ORIGINAL RESEARCH

Association between the imaging parameters of paraspinal muscles, clinical symptoms and functional status in patients with lumbar spinal stenosis

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ABSTRACT
The prevalence of low back pain ranges from 15 to 30 %. Approximately 80% of the population will experience low back pain at least once in their lifetime. Paraspinal muscles play an important role in the stability and functional movement of the lumbar vertebral column. Recent studies have suggested that patients with low back pain have increased muscle fat infiltration and reduced muscle cross sectional area of paraspinal muscles (multifidus, erector spinae, and psoas muscle) than asymptomatic control patients. Adult patients of either sex with low back pain due to degenerative lumbar spinal stenosis with or without neurological deficits visiting or admitted to our hospital from February 2021 to October 2022 were taken into the study. A total of 40 patients are included in this cross-sectional study. Quantitative measurements of multifidus, erector spinae, and psoas muscles were obtained from 1.5 Tesla MRI machine. All muscle measurements were taken bilaterally at the level of the superior endplate of the L5 vertebra and the inferior endplate of the L5 vertebra. There is a statistically significant association between AP canal diameter at the inferior endplate, Multifidus muscle fat infiltration at the superior and inferior endplate of the L5 vertebra, Multifidus RCSA at the superior endplate of the L5 vertebra with ODI score in univariate analysis. There is no statistically significant multivariate association between the paraspinal muscle morphology and low back pain disability measured by ODI score.

Key words: Lumbar spinal stenosis, Paraspinal muscles, Imaging parameters, Oswestry Disability Score

INTRODUCTION

Most of the individuals (60-80%) suffer from back pain at some point in their life. Low back pain is one of the commonest symptoms for which patients seek medical consultation. Low backache is the most common cause in young to middle-aged groups i.e. 20- 50 years for significant work absenteeism causing high medical care costs to society.[1-4]

Studies have found the incidence of low back pain is highest in the third decade, and overall prevalence increases with age until the 60–65year age group and then gradually declines[4]. Other commonly reported risk factors include low educational status, stress, anxiety, depression, job dissatisfaction, low levels of social support in the workplace, and whole-body vibration[5].

There are many causes of low back pain like lumbar sprain, herniated disc, spinal stenosis, spondylolisthesis, lumbar spondylolysis, osteoporotic compression fractures, traumatic fractures, facet joint diseases, congenital diseases, tumours, infections and inflammatory diseases.

Degenerative disc disease is manifested as loss of fluid, height, and integrity of the intervertebral disk. It may result in osteophyte formation, ligament hypertrophy, and synovial cyst formation[6].

Lumbar spinal stenosis (LSS) is a disabling condition associated with the narrowing of the spinal canal or vertebral foramina at one or several levels of the

lumbar spine. Typical symptoms of LSS include low back pain (LBP), leg pain, weakness, and pseudo-claudication, all of which can markedly reduce function and activity levels.

Although magnetic resonance imaging (MRI) is the gold standard modality to establish the diagnosis and extent of the disease, the severity of stenosis as judged by radiological findings often does not correlate with patient symptoms and functional impairments7.

Paraspinal muscles play an important role in the stability and functional movement of the lumbar vertebral column[3]. Paravertebral muscles are one of the pain generators in low back pain[1]. Here the imaging parameters of paraspinal muscles include cross-sectional area and fat infiltration in the multifidus muscle, erector spinae muscle, and psoas muscle.

Recent studies have suggested that patients with low back pain have increased muscle fat infiltration and reduced muscle cross sectional area of paraspinal muscles (multifidus, erector spinae) than asymptomatic control patients[7]. The atrophy of the paraspinal muscle reduces the internal stability of the lumbar vertebral column and causes low back pain. However, a cross-sectional study from Janan Abbas et al from Israel reported contradictive results showing greater paraspinal muscle density and cross sectional area in symptomatic degenerative lumbar spinal stenosis patients compared with the asymptomatic control group[3].

