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MULTIFIDUS ATROPHY AND/OR DYSFUNCTION FOLLOWING LUMBAR RADIOFREQUENCY ABLATION: A SYSTEMATIC REVIEW.

Vinny Francio, Michael Glicksman, Logan Leavitt, Benjamin Gill, Anuj Shah, Benjamin Westerhaus, Christopher Lam, Ryan D Souza

The University of Kansas Medical Center, Department of Anesthesiology and Pain Medicine

Introduction

Chronic low back pain (CLBP) is an increasingly prevalent condition with severe implications on a patient's function and quality of life (QoL). CLBP also presents a significant socioeconomic burden, and is one of the leading causes of disability worldwide. There are numerous etiologies to axial CLBP, yet one identifiable etiology is facetogenic pain, secondary to the zygapophyseal facet joint arthropathy. These joints are innervated by the lumbar medial branch nerves (LMBNs), and each lumbar facet joint is dually innervated by LMBN of the same level and the level above. A diagnostic LMBN block can confirm the diagnosis and LMBN radiofrequency ablation/neurotomy (LRFA) may be used to denervate the painful facet joints. However, these LMBNs also innervate the multifidus muscle (although there is debate if it is segmentally or polysegmentally innervated), and the interspinous and supraspinous ligaments. For years, it has been postulated that LRFA may result in multifidus denervation and potential atrophy/dysfunction. This has important clinical implications, since the multifidus muscle is the key stabilizer of the lumbar spine, and multifidus dysfunction has been associated with CLBP. As such, this study aimed to systematically review the available literature to address the debate if LRFA may lead to multifidus atrophy/dysfunction.

Materials and Methods

Systematic review registered with PROSPERO that sought to evaluate lumbar multifidus dysfunction/atrophy after LRFA. Available studies were identified using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1). Risk assessment of bias was performed utilizing the Newcastle–Ottawa Quality Assessment Scale (NOS) and the Grading of Recommendations Assessment, Development and Evaluation (GRADE) assessment standard criteria were used to evaluate the quality and certainty of evidence as being very low, low, moderate, or high with the GRADEpro software. IRB exempt.

Results/Case Report

1565 studies were identified after removal of duplicates and screened for eligibility. 46 full-text articles were reviewed

and 8 total studies were included (Table 1). Of these, only 5 directly assessed the intervention and primary outcome of interest. The quality of these studies based on the NOS are shown in table 2. GRADE certainty assessment in evaluating multifidus atrophy/dysfunction across these studies is displayed in table 3. All 5 studies were cohort studies, with 2 retrospective and 3 prospective. 3 other studies were not included on the NOS and GRADE assessment since 1 study assessed for progression of degenerative spondylolisthesis following LRFA, another study assessed for other complications (not multifidus-related), and another evaluated a modified LRFA technique, proposed to spare multifidus innervation.

4 out of 5 studies suggested LRFA may be associated with multifidus dysfunction/atrophy, however their assessments differed. Smuck et al (1) demonstrated a decrease in fat-subtracted multifidus cross-sectional area at a mean of 12.7 months after controlling for age and gender in 27 patients following LRFA. However, these results did not reach statistical significance. Yet, Sadeghi et al (2) found statistically significant multifidus dysfunction with reduction in the shear modulus of the multifidus muscle in sitting up and lifted arms postures between 10 participants following LRFA and age/gender-matched controls at a mean of 11.42 months. Dreyfuss et al (3) suggested some level of multifidus dysfunction may be plausible, with both electromyography-documented denervation and some amount of atrophy observed in all participants at 17-26 months after LRFA. However, the side and segments of denervation could not reliably be predicted. Conversely, Böning et al (4) demonstrated an increase in mean muscle size across 17 patients at 6-months. In contrast, Oswald et al (5) found no difference in pre- and post-LRFA multifidus intramuscular fat volume across 31 patients at a median of 1.4 years. They also found no difference in relative fat volume when comparing the treated versus non-treated side in the 9 patients who underwent unilateral procedures.

