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# Diagnostic Characteristics of Neuroradiological Tests in Lumbar Disc Herniation

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**Background.** Many apparent advantages of the magnetic resonance imaging (MRI) in establishing diagnosis of lumbar disc herniation are counter parted by its relatively high cost and sparse availability in developing countries. Thus, a significant portion of patients are still subjected to lumbar disc surgery based solely on computed tomography (CT) findings.

**Aim.** The aim of this study was to compare diagnostic characteristics of afore mentioned radiological tests (CT and MRI) and to investigate if the choice of diagnostic test influences outcome of discectomy.

**Methods.** Basic demographic, clinical and radiological variables were evaluated in a group of 70 patients operated on for disc herniation of whom 30 were operated based on MRI findings and the remainder were operated based on CT scan alone. Outcome was assessed using Visual Analogue Scale (VAS) and Roland-Morris (RM) scale 6 months postoperatively and correlated to the type of neuroradiological examination. Basic diagnostic characteristic of the two diagnostic modalities (MR and CT) were compared and relationship between type of neuroradiological test performed preoperatively and outcome was determined.

**Results.** CT proved to be 92.3% sensitive and 85.7% specific in detecting extrusion in contrast to MR that was 91.6% sensitive and 66.7% specific (in detecting extrusion). ROC curve analysis revealed a more favorable diagnostic profile for MR as compared to CT, with CT AUROC of 0.624 and MR AUROC of 0.875. The difference in recovery ( defined as the difference in VAS and RM measures preoperatively and 6 months after the surgery) between patients operated on based solely on CT findings and those operated on based on MR findings was insignificant (p=0.3671 using VAS as an outcome measure and p=0.9527 using RM as an outcome measure).

**Conclusion.** We conclude that since the presence of preoperative MR scan does not influence outcome and since both CT and MR exhibit similar sensitivity and specificity in detecting disc extrusions CT is still a viable preoperative diagnostic option prior to lumbar disc surgery.

**Keywords.** *lumbar disc herniation, discectomy, outcome, magnetic resonance, computedtomography*

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**Competing interests**
The authors declare no competing interests.

## INTRODUCTION

Magnetic resonance (MRI) depicts tissues with a digital matrix representing shades of gray, depending on the intensity of the radio waves emanating from the tissue. Due to its relatively high cost, sparse availability in developing countries and inability to subject patients with metallic foreign bodies to MRI a relatively large proportion of patients are still being operated for lumbar disc herniation based solely on CT findings [1]. Many lumbar disc herniations can be visualized on computed tomography (CT) that represents the method of choice if MR is not available or not tolerated by patients. In general, surgery is indicated based on CT scan alone if there is a clear correlation between history, neurological examination and CT scan. Several recent multicenter studies compared diagnostic value of CT, CT myelography and MRI revealing similar sensitivity and specificity of the CT scan as compared to the MRI while noting that both methods are superior to CT myelography. Aforementioned studies were based on correlation of the CT and MR findings with operative findings and failed to make any conclusion regarding outcome after surgery in respect to the choice of radiological study [2, 3, 4].

The aim of this study was to compare diagnostic characteristics of afore mentioned radiological tests and to investigate if the choice of diagnostic test influences outcome of discectomy.

## PATIENTS AND METHODS

The study was conducted prospectively and encompassed 70 patients operated on for lumbar disc herniation, 30 of which had