Although past studies associated the morphology of paraspinal muscles and low back pain[8], only a few studies have associated paraspinal morphology with the functional status and disability of patients. The results obtained in the above studies cannot be generalized because of contradictive results. These studies on the Indian population are fewer. Strengthening these muscles by, staged stabilization exercise for low back pain and concomitant increase in cross-sectional area of multifidus muscle and decrease in pain was shown in a study from Julie Hide et al[9]. Hence there is a need for a study to determine the association between the morphology of paraspinal muscle and functional status in patients with lumbar degenerative disorders that include degenerative lumbar spinal stenosis and chronic nonspecific low back pain.

METHODOLOGY

This study is a cross-sectional study done to determine the association between the imaging parameters of paraspinal muscles, clinical symptoms, and functional status in patients with lumbar degenerative disorders.

Adult patients of either sex with lumbar canal stenosis with neurogenic claudication/ radicular pain satisfying the inclusion criteria were selected. This study was done in the Department of Orthopaedics at Bangalore Medical College And Research Institute and Bowring And Lady Curzon Hospital between February 2021 to August 2022 were included in this study.

Patients with signs and symptoms of lumbar spinal stenosis, who come under the inclusion criteria and give informed written consent were selected. After the clinical assessment, investigations of the patients were done, which includes X-rays of the Lumbar spine both in AP and Lateral views, flexion and extension lateral views, and MRI. X-rays were done to rule out other causes of back pain like tumours, instability, spondylolisthesis, infections, osteoporosis, and thoracolumbar fractures.

MRI is done to assess nerve root compression, level, and stage of spinal stenosis. Following MRI Lumbar canal stenosis was confirmed.

INCLUSION CRITERIA

1. Age 18 years and above of either sex.
2. Patient willing to give informed consent.
3. Low back pain for at least 12 weeks.
4. Evidence of degenerative lumbar spinal stenosis on MRI.

EXCLUSION CRITERIA

1. Patients with spinal fractures.
2. Patients with spinal tumours.
3. Evidence of active Infection.
4. Previous spine surgery.
5. Scoliosis.
6. Pregnancy.

Patients were divided into two groups according to their ODI score (≤42 = moderate disability, >42 = severe disability), to compare the means for the different clinical characteristics and muscle parameters between groups.

Demographic data, history, clinical examination, and details of investigations were recorded in the study proforma.

Quantitative measurements of multifidus, erector spinae, and psoas muscles were obtained from 1.5 Tesla MRI machine. All muscle measurements were taken bilaterally at the level of the superior endplate of the L5 vertebra and the inferior endplate of the L5 vertebra using OSIRIX software by signal threshold intensity method

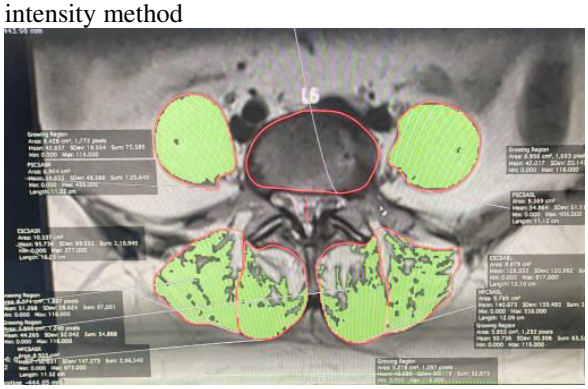

Fig1: Calculation of functional CSA (green colour) at L5 superior endplate

RESULTS

The following table describes the details of patient's age, BMI, Back pain duration, leg pain duration, and ODI score(Table 1).

Table 1: Descriptive data on patient characteristics

	N	Minimum	Maximum	Mean	S.D
Age	40	36.0	71.0	54.63	9.05
Height (cm)	40	158.0	176.0	166.18	5.48
Weight(Kg)	40	49.0	89.0	68.70	10.36
BMI	40	18.4	29.8	24.38	2.79
Back pain duration	40	3months	48months	17.87	11.31
Leg pain duration	40	3months	26months	11.85	6.82
Back pain VAS score	40	6.0	9.0	7.27	1.03
Leg pain VAS score	40	6.0	9.0	7.70	.99
ODI score	40	33.0	47.0	40.15	4.35

Univariate analysis was made between the muscle parameters, AP canal diameter at both superior and inferior endplate of L5 vertebra, and dural sac CSA at L4-5 mid disc level (Table 2) with ODI score as the dependent variable.

