Value of Perfusion and Permeability Measurements in Distinguishing Between Benign and Malignant Vertebral Lesions

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Introduction: Almost all studies on dynamic contrast-enhanced MRI (DCE-MRI) in the spine [1,2] are based on descriptive perfusion indices like maximum signal enhancement. These suffer from well-known limitations like dependence on experimental variables and an ill-defined relation to hemodynamic parameters. Quantitative analysis with the Tofts model resolves the first issue, but not the second [3]. When the data are measured at a sufficiently high temporal resolution, a more general two-compartment model can be used providing an unambiguous interpretation [4]. The purpose of this study was to assess the potential of this approach to distinguish between pathological and osteoporotic fractures based on perfusion metrixs.

Methods and Materials: For a first evaluation 26 patients with vertebral compression fractures (pathological n=14, osteoporotic n=19) were measured at 1.5T (Siemens Avanto, Erlangen, Germany). DCE-MRI was performed with a 2D-saturation-recovery Turbo-Flash, measuring 4 slices/s for 5 min (300 dynamics, matrix = 192x144, FOV = 300x225x50 mm³, TR/TE/flip angle = 3.1ms/1.37ms/12°). One slice was positioned axially to determine the AIF in the abdominal aorta, the other 3 slices were chosen sagittally intersecting the lesion. Data were post-processed using the software PMI 0.4 written in-house in IDL 6.4.Tracer concentration was approximated by relative signal enhancement (S/S0-1). Firstly parameter maps of Plasma Flow (PF) and Mean Transit Time (MTT) were calculated using a deconvolution analysis [5]. ROI's in the lesions (n=33) and in healthy vertebrae (n=64) were then defined on these maps. A two-compartment exchange model was fitted to the concentration-time curves in the lesions and an uptake model to the healthy vertebrae, producing 3 independent parameters: PF, Plasma Volume (PV) and Extraction Flow (EF).

Type	PF [ml/100ml/min]	PV [ml/100ml]	EF [ml/100ml/min]
Healthy BM	**13.3 (9.5)***	**4.8 (2.9)***	**0.1 (0.3)***
Pathological	**97.8 (42.7)**	**18.8 (7.5)**	**9.3 (6.5)**
Osteoporotic	**22.8 (19.7)△**	**19.7 (5.9)**	**7.4 (4.3)**

Table 1: Perfusion parameters calculated in healthy vertebral bodies (n=64), in pathological (n=14) and in osteoporotic fractures. * significant differences between healthy bm and pathologies, △ between osteoprotic and pathological fractures.

Results: The lesions could be differentiated from healthy bone marrow as regions of increased PF, Figure 1. All perfusion parameter exhibits significant differences for healthy marrow versus pathologies (p<=0.0001), Table 1. Comparing pathological and osteoporotic fractures PV and EF do not deviate significantly from each other. In contrast the PF values were significantly higher (p<0.005) in pathological fractures.

Conclusion: In agreement with previous studies perfusion was low in healthy marrow. As expected from other organs PF is significantly higher in malignant fractures. In osteoporotic fractures PF is only moderately increased. Therefore it might be possible to differentiate benign and malignant lesions, due to different effects on the bone marrow vasculature, using perfusion metrics.

References: [1] Griffith, et al. Radiology. 2005 Sep; 236(3):945-51 [2] Chen, et al., Radiology 2001 220: 213-218 [3] Michoux et al. ISMRM09 [4] Biffar et al. ISMRM Workshop on Advances in Musculoskeletal Imaging SF09 [5] S. Sourbron, et al. PMB, 52:429–447, 2007

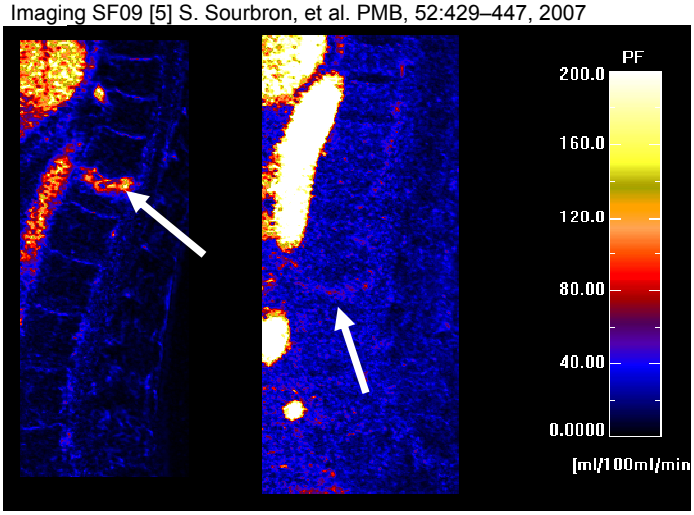

Figure 1: Parameter maps of the PF in a patient with a pathological fracture in T11 (left side) and patient with an osteoporotic fracture in L2 (right side). White arrows point at the lesion.

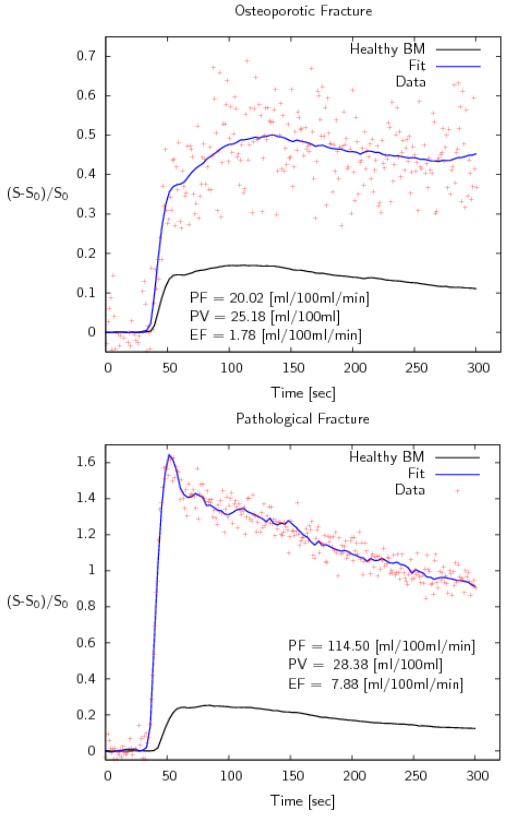

Figure 2: Plot of the data (red dots) vs the two compartment model fit (blue line). On the left side an osteoporotic and on the right side a pathological compression fracture is shown. For reference the