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SCIENTIFIC ARTICLE

Lumbar multifidus muscle changes in unilateral lumbar disc herniation using magnetic resonance imaging

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Abstract

Objective To assess multifidus muscle asymmetry using the cross-sectional area (CSA) and perpendicular distance of the multifidus muscle to the lamina (MLD) measurements in patients with nerve compression due to lumbosacral disc hernia.
Materials and methods In total, 122 patients who underwent microdiscectomy for unilateral radiculopathy caused by disc herniation, diagnosed by magnetic resonance imaging (MRI), were evaluated retrospectively. Posterolateral or foraminal disc herniation at only one disc level, the L3-4, L4-L5, or L5-S1 region, was confirmed using MRI. Subjects were divided by symptom duration: 1–30 days, (group A), 31–90 days (group B), and >90 days (group C). There were 48 cases in group A, 26 in group B, and 48 in group C.
Results In groups A, B, and C, the median MLD differed significantly between the diseased and normal sides ($P<0.05$). The MLD increased on the diseased side with symptom duration by lumbar disc herniation. The diseased side MLD was 5.1, 6.7, and 7.6 mm in groups A, B, and C, respectively ($P<0.05$). The cut-off values for the MLD measurements were 5.3 mm (sensitivity = 62.3 %, specificity = 55.5 %; $P<0.05$). In groups A, B, and C, the median CSA of the multifidus muscle was not significantly different between the diseased and the normal side ($P>0.05$).

Conclusions The MLD measurement correlated significantly with multifidus asymmetry in patients with lumbar disc herniation.

Introduction

Disc herniation is one of the most common conditions of the lumbar spine. Compression by a protruding disc on the dorsal and/or ventral rami of the nerve roots causes lower back pain, leg pain, muscle spasm, and restriction of trunk movement [1]. Paraspinal muscles are important in maintaining normal functioning of the lumbar spine. The multifidus muscle is the largest and most medial of the lumbar paraspinal muscles [2]. The muscle is innervated by the medial branch of the posterior root of the segmental nerve, and this innervation is always unisegmental; there is no collateral innervation [3]. Nerve root compression by lumbosacral disc herniation causes paraspinal muscle changes. Some investigators have reported histological changes in the multifidus muscles in lumbosacral disc herniation [1, 3, 4]. Others have reported morphological changes in the multifidus muscles in patients with lumbosacral disc herniation [5–8].

Previous studies have typically used the cross-sectional area (CSA) to assess multifidus muscle asymmetry. Farshad et al. [7], however, performed measurements of the multifidus muscle to the lamina (MLD) in addition to CSA. In clinical practice, CSA measurements to assess multifidus muscle asymmetry are often omitted because of their complexity. We sought a simpler and easier-to-apply method for the quantitative evaluation of fatty atrophy of the multifidus muscle in cases of nerve compression due to MLD disc hernia.

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This study aimed to determine the presence of multifidus muscle asymmetry by measuring CSA of the multifidus muscle using magnetic resonance imaging (MRI) and MLD measurements. We also addressed whether there was a correlation between multifidus muscle asymmetry and the duration and severity of radiculopathy in patients undergoing surgery for unilateral and single-level lumbar disc hernia.

Materials and methods

In total, 122 patients who underwent microdiscectomy for unilateral radiculopathy caused by disc herniation, diagnosed by MRI between January 2012 and June 2014 at our university hospital, were evaluated retrospectively. The patients comprised 58 females and 64 males, ranging in age from 16 to 80 years with a mean age of 46±12.7 years. The duration of symptoms up to MRI was documented for each patient. Subjects were divided by symptom duration: 1–30 days (group A), 31–90 days (group B), and >90 days (group C). There were 48, 26, and 48 cases in groups A, B, and C, respectively.

The inclusion criteria were: (1) posterolateral or foraminal disc herniation at only one disc level (L3-4, L4-L5, or L5-S1), confirmed by MRI studies, and (2) symptoms following a nerve root distribution in the leg or lower back pain on the side of the herniation. Exclusion criteria were bilateral signs or symptoms in the lower extremities, spinal tumors, and previous lumbosacral surgery, or having a preoperative lumbar MRI that was performed at another center. This study was approved by the institutional review board of our university hospital. It was supported by university research funds.

