

The effect of conventional lumbar spine surgery on the lumbar multifidus fat infiltration

ABSTRACT

Aims: Low back pain is considered as a common problem that affects most adults at least once in their lives. Almost 90% of people experience back pain during their lifetime. The total cost of treating chronic low back pain in the United States is estimated at more than \$ 100 billion annually. Hence, the present study aimed to investigate the effect of lumbar spine surgery on the lumbar multifidus fat infiltration in the patients referred to Imam Reza Hospital in 2020.

Study design: Prospective study

Place and Duration of Study: Department of Neurosurgery, AJA University of Medical Sciences (AJAUMS), Imam-Reza Hospital, Tehran between January 2020 and January 2021.

Methodology: In the present prospective study, patients with disk herniation or lumbar spine canal stenosis referred to the neurosurgery clinic of Imam Reza Hospital in 2020 that underwent surgery were enrolled. After six months, they underwent lumbosacral MRI again. Multifidus muscles in primary MRI and sixth month MRI were compared at L4-L5 and L5-S1 levels and the changes were recorded.

Results: A total number of 288 patients were enrolled in the present study during the study period. Based on the results, moderate fat infiltration (grade II) have had the highest frequency amongst the patients, and 52% of patients were in the moderate state in terms of adipose tissue infiltration in multifidus muscle postoperatively.

Conclusion: Increased adipose tissue infiltration in the postoperative period was high and can be considered as a cause of disability and severe pain in patients after surgery. Due to the muscle atrophy six months post-surgery owing to intraoperative muscle injuries and consequently postoperative movement restriction, some exercises and physical therapy can be suggested to correct movement patterns and further reduce pain in the patients.

Keywords: Lumbar surgery, Low back pain, Fat infiltration, Multifidus muscle

1. INTRODUCTION

Low back pain is considered a common problem that affects most adults at least once in their lifetime. Almost 90% of people experience low back pain during their lifetime [1]. The total cost of chronic low back pain management in the United States is estimated at more than \$ 100 billion annually [2]. Low back pain is one of the most common complains that bring the patients to neurosurgical clinics, and may have various mechanisms depending on different spinal components [3-5]. Nowadays, morphological factors and para-spinal muscles (including multifidus) thickness, and its possible association with low back pain have led to many studies on it [6]. Imaging modalities can show these

morphological changes caused by multifidus muscle weakness in people with low back pain. The fat infiltration in the multifidus muscle is a measurable index that can be detected by MRI precisely [7, 8].

Laboratory evidence shows that multifidus muscle can control intervertebral movement by tightening the spine, while each local para-spinal muscle helps stabilize the spine. Multifidus alone accounts for more than two-thirds of spinal stability through increased stiffness in the sagittal plane [9]. Despite extensive advances in spinal diseases, chronic low back pain is one of the most severe causes of disability and its prevalence during a person's lifetime is 65-80% (about 22-65% per year) [10]. No specific cause was found in 85% of all patients with low back disorders and these disorders are known as chronic nonspecific low back pain [11].

Spinal stabilization therapies have been more effective over time than limited interventions and exercise therapy alone. These therapies have reduced the recurrence rate of pain in addition to reducing pain, disability, and the rate of drug consumption. Moreover, one aspect of **treatment** concentrates on strengthening the para-spinal muscles to improve the long-term stability of the spine [12]. Studies have also shown that the multifidus muscle as a part of the extensor and stabilizer spinal muscles, has been atrophied in chronic low back pain **as well as post-surgery period** [13]. Liu et al. investigated the relationship between disk bulging rate and reduction of lumbar lordosis and adipose tissue infiltration in patients with lumbar segmental stenosis and concluded that lumbar disk herniation and reduced lumbar lordosis may be associated with adipose tissue infiltration of multifidus muscle at the L5-S1 level. **Various degree of muscular dysfunction including muscle atrophy, decreased muscular volume, and fat infiltration into the muscles have been seen after lumbar surgery.** The type of surgical procedure together with surgical invasiveness can waste the muscular fibers via different mechanisms. For example, lumbar surgery for internal fixation needs a wide exposure to define specific landmarks. This procedure will damage to the paraspinal muscles more than a simple lumbar discectomy due to a large muscular surface manipulation along with prolonged retractor placement. Also, lumbar surgery may lead to denervation atrophy because of dorsal rami damage that depends on the surgical approach. [14].

