

Lumbar Multifidus Muscle Fatty Atrophy and Lumbar Disc Degeneration: Are they Associated in Middle Aged Patients with Low Backache?

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ABSTRACT

Introduction: Low backache being one of the most common problems faced in the society mainly due to sedentary lifestyle and reduced physical activity which in turn leads to overweight, obesity and atrophy of paraspinal muscles. Disc prolapse is one of the most common causes of low backache. Hence, knowing the aetiological factors and treatment of the same at an early stage is beneficial.

Aim: To determine the association between the grades of lumbar disc degeneration with degree of fatty infiltration of lumbar multifidus muscle in middle aged patients with low backache using Magnetic Resonance Imaging (MRI).

Materials and Methods: A prospective observational study was conducted from April 2020 to February 2021 in Kempegowda Institute of Medical Sciences, Bengaluru, Karnataka, India, with a study population of 201 middle aged patients who complaints of low back pain for more than three months. All patients who met the inclusion and exclusion criteria underwent plain MRI for Lumbosacral (LS) spine with 16 channel 1.5 tesla strength MR

machine. Lumbar intervertebral disc degeneration was graded according to the Pfirrmann classification using T2 sequence in the sagittal plane. For the evaluation of the degree of fatty infiltration of lumbar multifidus muscle, axial T2-weighted slices were used to detect the cross-sectional area of the right and left lumbar multifidus muscle involvement. Chi-square test was used to find the association between varying grades of disc degeneration and severity of fat infiltration at Lumbar (L)4-L5 and L5-Sacral (S) 1 regions.

Results: There was significant association between the grade of lumbar disc degeneration and the degree of atrophy of multifidus muscle with p-value <0.001 in middle aged patients with low backache. There was significant relation with fatty muscle infiltration with a p-value of <0.001 in L4-L5 and 0.03 in L5-S1 disc spaces. Most of the patients had grade III intervertebral disc degeneration in both L4/L5 and L5/S1.

Conclusion: Lumbar multifidus muscle atrophy is common in grade 3 Pfirrmann classification of lumbar disc degeneration at both L4/L5 and L5/S1 levels.

Keywords: Fatty infiltration, Low back pain, Lumbar spine, Sedentary lifestyle

INTRODUCTION

Low back pain is a symptom, not a disease. It is the most common symptom, affecting 80% of the population during their lifetime [1]. Most commonly, elderly patients aged more than 60 years are more prone for low backache. Low back pain is no more considered a self-limiting symptom, but a recurrent syndrome [2-4]. Deterioration of the mechanical and chemical properties of the disc results in lumbar disc degeneration caused by the universal phenomenon of aging process and aggravated environmental factors like trauma, high impact activity, type of work and smoking are the other causes of lumbar disc degeneration [5].

Hence, knowing the factors affecting backache is important to diagnose and treat the condition. Most important stabilizers of lumbar neutral zone are the lumbar multifidus muscle [6]. The biomechanics and microstructures of the lumbar multifidus muscle have been investigated by several studies, but there are only few studies which documented the use of MRI in evaluating the lumbar multifidus muscle atrophy [7,8].

Faur C et al., [9] described the correlation of multifidus fatty atrophy and lumbar disc degeneration in low back pain in mostly elderly population. Low backache due to fatty infiltration of lumbar multifidus muscle in middle aged individuals with lumbar disc degeneration is questionable. Hence, in present study, the authors aimed to find an association between the atrophy of lumbar multifidus muscle and degree of disc degeneration in L4/5 and L5/S1 spaces to know if they are associated with low backache.

MATERIALS AND METHODS

This was a prospective observational study conducted in Kempegowda Institute of Medical Sciences, Bengaluru, Karnataka, India, from April 2020 to February 2021 with a study population of 201 patients. Prior Institutional Ethical Committee clearance (KIMS/IEC/A017/M/2020) and patient consent was obtained.

Inclusion criteria: Patients aged between 21-50 years with history of chronic low back pain (defined as back pain lasting for more than three months), were included in the study.

Exclusion criteria: Patients above 50 years, with spinal fractures, spinal cord injuries, spinal infections, spinal tumors, previous lumbosacral surgery and patients who were contraindicated for MRI were excluded from the study.