Imaging parameters

MRI of the lumbar spine was performed using a 1.5-T unit (Magnetom Avanto; Siemens Medical Solutions, Erlangen, Germany). The imaging protocols included axial T2-weighted images (TR/TE 3500/106, matrix size 208×320, slice thickness 4 mm) and sagittal T2-weighted images (TR/TE 3500/106, matrix size 208×320, slice thickness 4 mm).

Image analysis

The lumbar MR images were evaluated by an experienced neuroradiologist blinded to the side presenting the symptoms using a digital workstation. The measurements were done by one radiologist who repeated the measurements three times in different days to diminish the bias. We found an intra-observer correlation coefficient of 0.92. First, T2-weighted sagittal and axial images were used to determine the level, side, and site (recessal or foraminal) of the disc hernia. The severity of nerve compression due to disc hernia was categorized according to Pfirrmann [9].

T2-weighted axial MR images were used for evaluation of the multifidus muscles. Two parameters (CSA and MLD) were examined to assess multifidus muscle atrophy. We measured the MLD and the CSA of the multifidus muscle in patients on axial T2-weighed MR images at the facet joint level. The measurement of MLD is done beginning at the middle of the lamina ending at the multifidus muscle border on a line perpendicular to the lamina (Fig. 1). The CSA of the multifidus muscle and MLD were traced using the manual cursor technique (Fig. 2). The CSA of the multifidus muscle and MLD were measured on the side of compression and on the contralateral side. If the nerve root compression was in the recess, measurements at the level below were used, and if the nerve root compression was foraminal, measurements at the same level were used [7].

Statistical analysis

Statistical analyses were performed using the SPSS software (ver. 17.0; SPSS Inc., Chicago, IL, USA). If continuous variables were normally distributed, they are reported as means± standard deviations ($P>0.05$ in Kolmogorov-Smirnov test or Shapiro-Wilk ($n<30$)), and if they were not normally distributed, they are described medians. Comparisons among groups were made using one-way ANOVA for normally distributed data, and the Kruskal-Wallis test was used for non-normally distributed data. If ANOVA was significant, comparisons were made using a post hoc test and the Mann-Whitney U-test. Receiver operating characteristic (ROC) curves were generated, and the areas under the curve (AUCs) and sensitivity and specificity were calculated for CSA and MLD. Reliability analysis of congruence between measures to be tested, assessed by intra-observer correlations values. $P<0.05$ was considered to indicate statistical significance.
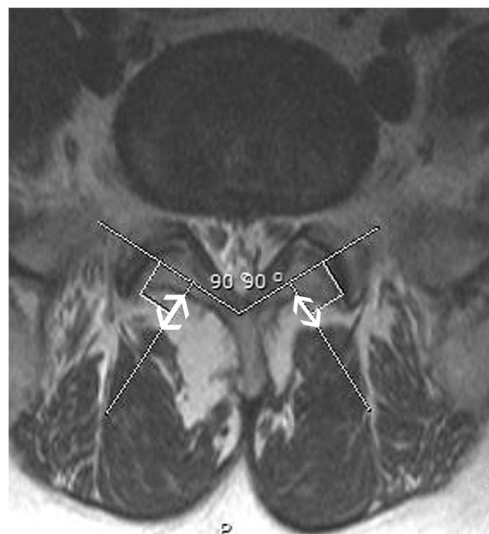

Fig. 1 The perpendicular distance between the multifidus muscle and the laminae (MLD) is indicated in the figure.

