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Postoperative Rehabilitation Following Lumbar Discectomy With Quantification of Trunk Muscle Morphology and Function: A Case Report and Review of the Literature

- **STUDY DESIGN:** A case report and literature review.
- **BACKGROUND:** Optimizing clinical outcomes following lumbar disc surgery is a research priority; however, relatively little attention has been paid to the postoperative management of this population. The transversus abdominis and lumbar multifidus (LM) muscles appear to play a unique role in lumbar spine stability, and may relate to clinical outcome following lumbar disc surgery. The purpose of this case report was to describe the preoperative LM morphology, clinical outcome, and change in transversus abdominis and LM muscle activation in a patient following lumbar disc surgery and motor control exercise initiated in the early postoperative period.
- **CASE DESCRIPTION:** A 29-year-old female underwent an 8-week postoperative rehabilitation program emphasizing motor control exercises to restore trunk muscle function 10 days following lumbar disc surgery.
- **OUTCOMES:** The patient experienced clinically important improvements in pain and disability following the postoperative rehabilitation program. Substantial improvements in muscle activation were observed of the transversus abdominis and the LM at the L4-5 level. Minimal change in LM activation and a higher proportion of intramuscular fat was observed at the L5-S1 level.
- **DISCUSSION:** This case report represents limited evidence regarding the feasibility of instituting a rehabilitation program in the early postoperative period following lumbar disc surgery. Improvements in clinical status and muscle function were observed, and a differential change in muscle activation between the L4-5 and L5-S1 levels was noted. The literature regarding rehabilitation following lumbar disc surgery, as well as the neuromuscular changes observed in this population, was reviewed. Additionally, a novel method of examining LM morphology was described and suggestions were made for directions of future research.
- **LEVEL OF EVIDENCE:** Therapy, level 4.

J Orthop Sports Phys Ther 2010;40(7):402-412. doi:10.2519/jospt.2010.3332

- **KEY TERMS:** *adipose, discectomy, exercise therapy, rehabilitation, skeletal muscle, ultrasonography*

Low back pain (LBP) is the most common type of pain reported by adults, with approximately 8 in 10 individuals experiencing LBP in their lifetime.[7] Recent research indicates that the prevalence of,[24] and expenditures related to,[78] LBP are increasing. Lumbar disc herniation is a type of low back disorder that sometimes requires surgery.[29,92] However, the clinical outcomes of disc surgery have been described as suboptimal due to recalcitrant pain, disability, and reduced quality of life that occur in some individuals following the procedure.[6,32,71,109] Consequently, some have described failed disc surgery as a major healthcare problem.[3] Therefore, optimizing clinical outcomes following lumbar disc surgery has been recognized as a priority for future research.[83] While attention has been paid to the technical details of the surgical procedures,[3,82,108,110] potentially important muscular impairments and clinical considerations in the postoperative management of this population have received less attention.

The lumbar multifidus (LM) is a com-

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plex muscular structure that is proposed to provide a unique contribution to lumbar spine stability[87,97,106,107] and account for approximately two thirds of the stability at the L4-5 segment.[111] Individuals with LBP appear to exhibit both impaired function and morphological changes of the LM. Decreased activation[61,63] and delayed contraction[51,76] of the LM have been reported in populations with LBP. Additionally, atrophy of the LM and other lumbar paraspinal muscles has been observed in persons with LBP,[1,13,37,41,57,88] lumbar disc herniation,[114,115] lower extremity pain originating from the lumbar spine,[56] and lumbar radiculopathy.[52] Furthermore, a higher proportion of intramuscular fat within the LM shows a strong relationship with the presence of LBP.[58,65,85] Investigations of patients following lumbar disc surgery have yielded similar results. Mayer and colleagues[79,80] reported structural and functional deficits of the LM in a sample of patients 3 months following lumbar disc surgery. The authors observed decreased paraspinal cross-sectional area, decreased muscle density (indicating a higher proportion of intramuscular fat), and impaired trunk extension strength. Likewise, other research has reported LM muscle atrophy and injury following lumbar disc surgery, although this appears to vary with surgical approach[53,64,98] and the amount of intraoperative retraction time.[14,28,59,70] Moreover, such changes may be related to the development of failed back syndrome or postdiscectomy syndrome.[95,117]

