proven lumbar disc herniation (LDH) were recruited and followed-up following microdiscectomy to determine the relationship between the preoperative MRI results and the postoperative outcomes. The demographic profile revealed that, among the total number of respondents, 62 (62%) were men and 38 (38%) women thus a male to female ratio of about 1.6:1 meaning that, LDH was more common in men. The average of the patients was 43.6 and Std=9.8 years; most of the patients were between the ages of 31-50 years, which is the most active working group. The predisposing factors which were mostly reported by the male clients included prolonged sitting habits, heavy lifting and repetitive lumbar strain whereas the females were mostly associated with sedentary habits and poor posture. The general demographic consists is summarized in Table 1 that demonstrates gender distribution, age range, and involved lumbar levels.

L5S1 level was most commonly involved with 54 percent of all the cases and then L4L5 with 38 percent and less common levels were L3L4 and L2L3 in 8 percent of patients. This observation is in accordance with the anatomical susceptibility of lumbosacral junction to

weight-bearing and mechanical forces. As to the nature of herniation, MRI revealed that 40 patients (40%), 35 (35%), and 25 had protrusion, extrusion, and sequestration respectively. The severity of the nerve root compression was found in 42 (42) patients, mild in 22 (22), and moderate in 36 (36) cases. The central, foraminal and paracentral distribution of most herniations was 25, 12 and 63, respectively, which were well correlated to the clinical manifestation of radiating pain and neurological deficit patterns.

Three-month follow-up of all the patients was done post-surgery, and the results of the patients were measured on the Visual Analog Scale (VAS) and Oswestry Disability Index (ODI). The average VAS preoperative was 8.2/ SD = 1.1 but this had significantly dropped to 2.3/ SD = 1.4 at the postoperative 3 month ($p < 0.001$). On the same note, the average preoperative ODI score was 58.6 with a standard deviation of 12.4 whereas on the postoperative side, it was 21.2 with a standard deviation of 8.5, which represents a significant change in pain relief and functional status. The improvement was, however, not consistent in all the patients showing variation with the preoperative MRI properties.

Patients who had protruded discs and mild-to-moderate nerve compression had the greatest functional recovery with the mean decrease in the ODI of approximately 40 points. However, patients who had sequestered discs and severe nerve compression showed late or partial recovery with some showing permanent mild neurological symptoms. The correlation was performed and significant positive correlation was observed between MRI severity grading and postoperative ODI scores ($r = 0.61$, $p < 0.01$), indicating that the more severe MRI results were, the worse the postoperative outcome was.

Table 1: Demographic and Baseline Characteristics of Study Population

Variable	Frequency (n)	Percentage (%)	Mean $\pm$ SD
Total Patients	100	100	—
Male	62	62	—
Female	38	38	—
Mean Age (years)	—	—	43.6 $\pm$ 9.8
Age Range (years)	25–60	—	—
Most Affected Level (L5–S1)	54	54	—
Next Common Level (L4–L5)	38	38	—
Other Levels (L3–L4, L2–L3)	8	8	—

Table 2: MRI Findings and Distribution of Lumbar Disc Herniation

MRI Parameter	Category	Frequency (n)	Percentage (%)
Type of Herniation	Protrusion	40	40
	Extrusion	35	35
	Sequestration	25	25
Degree of Nerve Compression	Mild	22	22
	Moderate	36	36
	Severe	42	42
Direction of Herniation	Central	25	25
	Paracentral	63	63
	Foraminal	12	12

Table 3: Correlation of MRI Findings with Postoperative ODI Scores

MRI Parameter	Category	Mean Post-op ODI $\pm$ SD	Correlation (r)	p-value
Type of Herniation	Protrusion	18.3 $\pm$ 5.9	—	0.041
	Extrusion	21.7 $\pm$ 6.8	—	0.038
	Sequestration	27.5 $\pm$ 7.3	—	0.019
Degree of Compression	Mild	16.4 $\pm$ 4.8	0.61	0.046
	Moderate	20.8 $\pm$ 6.5	—	0.033
	Severe	28.9 $\pm$ 7.1	—	0.012

Table 3 indicates that patients who had herniation that was sequestered and severe nerve compression recorded much higher postoperative ODI scores, which means that recovery is slow and residual functional limitations. On the contrary, the individuals with bulging discs and mild compression recorded almost full recovery in three months. The difference in the ODI improvement of mild and severe compression groups was statistically significant ($p < 0.05$).

Gender-based outcomes analysis showed that males and females improved following surgery but males had a slight increase in satisfaction with VAS and ODI scores reduction than females. This can be due to an increase in muscle strength, ambulation, and compliance with postoperative rehabilitation in male patients. There were no significant differences in the level of disc involvement but those with L5 S1 involvement had a slow recovery because of excessive mechanical load on lumbosacral junction.

In general, the study participants ($n=82$) showed a high percentage (82) of great clinical improvement compared to the set criteria of study (reduction in both ODI and VAS by greater than 50%). The rest 18% showed partial improvement, mainly those with developed MRI results, chronic preoperative symptoms, or postoperative fibrosis that was observed on a follow-up imaging. There were no any significant complications, including infection, herniation recurrence, or neurological decline that were noticed over the period of the following up.

To conclude, the research findings develop a definite correlation between the preoperative MRI features and its functional outcomes after microdiscectomy in lumbar disc herniation. Less severe MRI abnormalities in patients resulted in increased pain relief and speedy functional recovery. On the other hand, individuals who had sequestered or large extruded herniations and severe nerve compression had poor recovery, which supported the prognostic role of MRI parameters in predicting postoperative outcomes. The findings here are that although MRI is essential in the surgical planning, it offers useful prognosis in the case of postoperative recovery trends when used together with clinical parameters.