Various therapeutic interventions have been recommended to improve chronic low back pain, although the effectiveness of most of these interventions has not been well documented [15]. Among the available therapeutic interventions, exercise therapy is widely used to treat low back pain. In most cases, low-strength trunk and abdominal muscle training exercises have been introduced as the selected therapy [16]. Research suggests that stability training can reduce pain and disability, increase neuromuscular control, correct functional disorder, reduce recurrence of low back pain, and increase multifidus muscle size [12]. Accordingly, the present study aimed to investigate the effect of lumbar spine surgery on the lumbar multifidus fat infiltration in the patients referred to Imam Reza Hospital in 2020.

2. MATERIAL AND METHODS

This study was a prospective cohort study, was considered by the Ethics Committee of AJA University of Medical Sciences, and was approved (project number: 97001211), conducted on patients with disk herniation or lumbar canal stenosis referred to Imam Reza Hospital in January 2020 to January 2021. In this regard, all patients with disk herniation or lumbar canal stenosis referred to the neurosurgical clinic of Imam Reza Hospital were enrolled. Also, all patients signed the informed consent if they accepted to participate in the study.

The eligible patients underwent conventional lumbosacral MRI 6 months after surgery. Then, multifidus muscles in preoperative and postoperative MRI were compared at the L4-L5 level and the changes were recorded. It should be noted that all imaging was performed in the imaging center of Imam Reza Hospital. Adipose tissue infiltration in this muscle was measured based on visual assessment as: mild (infiltration of 0-10%), moderate (infiltration of 10-50%), and severe (infiltration of more than 50%).

Patients with the following: more than 65 years of age, a history of lumbar spine surgery, instrumentation surgery, cognitive impairment or psychosis, unwillingness to participate in the project, a history of a kind of minimally invasive surgery such as radiofrequency or peri-root injection were excluded. Data were analyzed in SPSS version 0.22 Software. Quantitative data were reported as "standard deviation \pm mean" and qualitative data were reported as "number (percentage)". Significance level in the tests was considered at 0.05. In all stages of this study, the principle of confidentiality was observed to prevent misleading and unrealistic results or any bias. The patient's participation in the study was completely voluntary and his acceptance or refusal had no effect on the patients' follow-up treatment process.

3. RESULTS AND DISCUSSION

Out of 288 participants in the study with mean age of 52.12 ± 10.11 , 155 (53.2%) were male and 135 (46.87%) were female, and the mean BMI was 28.5 ± 4.35 . The preoperative patient's Oswestry Disability Index (ODI) was 93.14 ± 8.040 versus 24.67 ± 2.257 in post-surgery period that showed significant difference between two groups ($P=0.016$). patient characteristics have been shown on table 1.

Table 1: Sociodemographic variables

Variables			
Age (Years±SD)	52.12±10.11		
Gender (%)	Male: 53.2	Female: 46.87	
Surgical level (%)	1 level Discectomy: 29.5		
	2 levels discectomy: 6.95		
	2 levels laminectomy: 13.9		
	3 levels or more laminectomy: 76.38		
	Lumbar instrumentation: 34.02		
Surgical time (Mean±SD)	152±15.80		
	Preoperative group	Postoperative group	p-value
BMI (Mean±SD)	28.5±4.35	29.5±2.45	0.120
ODI(Mean±SD)	93.14±8.040	24.67±2.257	0.016

*ODI: Oswestry Disability Index

The mean preoperative VAS score was 6.457±1.959, and preoperative and postoperative VAS scores showed a significant difference ($P<0.001$). Mean cross sectional area (CSA) of psoas (Ps) muscle, erector (Er) spinae muscle, and multifidus (Mf) muscle relative to the intervertebral disk, were measured in MRI of patients before and 6 months after surgery, and the results were displayed in Table 2. Based on the obtained results, the mean CSA of these three indices were lower in patients 6 months after surgery compared to the preoperative ones.

Table 2. Mean CSA of Mf:Disk, Ps:Disk, and Er:Disk between two groups

Variables	Group	Mean±SD	P value
Er:Disk ratio	Preoperative	1.242±0.117	<0.001
	Postoperative	0.83±0.076	
Ps:Disk ratio	Preoperative	0.867±0.907	0.027
	Postoperative	0.761±0.07	
Mf:Disk ratio	Preoperative	0.665±0.115	0.008
	Postoperative	0.556±0.813	

Er:Disk: Erector spinae muscle to Disk, **Ps:Disk: Psoas muscle to Disk, ***Mf:Disk: Multifidus muscle to Disk

According to the table 2, the difference between the mean CSA of Erector spinae to disk was statistically significant between the two groups ($P<0.001$). The mean CSA of psoas muscle to the intervertebral disk showed a significant difference as well. Also, significant difference was found in terms of multifidus to intervertebral disk ratio ($P=0.008$). Table 3 shows the fat infiltration rate in multifidus muscles pre- and postoperatively.