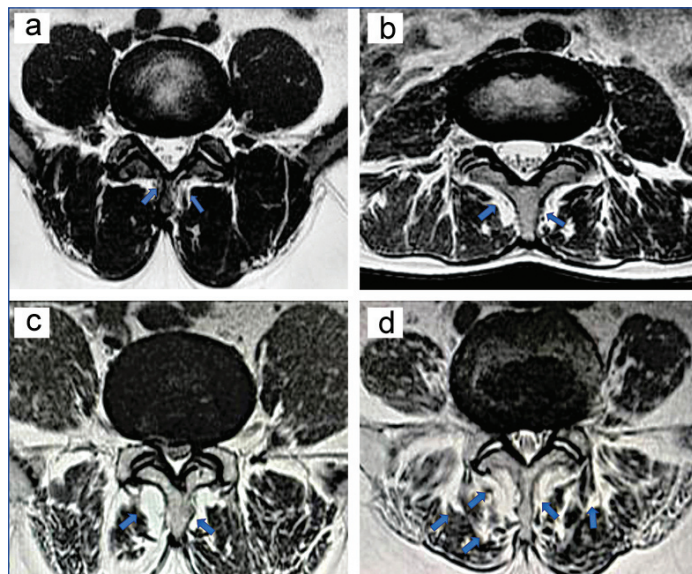
Procedure

All patients underwent MR imaging protocols for lumbosacral with GE Signa 16 Channel 1.5 Tesla. All the MRIs were reported by a single radiologist with 12 years experience. L4/L5 and L5/S1 vertebral spaces were evaluated. Lumbar intervertebral disc degeneration was graded according to the Pfirrmann classification [10,11] using T2 sequence in the sagittal plane.

For the evaluation of the lumbar multifidus muscles, axial T2-weighted sections were used. Extent of lumbar multifidus muscle fatty atrophy was evaluated by calculating the total muscle cross-sectional area and the pure fat cross-sectional area of the lumbar

multifidus muscle and calculating the percentage of the two on a 2D viewer by identifying hyperintense areas along the course of lumbar multifidus muscles on T2-weighted axial sequence. Microsoft photo viewer designed by MiniTool solution was used to identify the intensity differences and calculating the percentage of atrophy.

- Grade 1: A normal muscle having less than 10% of fatty infiltration [Table/Fig-1a].
- Grade 2: Mild muscle degeneration with 10-30% of fatty infiltration [Table/Fig-1b].
- Grade 3: Moderate muscle degeneration with 30-50% of fatty infiltration [Table/Fig-1c].
- Grade 4: Severe muscle degeneration with more than 50% of fatty infiltration [Table/Fig-1d].



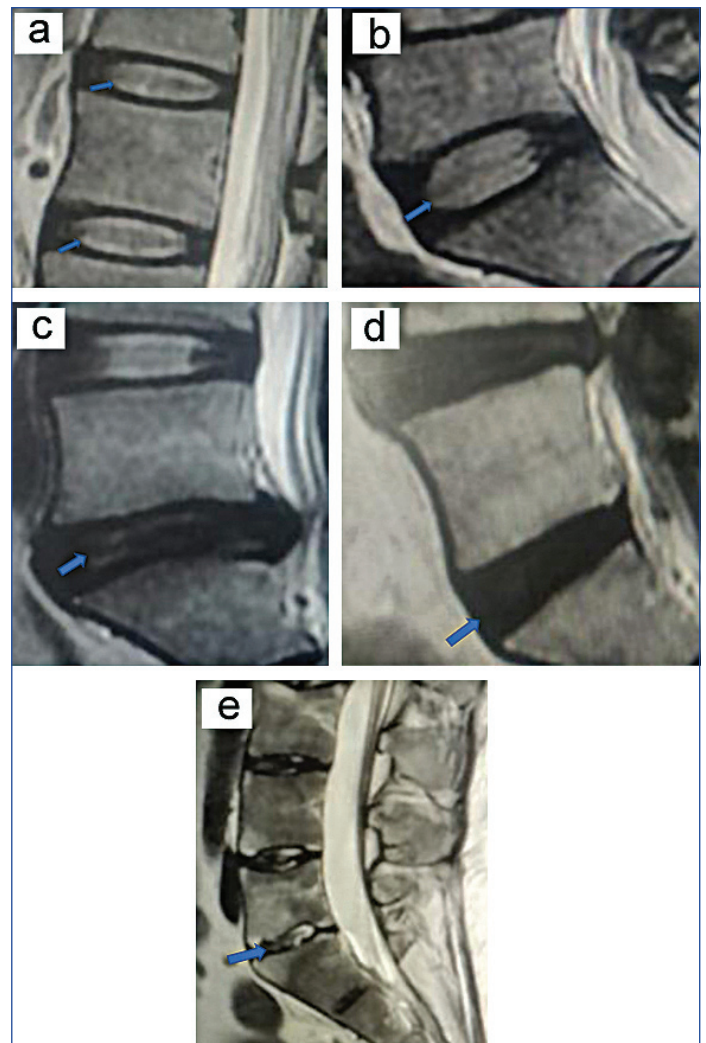
[Table/Fig-1]: a) Axial T2 weighted MR image of the Lumbo-sacral spine at the level of L5-S1 showing less than 10% of hyperintensity (normal fatty infiltration) involving Lumbar multifidus muscle. b) Axial T2 weighted MR image of the Lumbo-sacral spine at the level of L5-S1 showing 10-30% of hyperintensity (mild fatty infiltration) involving Lumbar multifidus muscle as indicated by the arrows. c) Axial T2 weighted MR image of the Lumbo-sacral spine at the level of L5-S1 showing 30-50% of hyperintensity (moderate fatty infiltration) involving Lumbar Multifidus Muscle (LMM) as indicated by the arrows. d) Axial T2 weighted MR image of the Lumbo-sacral spine at the level of L5-S1 showing more than 50% of hyperintensity (severe fatty infiltration) involving LMM as indicated by the arrows.

