Quantitative DCE-MRI in patients with hip implants

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Introduction: An increasing number of early adverse tissue reactions, which can lead to substantial soft tissue destruction and premature implant failure, have recently been reported in patients with metal-on-metal (MM) hip implants (1). In addition, histological differences have been observed between periprosthetic tissues from MM and metal-on-polyethylene (MPE) hip implants (2), caused by differences in the wear products. Hence, a difference in the patterns of overall periprosthetic tissue perfusion in MM and MPE patients might be expected. The purpose of this work was to develop and apply a quantitative dynamic contrast-enhanced (DCE) MRI technique to measure and compare the perfusion parameter Ktrans (index of flow and permeability) in periprosthetic tissues adjacent to MM and MPE implants.

Methods: 15 patients (55-74 y; 7 men & 8 women) with a hip implant (8 MM and 7 MPE) were imaged with DCE-MRI at 1.5T (post-op time 40 ± 7 months). Turbo spin-echo sequences were used to minimize metal artifacts (echo train length=7, BW=349 Hz, TE=6.8 ms, 16 slices, thick=6 mm). DCE was performed with TR=865 ms, temporal resolution=7.8 s, 0.1 mmol/kg Gd contrast agent, duration=4 min. Inversion-recovery T1 measurements (TR=8000 ms, TI=500, 1000, 3000 ms) were performed before and after DCE to allow calculation of Gd concentration-vs-time in tissues (the "Bookend Method", Fig. 1) (3). Tracer kinetic modeling was then used to obtain Ktrans maps (4-6). The median Ktrans value (excluding zero values, characteristic of those voxels highly affected by the metal artifact) in all periprosthetic tissues was calculated for each patient. Mann-Whitney U-test was used for statistical analysis.

Results: The distribution of Ktrans values was tri-modal: MM patients had low or high values, whereas MPE patients had intermediate values (Fig. 2). We also observed a significant difference in Ktrans values between men and women (p=0.003) (Fig 2).

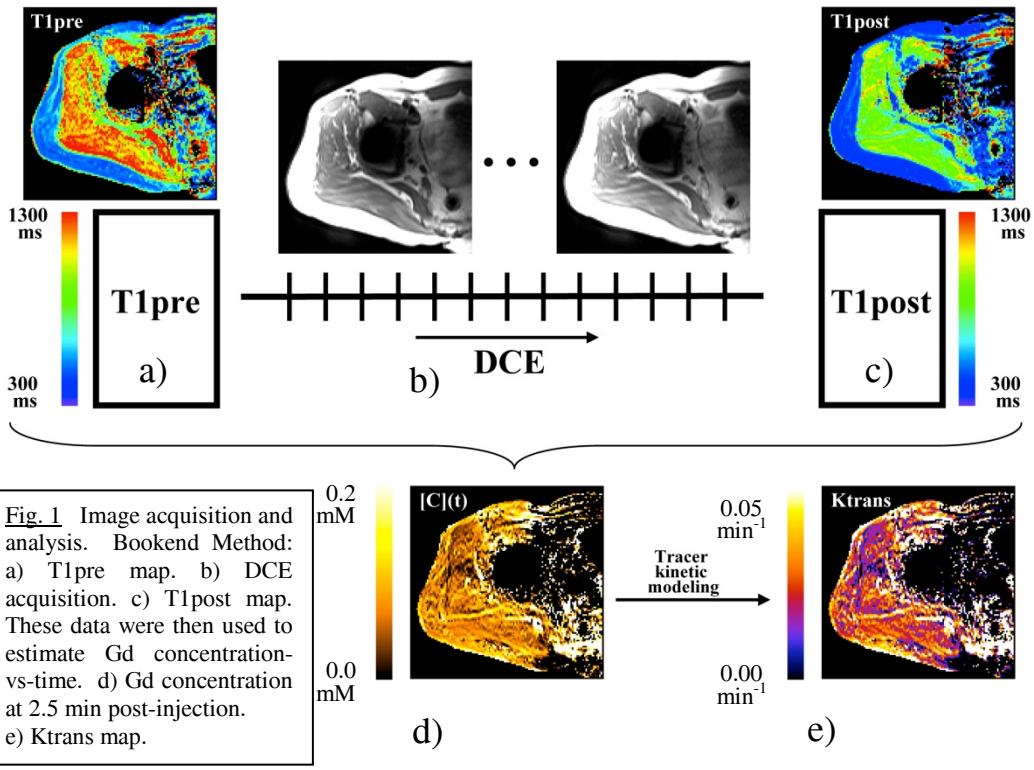

Fig. 1 Image acquisition and analysis. Bookend Method: a) T1pre map. b) DCE acquisition. c) T1post map. These data were then used to estimate Gd concentration-vs-time. d) Gd concentration at 2.5 min post-injection. e) Ktrans map.

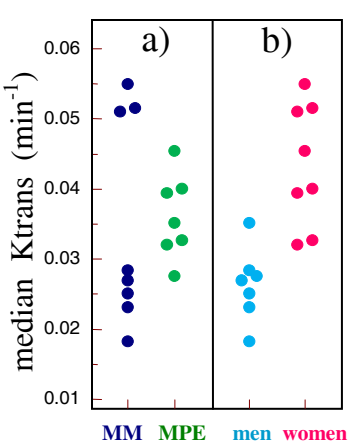

Fig. 2 Median whole-tissue Ktrans. a) Patients with metal-on-metal (MM) implants versus patients with metal-on-polyethylene (MPE) implants. b) Men versus women.

Discussion: To our knowledge, this is the first study reporting Ktrans measurements near human hip implants. We demonstrated differences in Ktrans values between tissues from MM and MPE implants (tri-modal distribution) and observed higher Ktrans values in women. The bimodal distribution in the MM group remains to be further investigated. However, the gender difference is consistent with brain and cardiac perfusion literature (7-8) and may be due to differences in hematocrit and blood viscosity (7).

Conclusion: This study shows that DCE MRI can be successfully used to measure Ktrans near hip implants.

References: 1. Catelas and Wimmer, J Bone Joint Surg Am 2011;93 Suppl 2:76. 2.Campbell et al, Acta Orthop Scand 2002;73:506. 3. Cron et al, MRM 1999;42:746. 4. Ott et al, Eur J Cancer 1991;27: 1356. 5. Tofts, JMRI 1997; 7: 91. 6. Tofts et al, JMRI 1999;10:223. 7. Parkes et al, MRM 2004;51:736. 8. Brinkley et al, PloS ONE 2011; 6: e28410.