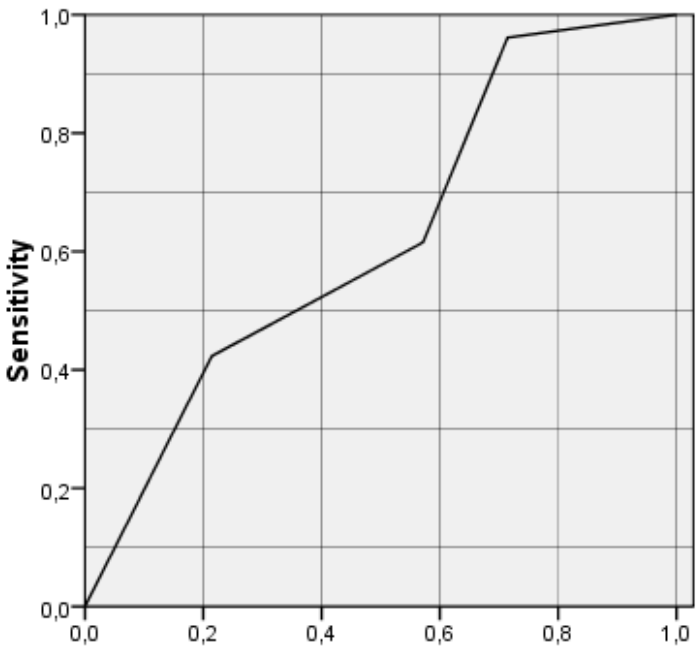


**Figure 1.** Receiver Operating Charactheristics Curve for CT. AUROC = 0.624; Std err = 0.095; 95% CI = 0.437 to 0.810

been subjected to MR scan prior to surgery and the remainder of patients ( a group of 40 patients) were subjected to surgery based solely on CT scan findings. Specific inclusion criteria at enrollment were radicular pain (below the knee for lower lumbar herniations, into the anterior thigh for upper lumbar herniations) and evidence of nerve-root irritation with a positive nerve-root tension sign (straight leg raise–positive between 30° and 70° or positive femoral tension sign) or a corresponding neurologic deficit (asymmetrical depressed reflex, decreased sensation in a dermatomal distribution, or weakness in a myotomal distribution). Additionally, all participants were surgical candidates who had undergone advanced vertebral imaging showing disk herniation (protrusion, extrusion, or sequestered fragment) at a level and side corresponding to the clinical symptoms.

Patients with multiple herniations were included if only one of the herniations was considered symptomatic (ie, if only one was planned to be operated on). Exclusion criteria included prior lumbar surgery, cauda equina syndrome, scoliosis greater than 15°, segmental instability (10° angular motion or 4-mm translation), vertebral fractures, spine infection or tumor, inflammatory spondyloarthropathy, pregnancy, comorbid conditions contraindicating surgery, or inability/unwillingness to have surgery within 6 months. Neuroradiological work-up encompassed either CT or MRI scan of the lumbar spine. Scans were analyzed by neuroradiologists and again by neurosurgeons. Neurosurgeon in charge was asked to grade disc herniation on CT or MR study on the scale of 1 to 4, depending on subjective conviction that the particular disc herniation was indeed an extrusion ( grade 1 on the scale denoting cases that an operator felt were "certainly non extrusion" and 4 denoting cases with "definite extrusion") (Table 1).

Measures used in the study were:

- *Roland-Morris (RM) Low Back Pain and Disability Questionnaire*
- *Visual Analogue Scale (VAS)*

A very popular assessment of pain severity in a clinical setting is the use of Visual Analogue Scale. The patient is given instructions to rate his or her perceived pain level by placing a mark on a 10 cm line and pain level is scored on a 0 to 10 scale [5]. Other measurement tool used, the RM questionnaire is one of the most commonly used tools for measuring spinal disability [6]. This questionnaire was developed by shortening the 136- item Sickness Index Profile, from which Roland and Morris originally extracted 24 items which they felt were relevant to low back pain.

A RM is relatively easy applicable in clinical practice. The patient simply answers Yes or No to 24 questions which refer to the effect of their back pain on daily activities. A score is obtained by summing all affirmative answers. When assessing clinical changes with RM questionnaire a range of 2.5 to 5 points is considered clinically relevant. A revised version of RM questionnaire containing only 18 items was shown to meet accepted validity and reliability criteria and was used in our study [7].

Patients were required to asses their level of pain and functional disability using afore mentioned scales preoperatively and 6 months after the surgery. All patients were operated by neurosurgeon and the procedure performed was standard open microdiscectomy. Disc herniation was defined as extrusion if posterior annulus was ruptured (as assessed during the surgery).

## STATISTICAL ANALYSIS

The diagnostic performance of CT and MR in detecting extrusion (as assessed during the surgery by the competence of posterior annulus) was determined and expressed as sensitivity and specificity values. ROC analysis was performed next (including AUROC values, standard error and CI values). Finally, a relationship between the outcome and the type of neuroradiological test was determined. The significance of the difference between baseline and 6 months follow-up within each group was calculated using the Wilcoxon Signed Rank test and the difference between the change in the two groups after 6 months was analyzed with the Mann Whitney U Test. The SPSS statistical software was used.

**Table 1.** Grading of CT and MRI scans

| Grade | Description |
|---|---|
| 1 | Definitely protrusion |
| 2 | Possible extrusion |
| 3 | Probable extrusion |
| 4 | Definite extrusion |

## RESULTS

70 patients were subjected to microdiscectomy in our department between January and June 2008. 36 (51, 4%) of which were male. The mean age at presentation was 45.8 years (SD = 9.39).

Table 3. depicts the distribution of various disc herniation types according to CT and MRI.

Correlation between CT findings and operative findings is depicted in table 4.

Correlation between MR findings and operative findings is depicted in table 5.

Figures 1 and 2 depict Receiver Operating Characteristic (ROC) curves for CT and MRI, respectively.

