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ORIGINAL ARTICLE

Correlation of Magnetic Resonance Imaging Changes of Multifidus Muscle with Other Degenerative Changes at Lumbosacral Spine in Patients with Low Back Pain

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ABSTRACT

Background: Multifidus muscle (MF) in the back of the vertebral column plays an important role in spinal stability. MF morphology and fatty infiltration can be influenced by factors affecting low back pain (LBP) and evaluated using MRI, CT and US, however MRI provides a higher resolution and allows for better detection of soft tissues. We proposed a new method to assess the degree of MF degeneration in this study.

Methods: The multifidus score was calculated by summation of degree of MF degeneration, with minimum score of 0 and maximum of 6. In cases of disproportion affection of MF on each side, we chose the higher degree of MF affection. A score of 6 means that MF degeneration is graded 2 in either side. We mentioned the influence of other vertebral degenerative pathologies including facet arthropathies, neural canal stenosis and Modic end plate changes. We defined disc pathology as disc bulge, herniation. The main factors affecting MF degeneration are age, body mass index (BMI), duration of compliant in years, presence of sciatica and VAS visual analogue scale (VAS) score.

Results: VAS scores were statistically significantly correlated with degree of MF degeneration, with p value < 0.001. The degree of MF degeneration was significantly correlated with a number of disc pathologies.

Conclusions: Our study concluded a significant relation between MF degeneration and each of VAS and duration of pain, although this relation was not related to the measurement of proportionate changes between each side and different degrees of MF degeneration.

Keywords: Lumbar spine, Magnetic Resonance Imaging, Low back pain, Multifidus muscle, Lumbosacral.

INTRODUCTION

Since years, there are many research efforts aimed to understand the changes related to low back pain (LBP). The morphological changes in all elements of the spine including vertebral end plates, intervertebral discs, posterior elements, neural canal, supporting ligamnts and spinal back muscles were related to the degree of pain, disability and morbidity associated with spine degenerative conditions, as well multiple factors are to be associated with more degree of degenerative changes in the spine including body mass index (BMI), duration of pain and degree of severity of pain [1].

The changes in back muscles of the spine are theoretically related to the degree of spondylodegenerative changes, fatty replacement is the main indicator for muscle atrophy and better depicted by MRI. These structural changes are also related to the degree and duration of pain and to BMI [1, 2].

The paraspinal muscles consist of two layers; the outer “extrinsic“ layer is comprised of the larger superficial back muscles, thought primarily responsible for spine and limb motion. The inner “intrinsic” muscle layer is made up of the deep spinal muscles, such as the multifidus muscle (MF), whose proposed role is the primary control intersegmental motion [2].

The presence of lumbar disc pathology either disc bulge, herniation or annular tear often result in manifestations of radiculopathy a leg pain due to nerve compression and release of inflammatory mediators, as well lumbar disc pathology affects the related paraspinal muscles, which unfortunately are often overlooked in clinical practice [3].

The MF arises from spinous processes and spreads caudolaterally from the midline. The essential role of the MF is to maintain lumbar lordosis, which helps in transmitting some of the axial compression force to the anterior longitudinal ligament. It also protects the discs, preventing unnecessary movements, such as torsion and flexion [4].

The lumbar MF is divided into deep and superficial fibers, the deep fibers spanning 2 vertebral segments and functioning tonically, and the superficial fibers spanning 3 to 5 levels and functioning physically [5].

Many studies were performed to assess the relation between MF atrophy and fatty replacement with many other factors, and the predictive outcome of low back pain in relation to the degree of MF atrophy [6,7]. Sciatica - known as leg pain due to disc pathology - is another factor with a significant association to the degree of MF atrophy [8].

Fatty infiltration can be evaluated using various imaging techniques including MRI, CT and US, but MRI provides higher resolution images as compared with CT and US and allows better detection of soft tissues [9].

The aim of this work is to study the value of MRI changes in MF in correlation with other degenerative changes at lumbosacral spine in patients with low back pain.

