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# Pre-operative magnetic resonance imaging as a predictor of success in lumbar disc herniation patients undergoing laminectomy

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## ABSTRACT

**Introduction**. Lumbar disc herniation is a condition in which annulus fibrosus in the lumbar area is herniated with numerous etiologies, such as degenerative. One of the mainstay treatment for lumbar disc herniation is decompressive laminectomy. Magnetic Resonance Imaging (MRI) with the diagnostic accuracy of 97% also has an excellent resolution for soft tissue. The aim of this study is whether pre-operative MRI may be a predictor of successful clinical outcome in lumbar disc herniation patients undergoing laminectomy surgery.

**Methods**. In this cross-sectional study, we consecutively collected all patients in Radiology Department Prof. dr. IGNG Ngoerah Hospital, Denpasar Bali between January 2021 to December 2022. We enrolled patients with older than 18 years old who had undergone pre-operative lumbosacral MRI and had laminectomy surgery within the sampling time period. The following variables were recorded from each patient: age, gender, Body mass index (BMI), history of diabetes mellitus, hypertension, number of herniated discs, herniation grade, spinal canal stenosis grade, neural foramen stenosis grade, lateral recess stenosis grade, annular tear, disc degeneration, facet disc degeneration, thickening of ligamentum flavum, modic changes, cerebrospinal liquor obstruction, and clinical outcome.

**Outcomes**. We collected 30 patients who underwent laminectomy surgery and had their pre-operative MRI. Patients' mean age ± SD was 57.7±10.9 years old with 20 male (66.7%) and 10 female (33.3%). There was no significant association between gender, hypertension, diabetes mellitus, body mass index, number of disc herniation, spinal canal stenosis, lateral recess stenosis, neural foramen stenosis, disc degeneration, facet joint degeneration, ligamentum flavum hypertrophy, Modic changes and cerebrospinal liquor obstruction with clinical outcome post laminectomy patients.

**Conclusion**. Pre-operative MRI can reliably diagnose lumbar disc herniation but are not a predictive tool in assessing the clinical outcome of post-laminectomy patients. Laminectomy has an excellent management value for lumbar disc herniation patients especially in reducing the pain, and for them to have better quality of life.

**Keywords:** lumbar disc herniation, pre-operative MRI, laminectomy

## INTRODUCTION

Low back pain is now one of the most common complaints in the elderly and also younger people, in which its prevalence keeps on increasing within the years. Lumbar disc herniation is a condition in which annulus fibrosus in the lumbar area is herniated with numerous etiologies, such as degenerative. The herniation will cause pain in the lower back due to stimulation of the nerve root in the spinal cord and cauda equina. The increase the prevalence of daily life disturbance will cause significant contribution in reducing the quality of life [1,2].

Imaging plays a very important role in making the diagnosis for lumbar disc herniation. X-ray as the initial imaging of choice with Anterior-Posterior (AP),

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lateral and oblique projection are often used to see the normal alignment of the spine, and also patients may be positioned in flexion and extension to look for spinal instability. In the case of fractured spine and bone integrity, Computed Tomography (CT) Scan is the most sensitive, however the golden standard to confirm the diagnosis of lumbar disc herniation is Magnetic Resonance Imaging (MRI) with the diagnostic accuracy of 97% also has an excellent resolution for soft tissue.[3] MRI can show multiplanar image in axial, sagittal, coronal and three-dimensional, and also numerous sequences to identify abnormalities in spinal cord, subarachnoid space, vertebral bodies, and intervertebral discs [2,4].

The general rules of MRI grading in lumbar disc herniation are normal disc, protrusion, extrusion and sequestration. These findings are evaluated from the displacement of the disc material with apophyseal ring tip. Bulging is defined as the extension of the disc to the apophysis more than 25% of the disc circumference, < 3 mm from the apophyseal tip. Focal protrusion is when the abnormality is less than 25%, extrusion is when the displacement of the disc is more than the disc base, and sequestered is when the nucleus pulposus detaches from the disc [5]. The other parameters are spinal canal stenosis, neural foramen stenosis, ligamentum flavum thickening, listhesis, and annular tear or fissure [5–7].

