ORIGINAL RESEARCH

Comparative study on lumbar paraspinal muscles imaging morphology and clinical symptoms between moderately and severely disabled Lumbar spinal stenosis patients

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Received: 12March, 2023 Accepted: 18April, 2023

ABSTRACT
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. Low back pain is one of the commonest symptoms for which patients seek medical consultation. Paraspinal muscles play an important role in the stability and functional movement of the lumbar vertebral column.However, our understanding of their contribution to low back pain and disability is unclear. Systematic reviews have reported conflicting evidence for an association between paraspinal muscle size and low back pain and a paucity of data examining muscle cross-sectional area (CSA) and low back disability. 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. 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 the groups. Quantitative measurements of multifidus, erector spinae, and psoas muscles were obtained from the 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. The comparison of muscle parameters done between patients with moderate disability and severe disability showed statistically significant greater Multifidus muscle atrophy and fat infiltration both at the superior and inferior endplate of L5.

Key words: Lumbar spinal stenosis, paraspinal muscles, imaging parameters, Oswestry disability score

Introduction

The prevalence of low back pain ranges from 15 to 30%[1]. Approximately 80% of the population will experience low back pain at least once in their lifetime[2]. Paraspinal muscles play an important role in the stability and functional movement of the lumbar vertebral column[3]. 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[5]. The atrophy of the paraspinal muscle reduces the internal stability of the lumbar vertebral column and causes low back pain. 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[4].

Paravertebral muscles are one of the pain generators in low back pain[1]. Here the imaging parameters of paraspinal muscles include cross-sectionalarea and fat infiltration in the multifidus muscle, erector spinae muscle, and psoas muscle. Although past studies compared the morphology of paraspinal muscles between lumbar spinal stenosis patients and asymptomatic subjects, only a few studies have compared the superior MRI paraspinal morphology between lumbar spinal stenosis patients with moderate

and severe disability[6]. 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 wasshown in a study from Julie Hide *et al*[7]. Hence there is a need for a study to determine the Comparison of lumbar paraspinal muscles imaging morphology between moderately and severely disabled Lumbar spinal stenosis patients.

Methodology

This study is a cross-sectional study done to determine the comparison of lumbar paraspinal muscles imaging morphology between moderately and severely disabled Lumbar spinal stenosis patients.

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.

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 weredone, 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 was done to assess nerve root compression, level, stage of spinal stenosis and paraspinal muscles morphology.

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 stenosison 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 Oswestry Disability Index (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.

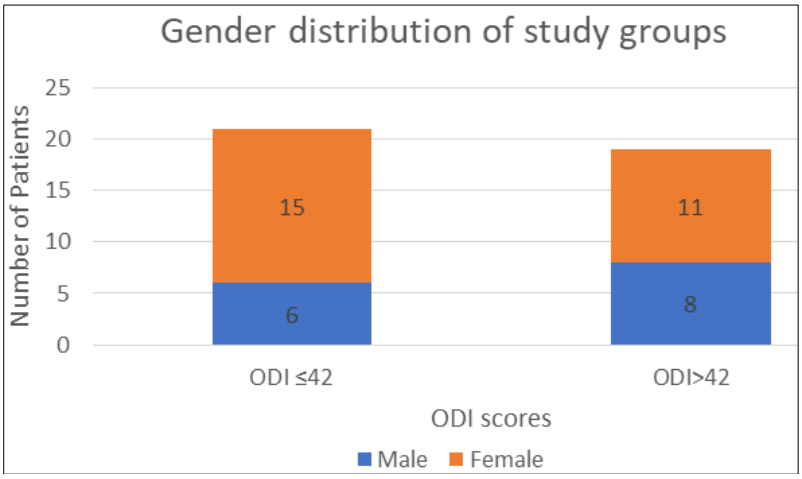
Quantitative measurements of multifidus, erector spinae, and psoas muscles were obtained from 1.5 Tesla MRI machine. The Muscle measurements include total cross-sectional area (CSA), Functional cross-sectional area (FCSA)i.e., the area of lean muscle tissue excluding fatty infiltration(Figure1), The ratio of functional cross-sectional area to total cross-sectional area (FCSA/CSA),The relative % asymmetry in CSA also was calculated using the following formulae: [(L - S)/L)] * 100,where L is the larger side and S the smaller side, Fatty infiltration by signal intensity method, Dural sac cross-sectional area at L4-5 mid-disc. The mean values of the right and left muscles were calculated for the paraspinal muscles. 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. Clinical scores that is visual analogue scores and pain interference scores were taken from patients.

SPSS(Statistical Package for Social Sciences)version 20. (IBM SPASS statistics [IBM Corp. released 2011] was used to perform the statistical analysis. Data was entered in the Excel spreadsheet. Descriptive statistics of the explanatory and outcome variables were calculated by the mean, and standard deviation for quantitative variables, frequency, and proportions for qualitative variables. An Independent sample t-test was applied to compare the quantitative parameters between the groups (based on the ODI score). The level of significance is set at 5%

Fig 1: Paraspinal muscles functional cross sectional area calculated by signal intensity threshold method on T2 weighted axial MRI image at superior end plate of L5 vertebra.

