

# HIGH RESOLUTION MR IMAGING OF PARASPINAL MUSCLE INJURY FOLLOWING MINIMALLY INVASIVE AND CONVENTIONAL OPEN POSTEROLATERAL LUMBAR FUSION

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**Introduction:** Lumbar spinal fusion is a commonly performed procedure in the United States for intractable low back pain from a variety of causes. However, surgery often has limited success, despite a satisfactory radiographic outcome. The conventional open posterior approach for placement of pedicle screws requires long incisions, and extensive deflection of muscle from the spinous processes. Subsequent prolonged wide retraction may result in denervation of the paraspinal musculature, leading to further muscle atrophy and on-going pain. Minimally invasive spinal fusion techniques have recently been developed in an attempt to minimize approach-related morbidity. The purpose of this prospective and randomized study was to use high resolution MR imaging to evaluate the paraspinal muscles, and to determine whether minimally invasive lumbar spinal fusion results in less paraspinal muscle damage than conventional open spinal fusion.

**Methods:** Patients with a recent minimally invasive or open single level posterolateral lumbar spinal fusion were recruited at a single institution by 2 spinal surgeons. MRI scans were performed approximately 6 months post operatively (range 4-10 months). All subjects were imaged in a supine position using a 1.5 T Signa LX (General Electric, Milwaukee, WI) with a phased-array spine coil. Axial multi-slice T1-weighted spin echo (SE) and axial flow-compensated T2-weighted fast spin echo (FSE) sequences were used for high-resolution structural imaging. In order to differentiate between edema and fatty atrophy, a combination of axial STIR T2-weighted FSE and fat-saturated T2-weighted FSE sequences were used. An oblique coronal T2 FSE or inversion recovery sequence was performed for better assessment of the overall extent of muscle damage. Edema and atrophy within the multifidus (MF) muscle was scored on a visual scale of 0 to 3 with 0 = none, 1= mild, 2= moderate, and 3 =severe (see Fig 1). Quantitative MRI was performed using rapid two-point T2 mapping technique and line scan diffusion imaging (LSDI; b=50 and 450s/mm<sup>2</sup>). ROI's with a minimum area of 10 mm<sup>2</sup> were placed on the individual bundles of the multifidus muscles bilaterally. A T2 relaxation time was calculated using a monoexponential fit on a per-pixel basis in the region of maximal signal intensity. Apparent diffusion coefficient (ADC) and T2 maps were reconstructed at a remote LINUX workstation. In order to compare the 2 surgical groups, the mean T2 relaxation time and mean ADC were calculated in the multifidus muscles at the level of the fusion and an unpaired student t-test applied.