METHODS

This cross-sectional study was carried out at Radiodiagnosis Department, Zagazig University Hospitals during the period from September 2019 to September 2020. It included patients complaining of low back pain referred to our department for lumbosacral MRI examination. Informed written consents were taken from all patients before the study.

Inclusion criteria were patients with low back pain with or without sciatica and the ages of the included patients shouldn't be less than 18 years or more than 80 years.

Exclusion criteria were related to spine including history of spine surgery or interventional procedure for pain, moderate and severe scoliosis, vertebral body fractures or history of recent trauma to the back, vertebral malignancies or malignancies elsewhere, history of radiation to spine, spina bifida or history of neural tube defects, massive hemangioma in any vertebral body, spondylolithesis or fracture pars interarticularis and rheumatologic diseases should be excluded. Exclusion criteria were also related to patients' condition including patients with contraindications to MRI, pregnant females, nephrolithiasis or other causes of referred pain and history of previous pelvic procedure or gynecological inflammatory lesions.

The study was performed in Zagazig University hospitals, from the period between January 2020 and March 2021. It was revised by the institution review board. 84 patients were enrolled in the study.

For all patients, complete history taking, and neurological examinations were performed to identify the intensity, location and duration of low back pain. Clinical criteria were recorded for all patients including the nature, intensity and longevity of LBP and presence of sciatica or leg pain, and either unilateral or bilateral. The clinical evaluation of body mass index was performed for all patients and VAS "visual analogue scale" score for pain in a scale from 1 to 10 scale was recorded. The VAS score was a 10-cm line scored by the patient based on how intense he/she thinks the pain is, where '0' implies very well tolerated patient and '10' implies that the pain was very poorly tolerable.

MRI examination:

Conventional MRI examination for a lumbosacral region was performed on all patients (Achieva 1.5 Tesla, Koninklijke Philips N.V. Amsterdam, Netherlands). The final questionnaire included answers to the following radiological findings including How many disc pathologies either disc bulge or herniation present, in addition; other parameters were recorded such as annular disc tears, presence of Modic end plate changes and/or Schmorl's nodes, presence of a neural canal stenosis, the degree of affection to facet joints and MS score in each side of each level. All MRI images were reviewed independently by two staff radiologists with at least 5 years of experience in MRI reporting.

Regarding multifidus muscle (MS) degeneration score was recorded for each side (right and left) and in the lowest three levels (L3/4, L4/5 and L5/S1). The scores are as follows; (1) grade 0: <10% fatty infiltration, (2) grade 1: 10:50% fatty infiltration; (3) grade 2: >50% fatty infiltration. The multifidus score was calculated by

summation of the MS score at the three lowest levels (L3/4, L4/5 and L5/S1) being from 0 to 6.

STATISTICAL ANALYSIS

Data were fed to the computer and analyzed using IBM SPSS "Statistical Product and Service Solutions", version 21.0. **(**Armonk, NY: IBM Corp**).** The Kolmogorov- Smirnov was used to verify the normality of distribution of variables. Comparisons between groups for categorical variables were assessed using **Chi-square test (Monte Carlo). Student t-test** was used to compare two groups for normally distributed quantitative variables while **ANOVA** was used for comparing the four studied groups. **Kruskal Wallis test** was used to compare different groups for abnormally distributed quantitative variables **Mann Whitney test** was used to compare between two groups for not normally distributed quantitative variables. Significance of the obtained results was judged at the 5% level.

RESULTS

Characteristics of the study population (table 1):

Eighty-four patients were included in the study, Mean age was 45.05 ± 12.53 years old, the median age was 43 years old. There were 46 females and 38 males. Regarding BMI, four patients (4.8%) were underweight (BMI < 18.5), 22 patients (26.2%) were normal weighted (BMI = 18.5 – 24.9), 32 patients (38.1%) were overweighted (BMI=25 – 29.9). Obese patients (BMI = 30 – 34.9) were 20 patients (23.8%). Regarding VAS score, the mean VAS was 4.25 ± 1.26, while the median VAS was 4.