DISCUSSION

The current research compared the association between the preoperative MRI results and postoperative outcomes of patients undergoing microdiscectomy of lumbar disc

herniation (LDH) at tertiary care centers in Punjab, Pakistan⁹. The findings demonstrated that there was a strong correlation between the kind and degree of herniation detected by MRI and the extent of functional outcome in the form of increasing the Oswestry Disability Index (ODI) and Visual Analog Scale (VAS). In particular, patients who had protruded or moderately compressed discs showed better recuperative patterns, whereas those who had sequestered herniations or severe compression of the nerve showed slow or incomplete healing after the surgery¹⁰.

These results correspond with other international and regional literature that has pointed to the predictive worth of MRI in establishing surgical prognosis. Harreld et al. (2017) and Gautschi et al. (2019) found that morphology and volume of disc herniation had a significant impact on postoperative outcomes with smaller herniations and light compression was associated with higher pain and disability improvements score¹¹. On the same note, Kim et al. (2018) and Yoshimoto et al. (2020) have established that extrusion and sequestration patterns were linked to a slower postoperative recovery course, which may be explained by higher levels of inflammatory and compressive processes on the nerve roots that occurred^{8,9}. The results of the current study are in agreement with these observations and present region-specific evidence provided by the Pakistani population in which occupational and ergonomic factors can affect the development and recovery of the disease¹².

The gender disparity of occupational exposure of the studied population by the predominance of males is a result of biased occupational roles in Pakistan where men are more likely to be exposed to activities that are physically demanding and demanding repetitiveness of bending, lifting, or even prolonged sitting all of which cause lumbar strain¹³. This population tendency is consistent with the results of Raza et al. (2022), who also found that the incidence of LDH among male workers was also higher. In the given research, both sexes also showed a positive response to surgical interventions, but males showed a slightly better outcome of postoperative recovery, which may be due to better muscle preparation before surgery and even faster recovery¹⁴.

The fact that the preoperative severity grading of MRI is significantly correlated with postoperative ODI scores ($r = 0.61$, $p < 0.01$) is another important fact that proves the fact that imaging severity directly affects surgical outcomes¹³. Patients with moderate to mild nerve

compression reported faster and greater recovery of symptoms than severe compression. This indicates that the chronic compression can result in permanent damage to the nerve fibres and hence restricts the possibility of a complete recovery of the postoperative neurological system despite sufficient decompression. O'Neill et al. (2020) have made similar conclusions, emphasizing that the regenerative ability of neural tissues is reduced by chronic nerve compression despite the successful discectomy¹⁴.

Surprisingly, even among those patients who had very severe MRI results, the postoperative results were good and this supports the fact that the radiological severity cannot be used to completely define the clinical outcome¹⁵. The length of the symptoms, results of the intraoperative observation, accuracy of the surgery, postoperative rehabilitation compliance are the elements that play the most significant role in defining the final outcomes¹⁹. The observation repeats the considerations of the works by Modic et al. (2018) and Pinto et al. (2018), who state that MRI should be considered along with a clinical examination and not be the only prognostic factor^{1,9}.

The research is strong because of the prospective study design, standardized surgical procedures, and the use of validated outcome measures (ODI and VAS). It fills a significant gap in the local literature by matching MRI morphology with clinical recovery in the South Asian setting because differences in healthcare access and patient adherence may affect recovery patterns. Nevertheless, some limitations are to be considered¹⁶. The research had a fairly limited sample size (n=100) and three months follow-up, which might not be adequate to measure long-term recurrence or delayed neurological recovery. Direct radiological correlation was not done after surgery because follow-up studies were not generally done by MRI after surgery. Also, socioeconomic status, psychological stress, and adherence to postoperative physiotherapy were not quantitatively evaluated but could have been the determining factors in functional recovery¹⁷.

Irrespective of these shortcomings, the results once again confirm the notion that preoperative MRI features, especially the nature of herniation and the extent of nerve root compression to be used as useful prognostic variables to predict postoperative outcomes¹⁸. Grading followed by the use of MRI can be integrated into preoperative counseling to enable spine surgeons to establish realistic expectations of the patients, customize the rehabilitation program, and maximize surgical outcomes²⁰.

CONCLUSION

The current research proves that the preoperative MRI results are largely associated with the postoperative functional outcomes in patients with lumbar disc herniation undergoing microdiscectomy. Patients that have protruded discs and mild to moderate nerve compression

report higher recovery rates in terms of reduction in pain and improvement in disability after the operation but those with sequestered discs and severe compression recover at a slower pace and might have a residual effect on the patient. The findings emphasize the need to conduct extensive preoperative MRI assessment as a diagnostic tool but also in predicting prognosis and surgical planning. The interpretation of MRI grading, used together with clinical parameters, can inform surgeons about patients who are likely to have the highest benefit undergoing surgery and in predicting the challenges during the postoperative period. Further studies are needed on larger and multicenter studies with prolonged follow-up periods and involve correlation of postoperative imaging results to MRI in order to further prove the value of MRI as a prognosis tool. Biochemical and neurophysiological markers as well as imaging parameters should also be incorporated to increase the predictive accuracy. To sum up, MRI is still one of the basics of lumbar disc herniation assessment and management as it gives important hints about the anatomical pathology and possible postoperative results. Its application in the preoperative assessment increases the decision-making in the field of surgery, patient counseling, and, eventually, leads to more customized and efficient spine treatment.

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