Pfirrmann grading system [10,11]

- Grade I: The structure of the disc is homogeneous, with a bright hyperintense white signal intensity and a normal disc height [Table/Fig-2a].
- Grade II: The structure of the disc is inhomogeneous, with a hyperintense white signal. The distinction between nucleus and annulus is clear and normal disc height, with or without horizontal gray bands [Table/Fig-2b].
- Grade III: The structure of the disc is inhomogeneous, with intermediate gray signal intensity. The distinction between nucleus and annulus is unclear, and normal or slightly decreased disc height [Table/Fig-2c].
- Grade IV: The structure of the disc is inhomogeneous, with a hypointense dark gray signal intensity. The distinction between nucleus and annulus is lost, and normal or moderately decreased disc height [Table/Fig-2d].
- Grade V: Inhomogeneous structure of the disc, with a hypointense black signal intensity. The distinction between nucleus and annulus is lost and collapsed disc space [Table/Fig-2e].

STATISTICAL ANALYSIS

Statistical Package for Social Sciences (SPSS) for Windows, version 22.0. Released 2013. Armonk, NY: International Business



[Table/Fig-2]: a) Pfirrmann Grade I - Disc is homogeneous, with a bright hyperintense nucleus pulposus (arrows). b) Grade II - Distinction between nucleus and annulus is clear and normal disc height (arrows). c) Grade III - Inhomogeneous disc, with intermediate gray signal intensity and no clear distinction between nucleus pulposus and annulus (arrow). d) Grade IV- Disc is inhomogeneous, with a hypointense dark gray signal intensity (arrow). e) Grade V Distinction between nucleus and annulus is lost and collapsed disc space (arrow).

Management (IBM) Corporation (Corp.) was used to perform statistical analyses. Chi-square test was used to find the association between varying grades of disc degeneration and severity of fat infiltration at L4-L5 and L5-S1 regions. The level of significance was set at p-value<0.05.

RESULTS

A total of 201 subjects were involved in the study, ranging between 21-50 years of age. Study had almost equal distribution of males (n=101) and females (n=100). Total 53.2% of the subjects were between the age of 31 to 40 years of age [Table/Fig-3].

Variable	Categories	N	%
Age (years)	21-30	41	20.4%
	31-40	107	53.2%
	41-50	53	26.4%
Gender	Males	101	50.2%
	Females	100	49.8%

[Table/Fig-3]: Age and Gender distribution among study patients (N=201).

Most of the subjects presented with Grade III lumbar disc degeneration in L4/L5 (n=79) and L5/S1 (n=79) region [Table/Fig-4]. There was no significant relation between the gender of the patient and degree of lumbar disc degeneration [Table/Fig-5] whereas there was significant relation with fatty muscle infiltration with a p-value of <0.001 in L4-L5 and

Region	Grades	21-30 years		31-40 years		41-50 years		χ^2 value	p-Value
		n	%	n	%	n	%		
L4-L5	Grade 1	4	9.8%	6	5.6%	3	5.7%	19.178	0.01*
	Grade 2	22	53.7%	30	28.0%	11	20.8%		
	Grade 3	12	29.3%	44	41.1%	23	43.4%		
	Grade 4	3	7.3%	27	25.2%	15	28.3%		
	Grade 5	0	0.0%	0	0.0%	1	1.9%		
L5-S1	Grade 1	4	9.8%	6	5.6%	5	9.4%	15.131	0.04*
	Grade 2	16	39.0%	20	18.7%	12	22.6%		
	Grade 3	15	36.6%	49	45.8%	15	28.3%		
	Grade 4	5	12.2%	31	29.0%	20	37.7%		
	Grade 5	1	2.4%	1	0.9%	1	1.9%		

