

# Quantitative analysis of perfusion parameters in osteoporotic patients with acute vertebral fracture using dynamic-contrast-enhanced MRI

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## Objectives:

To introduce quantitative analysis of high temporal resolution dynamic contrast-enhanced MRI (DCE-MRI) for the calculation of vertebral bone marrow perfusion parameters using a two-compartment model in patients with osteoporosis and acute osteoporotic vertebral compression fractures.

## Materials and Methods:

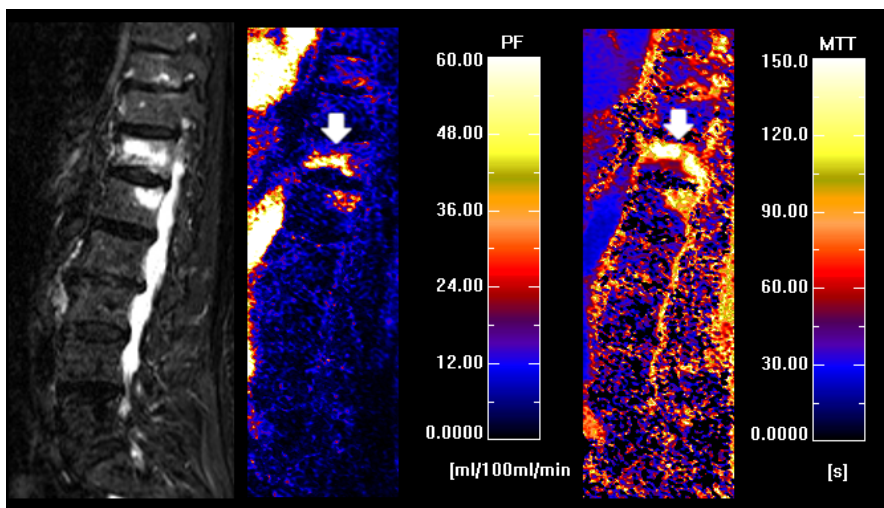
36 patients with osteoporosis and acute compression fractures and 7 healthy persons were examined with DCE-MRI on a 1.5 Tesla scanner (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) for the assessment of acute vertebral fractures. T1-w TSE-, STIR- and DCE-MRI was performed with a 2D-Saturation-Recovery Turbo-Flash sequence. 4 slices (one axially for measurement of the arterial input function and 3 slices sagittally through the lesion) were acquired with a temporal resolution of 1 second and a total acquisition time of 300s. For each dataset parameter maps of plasma flow (PF) and mean transit time (MTT) were calculated, using a model-free deconvolution analysis to aid in ROI selection [1]. ROIs were manually selected in the fractured vertebral bodies (n=40) and in normal appearing vertebrae (n=205). A two-compartment model was fitted to the concentration time curves, producing at least 3 independent parameters: PF, Plasma Volume (PV), and Extraction Flow (EF) [2,3]. Additionally, the interstitial volume (IV) was determined in the lesions. The perfusion parameters determined in normal appearing vertebrae were correlated with dual X-ray absorptiometry (DXA) (n=17) and computed tomography (CT)-densitometry (n=10) measurements.

## Results:

Quantitative perfusion parameters were statistically significantly higher in acute osteoporotic fractures (PV, PF, EF, IV, see **Table 1**) than in the adjacent normal appearing bone marrow and healthy control group ( $p < 0.0019$ ). Perfusion parameters in normal marrow were reproducible and decreased from the upper parts to the lower spine parts. Perfusion was significantly lower in severe osteoporosis and correlated well with q-CT results for grading of osteoporosis. In acute vertebral fractures two areas with different perfusion parameters could be separated (see **Figure 1**).

## Conclusion:

The analysis of dynamic contrast-enhanced data provides reproducible quantitative perfusion parameters in healthy and pathologic bone marrow. Perfusion is strongly increased in acute osteoporotic fractures yielding areas of different perfusion parameters. Furthermore, perfusion parameter changes correlate with severity of osteoporosis.



**Figure 1:** STIR-image and the corresponding PF- and MTT-maps. Patient has an acute osteoporotic fracture in Th12. MTT-map shows an area of increase, corresponding to the main site of fresh fracture edema. Corresponding plasma flow map shows increase in the adjacent groundplate impression zone, potentially corresponding to an area of increased vascularisation (e.g. in a fracture repair process).

| Vertebral Body | Parameter | PF<br>[ml/100ml/min] | PV<br>[ml/100ml] | EF<br>[ml/100ml/min] | IV<br>[ml/100ml] |
|----------------|-----------|----------------------|------------------|----------------------|------------------|
| Normal         |           |                      |                  |                      |                  |
| Osteoporotic   |           | 13.81 (9.49)         | 4.83 (3.02)      | 0.05 (0.09)          |                  |
| Healthy        |           | 20.11 (8.47)         | 6.43 (2.82)      | 0.08 (0.25)          |                  |
| Fracture       |           |                      |                  |                      |                  |
| Osteoporotic   |           | 57.06 (31.98)        | 22.30 (10.81)    | 8.13 (6.5)           | 14.63 (15.85)    |

**Table 1:** Summary of quantitative perfusion parameters, namely PF, PV, EF and IV using means and standard deviation.

[1] Sourbron S et al, ESMRMB 2009: 756 [2] Brix et al (2004), MRM 52: 420 [3] Biffar et al, ISMRM 2009 Adv in Musculoskel Imag: SF09