Table 2: Univariate analysis with ODI score as dependent variable

		95% C.I			
	Co-efficient	Lower	Upper		p-value
Age	0.003	-0.155	.161		0.971
BMI		-0.057	-0.568	0.455	0.824
Back Pain duration		-0.089	-0.213	0.034	0.151
Leg Pain duration		-0.095	-0.305	0.114	0.363
AP Canal Diameter	Superior	-2.84	-10.39	4.71	0.45
	Inferior	-16.21	-26.84	-5.58	0.004*
Multifidus RCSA	Superior	12.32	3.13	21.51	0.01*
	Inferior	5.005	0.047	9.96	0.048*
Multifidus FCSA/CSA	Superior	-37.36	-43.16	-31.57	0.001*
	Inferior	-23.65	-35.92	-11.38	0.001*
Multifidus CSA asymmetry%	Superior	0.054	-0.174	0.282	0.636
	Inferior	0.055	-0.182	0.292	0.641
Erector Spinae RCSA	Superior	1.99	-6.36	10.34	0.63
	Inferior	2.07	-2.82	6.97	0.39
Erector Spinae FCSA/CSA	Superior	-1.35	-16.57	13.87	0.85
	Inferior	-4.006	-20.35	12.34	0.623
Erector spinae CSA asymmetry%	Superior	-0.072	-0.32	0.182	0.56
	Inferior	0.152	0.034	0.27	**0.013***
Psoas Major RCSA	Superior	-0.64	-13.04	0.159	0.055
	Inferior	-6.46	-12.52	-0.405	**0.037***
Psoas Major FCSA/CSA	Superior	0.521	-24.72	25.76	0.967
	Inferior	14.35	-10.26	38.96	0.245
Psoas Major CSA asymmetry%	Superior	-0.072	-0.351	0.206	0.602
	Inferior	0.216	-0.026	0.459	0.079
Dural sac CSA		4.34	-3.14	11.83	0.248

*Suggestive significance (P value: 0.05<P<0.10), Moderately significant (P value:0.01<P < 0.05), Strongly significant (P value: P<0.01)

Here ODI score was the variable of interest and on Univariate analysis, the following parameters were statistically significant.

1. AP canal diameter at inferior endplate of L5 vertebra
2. Multifidus muscle RCSA at superior and inferior endplate of L5 vertebra
3. Multifidus muscle FCSA/CSA at superior and inferior endplate of L5 vertebra
4. Erector spinae muscle CSA asymmetry% at inferior endplate of L5 vertebra
5. Psoas major muscle RCSA at inferior end plate of L5 vertebra

Multivariate analysis was made between the muscle parameters, AP canal diameter at both superior and inferior endplate of L5 vertebra, and dural sac CSA at L4-5 mid-disc level (Table 3) with ODI score as the dependent variable.

Table 3: Multivariate analysis with ODI score as dependent variable

		Unstandardized Coefficients	p-value	95.0% Confidence Interval for B	
		B		Lower Bound	Upper Bound
(Constant)		-2.373	.979	-187.963	183.217
AP canal diameter	Inferior	-26.901	.308	-80.590	26.788
Vertebral body CSA	Superior	1.216	.525	-2.708	5.140
	Inferior	4.228	.430	-6.721	15.176
Right Multifidus CSA	Superior	1.206	.891	-16.934	19.346
	Inferior	.056	.994	-14.649	14.762
Left Multifidus CSA	Superior	-2.329	.730	-16.232	11.574
	Inferior	3.644	.492	-7.220	14.508
Right Multifidus FCSA	Superior	-.824	.877	-11.829	10.180
	Inferior	-.867	.842	-9.824	8.090
Left Multifidus FCSA	Superior	-4.827	.386	-16.200	6.545
	Inferior	5.518	.555	-13.659	24.695
Mean Erector Spinae CSA	Inferior	3.231	.584	-8.871	15.333
Erector Spinae CSA asymmetry%	Inferior	-.131	.861	-1.676	1.414
Left Psoas Major CSA	Superior	-4.129	.573	-19.159	10.901
Right Psoas Major FCSA	Superior	6.355	.413	-9.497	22.207
	Inferior	-2.075	.797	-18.713	14.563
Left Psoas Major FCSA	Superior	1.911	.783	-12.355	16.177
	Inferior	-10.364	.200	-26.666	5.938
Psoas Major RCSA	Inferior	40.381	.573	-106.747	187.509

*Suggestive significance (P value: 0.05<P<0.10), Moderately significant (P value:0.01<P < 0.05), Strongly significant (P value: P<0.01)

Here Multivariate analysis was made with ODI score as the dependent variable and found no statistically significant association between ODI score and Imaging parameters.