The transversus abdominis (TrA) is another muscle considered to be an important contributor to lumbar spine stability.[44,48] While the role of the TrA in spine stability is not completely understood, it is thought to modulate spinal stiffness through its connection with the thoracolumbar fascia,[2,100] and by its ability to alter intra-abdominal pressure.[10] Dysfunction of the TrA in the form of delayed and attenuated contractions has been reported among persons with LBP.[22,43,45,47,49,50,76] Therefore, it has been theorized that the impaired function of the this muscle may be related to the pathogenesis of LBP.[44]

Lumbar stabilization exercise[34] is a therapeutic approach which seeks to increase muscle strength and address the deficits in trunk muscle function and morphology often observed among individuals with lumbar spine disorders. There is some evidence supporting the clinical efficacy[39,72,73,91] of stabilization exercise programs, as well as the ability of stabilization exercise to improve LM atrophy[12,40,94] and TrA function.[102,103] Therefore, stabilization exercise would appear to be a good therapeutic option for individuals following lumbar disc surgery. Consistent with this, a recent systematic review[90] concluded that strong evidence exists for the use of strengthening exercises in this population.

Another aspect of patient management following lumbar disc surgery involves recommendations regarding activity restriction. The restriction of activity following lumbar disc surgery is highly variable[83] and may result from concerns on the part of clinicians of reinjury, reherniation, or instability. However, some have expressed concern that overly conservative return-to-activity recommendations and emphasis on the potential for reinjury might delay the recovery of patients following disc surgery.[5] Although there does not appear to be an evidence-based justification for the use of postoperative restrictions in this population, there is limited evidence to suggest that recovery may be enhanced in the absence of activity restrictions following lumbar disc surgery.[4,5]

Despite the evidence of benefit of rehabilitation following lumbar disc surgery, utilization appears to be low,[83,112] and there is little consistency between rehabilitation protocols used by clinicians[112] and researchers.[89] Therefore, the most efficacious approach to rehabilitating this population remains poorly defined. However, a review of relevant randomized trials investigating the efficacy of rehabilitation following surgery for lumbar disc herniation[9,11,16,17,19,23,33,66,74,77,86,113] reveals 2 common themes among positive trials.[9,11,16,23,66,74,77,86,113] First, there was a primary emphasis on lumbar stabilization exercises. Second, positive trials tended to initiate rehabilitation earlier in the postoperative period when compared to negative trials (approximately 4 versus 7 weeks).

The early introduction of rehabilitation following lumbar disc surgery, emphasizing a motor control approach to the restoration of LM and TrA function and minimal activity restriction, has not been described previously. Additionally, given the potential importance of TrA and LM muscle function, as well as LM morphology with regard to clinical status, the quantification of these parameters may provide additional understanding of this population. Therefore, the purpose of this study was to describe the preoperative LM morphology and the clinical and functional outcomes of a patient following lumbar disc surgery and a rehabilitation approach emphasizing the restoration of trunk muscle function applied early in the postoperative period.

CASE DESCRIPTION

Participant and History

The patient was a self-described sedentary 29-year-old female (height, 170.2 cm; body mass, 84.8 kg; body mass index, 29.3 kg/m^2) who underwent a L5-S1 microdiscectomy for lumbar disc herniation. Approximately 2 years prior, the patient experienced her first episode of severe LBP and left lower extremity pain radiating along the S1 dermatome to the lateral foot. At that time, she underwent a transforaminal epidural steroid injection directed at the left L5-S1 foramen. The patient did well following this procedure and remained virtually asymptomatic for the next 18 months.

At that point, the patient experienced a recurrence of LBP and left S1 dermatomal radicular pain and numbness. Distal sensorimotor function was intact. There was a positive straight leg raise, positive crossed straight leg raise, and pain peripheralization with lumbar spine extension. Lumbar spine magnetic resonance imaging (MRI) revealed a focal L5-S1 disc protrusion extending from the left paramedian region to the left neural foramen, resulting in a mass effect upon the exiting left L5 nerve root and the transiting left S1 nerve root (**FIGURE 1**). The patient consulted with an interventional spine physician who, over the course of several months, performed 6 transforaminal epidural steroid injections. Additionally, the patient consulted with a chiropractor who treated her with specific directional exercise to achieve centralization,[34] and mechanical lumbar spine traction therapy.[27] Once these conservative therapies were deemed to be unsuccessful, the patient consulted with a neurosurgeon, who performed a left L5-S1 microdiscectomy, and referred the patient to a physical therapist for postoperative rehabilitation.

