Quadrant Analysis of Femoral Head Perfusion After Fracture Using Dynamic Contrast Enhanced MRI

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Introduction: Quantitative assessment of femoral head vascularity following fracture of the femoral neck is valuable in predicting the development of avascular necrosis and the functional outcome thereafter. Fat suppressed dynamic contrast enhanced (DCE) MRI provides a technique to estimate bone perfusion in-vivo by imaging uptake of Gd-DTPA in the femoral head over time.[1-3] Accurate quantitation of bone perfusion may aid the clinician in determining whether to preserve the joint or proceed to hip arthroplasty depending on conservation of the surrounding vasculature.[4]

Methods: Twenty nine adult subjects [58.7±15.0 yrs, 9M/20F] presented with fractures of the femoral neck [Garden Score 3.3±0.6] as assessed in the emergency room. Injured and contralateral hips were imaged simultaneously using a 1.5 Tesla General Electric MRI system with an 8-channel phased-array torso coil. Injection of Gd-DTPA(Schering Plough, Wayne, NJ) was administered at 0.1 mM/kg using a power injector. The DCE-MRI sequence used a coronal fat suppressed 3D spoiled gradient echo pulse sequence (LAVA) with a temporal resolution of 7 sec/image over 45 time points for a scan time of 6 minutes. Additional parameters were a 40 cm FOV, 256x128 matrix, 26 slices of 4 mm thick, TR/TE 3.6/1.7 ms and a flip angle of 12 degrees. The Brix 2-compartment model was used to analyze the DCE-MRI uptake curves in the normal and injured femoral head.[5] The model contains the parameters: A(signal amplitude), k_{ep}(exchange rate between plasma and extravascular extracellular space (EES) in min^{-1}), and k_{el}(elimination rate in min^{-1}). Regions of interest (ROI) were taken over the entire femoral head and further subdivided into quadrants to produce time intensity curve using the control side as a reference in each subject. Analysis software was written in-house using IDL 8.1 (ITT Visual, Boulder,CO) to fit the time intensity curves. Model parameters were averaged for all subjects to create the time curves in Figure 1.

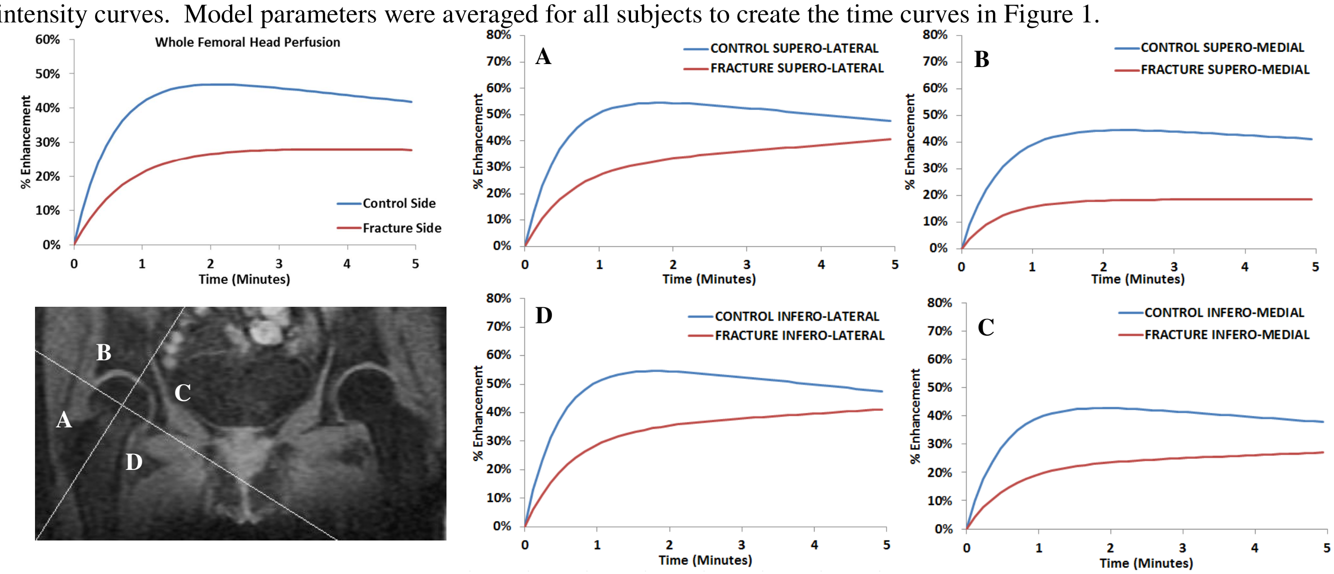

Figure 1: Displays quadrant definition and whole head DCE Time Intensity Curves.

Control vs. Fracture	A	k_{ep}	Ak_{ep}	k_{el}	IAUC (90s)	Peak Enh.
Whole Head	***0.53 vs. 0.29***	***1.82 vs. 1.32***	***0.97 vs. 0.29***	0.06 vs. 0.02	***0.44 vs. 0.17***	***0.40 vs. 0.17***
Supero-Lateral	***0.60 vs. 0.31***	2.09 vs. 1.72	***1.23 vs. 0.47***	***0.05 vs. -0.06***	***0.54 vs. 0.25***	***0.48 vs. 0.25***
Infero-Lateral	***0.60 vs. 0.35***	2.10 vs. 1.64	***1.24 vs. 0.58***	***0.05 vs. -0.04***	***0.55 vs. 0.30***	***0.50 vs. 0.29***
Supero-Medial	***0.48 vs. 0.19***	1.77 vs. 1.90	***0.68 vs. 0.24***	0.036vs.0.001	***0.33 vs. 0.14***	***0.31 vs. 0.14***
Infero-Medial	***0.47 vs. 0.23***	2.03 vs. 1.71	***0.89 vs. 0.33***	***0.05 vs. -0.04***	***0.41 vs. 0.18***	***0.38 vs. 0.18***

Results: There were significant ($p<0.01$) decreases in all perfusion parameters of the entire femoral head on the injured side vs. that of the control side excepting that of k_{el}. Quadrant analysis confirmed similar perfusion changes with the addition of delayed washout (k_{el}) in the fractured side possibly caused by venous obstruction and increased intra-articular pressure. Perfusion (Ak_{ep}, IAUC, Peak) was higher in the lateral compared to the medial side of the head which affirms results from previous cadaveric studies.[4]

Discussion: Knowledge of quadrant specific bone perfusion at the time of injury is essential in assessing whether adequate vascularity exists to predicate reliable healing. Further validation of this method to predict the occurrence of avascular necrosis following surgery will be essential in establishing the use of this technique in the clinic.

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