Decompressive laminectomy is a decompression surgery effective for lumbar disc herniation, in which whole vertebral arch from one facet joint to the other are removed. However, there are some complications reported such as intraoperative bleeding, paraspinal muscle devascularization, and iatrogenic risk of spinal segmental instability, so the decision to operate should be appropriate with the clinical needs and post-operative benefits [8]. Several studies have showed that pre-operative MRI not only become a diagnostic tool, but also the predictor of successful clinical outcome of the patients. Study by Lewandrowski et al, has shown that there are significant difference between lumbar disc herniation grading in MRI with patient's clinical outcome [9]. The aim of this study is whether pre-operative MRI may be a predictor of successful clinical outcome in lumbar disc herniation patients undergoing laminectomy surgery.

## METHODS

In this cross-sectional study, we consecutively collected all patients in Radiology Department "Prof. Dr. IGNG Ngoerah" Hospital, Denpasar Bali between January 2021 to December 2022. We enrolled patients with older than 18 years old who had undergone pre-operative lumbosacral MRI and had laminectomy surgery within the sampling time period. The exclusion criteria were patients who had surgery, but did the MRI in other hospital and patients with lumbar herniated disc who had undergone surgery other than laminectomy. The following variables were recorded from each patient: age, gender, Body mass index (BMI), history of diabetes mellitus, hypertension, number of herniated discs, herniation grade, spinal canal stenosis grade, neural foramen stenosis grade, lateral recess stenosis grade, annular tear, disc degeneration, facet disc degeneration, thickening of ligamentum flavum, modic changes, cerebrospinal liquor obstruction, and clinical outcome.

Herniation grade recorded including bulging, protruded and extruded discs, spinal canal stenosis grade, neural foramen stenosis grade, lateral recess stenosis grade were divided into I-III, disc degeneration including disc dehydration and desiccation, Modic changes type I-III and clinical outcomes were recorded by Numeric Rating Scale (NRS) improvement before surgery and 6 months after the surgery [5,6].

This study was approved by the ethics committee of Universitas Udayana – RSUP "Prof. Dr. IGNG Ngoerah". All study procedures were performed in accordance with the ethical standards.

The data was obtained from the medical record and interview. Distribution of patient characteristics and risk factors among patients with pre-operative lumbar disc herniation parameters in MRI were compared. Numerical variables were described as mean ± standard deviation (SD). Categorical variables were described as sum and proportion then analyzed based on the Chi-square test. To determine the relationship between pre-operative MRI results and patients' clinical outcome. We concluded all of them in accordance with 95% confidence interval and p-value. The statistical analysis was done by using IBM SPSS 25.0.

## OUTCOMES

Demographic and clinical characteristics of this study were shown in Table 1. We acquired mean age ± SD was 57.7±10.9 years old with 20 male (66.7%) and 10 female (33.3%). Patient subject with underweight, normal weight, overweight and obesity were respectively 1 patient (3.3%), 15 patients (50%), 13 patients (43.3%), and 1 patient (3.3%). Patients with comorbidity of diabetes mellitus was 6 patients (20%) and hypertension 11 patients (36.7%).