Relation between MF degeneration and different clinical parameters (table 2):

There was a statistically significant correlation (p <0.001) between age and degree of MF degeneration which was increased with age. Most of patients (n = 37) were recorded to have grade I MF degeneration with mean age = 44.5 ± 10.9 years old, while in patients with grade II MF degeneration (n = 16), the mean age was 58.4 ± 8.2 years old. In patients with grade I MF degeneration; 56.8% of them were females and 43.2% of them were males, no significant relation between MF degeneration and gender.

Regarding BMI, in underweighted patients with BMI < 18.5, only 3 patients were suffered from MF degeneration, while in obese and extremely obese patients with BMI ≥ 30, there are 16 patients suffered from MF degeneration and recorded to have either grade I or II degeneration, however there is no significant relation between MF degeneration and BMI.

Duration of complaint was significantly correlated with MF degeneration, with P value < 0.001. The mean duration of complaint in patients recorded to have grade II MF degeneration was 6.6 ± 2.1 years, while it was 3.6 ± 1.2 years in patients with grade 0 MF degeneration. In patients with sciatica, there was no correlation between the occurrence, unilaterality or bilaterality of sciatica and degree of MF degeneration, with p value = 0.124.

The degree of VAS score was statistically significantly correlated with degree of MF degeneration, with p value < 0.001, median VAS score was 5 in patients with grade II MF degeneration, however it was 4 in patients with grades 0 and I MF degeneration.

Relation between MF degeneration and different radiological parameters (table 3):

There was a significant correlation between number of disc pathologies in lower levels and degree of MF degeneration, with p value < 0.001, the more the disc pathologies at the lowest three levels, the higher the degree of MF degeneration.

In 16 patients with grade II MF degeneration, 75% of them had disc pathologies at the three lowest levels, on the other hand in 31 patients who had grade 0 MF degeneration, 11 patients (35.5%) had no disc pathology and 16 patients of them (51.6%) had one level disc pathology. All patients with three level disc pathologies (17 patients) had either grade I or II.

Regarding the presence of Schmorl's nodes and facet pathology, there were statistically significant correlations between each of them and the degree of MF with p value <0.001. In 16 patients with grade II MF degeneration, there were 11 patients with Schmorl's nodes, while all of them suffered from facet pathology at the same level.

Modic changes were detected in only 14 patients, in 9 of them MF degeneration was recorded as grade II being statistically significant with p value <0.001. Neural canal stenosis was detected in only 8 patients, in 7 of them MF degeneration was recorded as grade II being statistically significant with p value <0.001.

***Univariate and multivariate linear regression for factors affecting MF degeneration*:**

The most common factors associated with increased MS score were the duration in years and VAS score in the multivariate analysis model with B value equals 0.184 according to duration in years and equals 0.287 with VAS score according to 95% C.I (Figure 3).

Table (1): Distribution of the studied cases according to different parameters (n = 84)

	No. (%)
Age (years)	
Mean ± SD.	45.05 ± 12.53
Median (Min. – Max.)	43 (23 – 70)
BMI (kg/m²)	
<18.5 (Underweight)	4 (4.8%)
18.5 – 24.9 (Normal)	22 (26.2%)
25 – 29.9 (Overweight)	32 (38.1%)
30 – 34.9 (Obese)	20 (23.8%)
>35 (Extremely obese)	6 (7.1%)
Mean ± SD.	26.77 ± 4.70
Median (Min. – Max.)	27 (16 – 38)
Duration of complaint (years)	
Mean ± SD.	4.39 ± 1.96
Median (Min. – Max.)	4 (1 – 10)
Right sciatica	
No	36 (42.9%)
Yes	48 (57.1%)
Left sciatica	
No	46 (54.8%)
Yes	38 (45.2%)
Sciatica	
No	26 (31%)
Unilateral	30 (35.7%)
Bilateral	28 (33.3%)
VAS	
Mean ± SD.	4.25 ± 1.26
Median (Min. – Max.)	4.0 (2.0 – 8.0)