Among all studies, the pooled results demonstrated very low certainty of evidence supporting an association between multifidus atrophy/dysfunction following LRFA according to GRADE criteria. There is minimal published research that addresses this debate, and there are numerous limitations to establish a definitive conclusion. All 5 studies differed in multifidus dysfunction/atrophy assessment and all studies had fairly small sample sizes, with the smallest being 5 participants (3). 3 of the studies included both evaluation prior to and after LRFA(1,4,5). Only 2 studies included a control group (2,5) and only 1 study included relevant covariates in their statistical analysis (1). Furthermore, only 1 study explicitly described a blinded analysis, while the others either did not specify or were unblinded (5). All studies provided at least 6 months time between patients receiving LRFA and assessment of multifidus atrophy/dysfunction.

Discussion

This is the first study to systematically review the current literature on multifidus atrophy/dysfunction following LRFA. We found that there are 3 level IB and 2 level IC studies assessing this potential relationship. These studies are of poor-to-fair quality and with a very low level of certainty according to GRADE criteria. Given the nature of the LRFA procedure and the inherent denervation of segments of the multifidus, some degree of multifidus atrophy and/or dysfunction is possible. Importantly, multifidus dysfunction following LRFA denervation has been confirmed under electromyography within 6 weeks post-intervention, and confirmed with shear wave elastography. Therefore, it is feasible that functional changes may precede structural changes on MRI (2,3). Most studies reviewed have demonstrated multifidus muscle structural changes on MRI after LRFA, however statistical and clinical significance to pain relief, side of intervention and correlation with electromyographic findings has not been established. 2 studies demonstrated a decrease in multifidus muscle size on MRI after LRFA, while 1 study demonstrated no change, and 1 revealed an increase in size (1,3,4,5).

In sum, there are limited poor-to-fair quality level IB and IC studies with a very low level of certainty to demonstrate a clear association between LRFA and multifidus atrophy/dysfunction. Although it is plausible, the evidence remains inconclusive. Our findings also emphasize the lack of standardization in evaluating multifidus atrophy/dysfunction following LRFA and highlight the need for high-quality

prospective studies to address this debate and its relevance in clinical practice.

