Magnetic resonance imaging morphology of lumbar paraspinal muscles following successful bilateral facet joint denervation

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Purpose

Low back pain (LBP) is the second most common presentation in general practice, with 60-80% of people experiencing it in some form in their lifetime\(^1,2\).

The aetiology of one type of LBP is from pathology of the facet joints (facetogenic LBP), whose synovial capsules are innervated by the medial branch of the dorsal rami of nerves exiting the spinal canal at the same level as the joint and one level above\(^1\).

If conservative management fails, these nerves can be targeted with analgesic injection or medial branch block. If the joint is the cause of the pain then it should respond, although the effect is temporary.

More long-lasting analgesia is offered through radio-frequency facet joint denervation (RFJD), or rhizolysis, a surgical procedure where the medial branch is irreversibly cut. The medial branch however, also supplies parts of the paraspinal musculature including multifidus (MM), an important stabiliser of the lumbar spine neutral zone\(^2\). Denervation atrophy may theoretically occur following this procedure, where skeletal muscle fibres are replaced with fat leading to reduced function and therefore increased instability. MM atrophy has previously been shown to be strongly related to low back pain\(^4,5,6\). It is theoretically possible that by treating facetogenic LBP with this method that pain may arise later due to a different cause.

There are currently no prospective human studies which assess the morphological changes of the paraspinal musculature on MRI after RFJD or the variables affecting the magnitude of this change and this was the purpose of our research.
Methods and materials

This was a prospective study of adult patients enrolled from a single practice over a 2 year period with confirmed facetogenic chronic lower back pain, who had undergone successful bilateral L4/5 and L5/S1 RFJD. Success was defined as an improvement in VAS pain scores of 3 points or greater, or patient satisfaction at 6 weeks post-op. Those patients who had had spinal surgery in the 6 months prior, or who had contra-indications for MRI were excluded from participation.

MRIs were performed pre-operatively and at 6 and 24 weeks post-op. For each scan, seven T2-weighted slices were de-identified, de-temporised and randomised before being presented to 2 independent, blinded observers for analysis. The seven slices consisted of axial slices at the levels of the L4/5 and L5/S1 intervertebral discs and facet joints, and sagittal slices in mid-line and paracentrally to best demonstrate the left and right neural exit foramina.

In axial, freehand tracings of the outlines of MM, erector spinae (ES) and intervertebral discs were recorded using tablet computer and stylus Fig. 1 on page 4.

Post-processing gave a measure of the total cross-sectional area of each muscle in pixels. Further processing to determine lean or fat subtracted muscle cross-sectional area was possible by setting a grayscale cut-off and was standardised for each image Fig. 2 on page 4.

Tracings of the intervertebral discs at each level also allowed calculation of antero-posterior and lateral distances and provided a constant in order to account for any scaling or rotational variation across each patient's MRI scans.

Assessment of the degree of facet joint degeneration was made by each observer using the Weishaupt lumbar facet joint disease severity grading scale\textsuperscript{7}. In sagittal, freehand tracings of the anterior and posterior boundaries of the spinal canal between L4 and S1 were made in the mid-line slice which allowed calculation of the minimum diameter and therefore degree of central canal stenosis Fig. 3 on page 5. Assessment of the degree of intervertebral disc degeneration was made by each observer using the Pfirrmann grading scale\textsuperscript{8}. L4 and L5 neural exit foramina were also traced in left and right paracentral slices to calculate diameter and stenosis Fig. 4 on page 6.
Fig. 1: Freehand tracings around multiple structures allowed calculation of cross-sectional area and maximal AP and lateral dimensions

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**Fig. 2:** Fat subtracted muscle cross-sectional area was calculated by setting a grayscale cut-off and was standardised for each image

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**Fig. 3:** Freehand tracing of the boundaries of the spinal cord between L4 and S1 allowed calculation of the minimum AP diameter between these levels

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**Fig. 4**: Freehand tracing of boundaries of neuroforamina

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Results

Patient Data

There were 23 patients eligible for analysis, comprising of 13 females (57%) and 10 males (43%) with a mean age of 65 years (range 31-86). All patients had 6-week follow up MRIs and 15 had 24-week scans. All patients underwent bilateral RFJD of at least the two levels of interest, with most having denervation at additional levels. A total of 122 MRI scans were analysed.

Multifidus (MM) Fig. 5 on page 9 Fig. 6 on page 9

There was a statistically significant reduction in size of multifidus over the 24 week period in both total MM CSA in L4/5 (5%, 0=0.012) and L5/S1 (6%, p=0.010), as well as lean MM CSA at L4/5 (9%, p=0.002). There was a reduction in lean MM CSA at L5/S1 although it did not reach statistical significance (9%, p=0.076).

Erector Spinae (ES) Fig. 7 on page 10

There was no statistically significant change in size in total or fat-subtracted ES CSA over the study period.

Other outcomes:

The degree of central canal stenosis, intervertebral disc and facet joint degeneration or neuroforaminal stenosis had no significant effect on the degree of change in MM or ES CSA over the given time period.
**Fig. 5:** Total and lean multifidus muscle cross-sectional area in axial plane at L4/5 and L5/S1 at all time points

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Fig. 6: Percentage change in total and lean multifidus muscle cross-sectional area at 6 and 24 weeks post-operatively compared with pre-operative measurements at L4/5 and L5/S1

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**Fig. 7:** Percentage change in total and lean erector spinae muscle cross-sectional area at 6 and 24 weeks post-operatively compared with pre-operative measurements at L4/5 and L5/S1

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Conclusion

This is the first prospective study in humans of MRI morphology of lumbar paraspinal muscles following clinically successful bilateral RFJD.

We found that patients who underwent bilateral RFJD had significant, moderate atrophy of their multifidus muscles by way of total size at both levels investigated and a change in composition at one of the two levels, where muscle fibres were replaced with fat. Neither size nor composition of erector spinae was significantly affected by surgery. Degree of spinal canal stenosis, neuroforaminal stenosis, disc and facet joint degeneration had no significant effect on degree of change of size of paraspinal musculature.

Limitations of this study relate to the fact that patients were only enrolled from a single centre and procedures were performed by a single operator. Further useful information could be obtained by direct assessment of any change in patients’ subjective LBP over the same time points.

We have demonstrated a link between facet joint denervation and multifidus atrophy and, given that previous literature has shown that atrophy and fat infiltration of multifidus is strongly associated with LBP in adults, it is possible that facet joint denervation could be directly linked to low back pain although further research would be required to establish this.

Given how important a contributor multifidus is to the stability of the lumbar neutral zone and the association between facet joint denervation and multifidus atrophy, more judicious use of RFJD in patients with facetogenic LBP is required.
References