Results

Among the study population, patients were divided into two groups based on ODI score i.e., the moderate disability group (ODI ≤42) and the severe disability group (ODI>42). There were 15 females, 6 males (n=21) and the Male:Femaleratio was 2:5 in group 1 (ODI≤42).In group 2(ODI>42), there were 11 females, 8males(n=19) and Male:Female ratio was 8:11 (Graph 1), (Table 1).



Graph1: Gender distribution of study groups

Table 1: Distribution of patients based on ODI score

ODI score	Frequency	Percentage
≤ 42	21	52.5
>42	19	47.5
Total	40	100.0

The comparison was made between the muscle parameters and clinical symptoms of both the groups based on ODI score using an independent sample T-test (Table 2)

Table 2: comparison of the lumbar paraspinal muscle parameters based on ODI using independent sample t-test

	ODI	N	Minimum	Maximum	Mean	S.D	Mean diff	p-value
Age	≤42	21	40.0	70.0	53.71	8.12	-1.91	0.51
	> 42	19	36.0	71.0	55.63	10.10		
BMI	≤ 42	21	18.40	28.40	24.67	2.64	0.59	0.508
	> 42	19	19.10	29.80	24.07	3.00		
Back Pain duration	≤42	21	3.0	48.0	18.81	13.22	1.91	0.59
	> 42	19	3.0	36.0	16.89	8.90		
Leg pain duration	≤ 42	21	3.0	26.0	12.14	7.07	0.51	0.81
	> 42	19	3.0	24.0	11.63	6.57		
Back pain VAS score	≤42	21	6	8	6.48	0.68	0.18	**0.001***
	>42	19	7	9	8.16	0.50		
Leg pain VAS score	≤42	21	6	8	6.95	0.59	-0.02	**0.001***
	>42	19	7	9	8.53	0.61		
Pain Interference scale	≤42	21	3	4	3.29	0.46	-0.07	**0.001***
	>42	19	3	5	4.21	0.53		
Multifidus FCSA/CSA	Superior	≤ 42	21	0.621	0.837	0.748	0.063	0.168	**0.001***
		> 42	19	0.423	0.703	0.58	0.063		
	Inferior	≤ 42	21	0.48	0.751	0.591	0.088	0.107	**0.001***
		> 42	19	0.379	0.579	0.484	0.077		
Multifidus CSA asymmetry%	Superior	≤ 42	21	0.485	16.669	6.947	6.061	-2.43	0.224
		> 42	19	2.481	21.648	9.379	6.366		
	Inferior	≤ 42	21	0.028	11.918	7.132	3.506	-0.941	0.627
		> 42	19	1.582	25.472	8.074	8.008		
Erector Spinae FCSA/CSA	Superior	≤ 42	21	0.487	0.848	0.625	0.109	0.008	0.79
		> 42	19	0.491	0.725	0.616	0.077		
	Inferior	≤ 42	21	0.383	0.645	0.507	0.091	0.021	0.452
		> 42	19	0.37	0.646	0.486	0.084		
Erector spinae CSA asymmetry%	Superior	≤ 42	21	0.416	19.021	9.565	6.401	0.02	0.991
		> 42	19	1.477	15.749	9.544	4.722		
	Inferior	≤ 42	21	0.233	29.826	8.561	10.371	-9.56	0.005*
		> 42	19	5.061	33.998	18.124	9.912		
Psoas Major FCSA/CSA	Superior	≤ 42	21	0.773	0.94	0.877	0.044	0.002	0.904
		> 42	19	0.759	0.955	0.875	0.069		
	Inferior	≤ 42	21	0.813	0.951	0.883	0.05	-0.023	0.199
		> 42	19	0.788	0.98	0.907	0.063		
Psoas Major CSA	Superior	≤ 42	2	1.4	13.825	7.568	4.754	0.303	0.854

asymmetry%			1	57					
		> 42	19	0.576	14.692	7.264	5.619		
	Inferior	≤ 42	21	0.189	9.959	5.544	3.674	-2.31	0.2
		> 42	19	1.307	21.422	7.859	7.168		
Dural sac CSA	≤ 42		21	0.25	0.759	0.58	0.168	-0.064	0.28
	> 42		19	0.262	0.951	0.645	0.206		