[Table/Fig-4]: Comparison of grades of Disc Degeneration at different regions based on the age of the patients. Chi-square test used for calculating significance; *Bold p-values are significant

Region	Grades	Males		Females		χ^2 value	p-value
		n	%	n	%		
L4-L5	Grade 1	6	5.9%	7	7.0%	3.509	0.48
	Grade 2	37	36.6%	26	26.0%		
	Grade 3	37	36.6%	42	42.0%		
	Grade 4	21	20.8%	24	24.0%		
	Grade 5	0	0	1	1.0%		
L5-S1	Grade 1	10	9.9%	5	5.0%	4.930	0.30
	Grade 2	23	22.8%	25	25.0%		
	Grade 3	41	40.6%	38	38.0%		
	Grade 4	27	26.7%	29	29.0%		
	Grade 5	0	0	3	3.0%		

[Table/Fig-5]: Comparison of grades of Disc Degeneration at different regions based on the gender of the patients. Chi-square test used for calculating significance

0.03 in L5-S1 disc spaces [Table/Fig-6]. With the increase in age, severity of fatty infiltration of lumbar multifidus muscle increases [Table/Fig-7]. Grade of lumbar disc degeneration and severity of fatty infiltration of lumbar multifidus muscle are statistically significant in both L4/L5 and L5/S1 levels [Table/Fig-8,9].

Region	Fat Infiltration	Males		Females		χ^2 value	p-value
		n	%	n	%		
L4-L5	Normal	66	65.3%	30	30.0%	28.343	<0.001*
	Mild	29	28.7%	54	54.0%		
	Moderate	3	3.0%	14	14.0%		
	Severe	3	3.0%	2	2.0%		
L5-S1	Normal	31	30.7%	16	16.0%	8.684	0.03*
	Mild	57	56.4%	59	59.0%		
	Moderate	11	10.9%	22	22.0%		
	Severe	2	2.0%	3	3.0%		

[Table/Fig-6]: Comparison of severity of fat muscle Infiltration at different regions based on the gender of the patients. Chi-square test used for calculating significance; bold p-values to be significant

DISCUSSION

Lumbar Multifidus Muscles (LMM) are large in number and are packed through smaller opening, hence they produce larger forces over a smaller operating range, which is suited for stability as opposed to motion [12,13]. Functionally, the LMM are divided into deep and superficial fibres, with deep fibres spanning two vertebral segments

Regions	Fat Infiltration	21-30 years		31-40 years		41-50 years		c ² Value	p-value
		n	%	n	%	n	%		
L4-L5	Normal (96)	28	68.3%	47	43.9%	21	39.6%	12.669	0.04*
	Mild (83)	12	29.3%	45	42.1%	26	49.1%		
	Moderate (17)	0	0	13	12.1%	4	7.5%		
	Severe (5)	1	2.4%	2	1.9%	2	3.8%		
L5-S1	Normal (47)	11	26.8%	28	26.2%	8	15.1%	4.551	0.60
	Mild (116)	25	61.0%	58	54.2%	33	62.3%		
	Moderate (33)	4	9.8%	19	17.8%	10	18.9%		
	Severe (5)	1	2.4%	2	1.9%	2	3.8%		

[Table/Fig-7]: Association between severity of fat Infiltration based on the age at L4-L5 and L5-S1 region. Chi-square test used for calculating significance; *Bold p-values are significant

and functioning tonically, and the superficial fibres spanning three to five levels and functioning physically [5,14]. This arrangement makes the deep fibres of the lumbar multifidus muscles anatomically and biomechanically well suited for stabilization. Atrophy or fatty infiltration of the lumbar multifidus muscle causing low backache is likely [15].

This is the first study where middle-aged patients (<50 yrs) with low backache were taken and association between lumbar disc degeneration and fatty atrophy of lumbar multifidus muscle was demonstrated.

Hides JA et al., found that fatty muscle infiltration was associated with low backache in a large population irrespective of body mass index or physical activity of the patient. In the study, fatty infiltration was assessed visually. The study also mentioned that women are most commonly associated with fatty muscle infiltration, disc degeneration and low back pain [16]. It is believed that muscular atrophy and low back pain are linked [14,15]. Similarly in the present study, the degree of fatty muscle infiltration was assessed by visual inspection in T2 weighted MRI sequence. There is no significant relation between gender and lumbar disc degeneration.