This study was analysed comparatively by using Chi square. According to our comparative study, there were no significant association between gender, hypertension, diabetes mellitus, body mass index, number of disc herniation, spinal canal stenosis, lateral recess stenosis, neural foramen stenosis, disc degeneration, facet joint degeneration, ligamentum flavum hypertrophy, Modic changes and

**TABLE 1.** Demographic and clinical characteristics

| Variable | N=30 |
|---|---|
| Age ± SD | 57.7±10.9 |
| Gender | |
| Male | 20 (66.7%) |
| Female | 10 (33.3%) |
| BMI | |
| Underweight | 1 (3.3%) |
| Normal | 15 (50%) |
| Overweight | 13 (43.3%) |
| Obese | 1 (3.3%) |
| Hypertension | |
| No | 19 (63.3%) |
| Yes | 11 (36.7%) |
| Diabetes mellitus | |
| No | 24 (80%) |
| Yes | 6 (20%) |
| Number of herniated discs | |
| Single | 12 (40%) |
| Multiple | 18 (60%) |
| Herniation grade | |
| Bulging | 4 (13.3%) |
| Protuded | 22 (73.3%) |
| Extruded | 4 (13.3 %) |
| Spinal canal stenosis | |
| Grade I | 7 (23.3%) |
| Grade II | 7 (23.3%) |
| Grade III | 16 (53.3%) |
| Neural foramen stenosis | |
| None | 2 (6.7%) |
| Grade I | 6 (20%) |
| Grade II | 10 (33.3%) |
| Grade III | 12 (40%) |
| Lateral recess stenosis | |
| None | 12 (40%) |
| Grade I | 2 (6.7%) |
| Grade II | 3 (10%) |
| Grade III | 13 (43.3%) |
| Annular Tear | |
| No | 29 (96.7%) |
| Yes | 1 (3.3%) |
| Disc Degeneration | |
| Disc dehydration | 20 (66.7%) |
| Disc dehydration and disc desiccation | 10 (33.3%) |
| Facet joint degeneration | |
| No | 8 (26.7%) |
| Yes | 22 (73.3%) |
| Ligamentum flavum thickening | |
| No | 15 (50%) |
| Yes | 15 (50%) |
| Modic changes | |
| No | 20 (66.7%) |
| Modic type I | 7 (23.3%) |
| Modic type II | 3 (10%) |
| Cerebrospinal liquor obstruction | |
| No | 4 (13.3%) |
| Partial | 25 (83.3%) |
| Total | 1 (3.3%) |
| Clinical outcome | |
| No improvement | 6 (20%) |
| Improvement | 24 (80%) |

cerebrospinal liquor obstruction with clinical outcome post laminectomy patients (p>0.05).

## DISCUSSION

In this study, the mean age of the research subjects was 57.7 ± 10.49 years, this is in accordance

**TABLE 2.** Gender and clinical outcome of post laminectomy patients

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Gender | | | 0.065 |
| Male | 14 (70%) | 6 (30%) | |
| Female | 10 (100%) | 0 (0%) | |

**TABLE 3.** Hypertension and clinical outcome of post laminectomy patients

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Hypertension | | | 0.261 |
| No | 14 (73.7%) | 5 (26.3%) | |
| Yes | 10 (90.9%) | 1 (9.1%) | |

**TABLE 4.** Diabetes mellitus and clinical outcome of post laminectomy patients

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Diabetes mellitus | | | 0.344 |
| No | 20 (83.3%) | 4 (16.7%) | |
| Yes | 4 (66.7%) | 2 (33.3%) | |

**TABLE 5.** Body mass index and clinical outcome post laminectomy patients

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| BMI | | | 0.384 |
| Underweight | 1 (100%) | 0 (0%) | |
| Normal | 12 (80%) | 3 (20%) | |
| Overweight | 11 (84.6%) | 2 (15.4%) | |
| Obese | 0 (0%) | 1 (100%) | |

**TABLE 6.** Number of disc herniation and clinical outcome post laminectomy patients

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Number of disc herniation | | | 0.545 |
| Single | 10 (83.8%) | 2 (16.7%) | |
| Multiple | 14 (77.8%) | 4 (22.2%) | |

**TABLE 7.** Herniated disc types and Clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Herniation Types | | | 0.385 |
| Bulging | 3 (75%) | 1 (25%) | |
| Protuded | 17 (77.3%) | 5 (22.7%) | |
| Extruded | 4 (100%) | 0 (0%) | |