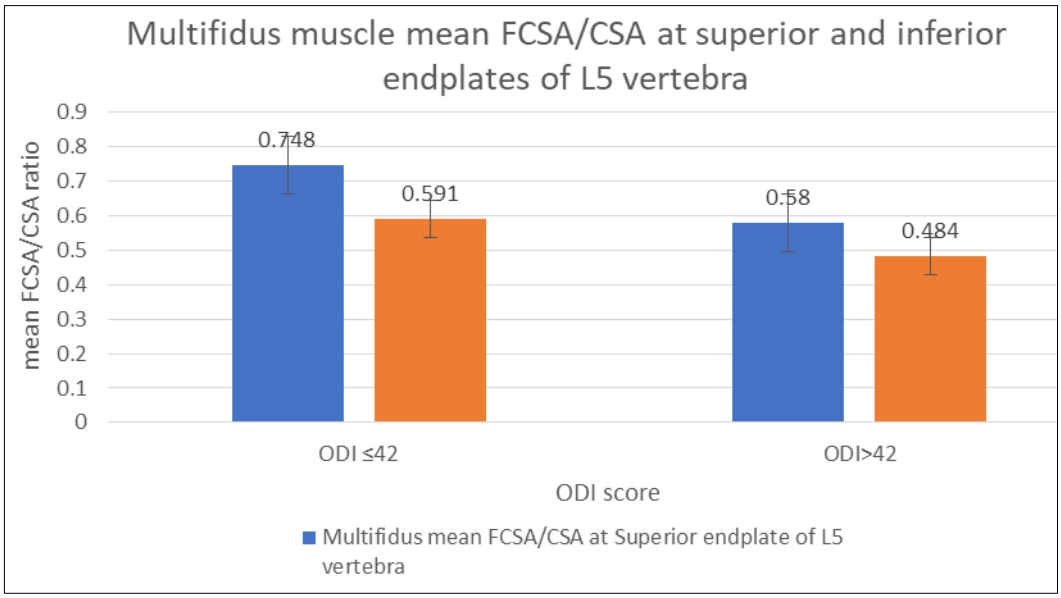
*Suggestive significance (P value: 0.05<p<0.10), Moderately significant (P value:0.01<P < 0.05), Strongly significant (P value: p<0.01)

Clinical Results

From the above table, the difference in the mean values of Age, BMI, Back pain duration, and Leg pain duration between both groups was not statistically significant(p> 0.05).Back pain VAS score, leg pain VAS score and Pain interference score between the groups were found to be statistically significant.

Radiological Results

The difference in the mean values of Multifidus muscle FCSA/CSA (fat infiltration) at the superior and inferior endplate of the L5 vertebra, Erector spinae CSA asymmetry% at the inferior endplate of L5 vertebra was found to be statistically significant (Graph 2).



Graph2: Multifidus muscle mean FCSA/CSA at superior and inferior endplates of L5 vertebra.

Discussion

This study was conducted to test the hypothesis that low back pain may be caused by spinal column instability due to paraspinal muscles atrophy in lumbar spinal stenosis. Many recent studies have shown no significant association between the dural sac CSA at L4-5 disc level and disability in lumbar spinal stenosis[3-5]. Many individuals with severe stenosis didn't have pain and disability but the individuals with mild to moderate lumbar spinal stenosis have severe pain and disability. This led us to do a comparative study on lumbar paraspinal muscles imaging morphology, and clinical symptoms between moderately and severely disabled lumbar spinal stenosis patients. In our study,the Oswestry disability index score was used to quantify the low back pain disability[8] in lumbar spinal stenosis patients.

The lumbar multifidus muscles consist of multiple separate bands arising from each vertebral spinous process and lamina, and inserting from two to four segments below the level of origin[9]. All multifidus muscles that arise from a given level are innervated by the medial branch of the primary dorsal rami of the spinal nerve from a single segment. The principal action of the multifidus is the extension and to produce small vertebral stabilizations[9].

In our study, we found statistically significant differences in the mean values of Back pain VAS score, leg pain VAS score and pain interference score between the two groups. The atrophy and fat infiltration in the lumbar multifidus muscle

werestatistically more in severe disability patients compared to moderate disability patients with Lumbar spinal stenosis(p<0.001) both at the superior and inferior endplate of the L5 vertebra. This may be because the multifidus muscle innervation was segmental. In our study, it was found that the multifidus muscle was affected more than the erector spinae and psoas major muscle in patients with lumbar spinal stenosis. This finding was in accordance with the studies conducted by Fortin M *et al*[10], Kalichman L *et al*[11], Cooley JR *et al*[12], Cooper RG *et al*[13].

There was no statistical difference in means of dural sac cross sectional area between the two groups.Our study results indicate that lumbar spinal stenosis is not solely an anatomical disorder, but that this disease may have other underlying pathobiological mechanisms to be discovered[14].Our study results concur with the studies conducted by Pekka Kuittinen *et al*.[14], Sirvanci *et al*.[15], Jonsson *et al*[16]. which showed no association between severity of canal stenosis and functional disability in lumbar spinal stenosis patients.

Conclusion

In our study, we found that the Lumbar multifidus muscle atrophy and fat infiltration at the superior and inferior endplate of the L5 vertebra in severely disabled LSS patients was statistically significantcompared to the patients with moderately disabled lumbar spinal stenosis patients. There was no statistical difference in means of dural sac cross sectional area between the two groups. Further Prospective studies with large sample sizes are required to prove a causal relationship between multifidus muscle atrophy and low back pain in patients with lumbar spinal canal stenosis.

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