References

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Disclosures

Yes

Tables / Images

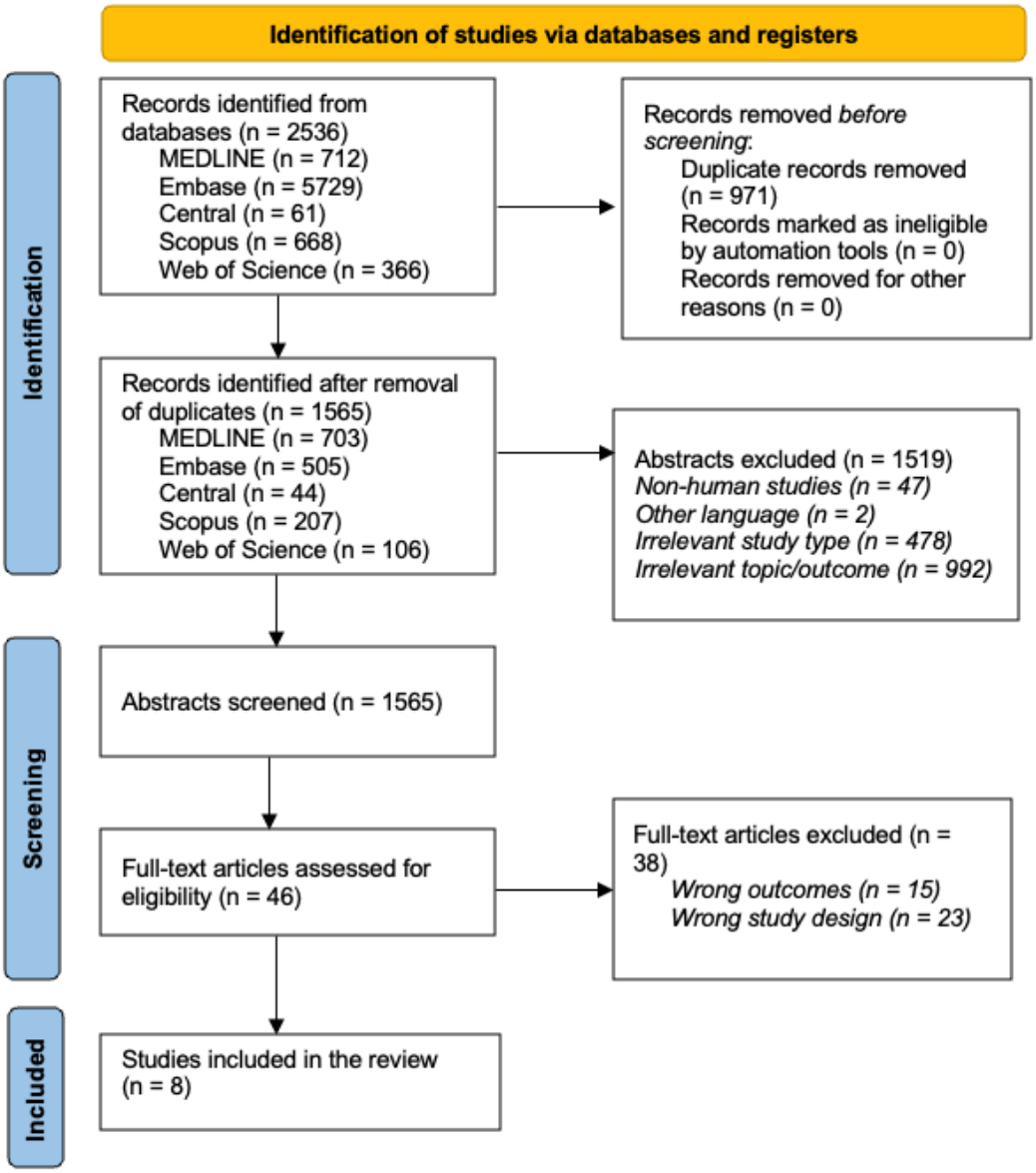

Figure 1. PRISMA diagram. Flow chart for study selection process including identification of studies from multiple databases and sources, screening process, assessment of eligibility and final study inclusion. PRISMA, Preferred Report Items for Systematic Reviews and Meta-Analyses.

Table 1. Characteristics and Outcomes of Eight Identified Studies

Author & Year	Study Design	Mean Age of Subjects	Method of Assessment	Sample Size	Follow-up Period	Primary Outcome Results	Secondary Outcome Results
Oswald 2023	Retrospective cohort study	60	Pre- and post-LRFA MRI analysis of multifidus intramuscular fat volume using iSix software	20	Median of 1.4 years	There were no differences in the relative intramuscular fat volume of the paraspinal autochthonous musculature after LRFA. In those patients with unilateral procedures, there were no differences in the relative intramuscular fat volume between the treated and non-treated sides before and after LRFA.	82% of patients reported pain alleviation after LRFA Of those patients specifically, 67% reported a pain reduction of over 50%. The subjective activity level was reported to be higher in 86% of patients. The mean NRS reduction was 6 +/- 2.
Böning 2021	Prospective, exploratory single-center study	58	Open 1.0 Tesla MRI system assessment of multifidus muscle size before and after LRFA	17 participants	6 months	MRI-guided LRFA in an open 1.0-Tesla MRI system is a safe, feasible, and promising treatment option for patients with chronic lumbar pain syndrome. VAS pain scores were improved at one week and six months following the intervention.	The mean multifidus muscle volume before/after the intervention increased significantly.
Patel 2021	Single center, prospective, observational pilot study	Unknown (median age 66)	Pre- and post-procedure LRFA lateral imaging (lumbar radiograph , lumbar MRI, fluoro)	14 participants	Median of 23.5 months and mean of 23.86 months (range 17-27 months)	There was no significant difference between the percent advancement of spondylolisthesis per year between those undergoing LRFA as compared to non-intervention inferred baseline controls (from Denard study).	None

Russo 2021	Retrospective cohort study	Initial: LRFA - 70.7, multifidus-sparing LRFA-61.7 Repeat: LRFA- 66.3, multifidus-sparing LRFA-62/2	Multifidus-sparing LRFA	Initial: 495 (94 traditional LRFA and 401 multifidus-sparing LRFA procedures) Repeat: Unknown	Unknown	There were similar positive outcomes following initial procedures (58.5% vs. 56.1% for LRFA vs. multifidus-sparing LRFA, respectively).	Similar proportion of repeat procedures following LRFA (28.4%) and multifidus-sparing LRFA (23.4%) both with a median repeat interval of 12 months [LRFA IQR 10 months (8-18 months); multifidus-sparing LRFA IQR 4 months (11-15 months)] One patient in each of the LRFA and multifidus-sparing RFA groups had post-initial procedural pain and paresthesias. One patient in the multifidus-sparing LRFA group had a post-initial procedural psoas muscle spasm.
Sadeghi 2020	Prospective observational analysis	LRFA: 61.15 LRFA healthy controls: 60.31 PLF: 60.9 PLF healthy controls: 60.80	Shear wave elastography of multifidus muscle contraction in prone, sitting up and lifted arms postures	46 participants	LRFA: 11.42 months PLF: 33.88 months	The shear modulus of the LRFA and posterior lumbar fusion groups was significantly lower in the sitting up and lifted arms postures as compared to healthy controls There was a significant increase in the shear modulus of the multifidus muscle in PLF patients when going from prone to sitting up and from sitting up to the lifted arms posture, while there was no such significant difference between postures in the RFA groups	There were no significant differences between the pain catastrophizing scale, VAS, or modified ODQ between the RFA and PLF groups. However, the median ODQ score of the RFA group was in the severe disability range while the PLF group was in the moderate disability range.