Hides JA et al., included patients with L4/L5 unilateral root conflict. Total 37 patients were included in the study with unilateral single radiculopathy [16]. The Total Muscle Cross-sectional Area (TMCSA) of the LMM is compared between the involved and uninvolved sides, where no significant differences are observed [16,17]. In the present study, no unilateral nerve root conflicts was considered and no comparison between right and left lumbar multifidus fatty infiltration was done.

Barker KL et al., confirmed in his study that fat infiltration in lumbar multifidus muscle is reversible and there was improvement of symptoms after the reversal [18]. The present study lacks follow-up of subjects to assess improvement of symptoms. Also, the study lacks whether fatty infiltration can be reversed, or the severity can be decreased with physiotherapy.

Woodham M et al., demonstrated that low back exercises can decrease the fatty infiltration and atrophy of lumbar multifidus muscle in the patients [19]. Functional improvements were noted in patients with exercise. This study demonstrates the association between severe disc degeneration and severe atrophy of lumbar multifidus muscle. Sun D et al., divided the study population in herniated group and control group at the level of L3/L4 to L5/S1 lumbar disc spaces. The difference in lumbar multifidus atrophy between the herniated and control

Fat Infiltration	Grade 1		Grade 2		Grade 3		Grade 4		Grade 5		χ^2 value	p-value
	n	%	n	%	n	%	n	%	n	%		
Normal	10	76.9%	41	65.1%	36	45.6%	9	20.0%	0	0	39.854	<0.001*
Mild	3	23.1%	19	30.2%	37	46.8%	23	51.1%	1	100.0%		
Moderate	0	0	1	1.6%	5	6.3%	11	24.4%	0	0		
Severe	0	0	2	3.1%	1	1.3%	2	4.4%	0	0		

[Table/Fig-8]: Association between severity of fat Infiltration at varying grades of Disc degeneration at L4-L5 region.
p-value <0.05 considered significant

Fat Infiltration	Grade 1		Grade 2		Grade 3		Grade 4		Grade 5		χ^2 value	p-value
	N	%	n	%	n	%	n	%	n	%		
Normal	12	80.0%	16	33.3%	15	19.0%	4	7.1%	0	0	57.612	<0.001*
Mild	3	20.0%	28	58.3%	49	62.0%	35	62.5%	1	33.3%		
Moderate	0	0	4	8.3%	14	17.7%	14	25.0%	1	33.3%		
Severe	0	0	0	0	1	1.3%	3	5.4%	1	33.3%		

[Table/Fig-9]: Association between severity of fat Infiltration at varying grades of Disc degeneration at L5-S1 region.
p-value <0.05 considered significant

group appeared statistically significant at all three levels with a p-value of <0.05 [20].

Faur C et al., [9] in their study mentioned that fatty infiltration of LMM was seen most commonly medially, with grade III Pfirrmann classification at both spinal levels with predominance in males. They also concluded that fatty atrophy was more in the lower levels compared to the higher levels and there was a correlation with the grade of disc degeneration. Shahidi B et al., in their study involved individuals with chronic degenerative lumbar spine pathologies concluded that multifidus muscles in individuals with lumbar spine pathology demonstrate profound levels of muscle loss via imbalanced degeneration/regeneration, increased inflammation, and decreased vascularity. For these reasons, treatments aimed at reversing simple atrophy (i.e. muscle overload) may not be appropriate. This framework is consistent with the finding of unresolved atrophy in these patients, despite postoperative improvements in pain, and rehabilitation efforts [21].

As we all know that low backache has many aetiological factors including genetic and environmental factors, out of which, more importance should be given for lumbar disc degeneration. Lumbar multifidus muscle atrophy adds to the effect of lumbar disc degeneration in causing low backache. Hence, it is important to know the association between these two factors at an early age, to plan for early intervention and to prevent further progression of disc degeneration and associated fatty atrophy.

Limitation(s)

Authors did not assess the correlation of the time period with severity of symptoms and degree of fatty infiltration. The time period which is actually necessary for fatty infiltration to occur in the lumbar disc degeneration was not assessed. There was no follow-up of these patients post treatment to see if there is any regression in fatty infiltration and improvement of symptoms.

CONCLUSION(S)

There is a strong association between varying grades of disc degeneration and degrees of fatty infiltration in both L4-L5 and L5-S1 disc spaces in middle aged patients with low back pain. Grade III disc degeneration is more common in lumbar spine at both L4-L5 and L5-S1 levels. Comparatively, females are more prone to fatty infiltration. Low backache in middle aged patients especially females should not be neglected and prompt treatment should be considered.

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