Fig. 2 Sagittal T2-weighted image of the lumbar spine shows disc herniation (*arrow*) at the level of L4/L5 (**a**). Axial T2-weighted image at the level of L4/L5 shows a right recessal disc herniation (*arrow*) deviating the L5 nerve root (**b**). The perpendicular distances of the multifidus muscles to the laminae (MLD) on the compressed nerve side (**c**) and the contralateral side (**d**) are *outlined*. The cross-sectional area (CSA) of the multifidus muscle on the compressed nerve side (**e**) and the contralateral side (**f**) are *outlined*
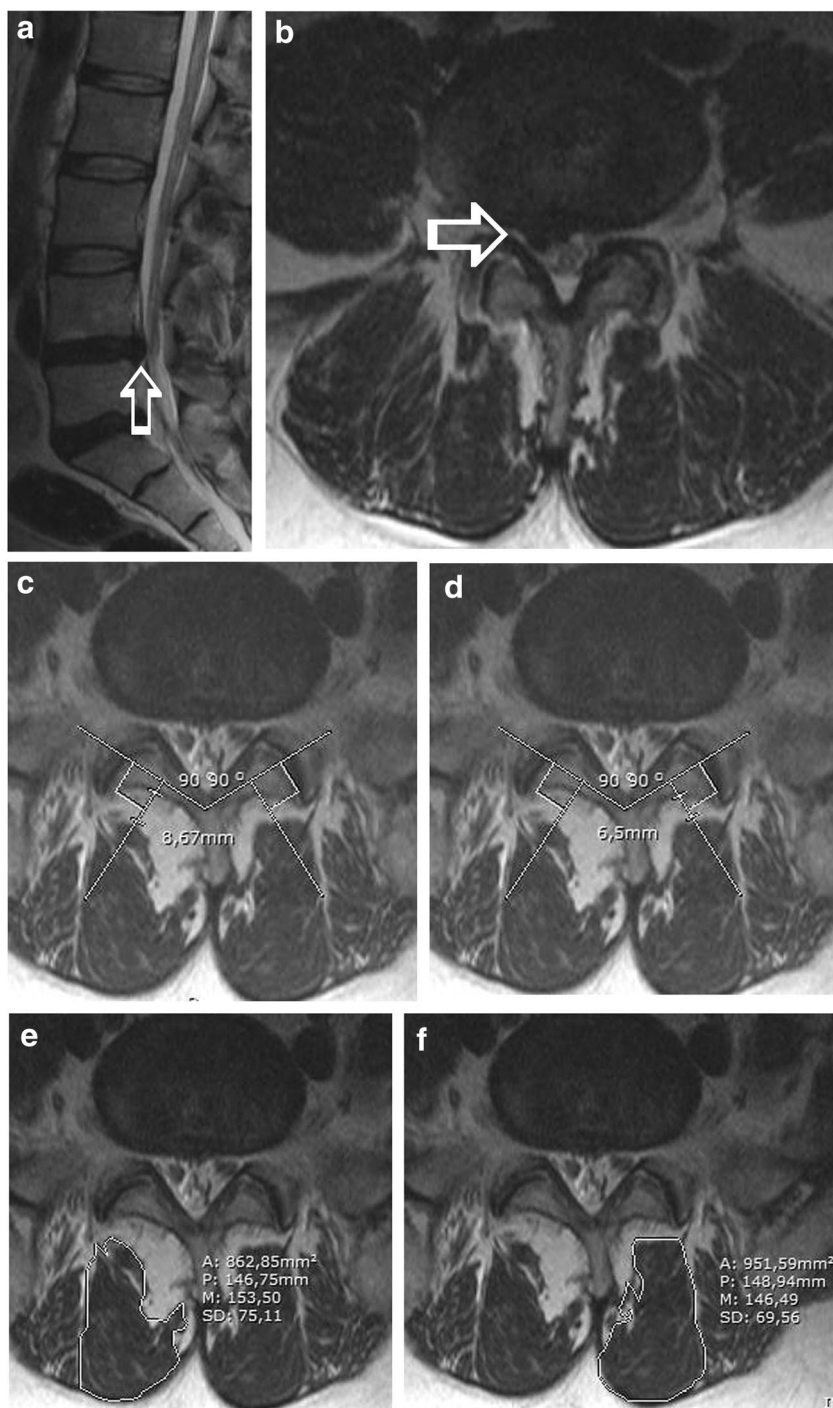
Results

There were 105 recessal and 17 foraminal symptomatic nerve compressions at levels L3/L4 ($n=7$ recessal and $n=4$ foraminal), L4/L5 ($n=51$ recessal and $n=11$ foraminal), and L5/S1 ($n=47$ recessal and $n=2$ foraminal).