Table (2): Relation between MF degeneration and different parameters (n=84)

	Grade 0 (n = 31)	**Grade I (n = 37)**	**Grade II (n = 16)**	**χ^2**	**p**
Age (years)					
Mean ± SD.	38.9 ± 11.1	44.5 ± 10.9	58.4 ± 8.2	F= 18.188*	<0.001*
Median (Min. – Max.)	35 (23 – 67)	42 (28 – 70)	58.5 (46 – 70)		
Gender					
Male	13 (41.9%)	16 (43.2%)	9 (56.3%)	χ^2= 0.979	0.613
Female	18 (58.1%)	21 (56.8%)	7 (43.8%)		
BMI (kg/m²)					
<18.5 (Underweight)	1 (3.2%)	1 (2.7%)	2 (12.5%)	χ^2= 9.749	MCp= 0.244
18.5 – 24.9 (Normal)	8 (25.8%)	11 (29.7%)	3 (18.8%)		
25 – 29.9 (Overweight)	12 (38.7%)	16 (43.2%)	4 (25%)		
30 – 34.9 (Obese)	6 (19.4%)	9 (24.3%)	5 (31.3%)		
>35(Extremely obese)	4 (12.9%)	0 (0%)	2 (12.5%)		
Mean ± SD.	27.4 ± 4.8	26.3 ± 4.0	26.6 ± 6.0	F= 0.435	0.649
Median (Min. – Max.)	27 (18 – 38)	27 (18 – 33)	27.5 (16 – 35)		
Duration of complaint (years)					
Mean ± SD.	3.6 ± 1.2	4.1 ± 1.8	6.6 ± 2.1	H= 21.454*	<0.001*
Median (Min. – Max.)	3 (1 – 6)	4 (1 – 8)	6.5 (3 – 10)		

Right sciatica					
No	19 (61.3%)	14 (37.8%)	3 (18.8%)	χ^2= 8.479*	0.014*
Yes	12 (38.7%)	23 (62.2%)	13 (81.3%)		
Left sciatica					
No	18 (58.1%)	22 (59.5%)	6 (37.5%)	χ^2= 2.391	0.303
Yes	13 (41.9%)	15 (40.5%)	10 (62.5%)		
Sciatica					
No	13 (41.9%)	12 (32.4%)	1 (6.3%)	χ^2= 7.235	0.124
Unilateral	11 (35.5%)	12 (32.4%)	7 (43.8%)		
Bilateral	7 (22.6%)	13 (35.1%)	8 (50%)		
VAS					
Mean ± SD.	3.7 ± 1	4.2 ± 1.1	5.4 ± 1.5	H= 15.896*	<0.001*
Median (Min. – Max.)	4 (2 – 6)	4 (2 – 6)	5 (3 – 8.0)		

χ^2: Chi square test MC: Monte Carlo
F: F for ANOVA test, H: H for Kruskal Wallis test
p: p value for association between MF degeneration and different parameters
*: Statistically significant at $p \leq 0.05$
Grade 0: <10% fatty infiltration.
Grade I: 10:50% fatty infiltration
Grade II: >50% fatty infiltration.