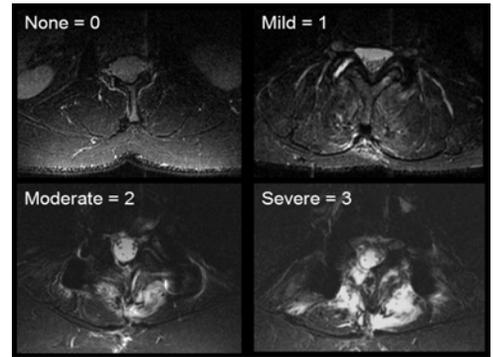


Figure 1 (above) – Edema scoring

**Results:** Twelve patients (9 females, 3 males) with a mean age of 52.7 years (range 38 – 71yrs) were enrolled in the study. The average duration of symptoms prior to fusion was 7.4 years (range 1-20 yrs). Six had a minimally Endius Atavi fusion, and 6 had conventional open spinal fusion. The average operative procedure times for the Atavi and Open groups were 251 minutes (range 198-285 mins) and 221 minutes (range 140-262 mins) respectively. There was no statistical difference in age, duration of symptoms or operative procedure time between the two surgical groups. There was a striking difference in muscle edema between the minimally invasive and open spinal groups (Figs 2 and 3). T2 values correlated well with the visual estimate of edema at each site ( $r = 0.76, p < 0.0001$ ). The mean T2 relaxation time at the level of the fusion was 85.8 ms ( $\pm 19.5$ ) in the open group, compared with 51.3 ms ( $\pm 13.4$ ) in the minimally invasive group ( $p = 0.0051$ ). The mean ADC was  $1626(\pm 132) \times 10^{-6} \text{ mm}^2/\text{s}$ , compared to  $1357 (\pm 104) \times 10^{-6} \text{ mm}^2/\text{s}$  ( $p = 0.0184$ ) respectively. In most patients, edema was seen in a chevron configuration on coronal images, following the anatomy of MF fibers. Therefore edema, T2, and ADC measurements were also analyzed in this distribution, using measurements from the medial bundles at the level above the fusion, the medial and central bundles at the level of the fusion and from all three muscle bundles at the level below the fusion. The mean T2 was 98.6 ms ( $\pm 18.1$ ) in the open group and 53.2 ms ( $\pm 8.9$ ) in the Atavi group ( $p = 0.0005$ ), with a mean ADC of  $1656 (\pm 119) \times 10^{-6} \text{ mm}^2/\text{s}$  and  $1332(\pm 100) \times 10^{-6} \text{ mm}^2/\text{s}$  respectively ( $p=0.0059$ ). Muscle atrophy was present in both groups, but there was no significant difference between the atrophy scores in the open and minimally invasive groups.

Figure 2. Coronal T2 FSE (left) and axial STIR (right) images of the paraspinal muscles in a female patient 6 months after having open posterior L4-5 spinal fusion, showing severe edema in the multifidus muscle

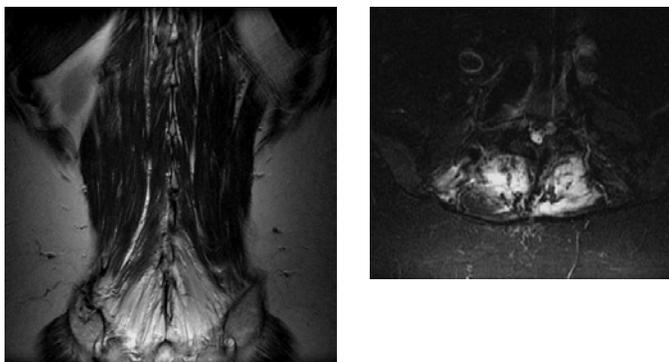
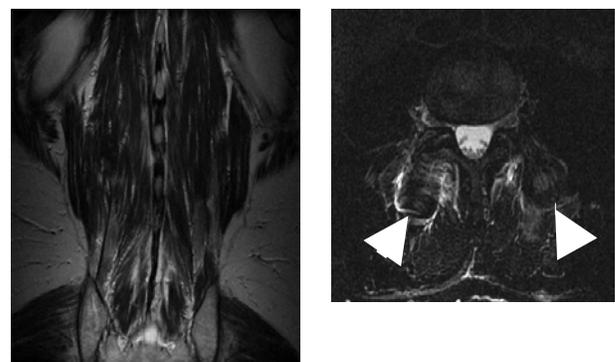


Figure 3. Coronal T2 FSE (left) and axial STIR (right) images in a male patient 5 months after having a minimally invasive L3-4 fusion, showing mild edema in multifidus. Metallic artifact is seen around the hardware (arrows).



**Discussion :** Instrumented spinal fusions do not always have a satisfactory outcome, and one contributing factor is postulated to be the dissection and retraction of paraspinal muscles needed to perform a standard posterior instrumented spinal fusion. Minimally invasive techniques have recently been developed to minimize such damage. Conventional MR scans of the lumbar spine show only limited detail of the paraspinal muscles, and there are very few MRI papers focusing specifically on the paraspinal muscles in the literature<sup>1,2</sup>. The T2 relaxation time is a quantitative measure of edema within the muscle, and has been shown to correlate with the severity of muscle damage. The mean T2 and ADC measurements were significantly lower in the Atavi group, suggesting that less muscle damage occurs using a minimally invasive approach.

**References:** <sup>1</sup>Chan Y, *et al.* *Pediatr Radiol* 1999; 29: 360-363. <sup>2</sup>Gejo R, *et al.* *Spine* 1999; 24 : 1023-1028.

**Acknowledgements.** This work was supported supported in part by the NIH (1R01EB002771), the Center of Advanced MR Technology at Stanford (P41RR09784), Lucas Foundation, and Oak Foundation.