Evaluation

The patient underwent repeated measures of TrA and LM function, as well as self-reported pain and disability. These measurements took place 1 week prior to surgery, and after 1 and 10 postoperative weeks and 6 postoperative months. Additionally, LM muscle morphology was examined using the patient's MRI, which was performed 4 weeks prior to surgery.

Self-Report Measures The Modified Oswestry Disability Questionnaire provides a quantitative assessment of LBP-related disability.[20] Individuals rate the difficulty of 10 functional activities (eg, walking, standing, lifting) on a scale from 0 to 5, with higher scores indicating greater disability. This questionnaire is reported to have good levels of test-retest reliability, responsiveness, and a minimum clinically important difference estimated as 6%.[26] Moreover, treatment success has been defined as a 50% reduction in the Modified Oswestry Disability Questionnaire score.[25]

Pain intensity was represented by scores on the numeric pain rating scale. Participants rate the intensity of their pain on a scale from 0 to 10, with 0 representing the absence of pain and 10 representing the worst pain imaginable. Pain scores were obtained for the patient's current pain intensity, as well as the best and worst pain scores in the preceding 24 hours.[21,54,75] The 3 scores were averaged to derive an estimate of pain intensity. The numeric pain rating scale has been demonstrated to have good reliability, responsiveness, criterion validity, and a minimum level of clinically important change equal to 2 points.[8,54,75]

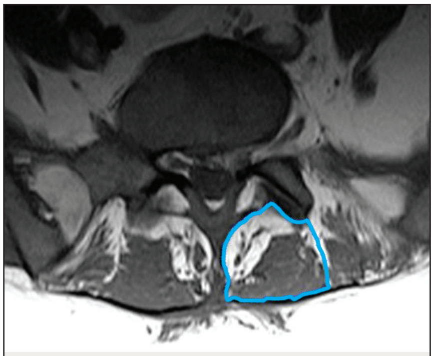

FIGURE 1. Region of interest indicating the left lumbar multifidus at the L5-S1 level.

Muscle Function We used rehabilitative ultrasound imaging (RUSI) to estimate muscle activation by assessing changes in thickness of the LM and TrA from rest to contraction. Recent research has demonstrated RUSI estimates of LM and TrA activation to have good rater reliability.[35,67] Criterion validity has been established by comparing RUSI and electromyography estimates of muscle activation.[46,62,68,84] Additionally, responsiveness has been demonstrated by observing changes in RUSI measures before and after the induction of LBP by means of hypertonic saline injection.[61]

The patient's LM and TrA muscle activation was assessed on the symptomatic (left) side by examining the change in muscle thickness from rest to submaximal contraction. While the examiner was aware of the patient's clinical status at the time of image acquisition, the measurement procedures were performed in a blinded fashion. The full details of these techniques have been reported elsewhere.[67] Parasagittal images of the LM were acquired at rest and during a submaximal contraction using the Sonosite Titan (Sonosite Inc, Bothell, WA) and a 2-5 MHz curvilinear array. The left LM was assessed at the L4-5 and L5-S1 levels using a prone contralateral arm lift to elicit a submaximal contraction while the participant held a 0.90-kg hand weight. This task is thought to elicit approximately 30% of the maximum voluntary isometric contraction for the LM when measured at the L4-5 level.[62] The left TrA was examined using the abdominal drawing-in maneuver and the active straight leg raise tasks to elicit a volitional and automatic muscle activation.[67]

Three images were acquired of each muscle in each state (resting and contracted), and the values were averaged to reduce variability.[69] The images were transferred to a desktop computer and measured offline using Image J software Version 1.38t (National Institutes of Health, Bethesda, MD). LM thickness measures were made between the posterior aspect of the L4-5 and L5-S1 zygapophyseal joints and the fascial plane between the muscle and subcutaneous tissue. Measures of TrA thickness were made between the hyperechoic fascial lines representing the superficial and deep borders of the muscle.

