Published in final edited form as:

Spine J. 2014 June 01; 14(6): 1088–1089. doi:10.1016/j.spinee.2014.01.049.

Letter to the Editor:

Re: Smuck M, Cristostomo RA, Demirjian R, Fitch DS, Kennedy DJ, Geisser ME.

Morphologic change in the lumbar spine after lumbar medial branch radiofrequency neurotomy: a quantitative radiological study. *Spine J* 2013; doi: 10.1016/j.spinee.2013.06.096

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We read this retrospective study with great interest and wish to commend the authors on their work examining the effects of medial branch radiofrequency neurotomy (RFN) on intervertebral discs, facet joints, and multifidus cross-sectional area in the lumbar spine. Convergent and divergent evidence is available with respect to altered muscle morphometry, and persistent pain and disability in patients with low back [1, 2], neck pain [3–6], rotator cuff pathology [7, 8] and fibromyalgia[9]. There is unequivocal evidence demonstrating the benefits of RFN on facetogenic pain-related disability, but as stated, a paucity of available evidence investigating the influence that RFN may have on the structure and function of the paraspinal muscles and in particular, the architecturally complex, multi-segmental multifidus.

A major limitation in this research, however, involves the inherent difficulty of isolating confounding factors to make definitive conclusions about the underlying mechanisms, rather than indirect correlations. As the authors point out, the RFN population offers a unique and more controlled opportunity for understanding the direct impact of denervation on muscle structure, segmental stability, and sensorimotor function. A major limitation of this paper is the use of repeated serial clinical MRI as the measure of structural changes in the muscle.

The T2-weighted images were taken over a year apart and compared. There is no description of how the acquisition of the data was controlled for software or hardware changes. Furthermore, the orientation of the slice is critical when comparing slice volume changes. Just a slightly different angulation will result in an apparent volume change on the order of the non-significant differences reported. To improve the error rate, the authors might have resorted to using vertebral body volume as a means to normalize each measurement over time.

The authors state...*"For the CSA measure, the image was calibrated by drawing a line along the centimeter ruler at the bottom of the MR image, thus determining the number of pixels per centimeter."* This is not needed as the voxels have a specified in plane dimension as well as a physical thickness. Therefore, CSA should be accurately categorized as a 3D volume. Accordingly, the volumetric measure (CSA) in this study (and others[5, 10]) may have partial volumes due to the slice thickness and slice gaps used. These partial volumes would change as the slice angulation changes per visit adding to the error of the measure. An alternative approach is to acquire the data utilizing a truly 3D acquisition and analyze the entire muscle in the region of interest.

The use of the "fat subtracted" method is misleading and described incorrectly. The authors state...*"Specifically, a gray-scale cutoff was used to perform a dichotomous transformation of each pixel within the image. All pixels at or above the cutoff were converted to black (muscle) and all of those below, to white (fat)."* In the T2-weighted image, the fat is bright and has higher signal intensity and the muscle is dark having a lower intensity. Therefore, the description of the method would result in the labeling of fat instead of muscle. The 'fat-subtraction' method is simply a threshold based binary segmentation of the fat and muscle in a hard drawn region of interest. This method also assumes that a voxel can only contain just muscle or just fat, when we know that there is a critical mixture of these species. This inference does not account for other tissues that contain a significant quantity of MR-invisible material that is not measured using conventional MR-based methods.[11] It will be necessary in future research to use more advanced, but available MR applications (e.g., proton-density fat fraction or multiecho, gradient echo fat/water separation) to accurately quantify muscle size/shape and fat content.

In addition, some thought should be provided to operationally defining "degeneration" by affected structures. It is not clear, given the architectural complexity of the multisegmental multifidus, that the segmental facet joint on the same side as a denervated multifidus would most likely experience an increased rate of degeneration. Further prospective research investigation involving the quantitative analysis of RFN effects on 3D muscle structure, content and function will allow for more definitive conclusions.

While Smuck and colleagues found a trend toward greater multifidus muscle atrophy following RFN treatment, the MR imaging approach to subtract fat from muscle cross-sectional area (CSA) measures is neither reliable or valid. The authors mention the subjective nature of freehand delineation of the multifidus fat infiltration as a limitation in the discussion section. Once again, these methods could have been cross-validated with currently accepted (and available) MRI muscle-fat quantification methods (e.g. proton-

density fat fractions [11] or a 3-dimensional multi-echo gradient echo chemical shift based Dixon method). Such methods, which have been recognized in the quantification of cervical muscle fat [12], allow for a 3D high resolution visual separation of fat and water, reliable and valid estimation of muscle fat percentage when compared to histology (in review), and short acquisition and reconstruction times while preserving image quality. Future methods should be validated by comparison, and researchers should utilize this approach for quantitative analysis of muscle morphometry.

In conclusion, we commend Smuck and colleagues for their efforts investigating the quantification of muscle, disc, and joint architectural changes following the performance of a clinically established procedure: RFN. However, if one is going to investigate the impact of treatment on recovery, it is critical to conduct larger scaled prospective studies using the state of the art methods in properly designed protocols.

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