DISCUSSION

Age

In the study conducted by Fortin M et al[7]., the average age group was 66.9 years (range 51-80 years). In the study conducted by Chen YY et al[10]., the average age group was 63.69 years (range 46- 84 years).

In our study, the average age group was 54.63 years (range 36-71 years). The largest group was from 51 to 60 years.

Our study concurs that Lumbar spinal stenosis appears to be more common in the 5th – 6th decade.

Sex distribution

In the study conducted by Fortin M7 et al., male to female ratio was 9:16 and in the study conducted by Chen YY et al.10, male to female ratio was 17:45.

In our study, there are 26 females and 14 males with a male to female ratio of 7:13.

All the above studies show female preponderance. Our study concurs that Lumbar spinal stenosis appears to be more common in the female population.

BMI

The average BMI in the study of Fortin M et al.7, was 29.14 Kg/m2 and the average BMI in the study of Chen YY et al.10, was 25.72 Kg/m2.

In our study population, the average BMI was 24.38 Kg/m2 (range 18.40 – 29.80 kg/m2).

Our study concurs that Lumbar spinal stenosis appears to be more common in Obese individuals.

Back Pain Duration

Lumbar spinal stenosis is a chronic degenerative disorder of the spine which starts insidiously and progresses gradually constricting the spinal canal and

foramen and causing nerve irritation/impingement and low back pain.

In the study conducted by Fortin M et al.[7], the average back pain duration was 59 months, and, in the study, conducted by Chen et al.10, the average back pain duration was 33 months.

In our study population, the average Back pain duration was 17.9 months ranging from 3 months to 48 months.

Leg Pain Duration

Leg pain in lumbar spinal stenosis is due to neurogenic claudication or nerve impingement due to foraminal stenosis. Patients can either present directly with neurogenic claudication or low back pain radiating to either or both lower limbs.

In the study conducted by Fortin M et al.7, the average leg pain duration was 24 months.

In our study population, the average leg pain duration of patients was 11.85 months (range 3 – 26 months).

Back pain vas score

In our study population, the average back pain VAS score was 7.27 ranging from 6 to 9. By the time our patients reached us, the back pain VAS score was already moderately high. Back pain was insidious in onset and gradually progressive in most of our study population. It may have been caused by atrophy of paraspinal muscles or gradual progression of degenerative disc pathology leading to vertebral column instability.

Leg pain vas score

In our study population, the average leg pain VAS score was 7.70 ranging from 6 to 9. From our study, it was noted that average leg pain was more than average back pain. This was probably due to nerve root irritation caused by foraminal stenosis and altered nerve metabolism caused by central canal stenosis.

Radicular pain

Lumbar spinal stenosis patients commonly have neurogenic claudication pain in both lower limbs due to central canal stenosis, followed by radicular pain due to foraminal stenosis causing nerve root compression.

In the study conducted by Fortin et al.7, 61% of patients had pain in both lower limbs, 28% had pain right lower limb and 11% patients had pain left lower limb.

In our study population, 50% of patients had neurogenic claudication in the bilateral lower limb and 35% of patients had radicular pain in the right lower limb and 15% of patients had radicular pain in the left lower limb.

ODI score (Oswestry disability index score)

The ODI score gradually increased from mild to moderate to severe disability as the degenerative disc disease progressed and cause significant discomfort and morbidity to patients.

In our study, the average ODI score of the study population was 40.15 ranging from 33 to 47. Here ODI score of less than or equal to 42 was taken as moderate disability and ODI score of more than 42 was taken as a severe disability.