Muscle Morphology Axial T1-weighted images from the patient's clinical preoperative lumbar spine MRI study were assessed to quantify the cross-sectional area (CSA) and extent of fatty infiltration of the LM at the L4-5, L5-S1, and S1-2 levels bilaterally. To ensure consistency with the RUSI measures, the respective levels were identified by the L4-5 and L5-S1 facet joints. The S1-2 level was identified by calculating the number of MRI slices between the L4-5 and L5-S1 levels and proceeding caudally the same distance from the L5-S1 facet. All images were collected on a 1.5-T Phillips Eclipse MRI scanner (Philips Medical Systems, Bothell, WA), with the standard phased-array body coil, using a 4-mm slice thickness, 180-mm^2 field of view, and a 256 × 256 matrix. The images were transferred to a desktop computer, and measurements were performed using custom-written image analysis software (MatLab; Mathworks, Natick, MA). For each image, the LM was identified and manually traced using a computer mouse to create a region of interest (**FIGURE 1**) for the muscle on each side, and at each level. This technique is based upon previous research investigating the CSA and proportion of intramuscular fat within the quadriceps[15,18,31] and tibialis anterior[60] musculature, and allows for the quantification of separate tissue components, based upon their pixel signal intensity.

The software then calculated and displayed an intensity histogram representing the frequencies and intensities for all pixels within the respective regions of interest. A representative histogram is presented in **FIGURE 2**. Each histogram displayed 2 distinct peaks, with the lower signal intensity peak representing muscle and the higher signal intensity peak representing fat. The midpoint between the 2 peaks was calculated to differentiate between muscle and fat, with everything below this threshold considered muscle and everything above this threshold representing fat. The software provided the following output: total CSA for the region of interest (cm^2), muscle CSA (cm^2), fat CSA (cm^2), percent muscle (muscle CSA/total CSA), and percent fat (fat CSA/total CSA). As recommended by previous research,[60] each image was analyzed 3 times, and mean values were recorded to minimize measurement error. Previous research investigating similar techniques has found this approach to demonstrate high levels of intrarater reliability,[15] test-retest reliability,[18,31] and concurrent validity when compared to phantom imaging.[15]

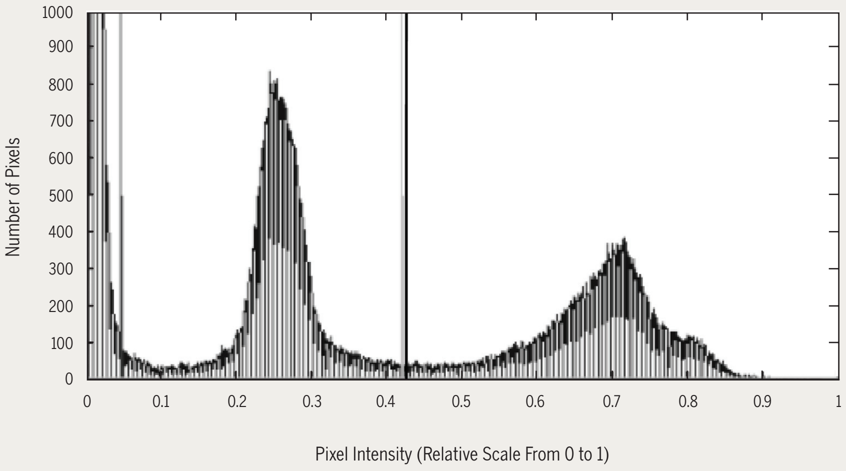

FIGURE 2. Representative pixel intensity histogram.

Postoperative Intervention

After 10 postoperative days, the patient initiated a physical therapy rehabilitation program. The patient participated in 8 therapy sessions, 1 session per week, supervised by 1 physical therapist. Additionally, on the days that she was not attending supervised therapy the patient performed daily home exercises that were reviewed with her physical therapist on each visit. The patient was encouraged to continue with her exercise program following the supervised exercise period. While this protocol relied heavily on home-based exercise, there is evidence to suggest that this is an effective approach in this population.[55,89] The treating physical therapist had 14 years of experience and was board certified and fellowship trained in orthopaedic and manual physical therapy. The patient received education regarding the importance of maintaining a neutral lumbar spine lordosis, and strategies were developed to accomplish this during her activities of daily living (eg, when arising from bed in the morning). Treatment approaches included stretching, range of motion, aerobic, and stabilization exercises; however, the focus of the rehabilitation program was the restoration of TrA and LM muscle function.

Exercises addressing TrA and LM function were applied in 2 phases. In the first phase, specific motor control exercises were utilized to reeducate the volitional contractions of the TrA and LM musculature. Initial efforts gave attention to the isolated contraction of the TrA using the abdominal drawing-in maneuver.[38,101] A pelvic floor muscle contraction was used to facilitate this task. Once the patient was able to adequately demonstrate an isolated TrA contraction, she was instructed in the performance of an isometric LM contraction.[93] Initially these motor control activities were performed in the quadruped position, with progression to the supine, seated, and standing positions.