In groups A, B, and C, the median CSA of the multifidus muscle was not significantly different between the diseased side and the normal side. In groups A, B, and C, the median MLD was significantly different between the diseased side and the normal side (Table 1). On ROC curve analysis, cut-off values for MLD measurements were 5.3 mm, and the sensitivity and specificity values were 62.3 and 55.5 %, respectively ($P<0.05$; Fig. 3). For group C, cut-off values for MLD measurements were 5.3 mm, and the sensitivity and specificity were 75 and 62.5 %, respectively ($P<0.05$). For groups A and B, we were unable to determine specific cut-off values.

Table 1 Perpendicular distance of the multifidus to the lamina (*MLD*) and cross-sectional area (*CSA*) of the multifidus muscle in groups *A*, *B*, and *C*

		Diseased side CSA (mm^2)	Normal side CSA (mm^2)	Diseased side MLD (mm)	Normal side MLD (mm)
Patient groups according to duration of symtoms					
A (*n*=48)	Median (Min-Max)	778.4 (346–1,160.3)	779.7 (347.4–1,258.0)	5.1 (2.3–12.8)	4.8 (2.5–12.4)
B (*n*=26)	Median (Min-Max)	719.9 (448.2–1,147.5)	742.8 (548.5–1,219.6)	6.7 (3.0–11.2)	5.4 (2.8–10.7)
C (*n*=48)	Median (Min-Max)	666.4 (273.6–1,374.9)	736.1 (391.2–67,997)	7.6 (3.3–13.7)	5.0 (2.1–12.0)
	P	0.230	0.972	0.021	0.537

CSA cross-sectional area, *MLD* perpendicular distance of the multifidus to the lamina

A: group of patients with symptom duration 1–30 days

B: group of patients with symptom duration 31–90 days

C: group of patients with symptom duration >90 days

Nerve compression was evaluated according to Pfirrmann (9) and showed a severity of 1 in 10 cases, 2 in 55 cases, and 3 in 57 cases. There was no significant difference in the nerve compression degree or between the pathological and normal sides with respect to CSA or MLD (Table 2).

Discussion

In this study, we demonstrated that in groups A, B, and C, the median MLD was significantly different between the diseased side and the normal side. We used MLD to assess fatty atrophy in the medial multifidus muscle due to disc hernia. Multifidus muscle atrophy tends to be localized: medial and deep along the multifidus muscle myofascial sheath on the side of the symptoms [10].

Fig. 3 Receiver operating characteristic curves of MLD measurements of the multifidus muscle on the compressed nerve side. Area under the curve=0.626

Changes in the multifidus muscles were found in patients with lumbar disc herniation. Zhao et al. [1] and Yoshihara et al. [4] reported histological investigations that showed that type I and II fibers on the side of the disc herniation were significantly smaller than those on the normal side. Changes in the multifidus muscles have been reported to be influenced by the duration of symptoms. Atrophy of these muscles tends to occur more often in patients with longer symptom duration [6]; furthermore, in an experimental study, Hodges et al. [11] found rapid atrophy of the multifidus muscles after disc damage and root injury. Our study demonstrated that MLD measurements were correlated significantly with multifidus asymmetry due to disc hernia, even in group A, which experienced short symptom duration. We also found that asymmetry of the multifidus increased with the duration of symptoms.

Farshad et al. [7] found that neither the CSA nor the MLD ratio was associated with the severity or duration of nerve root compression, and we found the same result. Also, in groups A, B, and C, the median CSA of the multifidus muscle was not significantly different between the diseased and normal sides. Unlike their study, we found in groups A, B, and C that the median MLD was significantly different between the diseased and normal sides.