Table (3): Relation between MF degeneration and other lumbar spine degenerative changes (n = 84)

	Grade 0 (n = 31)	Grade I (n = 37)	Grade II (n = 16)	χ^2	p
Disc Pathology No.					
0	11 (35.5%)	7 (18.9%)	0 (0%)	39.641*	MCp <0.001*
1	16 (51.6%)	15 (40.5%)	1 (6.3%)		
2	4 (12.9%)	10 (27%)	3 (18.8%)		
3	0 (0%)	5 (13.5%)	12 (75%)		
Bulge					
No	27 (87.1%)	28 (75.7%)	6 (37.5%)	13.366*	0.001*
Yes	4 (12.9%)	9 (24.3%)	10 (62.5%)		
Herniation					
No	31 (100%)	36 (97.3%)	12 (75%)	8.959*	MCp= 0.003*
Yes	0 (0%)	1 (2.7%)	4 (25%)		
ANN					
No	31 (100%)	34 (91.9%)	13 (81.3%)	5.438	MCp= 0.052
Yes	0 (0%)	3 (8.1%)	3 (18.8%)		
MODIC					
No	30 (96.8%)	33 (89.2%)	7 (43.8%)	22.996*	<0.001*
Yes	1 (3.2%)	4 (10.8%)	9 (56.3%)		
Schmorl					
No	28 (90.3%)	29 (78.4%)	5 (31.3%)	19.764*	<0.001*
Yes	3 (9.7%)	8 (21.6%)	11 (68.8%)		
NCS					
No	31 (100%)	36 (97.3%)	9 (56.3%)	18.925*	<0.001*
Yes	0 (0%)	1 (2.7%)	7 (43.8%)		
FACET					
Normal	19 (61.3%)	14 (37.8%)	0 (0%)	28.018*	MCp <0.001*
Effusion	12 (38.7%)	22 (59.5%)	10 (62.5%)		
Sclerosis	0 (0%)	1 (2.7%)	6 (37.5%)		

χ^2: Chi square test MC: Monte Carlo
p: p value for association between MF degeneration and different parameters

*: Statistically significant at $p \leq 0.05$
Grade 0: <10% fatty infiltration.
Grade I: 10:50% fatty infiltration
Grade II: >50% fatty infiltration.

