Quantification of perfusion and endothelial permeability in inflammatory joint diseases:

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Purpose: Current approaches for the evaluation of Dynamic Contrast Enhanced MRI (DCE-MRI) data in inflammatory joint diseases are either semi-quantitative [1] or use an approximate two-compartment model to quantify endothelial permeability [2]. The use of an exact two-compartment model may improve the accuracy of such parameters, and has the benefit of producing an additional parameter that measures perfusion. The method has been applied successfully to breast tumors [3], but has not yet been evaluated in the context of inflammatory joint diseases. The purpose of this ongoing study is to evaluate the feasibility of the approach, identify methodological issues and optimize the implementation. We present here the first results obtained in a limited patient group.

Material and Methods: DCE-MRI was performed at a 3.0 T magnet (Magnetom Trio, Siemens Medical Solutions, Germany) in 7 patients with rheumatoid or psoriatic arthritis in the hand, and 1 in the knee. 40 slices were acquired every 5 seconds using a 3D-FLASH sequence and 0.1 mmol/kg gadobenate dimeglumine (Multihance®) as contrast medium, injected at 3 ml/s. Regions of interest (ROI) were drawn manually in an artery to obtain an Arterial Input Function (AIF) and in three different tissue types: muscle, skin and inflammatory tissue. Enhancement curves were fitted to a two-compartment model and the model parameters were interpreted as Plasma Flow (PF), Plasma Volume (PV), Extraction Flow (EF) and Interstitial Volume (IV). The accuracy of the model fit is measured by a Chi-Square value defined as the mean-square difference between data and fit, relative to the mean-square of the data.

Results and Discussion: One patient data set was excluded since the total acquisition time (30 seconds) was too short to produce meaningful results. In some cases the selection of a valid ROI was problematic due to the small anatomical structures of the hands, leading to enhancement curves with low SNR values and consequently large errors in the model fits (Chi-Square > 1.5 %) with non-physiological (eg. negative) values for some of the model parameters. For these reasons, two such ROIs were excluded from the analysis. In addition, the largest arteries in the hand had a diameter close to the voxel size, so that scaling errors due to partial volume effects in the AIF can not be excluded. First results demonstrated that the precise value of the delay time between artery and tissue (AT) had a significant effect on the outcome of the measurement, so AT was systematically fitted as an additional parameter. An illustration of the dynamic data at maximal enhancement is given in figure 1, clearly showing the inflammatory region. The mean values (MV) and standard deviations (SD) of EF, PF, PV, IV and TA for inflammation, muscle and skin ROIs in the data of the hand are depicted in table 1. A typical example of the enhancement curves and the model fits for all three tissue types is given in figure 2. The model provides a good fit to the data (table 1 and fig 2) and values for muscle perfusion (PF) are comparable to those previously published in literature [4]. Perfusion values (PF) for ROIs in inflammatory tissue are substantially higher, and vary over a broad range. Another clear difference between inflammation and muscle is in the higher volume of both intercellular spaces (IV and PV), and the flow across the capillary wall (EF). The values of the fitted parameters in the knee were substantially lower than those in the hand, presumably since the larger diameter of the arteries reduces the partial volume effects in the AIF.

	Chi-Square (%)	EF (ml/100 ml/min)	PV (ml/100 ml)	IV (ml/100 ml)	AT (s)	PF (ml/100 ml/min)
MV inflammation	0,3	25	12	53	4,4	315
SD	0,5	10	5	28	4,0	273
MV muscle	0,8	13	1,6	11	8,3	23
SD	0,7	7	1,6	2	5,7	9
MV skin	0,3	15	19	53	6,4	196
SD	0,4	10	12	45	6,0	187

Table 1. Mean values (MV) with standard deviation (SD) for EF, PF, PV and IV for inflammation, muscle and skin.

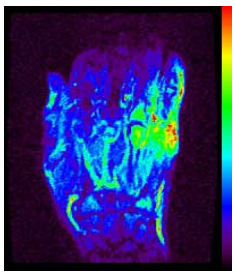
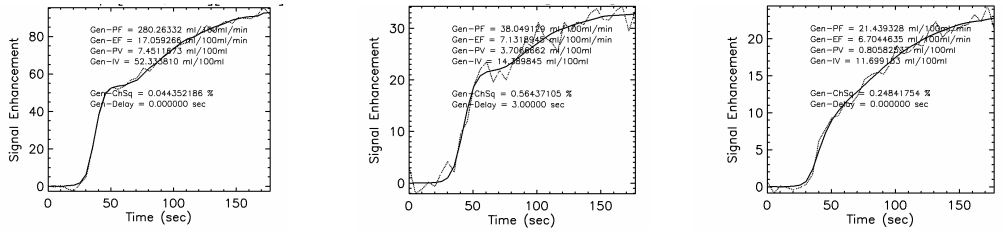


Figure 1. Color coded perfusion image of one representative slice.



Inflammation **Muscle** **Skin**

Figure 2. Enhancement curves in a patient with rheumatoid arthritis. The data are shown in a dotted line, the model fit in a full line.

Conclusion: These first results in a small patient group suggest that the use of an exact two compartment model produces reasonable values for hemodynamic parameters characterizing perfusion and permeability. The parameters are clearly sensitive to tissue type, suggesting potential applications in the evaluation of therapy or questions of differentiation. The methodology should be improved by including tools for (semi)automatic ROI selection, maximizing SNR in the data and reducing partial volume errors in the Arterial Input Function. Also, a larger patient Cohort should be examined before final conclusions can be reached on these issues.

References:

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