In our study population, 52.5% had ODI score of less than 42, and 47.5% has ODI score of more than 42. In the study conducted by Fortin M et al., 47% had ODI score of less than 42, and 53% had ODI score of more than 42.

Univariate and multivariate analysis with ODI score as dependent variable

With ODI score as the dependent variable of interest, we did univariate and multivariate analysis to find the association between the paraspinal muscle parameters and disability in patients with lumbar spinal stenosis.

In a study done by Fortin M et, al.[7], they found a significant association between the multifidus muscle FCSA/CSA and ODI score.

In our study, AP canal diameter at the inferior endplate($p=0.004$), Multifidus muscle fat infiltration($p=0.001$) at the superior and inferior endplate, Erector spinae muscle asymmetry at the inferior endplate($p=0.013$), and Psoas RCSA at inferior endplate($p=0.037$) were found to be a statistically significant univariate association with disability.

As an independent variable, the above-mentioned variables are associated with disability, but in multivariate analysis, the association was not statistically significant($p>0.05$).

Dural sac CSA

Dural sac CSA was not statistically significantly associated with the disability in patients with spinal canal diameter.

CONCLUSION

In our study, we found that Low back pain due to lumbar spinal stenosis appears to be more common in the 5th – 6th decade, female population, and obese individuals. Stenosis is seen more commonly in lower lumbar segments (L4 and L5 segments). In our study, Dural sac cross-sectional area was not associated with the functional status and disability in patients with lumbar spinal stenosis.

In our study, there is a statistically strong significant Univariate association between the Multifidus muscle fat infiltration at the superior and inferior endplate of L5 vertebra, Multifidus muscle relative cross-sectional area at the superior endplate of L5 vertebra and AP canal diameter at inferior endplate of L5 vertebra with ODI score. From our study, it appears that these parameters independently are associated with disability

REFERENCES

1. Shivananthan S, Sherry E, Warnke P, Miller M. Mercer's Textbook of Orthopaedics and Trauma. Ed 10, London, Edward Arnold, 2012.[86], Pathophysiology of low back ache; 976.
2. Waddell G.1987 Volvo award in clinical sciences: a new clinical for the treatment of low-back pain. Spine(Phila Pa 1076). 1987;12:632-644.
3. Abbas J, Slon V, May H, Peled N, Hershkovitz I, Hamoud K. Paraspinal muscles density: a marker for degenerative lumbar spinal stenosis?. BMC Musculoskelet Disord. 2016;17(1):422.
4. Urrutia J, Besa P, Lobos D, Campos M, Arrieta C, Andia M, et al. Lumbar paraspinal muscle fat infiltration is independently associated with sex, age, and intervertebral disc degeration in symptomatic patients; Skeletal Radiol. 2018;47;955961.
5. Hoy D, Brooks P, Blyth F, Buchbinder R. The Epidemiology of low back pain, Best Practice & Research Clinical Rheumatology. 2010;24(6): 769-781.
6. Carragee EJ. Lumbar Degenerative Disk Disease Understanding the Pain Generator. In: Vaccaro A R, editor. Spine Core Knowledge in Orthopaedics. Philadelphia, Pennsylvania: Elsevier mosby; c2005. p. 55-65.
7. Fortin M, Lazary A, Varga PP, Battie MC. Association between paraspinal muscle morphology, clinical symptoms and functional status in patients with lumbar spinal stenosis. Eur Spine J. 2017;26(10):2543-51.
8. Van Middelkoop M, Rubinstein SM, Verhagen AP, Ostelo RW, Koes BW, van Tulder MW. Exercise therapy for chronic nonspecific low-back pain. Best Pract Res Clin Rheumatol. 2010;24(2):193-204.
9. Hides JA, Stanton WR, McMahon S, Sims K, Richardson CA. Effect of stabilization training on multifidus muscle cross-sectional area among young elite cricketers with low back pain. J Orthop Sports Phys Ther. 2008;38(3):101-8.
10. Chen YY, Pao JL, Liaw CK, Hsu WL, Yang RS. Image changes of paraspinal muscles and clinical correlations in patients with unilateral lumbar spinal stenosis. Eur Spine J. 2014;23(5):999-1006.