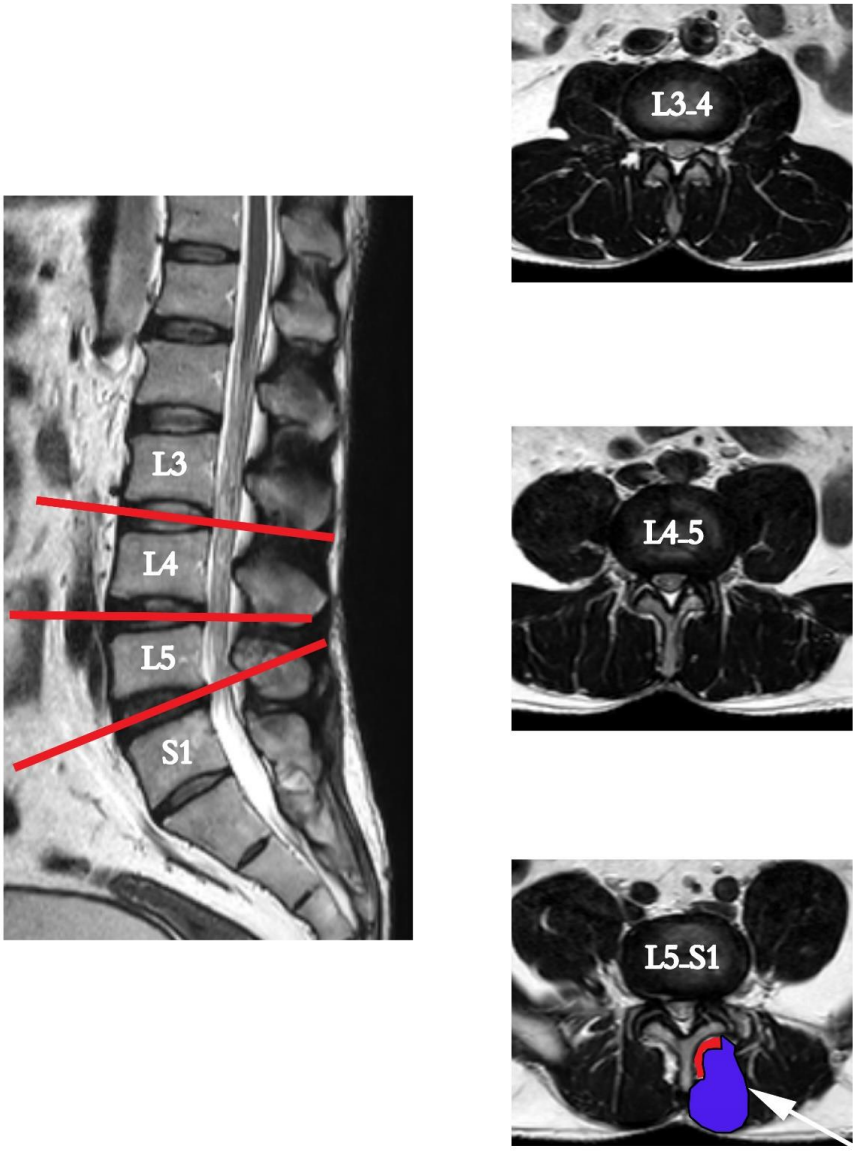

Figure (1): Lumbosacral MRI, of 57 years old man with 2 years history of LBP without sciatica, BMI = 25, there is disc bulge at L5/S1 level. No neural canal stenosis. Average VAS score = 2. Axial cuts revealed grade 0 MF degeneration in both sides at L3/4 and L4/5 levels and grade 1MF degeneration in both sides at L5/S1 level (white arrow), MF score = 1. Area of fatty infiltration in L5/S1 level was colored in the left side by red, and the remaining muscle is colored in the left side by the blue.

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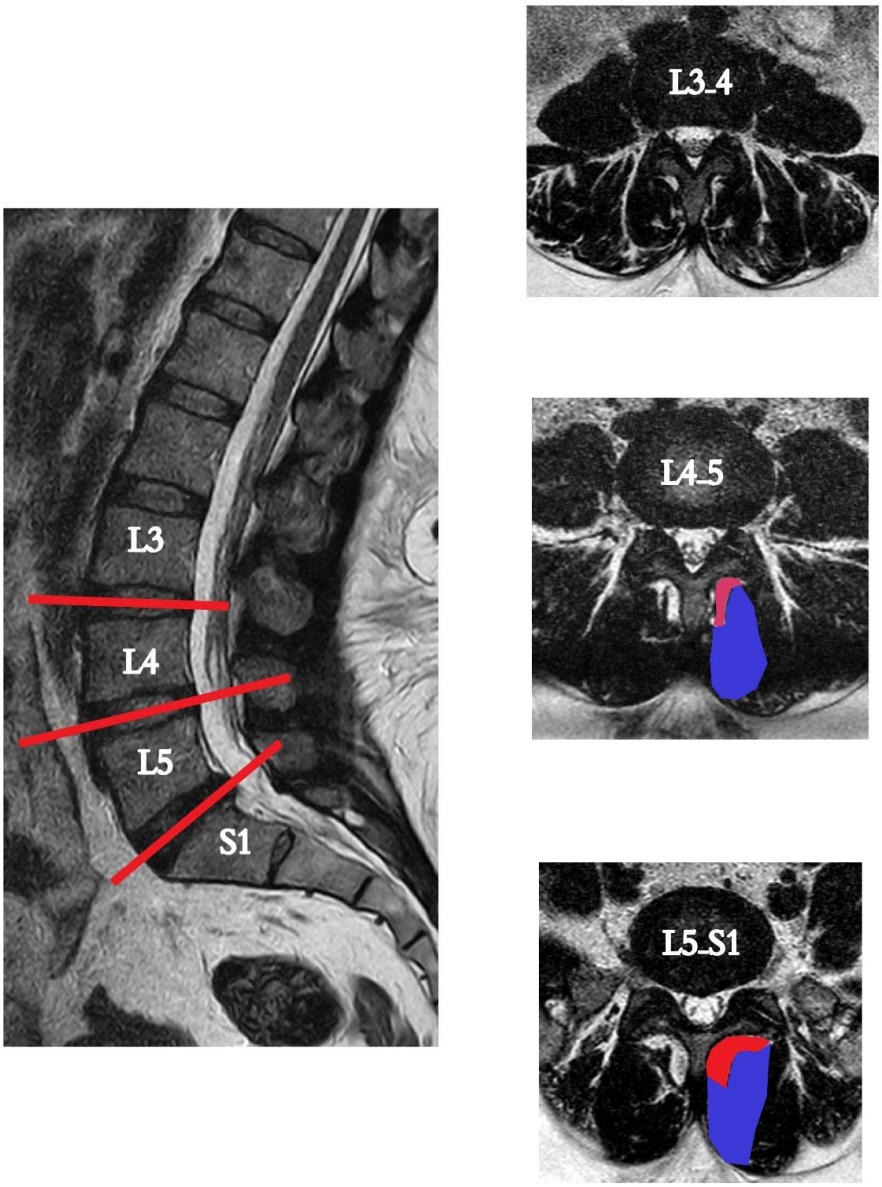