## DISCUSSION

Most patients in our study had a neuroradiological (CT or MRI) signs of disc extrusion, which correlates well with operative findings as graded by annular competence, meaning that there was no statistically significant difference between operative findings and CT or MR findings in terms of disc herniation type. Likewise, it was shown that MR and CT exhibit similar diagnostic characteristics (sensitivities of 91.6% and 92,3% for MRI and CT, respectively) (Tables 4 and 5). ROC curve analysis revealed a more favorable diagnostic profile for MR as compared to CT (Figures 1 and 2), with CT

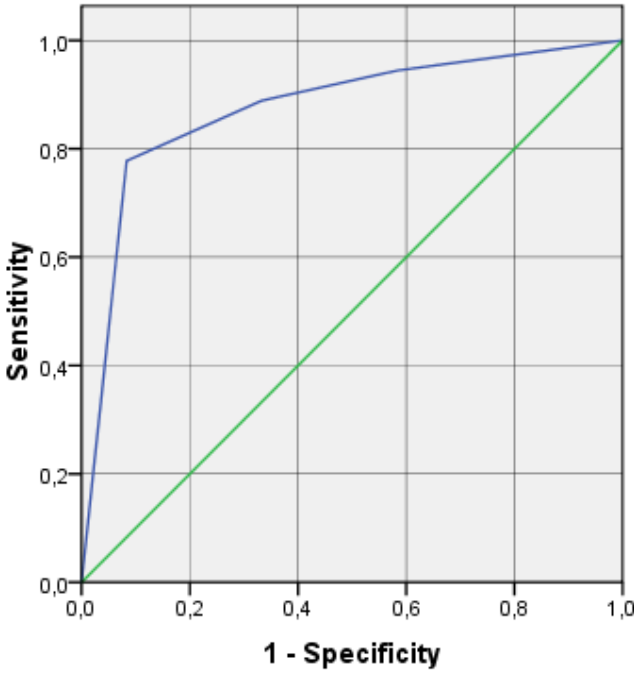


**Figure 2.** Receiver Operating Charactheristics Curve for MRI. AUROC = 0.875; Std err = 0.069; 95% CI= 0.686 to 0.959

AUROC of 0.624 and MR AUROC of 0.875. Early studies investigating a role of MR imaging in the treatment of lumbar disc herniation [9] revealed an excellent sensitivity and specificity of MR imaging in detecting annular competence and thus in detecting type of disc

**Table 2.** Patient baseline demographic and clinical characteristics

| | Patients with CT No. (%) | Patients with MR No. (%) | *p |
|---|---|---|---|
| Age, mean (SD), y | 46.2 (9.30) | 45.3 (9.42) | NS** |
| Gender | 20 (50) | 16 (53.4) | NS |
| Pain intensity (VAS), mean (SD) | 75.4 (21.20) | 77.4 (21.23) | NS |
| Pain duration, mean (SD), m | 17.6 (37.05) | 17.2 (35.2) | NS |
| Dermatomal distribution | | | |
| L5 | 16 (40) | 15 (50) | NS |
| S1 | 17 (42.5) | 10 (33.3) | 0.020 |
| L5 and S1 | 3 (7.5) | 3 (10) | NS |
| Other | 4 (10) | 2 (6.7) | NS |
| Pain with SLR | 40 (100) | 30 (100) | NS |
| Motor deficit | 7 (17.5) | 5 (16.7) | NS |
| Herniation type (according to imaging study) | | | |
| Extrusion | 26 (37.1) | 17 (24.3) | 0.026 |
| Protrusion | 13 (18.6) | 11 (15.7) | NS |
| Other | 1 (2.5) | 2 (2.8) | NS |

*Statistical significance was calculated with Fisher's Exact test.
** NS- not significant

**Table 3.** Disc herniation type according to CT and MRI

| Finding | Extrusion | | Protrusion | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|
| Test | N | % | N | % | N | % | N | % |
| CT | 26 | 37.10 | 13 | 18.60 | 1 | 2.50 | 40 | 57.00 |
| MR | 17 | 24.30 | 11 | 15.70 | 2 | 2.80 | 30 | 43.00 |
| Total | 43 | 60.50 | 24 | 34.20 | 3 | 5.30 | 70 | 100.00 |

**Table 4.** Correlation between CT findings and operative findings

| Operative finding | Extrusion | | Protrusion | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|
| CT finding | N | % | N | % | N | % | N | % |
| Extrusion | 24 | 40.00 | 1 | 2.50 | 1 | 2.50 | 26 | 65.00 |
| Protrusion | 2 | 5.00 | 6 | 15.00 | 5 | 12.50 | 13 | 32.50 |
| Other | 0 | 0.00 | 0 | 0.00 | 1 | 2.50 | 1 | 2.50 |
| Total | 26 | 65.00 | 7 | 17,50 | 7 | 17.50 | 40 | 100.00 |