Smuck 2013	Retrospective, Single-cohort	55.6	Pre- and post-LRFA MRI assessment of fat-subtracted multifidus CSA	27 participants	Mean of 12.7 months	Mean multifidus CSA pre-treatment was 6.2 cm^2 & post-treatment was 5.7 cm^2 compared to 5.9 cm^2 in the control multifidus. There was a decrease in multifidus CSA at the treated vs control side but it didn't reach statistical significance.	Affected levels demonstrated a significantly greater increase in disc degeneration grade from pre to post-treatment when compared with unaffected levels (14.89% vs. 4.55%, p=5.0489). There was no statistical difference in the rates of zygapophyseal joint degeneration between affected and unaffected levels (6.76% vs. 9.74%, p=5.6322).
Dreyfuss 2009	Prospective Observational Analysis	Unknown	Pre-and post LRFA EMG, post-LRFA MRI evaluating for perceived atrophy of particular segmental bands of the multifidus muscle	5 participants	Mean of 21 months (range, 17-26)	Diffuse lumbar multifidus atrophy was detectable in all cases. However, although all the radiologists agreed that every patient had multifidus atrophy, they could not predict the sides and segments that had been treated with LRFA.	VAS documented a mean of 80% relief at six weeks and one year after neurotomy. At the time of the MRI, all patients had sufficient relief of pain that none required or requested further evaluation or treatment for low back pain.
Kornick 2004	Retrospective, cohort study	66.9	Patient-reported	92 participants, 616 denervation procedures, 116 total procedures	<8 weeks	There were a total of 6 minor complications (overall incidence of 1.0% per RFA site). Complications included 3 cases of localized pain lasting >2 weeks (0.5%) and 3 cases of neuritic pain lasting >2 weeks (0.5%). Zero cases identified of infection or new motor/sensory deficits	None

LRFA = Lumbar radiofrequency ablation; NRS = Numerical rating scale; VAS = Visual analog scale; ODQ = Oswestry low back pain disability questionnaire; PLF = Posterior lumbar fusion; CSA = Cross-sectional area; RFA = Radiofrequency ablation; MRI = Magnetic resonance imaging; EMG = Electromyography.

Table 2. Newcastle–Ottawa Quality Assessment Scale

Author	Year	Selection	Comparability	Exposure/ Outcome
Multifidus Dysfunction/Atrophy Studies following Lumbar Radiofrequency Ablation				
Oswald et al.	2023	****	*	***
Sadeghi et al.	2020	**	*	**
Böning et al.	2019	***	–	**
Smuck et al.	2013	***	*	**
Dreyfuss et al.	2009	*	–	**

Quality of cohort studies was determined using the Newcastle-Ottawa scale, which evaluates three categories: selection (maximum 4 stars), comparability (maximum 2 stars), and outcome (maximum 3 stars). Only five of the eight selected studies were evaluated for multifidus dysfunction and/or atrophy and are shown here.

Table 3. Grading of Recommendations Assessment, Development and Evaluation (GRADE)

Certainty assessment							№ of patients		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	lumbar medial branch RFA	control	Relative (95% CI)	Absolute (95% CI)	
Multifidus Dysfunction											
5	observational studies	very serious[a]	very serious[b]	very serious[c]	not serious	all plausible residual confounding would suggest spurious effect, while no effect was observed	-/115	NA	not pooled	see comment	⨁◯◯◯ Very low

Grading of Recommendations Assessment, Development and Evaluation (GRADE) assessment standard criteria to assess multifidus dysfunction and atrophy across the five studies that analyzed this outcome