The second stage emphasized the endurance of the TrA, LM, and other trunk muscles and was initiated after 3 postoperative weeks. These exercises were described by Hicks et al,[36] and include (1) quadruped arm and/or leg lifting and (2) horizontal side support with knees flexed or extended. Consistent with the stabilizing role of the lumbar and abdominal core musculature, this exercise approach utilized sustained isometric contractions to increase the strength and endurance of the global muscles, while minimizing potentially harmful compressive and shear loading of the spine.[81] During the performance of these exercises, the patient was instructed to maintain a TrA/LM cocontraction and a neutral lumbar lordosis throughout each repetition. The initial exercise dosage was 5-second contractions and 30 repetitions per day. As the patient's ability improved, the difficulty of the exercises were increased by alter-

TABLE 1 **Self-Report Measures of Low Back-Related Pain and Disability**

	Preoperative	1 wk Postoperative	10 wk Postoperative	6 mo Postoperative
Pain*	8	4	0	1
Disability†	46	26	0	4

Abbreviations: NPRS, numeric pain rating scale; ODI, Modified Oswestry Disability Index.
** NPRS, 0-10 scale.*
† ODI, 0-100 scale.

TABLE 2 **Left TrA and LM Muscle Thickness Measures (cm)***

	Preoperative	1 wk Postoperative	10 wk Postoperative	6 mo Postoperative
TrA (rest)	2.67 ± 0.14	2.22 ± 0.18	1.91 ± 0.16	2.38 ± 0.00
TrA (ADIM)	3.03 ± 0.31	3.91 ± 0.34	3.72 ± 0.28	5.84 ± 0.05
TrA (ASLR)	3.88 ± 0.38	2.58 ± 0.34	3.70 ± 0.36	4.54 ± 0.13
LM (L4-5 rest)	33.33 ± 0.78	30.50 ± 0.43	32.91 ± 0.56	30.50 ± 0.29
LM (L5-S1 rest)	33.64 ± 0.61	30.41 ± 0.95	30.89 ± 0.53	28.63 ± 0.34
LM (L4-5 CAL)	32.78 ± 0.93	31.03 ± 0.73	35.39 ± 1.32	33.67 ± 1.15
LM (L5-S1 CAL)	33.92 ± 0.32	30.19 ± 1.07	31.56 ± 0.73	29.01 ± 0.25

Abbreviations: ADIM, abdominal drawing in maneuver; ASLR, active straight leg raise task; CAL, contralateral arm lift; LM, lumbar multifidus; TrA, transversus abdominis.
** Values represent the mean of 3 measurements ± SD.*

TABLE 3 **Left TrA and LM Percent Thickness Change**

	Preoperative	1 wk Postoperative	10 wk Postoperative	6 mo Postoperative
TrA (ADIM)	13.48%	76.13%	94.76%	145.38%
TrA (ASLR)	45.32%	16.22%	93.72%	90.76%
LM (L4-5)	–1.65%	1.74%	7.54%	10.39%
LM (L5-S1)	0.83%	–0.72%	2.17%	1.33%

Abbreviations: ADIM, abdominal drawing in maneuver; ASLR, active straight leg raise task; LM, lumbar multifidus; TrA, transversus abdominis.

ing the activity (eg, performing the horizontal side support exercise with knees extended) and/or increasing the number of repetitions as based upon the clinical judgment of the treating therapist.

OUTCOMES

Self-Report Measures

Outcomes of pain and disability at each of the evaluations are presented in **TABLE 1**. The patient experienced clinically important improvements in pain and disability immediately following microdiscectomy, and at the completion of her postoperative rehabilitation program. By 10 postoperative weeks, the patient reported no pain and no disability.

Muscle Function

TrA and LM muscle thickness values are presented in **TABLE 2**. Percent muscle thickness change during activation for the LM at the L4-5 and L5-S1 levels and at the TrA during the active straight leg raise and abdominal drawing-in maneuver is presented in **TABLE 3** and in **FIGURES 3** and **4**. Substantial improvement in TrA and L4-5 LM muscle function was observed during the 8-week rehabilitative program. However, there was minimal change in LM muscle function at the L5-S1 level.