*Sensitivity 92.30%; specificity 85.70% (in detecting extrusion)*

**Table 5.** Correlation between MR findings and operative findings

| Operative finding | Extrusion | | Protrusion | | Other | | Total | |
|---|---|---|---|---|---|---|---|---|
| MR finding | N | % | N | % | N | % | N | % |
| Extrusion | 11 | 36.60 | 5 | 16.70 | 1 | 3.30 | 17 | 56.60 |
| Protrusion | 1 | 3.40 | 7 | 23.30 | 3 | 10.00 | 11 | 36.60 |
| Other | 0 | 0.00 | 0 | 0.00 | 2 | 6,60 | 2 | 6.80 |
| Total | 12 | 40.00 | 12 | 40.00 | 6 | 20.00 | 30 | 100.00 |

*Sensitivity 91.60%; Specificity 66,70% (in detecting extrusion)*

herniation. Investigating the sample encompassing 17 patients with total of 19 disc herniations, using 0,5 T MR Scanner Grenier et al. [9] correlated operative findings with imaging findings. They revealed that the posterior longitudinal ligament was compromised in 8 cases and intact in 11 cases intraoperatively. The lack of low-intensity signal line around the disc herniation was the most consistent predictor of disc extrusion (without false positive or false negative results). The presence of low-intensity signal line excluded annular disruption. Total test sensitivity in this series proved to be 100%, whilst total specificity reached 78%. More recent studies failed to confirm afore mentioned results. The study conducted by Silverman [10] in 1995. correlated 3 MR features with operative findings: the presence and integrity of low- signal intensity line around the disc herniation, disc size to spinal canal size ratio and the presence of free discal fragment. The author concluded that MR parameters are not reliable predictors of annular competency. Weiner and Patel [11] reached similar conclusions in 2008. Their study revealed the MR sensitivity of 72% and specificity of 68%. In 2004. Pfirrmann [12] developed a grading system for nerve root compression on MR imaging, derived from the specimen of over 250 subjects. MR imaging features correlated well with operative findings (r = 0.86). Sensitivity and specificity of CT proved to be similar to those of MRI in most studies. In the study designed to compare radiological evaluation of spiral CT with MRI in patients with suspected herniated discs 57 patients with lumbosacral radicular syndrome underwent spiral CT and 1.5 T MRI. For detection of herniated or bulging discs, no significant difference in interobserver agreement was noticed (CT kappa 0.66 vs. MRI kappa 0.71; $p<0.40$). For root compression, significantly better interobserver agreement at MRI evaluation (CT kappa 0.59 vs. MRI kappa 0.78; $p<0.01$) was noticed. In the cases without disagreement, CT differed from MRI in 6

**Table 6.** Relationship between type of neuroradiological examination and outcome

| Group/ Outcome | MR Pre-op | Post-op | Diff | p* | CT Pre-op | Post-op | Diff | p* | Diff p** |
|---|---|---|---|---|---|---|---|---|---|
| **VAS** | 74.56 | 24.00 | 50.56 | <0.0001 | 77.75 | 21.65 | 56.10 | <0.0001 | **0.3671** |
| **RM** | 14.03 | 5.63 | 8.40 | <0.0001 | 13.98 | 5.72 | 8.26 | <0.0001 | **0.9527** |

**The significance of the difference between baseline and 6 months follow-up within each group was calculated with the Wilcoxon Signed Rank test.*
***The difference between the change in the two groups after 6 months was analysed with the Mann Whitney U Test.*

discs (3.5%) and in 3 nerve roots (0.7%). The authors concluded that for radiological evaluation of lumbar herniated discs, there is no evidence that spiral CT is inferior to MRI. For evaluating lumbar nerve root compression, spiral CT is less reliable than MRI [13]. Thus, our study is in a closer concordance with the results of more recent series.

Our study failed to reveal significant relation between the type of preoperative neuroradiological examination (CT vs. MRI) and outcome (p= 0.3671 for difference in outcome between patients with MR and those with CT according to VAS scale; p= 0.9527 according to RM scale) (Table 5). Very few studies investigated the influence of preoperative neuroradiological study on outcome. Several authors investigated MR findings in relation to outcome in conservatively treated patients [14]. Several studies correlated MR findings with the disc herniation propensity to recur and revealed that some MR features are predictive of disc herniation recurrence. Dora in 2005. retrospectively compared preoperative MR findings in 30 patients exhibiting reherniation after surgery and 30 patients without reherniation 2 years upon surgery. Reherniation risk decreased by 3,4 times with each disc degeneration level [15].

## CONCLUSION

We conclude that since the presence of preoperative MR scan does not influence outcome and since both CT and MR exhibit similar sensitivity and specificity in detecting disc extrusions CT is still a viable preoperative diagnostic option prior to lumbar disc surgery.

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