**TABLE 8.** Spinal canal stenosis and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Spinal canal stenosis | | | 0.663 |
| Grade I | 5 (71.4%) | 2 (28.6%) | |
| Grade II | 6 (85.7%) | 1 (14.3%) | |
| Grade III | 13 (81.3%) | 3 (18.8%) | |

**TABLE 9.** Lateral recess stenosis and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Lateral recess stenosis | | | 0.897 |
| None | 9 (75%) | 3 (25%) | |
| Grade I | 2 (100%) | 0 (0%) | |
| Grade II | 3 (100%) | 0 (0%) | |
| Grade III | 10 (76.9%) | 3 (23.1%) | |

**TABLE 10.** Neural foramina stenosis and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Neural foramen stenosis | | | 0.499 |
| None | 2 (100%) | 0 (0%) | |
| Grade I | 3 (50%) | 3 (50%) | |
| Grade II | 9 (90%) | 1 (10%) | |
| Grade III | 10 (83.3%) | 2 (16.7%) | |

**TABLE 11.** Annular tear and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Annular tear | | | 0.800 |
| No | 23 (79.3%) | 6 (20.7%) | |
| Yes | 1 (100%) | 0 (0%) | |

**TABLE 12.** Disc degeneration and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Disc degeneration | | | 0.674 |
| Disc dehydration | 16 (80%) | 4 (20%) | |
| Disc dehydration and disc desiccation | 8 (80%) | 2 (20%) | |

**TABLE 13.** Facet joint degeneration and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Facet joint degeneration | | | 0.520 |
| No | 6 (75%) | 2 (25%) | |
| Yes | 18 (81.8%) | 4 (18.2%) | |

**TABLE 14.** Ligamentum flavum hypertrophy and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Ligamentum flavum hypertrophy | | | 0.326 |
| No | 11 (73.3%) | 4 (26.7%) | |
| Yes | 13 (86.7%) | 2 (13.3%) | |

**TABLE 15.** Modic changes and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Modic changes | | | 0.788 |
| None | 16 (80%) | 4 (20%) | |
| Modic Type 1 | 6 (85.7%) | 1 (14.3%) | |
| Modic Type 2 | 2 (66.7%) | 1 (33.3%) | |

**TABLE 16.** Cerebrospinal liquor obstruction and clinical outcome post laminectomy

| Variable (n=30) | Clinical outcome | | p |
|---|---|---|---|
| | Improvement | No improvement | |
| Cerebrospinal liquor obstruction | | | 0.855 |
| No | 3 (75%) | 1 (25 %) | |
| Yes | 20 (80%) | 5 (20%) | |

with the prevalence of lumbar disc herniation which generally appears in the third to fifth decades. This is associated with spinal degeneration in which changes in bone structure causes vertebral column alteration, the structure becomes stiffer, the density of the nucleus pulposus decreases, changes

in the composition of the intervertebral disc, so inflammation easily occurs and triggers lower back pain [10].

The gender of the subjects in this study was dominated by men, 20 patients (66.7%), similar to the study by Azemi et al., who got male to female ratio of 2:1 (10). However, the result was different from research by Wibhawa et al, which states that the incidence of lumbar disc herniation is dominated by women, especially after menopause, which is thought to be related to estrogen levels which influence a decrease in bone density [11].

Comorbid factors such as diabetes, hypertension, obesity were known to be poor predictors in patients with post-operative lumbar disc herniation [12]. In this study, BMI was measured to assess the patient's nutritional status. BMI can determine health conditions and see risk factors for a disease, in this study we only found 1 case (3.3%) with obese nutritional status. In contrast, research from Wibhawa et al that suggests that there is no relationship between the incidence of lumbar disc herniation and the patient's nutritional status [11].