Table 3: MRI-based multifidus fat infiltration (mild, moderate and severe) among two groups

Group	Sub-group	N(%)
Preoperative	Mild	250 (86.80%)
	Moderate	32 (11.11%)
	Severe	6 (2.08%)
Postoperative	Mild	130 (45.13%)
	Moderate	150 (52.08%)
	Severe	8 (2.77%)

Our results revealed that the moderate fat infiltration had higher frequency in six months follow-up period, while mild fat infiltration had the lowest one. Additionally, 52% of patients were in moderate state in terms of multifidus fat infiltration after surgery.

3.1 Discussion Subheading

The present study was conducted to compare the adipose tissue infiltration in the multifidus muscle in lumbosacral MRI of patients with low back pain referred to Imam Reza Hospital before and 6 months after conventional surgical approaches. Several studies have been conducted to examine the association between muscle atrophy and back pain and the effect of recovery of atrophy in reducing pain in people with varying degrees of lower back pain. In this study, we compared our results with the results of some of previous studies conducted in this regard.

In the present study, the ratio of multifidus muscle CSA to disk in the postoperative group was significantly lower than the preoperative group, which might be attributed to long term movement restrictions and surgical manipulations in these patients. The results of this study are in line with those of a study conducted by Teichtahl et al. [17], Tabaraei et al. [18], and Gille et al. [19]. Other parameter examined in this study was Oswestry disability index score and examining the disability in both groups. It was significantly higher in preoperative group patients which is completely in concordance with the literature.

In addition, the frequency of moderate fat infiltration was higher in the postoperative group. This means that the surgical approach can decrease the muscular bulk of the paravertebral muscles. This result was attributed to movement restriction due to a long term pain and thus the atrophy of muscles, but it is not the only cause of muscle atrophy. As our results represented, surgery exacerbates the muscle atrophy along with fat infiltration. This result was consistent with the results of studies conducted by Stuber et al. [20] and Middlekoop et al. [21]. However, these results were inconsistent with the results of studies conducted by Teichtahl et al., which attributed an increase in adipose tissue infiltration to body disability to lumbar pathological, including canal stenosis and lumbar discopathy [17].

In lumbar surgery, especially in instrumentation procedures, high rate of muscle injury and dorsal rami damage could predispose to the muscle atrophy. Postoperative muscle weakness may result in chronic low back pain due to instability occurrence. Consequently, early postoperative physical therapy may be a need. Physical therapy and extension exercise in particular, have positive effects on muscular function and strength that are recommended in postoperative period. This exercises prevent muscular fat infiltration accompany by increased muscle volume and strength [22].

According to our findings revealing the adverse effect of operation on paravertebral muscles, the role of minimally invasive surgery (MIS) is more prominent, and the neurosurgeons' opinion may shift to this kind of operation increasingly. Moreover, in patients who are not a candidate of MIS, postoperative paravertebral muscle reinforcement methods and physical therapies should be considered more than before.

Although we included all patients who underwent conventional lumbar surgery in this study, it is recommended to enroll more specific pathologies such as single level surgery, or only decompressive laminectomy in future investigations to help us judging precisely.

4. CONCLUSION

Increased adipose tissue infiltration in the postoperative period was high and can be considered as a cause of disability and severe pain in patients after surgery. Due to the muscle atrophy six months post-surgery owing to intraoperative muscle injuries and consequently postoperative movement restriction, some exercises and physical therapy can be suggested to correct movement patterns and further reduce pain in the patients. Strengthening exercises such as water therapy, due to the direct effect on the stabilizing muscles of the lumbar spine, may correct the movement patterns and thus reduce pain severity.

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COMPETING INTERESTS

The authors declare no conflict of interests.

AUTHORS' CONTRIBUTIONS

SSGM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. APB and MMN managed the analyses of the study. EF managed the literature searches. All authors read and approved the final manuscript.

CONSENT (WHERE EVER APPLICABLE)

All the patients who were enrolled in this study signed the consent form that **were available** from the corresponding author, upon reasonable request. Written informed consent was obtained from the patients for publication of this case series and any accompanying images.

All authors declare that 'written informed consent was obtained from the patients for publication of this article. A copy of the written consent is available for review by the Editorial office/Chief Editor/Editorial Board members of this journal.'

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

This study was a prospective cohort study, was considered by the Ethics Committee of AJA University of Medical Sciences, and was approved by project number of 97001211.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

ODI: Oswestry Disability Index

CSA: Cross sectional area

Ps: Psoas

Er: Erector spinae

Mf: Multifidus