Figure (2): Lumbosacral MRI, of 27 years old lady with 6 years history of LBP without sciatica, BMI = 28, there is disc bulge at L5/S1 level. No neural canal stenosis. Average VAS score = 5. Axial cuts revealed grade 0 MF degeneration in at L3/4 level, grade 1 MF degeneration at L4/5 level and grade 2 MF degeneration at L5/S1 level, MF score = 3. Area of fatty infiltration in each of L4/5 and L5/S1 levels were colored in the left side by red, and the remaining muscle is colored in the left side by the blue

	Univariate		Multivariate	
	r	p	p	B (95%C.I)
Age (years)	0.371	0.001*	0.136	0.017(0.04 – 2.27)
BMI (kg/m2)	0.104	0.347	–	–
Duration (years)	0.497	<0.001*	0.028*	0.184(-0.01 – 0.04)
Sciatica	0.254	0.020*	0.629	0.081(0.02 – 0.35)
VAS	0.463	<0.001*	0.015*	0.287(0.06 – 0.52)
			$p<0.001^*/r^2=0.339$	

B: Unstandardized Coefficients r: Pearson coefficient
C.I: Confidence interval R^2: Coefficient of determination
#: All variables with p<0.05 was included in the multivariate
@:Duration and VAS with included in the multivariate
*: Statistically significant at $p \leq 0.05$

Figure (3): Univariate and multivariate linear regression analysis for the parameters affecting Multifidus muscle degeneration score

DISCUSSION

Low back pain is considered one of the most disabling complaints worldwide. The degree of pain and disability is primarily depending on the degree of degenerative changes affecting one of the components of the spine including muscles of the back. The incidence of degenerative spine disease (DSD) is increasing with age and weight and the degree of back muscle degenerative changes especially MF degeneration is directly proportional to the degree of DSD [10].

Multifidus muscles located in adjacency to the spinous process are amenable to degenerative process involving the whole spine, the degenerative changes are reflecting in fatty changes depicted by MRI studies. MF degeneration is correlated with stability and integrity of the spine [11].

In our study, we proposed a new method to assess the degree of MF degeneration. The multifidus score was calculated by summation of degree of MF degeneration, with minimum score of 0 and maximum of 6. In cases of disproportion affection of MF on each side, we chose the higher degree of MF affection. A score of 6 means that MF degeneration is graded 2 on either side at the lowest three levels.

In our study, we mentioned the influence of other vertebral degenerative pathologies including facet arthropathies, neural canal stenosis and Modic end plate changes. We defined disc pathology as disc bulge, herniation.

We supposed that the main factors affecting MF degeneration are age, BMI, duration of compliant in years, presence of sciatica and VAS score. Most of studies in literature described the degree of MF affection in relation to VAS score and duration of compliant in years [1,2,4,6,7]. In this study we considered that changes in MF score was dependent on multiple factors, according to a univariate and multivariate linear regression analysis was made for the parameters affecting multifidus muscle degeneration score; the most common factors associated with increased MS score were the duration in years and VAS score in the multivariate analysis model (figure 3).

