Use of a Rabbit Model for MRI Investigation of Scar Formation Following Laminectomy

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Introduction:

Excessive scar formation following laminectory can lead to epidural tethering of the nerve roots impeding their normal motion in the vertebral column. The tethered roots are stretched by normal movement of the vertebral column which irritates them and can cause pain – the "failed back syndrome". Clinical MRI in the postoperative spine readily demonstrates the normal inflammatory changes and scar deposition that follows surgery, however characterization of scar formation and its function in dural tethering remains an area of active research [1]. In order to better understand the pathophysiology of the failed back syndrome, and to evaluate the efficacy of potential mechanical or pharmacological interventions, there is a need for a reproducible animal model of post-laminectomy adhesion and to be able image the post operative changes to correlate the clinical radiological signs from MRI with the underlying pathophysiology.

To address this relationship, we have developed such an animal model in the New Zealand White rabbit. We present here the utility of this rabbit model combined with MR imaging for (a) reproducibility of the surgical lesion and (b) MRI demonstration of postoperative inflammation & scar formation.

Methods:

Surgery: Six New Zealand White adult rabbits weighing 4-5.2 kg were used in this study. Bilateral complete laminectomy was performed on all rabbits at the lower lumbar level (L6). The dura was left intact, and the fascia and superficial tissues closed in layers. After 30 days, the animals underwent MR imaging. The animals were euthanized, and the spinal section was removed for histological processing.

MRI: All animals were imaged on a Varian 4T 90cm system running INOVA software. Following localization images, T_1 weighted 3D MPRAGE (magenetization prepared rapid acquisition gradient echo) sequence was used TR/TE 11.7 / 4.9 ms, TI 300 ms. FOV 64 x 64 mm and matrix 128 x 128, Slab dimension 96mm with 192 phase encodes giving isotropic 0.5mm^3 resolution. Imaging was repeated after iv injection of gadolinium (Omniscan, Nycomed) into an ear vein (250 µl /kg). Images were post processed using AFNI software [2]. The 3D dataset was aligned to provide anatomically true axial/sagital/coronal images. Two measures were made of scar formation: (1) a 4-point scale (0 through 3) of focal contrast enhancement in the perisurgical tissues, and (2) a 2D measure of the area of enhancement immediately abutting the laminectomy site (in mm2) by integrating the 1D length of enhancement on sequential slices.

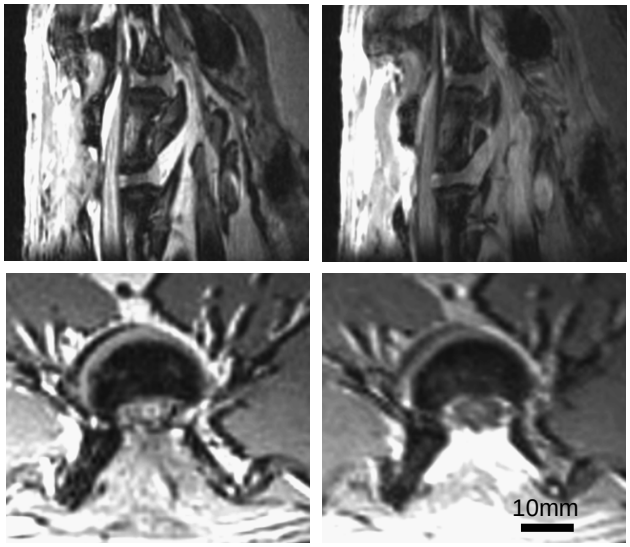

Figure:
Patterns of enhancement: Epidural scar tissue and adhesion on sagittal (upper panels), and axial MRI (lower) or Rabbit model. Left: T_1 weighted MRI, Right: T_1 weighted MRI post-contrast.

Results:

Surgery in all six animals yielded a reproducible laminectomy, without complication or mortality. Enhancement in the T_1 imaging post-gadolinium clearly delineated the inflammation and scar formation in the perisurgical tissues. Measurements of MRI gray scale was readily quantifiable, as was the area of abuttal of the scar.

Discussion:

The New Zealand White rabbit provides and excellent model for studying postoperative changes following laminectomy. The animal is sufficiently large to allow high resolution imaging, and for the surgery not to be unnecessarily microscopic. Despite the slight difference in lumbar vertebral anatomy compared with humans, this animal represents an excellent species for studying recovery from laminectomy. In combination with MRI, this provides a robust method to study postoperative scar formation. The patterns of enhancement following intravenous gadolinium contrast agent mirror those seen in clinical imaging. This can be integrated with histological and biomechanical measures in the evaluation of the pathophysiology of the failed back syndrome. It also provides a platform for evaluating potential therapeutic interventions for post operative epidural tethering.

References:

[1] Abitbol et al. Spine. 19,1809-14 (1994) , [2] **.** Cox RW; Hyde JS. NMR Biomed 10, 171-8 (1997)