Muscle Morphology

The quantitative analyses of the patient's preoperative MRI are presented in **TABLE 4**. A greater proportion of intramuscular fat within the LM was observed in the more distal aspects of the lumbosacral spine. Additionally, at the L5-S1 and S1-2 levels there was a greater proportion of intramuscular fat within the left LM than the right LM.

DISCUSSION

Current best practices promote the use of postoperative rehabilitation following lumbar disc surgery; however there are no widely accepted criteria as to what constitutes an optimal rehabilitation program.[90] Clinical trials demonstrating improved outcomes following postoperative rehabilitation emphasize the use of lumbar stabilization exercise, and initiate treatment sooner in the postoperative period.[9,11,16,23,66,74,77,86,113] Additionally, morphological changes of the LM and functional impairments of the LM and TrA are related to disorders of the lumbar spine.[1,13,37,41,48,50,51,57,61,63,88] Integrating these 3 issues was the impetus in the design of the rehabilitation approach used in this case report. One week following lumbar disc surgery, the patient initiated a lumbar stabilization program emphasizing a motor control approach to restoring trunk muscle function. The patient did not experience an adverse reaction to the early initiation of lumbar stabilization exercise and had no difficulty completing the rehabilitation program. Moreover, during the course of the 8-week treatment period, the patient reported improvements in pain and disability that were accompanied by improved TrA and LM muscle function. Thus, this case report represents limited evidence regarding the feasibility of instituting a lumbar stabilization exercise in the early postoperative period following lumbar disc surgery.

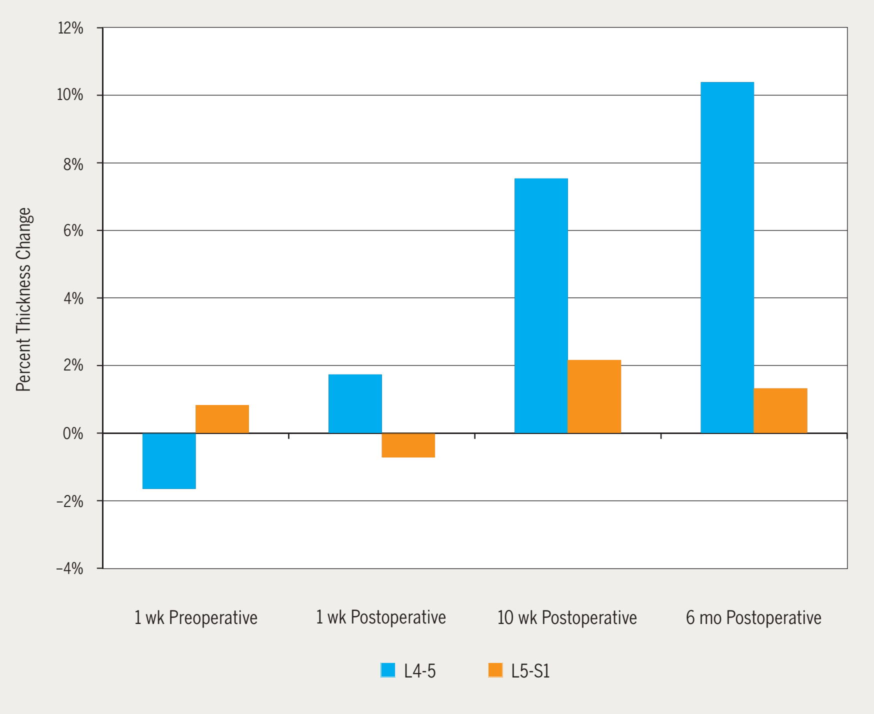

FIGURE 3. Left lumbar multifidus percent thickness change at the levels of L4-5 and L5-S1.