Kjaer et al. [6] have described the multifidus atrophy and replacement by fat after low back injury. They evaluated the lumbar magnetic resonance imaging (MRI) results for 412 adult and 442 adolescent subjects in a cross-sectional study of multifidus atrophy. They found that fat infiltrations of the multifidus were strongly associated with LBP in adults, and the association was independent of body mass index (BMI).

Ranger et al. [7] have assessed the relationship of paraspinal muscle morphology with LBP, the impact of paraspinal muscle atrophy and/or fatty replacement on clinical outcomes, and the predictive value of paraspinal muscle morphology with clinical outcomes. Kader et al. [8] showed a significant association between MF atrophy and unilateral leg pain using a semi-quantitative method.

In a systematic review made by Fortin and Macedo [12], on 11 studies to evaluate paraspinal muscle morphology in patients with LBP and control patient, they concluded that the results of most studies suggest that multifidus and paraspinal muscle groups are smaller in patients with chronic LBP than in control patients who are healthy, and all pooled estimates were statistically significant.

In a retrospective analysis on 16 males and 19 females with chronic LBP, Faur et al. [13], by measuring the cross-sectional area (CSA) of the pure fat component of multifidus at L4-5 and L5-S1 levels, they found a low correlation and significant association between the grade of lumbar disc degeneration and the degree of multifidus fatty atrophy. The degree of MF degeneration is more in L5-S1 level than in L4-5 level.

Regarding pain and its measures, the visual analogue scale (VAS) score was used to evaluate the degree of LBP; in this study we used the same scale to measure one of our primary outcomes. VAS scores were statistically significantly correlated with degree of MF degeneration at the lower three lumbar levels, with p value < 0.001 at L3-4 level, 0.022 at L4-5 level and 0.013 at L5-S1 level. The median VAS was 4:5 in patients with grade II MF degeneration while it was 3:4 in patients with grade I MF degeneration [10].

On the other side, in a cross-sectional study performed on 45 patients with normal MRI and non-specific LBP, Rezazadeh et al. [14] concluded that the thickness of MF at L4-5 and L5-S1 levels has no relation to the severity index.

In our study, the degree of MF degeneration was significantly correlated with number of disc pathologies. In a study on 80 patients (32 men and 48 women), Ogon et al. [15] found a significant positive correlation of extramyocellular lipids (EMCL) with age and BMI and a significant negative correlation of EMCL with CSA. There was a significant positive correlation between

intramyocellular lipids (IMCLs)and VAS. The EMCL and CSA of the MF decreased with age, whereas fat infiltration increased with age. This is like our results regarding age at L3-4 and L4-5 levels, however at L5-S1 level no correlation between age and degree of MF degeneration. We supposed that MF degeneration at L5-S1 level is influenced by other independent factors rather than age of the patient and duration and severity of complaints, taking in consideration the previous studies that reported no correlation between MF degeneration at L5-S1 with number of disc pathologies in the lowest three lumbar levels.

The limitations of the study included relatively small sample size, exclusion of patients with failed back syndrome after surgery from this study, patients with spinal instability were excluded from the study despite they are a large sector in patients with LBP, and lack of data about the dynamic changes of MF within years in patients with chronic LBP.

CONCLUSION

Our study concluded a significant relation between MF degeneration and each of VAS and duration of pain, although this relation was not related to the measurement of proportionate changes between each side and different degrees of MF degeneration at the same level, the duration of pain is considered one of the most important indicators of the degree of MF degeneration.

MF degeneration is influenced by other independent factors rather than age of the patient and duration and severity of complaints, taking in consideration the previous studies that reported no correlation between MF degeneration with number of disc pathologies in the lowest three lumbar levels.

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