Comorbid factors such as hypertension and diabetes mellitus in this study did not have a relationship with the clinical outcomes of post-laminectomy lumbar disc herniation patients. This is in consistent with research by Sunjata et al, which also found that there was no significant relationship between hypertension and the incidence of lumbar disc herniation [12]. Meanwhile, the positive relationship between diabetes and lumbar disc herniation is not yet clear. A study shows that patients suffering from diabetes mellitus for more than 10 years and uncontrolled diabetes patients suffer from premature and excessive apoptosis in the notochordal cells of the nucleus pulposus, another study associates that hyperglycemia conditions result in the formation of AGEs (advanced glycation end products) and microangiopathy which results in accelerated degeneration. disc, so it may interfere with the post-operative healing process [13–16].

However, the absence of a relationship between age, gender, BMI, hypertension and diabetes mellitus and the clinical outcomes of post-laminectomy lumbar disc herniation patients in the study is likely due to the small study sample and because laminectomy management was excellent, so that these factors do not influence the patients' clinical outcomes. Other than that, it may also be due to the duration of the follow-up being too short, because in the research of Yamashita et al., it was stated that the older the patient, the worse the clinical outcome after surgery due to the degenerative process and neuroischemic changes, where in their research the clinical outcomes between older and younger patients in the first 36 months will be the same, but in the 60 months after that it will be significantly different with older patients showing less good outcomes than young people [17].

Twenty-four research subjects (80%) experienced post-laminectomy clinical improvement in the degree of pain and neurological deficits, which was in accordance with research by Alicioglu et al, which also found more (64%) patients with lumbar canal stenosis who had good outcomes post-operatively and there were no significant differences between age, duration of symptoms, gender, degree of pain, paresthesis, straight leg raising test (SLR), motor deficit, sensory deficit, urinary function and degree of spinal canal stenosis, lateral recess, neural foramina, disc degeneration, ligamentum flavum thickening, listhesis and alignment, however there are differences in clinical outcomes with the degree of facet joint degeneration where patients with severe facet joint degeneration have worse outcomes. This may be due to differences in the onset of stenosis, comorbidities, choice of treatment and surgical technique (conservative, wide decompression, medial facetectomy, foraminotomy, microdiscectomy, etc.) and the clinical outcome assessment used [18].

In this study, the pre-operative MRI images that underwent laminectomy were dominated by patients with multiple herniated discs, protruded type, spinal canal stenosis grade III, lateral recess stenosis grade III, neural foramina stenosis grade III, no annular tear, disc dehydration, no modic changes and partial obstruction of cerebrospinal liquor. It can be seen that the frequency distribution of lumbar disc herniation patients who underwent laminectomy were patients with severe herniated disc conditions. So that clinical outcomes such as the pain scale in patients with severe herniated disc conditions are reduced significantly after operative decompression, in accordance with research by Fokter et al, where patients aged under 65 years with severe clinical and physical function disorders underwent laminectomy at one or two vertebral levels showed better clinical outcomes. Apart from that, factors that influence post-operative clinical outcomes are the degree of pre-operative leg and low back pain, good mental status, shorter duration of symptoms, young age and pre-operative physical activity [19]. In a study by Amin et al., it was also explained that motor deficits, vertebral level, type of herniation, gender and modic changes had no relationship with post-operative clinical outcomes [1]. Research by Lewandrowski et al, 2019 also states that there are differences in the degree of stenosis and nerve compression between intraoperative radiologists and surgeons, this may also cause differences in the clinical outcomes of patients after surgery [9].

## CONCLUSION

Pre-operative MRI can reliably diagnose lumbar disc herniation but are not a predictive tool in assessing the clinical outcome of post-laminectomy patients. Laminectomy is an operative procedure that has been abandoned in many developed countries, where minimally invasive procedures are more of an option, however in this study laminectomy still has an excellent management value for lumbar disc herniation patients especially in reducing the pain, and for them to have better quality of life.

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