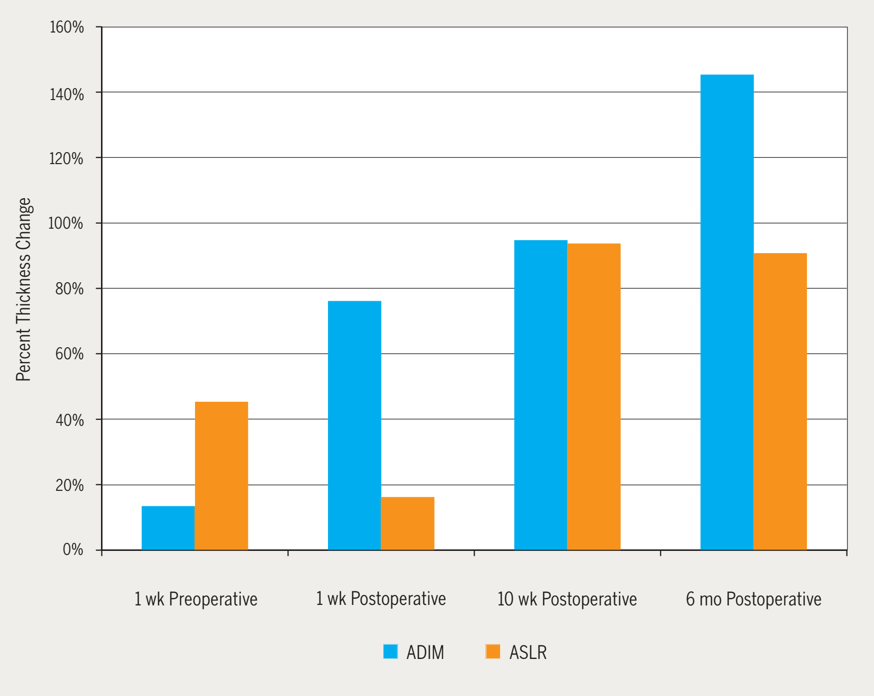

FIGURE 4. Left transversus abdominis percent thickness change during the abdominal drawing-in maneuver (ADIM) and active straight leg raise test (ASLR).

A novel aspect of this case report is the use of a new method of quantifying intramuscular fat within the LM. The approach used in this case report addresses some of the limitations of previous research examining LM morphology. The qualitative grading of LM fatty infiltration on MRI images has been used previously.[58,65,96] This method involves the visual estimation of the extent of fatty change as "normal" for an estimate of 0% to 10% intramuscular fat, "slight" for 10% to 50% intramuscular fat, and "severe" for greater than 50% intramuscular fat. While a visual estimate of fatty infiltration may have intuitive appeal to clinicians, this method has been demonstrated to have an unacceptable degree of measurement error in some populations,[65] thus a quantitative measure would provide a more precise estimate of intramuscular fat.

A quantitative approach was undertaken by Mengiardi et al,[85] who used single-voxel proton MR spectroscopy to estimate the proportion of intramuscular fat within the LM and lumbar longissimus muscles of 25 patients with chronic LBP and 25 asymptomatic volunteers matched with regard to age, sex, and body mass index. The authors reported significant differences in the proportion of LM intramuscular fat between the patients and volunteers, while there were no between-group differences noted in longissimus intramuscular fat. While MR spectroscopy can quantify intramuscular fat with accuracy comparable to biochemical analyses,[99] the analysis does not allow for the examination of the entire region. Thus, estimates may vary depending on voxel placement within the muscle.

We obtained measures of LM morphology using a quantitative approach, which allows for the measurement of intramuscular fat within a region of interest comprised of the cross-section of the muscle at several spinal segments. Additionally, we obtained concurrent and repeat measures of LM activation. Of interest in this case was the apparent differential change in LM activation between the L4-5 and L5-S1 levels. There are several possible explanations for this.

TABLE 4 Lumbar Multifidus Preoperative Cross-sectional Area and Proportion of Intramuscular Fat at the L4-5, L5-S1, and S1-2 Levels*

	CSA Total (cm^2)	CSA Muscle (cm^2)	CSA Fat (cm^2)	Fat (%)
L4-5 right	5.66 ± 0.01	4.81 ± 0.01	0.85 ± 0.02	15.09
L4-5 left	5.84 ± 0.09	4.98 ± 0.08	0.86 ± 0.01	14.67
L5-S1 right	6.51 ± 0.04	5.11 ± 0.03	1.41 ± 0.02	21.6
L5-S1 left	6.69 ± 0.09	4.52 ± 0.08	2.18 ± 0.04	32.51
S1-2 right	7.91 ± 0.07	5.64 ± 0.05	2.26 ± 0.02	28.64
S1-2 left	8.72 ± 0.04	5.24 ± 0.03	3.48 ± 0.01	39.89

Abbreviation: CSA, cross-sectional area.
** Values represent the mean of 3 measurements ± SD.*