Following surgery, multifidus muscle dysfunction was correlated significantly with lower back pain and worse prognosis. Lower back pain can recur more commonly in the case of weakened paraspinal muscles and resulting instability; the latter can be addressed by rehabilitation exercise programs [6, 12]. Choi et al. [12] demonstrated that pain, duration of recuperation, and back muscle strength can be affected favorably by lumbar extension muscle-strengthening programs after lumbar disc hernia surgery; thus, radiologists should provide a description of multifidus muscle atrophy in reports of cases with disc hernia; they should also draw clinicians' attention to multifidus atrophy to institute lumbar extension muscle-strengthening programs. Although the ROC curve analysis showed a weak discrimination between MLD measurements on the compressed nerve side versus the normal side with low sensitivity and specificity (62.3 % and 55.5 %, respectively), it
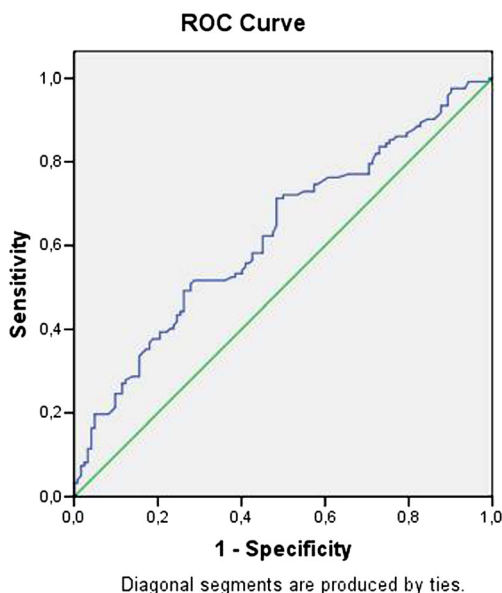
Table 2 Perpendicular distance of the multifidus to the lamina (*MLD*) and cross-sectional area (*CSA*) of the multifidus muscle by nerve compression severity

		Diseased side CSA (mm^2)	Normal side CSA (mm^2)	Diseased side MLD (mm)	Normal side MLD (mm)
Patient groups according to nerve compression severity					
1 (*n*=10)	Median (Min-Max)	678.7 (472.2–929.1)	697.0 (462.3–69,997.0)	4.9 (3.4–8.1)	4.9 (2.9–8.3)
2 (*n*=55)	Median (Min-Max)	733.5 (273.6–1,374.9)	764.9 (391.2–1,560-4)	6.5 (2.3–13.7)	4.9 (2.1–12.4)
3 (*n*=7)	Median (Min-Max)	726.1 (346–1,110.9)	774.2 (347.4–1,219.6)	6.7 (3.0–13.4)	4.9 (2.5–11.4)
	P	0.945	0.972	0.136	0.741

CSA cross-sectional area, *MLD* perpendicular distance of the multifidus to the lamina

1: group of patients with nerve compression with a severity of grade 1 (contact), according to Pfirrmann

2: group of patients with nerve compression with a severity of grade 2 (deviation), according to Pfirrmann

3: group of patients with nerve compression with a severity of grade 3 (compression), according to Pfirrmann

was statistically significant and we identified a cut-off level of 5.3 mm for MLD in patients with nerve compression due to disc hernia. Additionally, in the group with symptoms more than 90 days (Group C) the cut-off level was 5.3 with a higher sensitivity and specificity (75 and 62.5 %, respectively) (*P*<0.05). In the assessment of disc hernia-induced nerve compression, patients with a MLD greater than 5.3 mm on the compression side, may be primarily candidates for lumbar extension muscle-strengthening programs, especially if they have symptoms for more than 90 days.

There are several limitations to the present study. The first is the absence of a control group; however in literature, it is shown that the measurements done on the asymptomatic side are similar to CSA results from asymptomatic participants [13]. Second, interobserver variability could not be assessed, because one radiologist performed all measurements. Third, we could not perform electrodiagnostic testing to evaluate radiculopathy. Finally, we attempted to exclude fatty tissue in the multifidus muscle as much as possible at the time of CSA measurements; however, performing drawings using the manual cursor technique was a limitation of our study. In conclusion, in groups A, B, and C, the median MLD was significantly different between the diseased side and the normal side.

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