First, the proportion of LM intramuscular fat may affect the contractile properties of the muscle. Consistent with this, when compared to the L4-5 level, we observed a greater proportion of LM intramuscular fat at the L5-S1 level. Additionally, the patient experienced greater gains in muscle function at the level, with less fatty infiltration (L4-5), while little functional improvement was observed at the level with a larger proportion of intramuscular fat (L5-S1). If this hypothesis is accurate, it could also help to understand the differential activation between the deep and superficial fibers of the LM. MacDonald and colleagues[76] reported that, compared to healthy volunteers, individuals with recurrent LBP have greater impairments in the deep LM fibers than the superficial fibers. A review of **FIGURE 1** reveals a clustering of intramuscular fat within the deeper aspects of the LM, and this is a trend we have observed in clinical MRI studies and cases from an ongoing research study. While increased skeletal muscle lipid content and its effects on function have been associated with decreased muscle performance and disability for other bodily regions such as the thigh,[30,104,105] the relationship between LM or other paraspinal muscle morphology and function remains unexplored.

An alternate explanation for the differential change in activation is that the original pathology and the primary effects of the surgery occurred at the L5-S1 level. Therefore, it is intuitive to think that the muscle function at this level would be more impaired and the recovery more prolonged than that observed above the level of pathology and surgery. Indeed, there is some evidence in support of this premise, as LM muscle deficits are thought to occur in a manner specific to the side and segmental level of back pain.[41,42,114,116] Finally, as with any measurement, RUSI estimates of muscle activation have inherent error and may not be responsive to change among a postoperative population. To our knowledge, this is the first report of using RUSI estimates of muscle activation in this population. However, there is some evidence to suggest that RUSI measurements are responsive in detecting changes in activation among individuals with pain induced by injections of hypertonic saline solution.[61]

A greater understanding of the relationship between LM morphology and function may improve clinical decision making for clinicians using rehabilitation. For instance, such understanding would raise the question as to whether individuals with disorders of the lumbar spine could be categorized based upon the presence of either a primary functional impairment (resultant from pain or pathology) or morphological alteration (resultant from atrophy or fatty infiltration) with consequential functional impairment. A reliable and valid approach to classifying muscle impairment as functional or structural could result in more efficient treatment strategies by tailoring the exercise approach to address the primary impairment. For example, among individuals with a large proportion of LM intramuscular fat, a functional approach emphasizing motor control may not be as effective as treatment strategies emphasizing aggressive strength training such as an eccentric exercise program. Conversely, in an individual thought to have a primary functional LM impairment, a motor control approach could be most appropriate.

There were several limitations of this study. First, due to the inherent nature of case reports, conclusions of causation cannot be made. Additionally, our measures of LM morphology and function were suboptimal. We were only able to obtain baseline measures of LM morphology; therefore, it was not possible to examine for morphological alterations over time and to describe the relationship with the functional change reported. Additionally, there is no established methodology for measuring LM activation with RUSI distal to the L5-S1 spinal segment.

The primary mode of treatment in this case was a motor control strategy to trunk muscle stabilization exercise. This approach has been previously demonstrated to normalize the feedforward activation of the TrA[102,103] and resolve the asymmetry associated with unilateral LM atrophy.[40] However, to our knowledge, there have been no prior investigations on the effects of exercise upon LM intramuscular fat. Future research should examine the relationship between LM morphology and function, and the effects of exercise interventions on clinical outcome on the neuromuscular impairments observed among individuals with LBP and other lumbar spine disorders.

CONCLUSION

We present the case of an individual who demonstrated a favorable clinical response following lumbar disc surgery and a rehabilitation program emphasizing motor control exercises initiated in the early postoperative period. A novel approach to measuring intramuscular fat within the LM was performed preoperatively, and repeated measures of trunk muscle function were obtained. Following the postoperative rehabilitation program, the patient experienced clinically important improvements in pain and disability, and demonstrated improved trunk muscle function. Of interest was the finding that less improvement in LM function following the rehabilitation program was observed at the spinal level with a greater proportion of LM intramuscular fat. Though the impact of rehabilitation on LM morphology is presently unknown, this outcome should be further explored. Finally, a review of the literature was presented and suggestions made for directions of future research. ◉

ACKNOWLEDGEMENT: *We would like to thank Jake Magel, PT, DSc of Intermountain Healthcare, Salt Lake City, UT for implementing the postoperative rehabilitation program.*

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