

## Introduction:

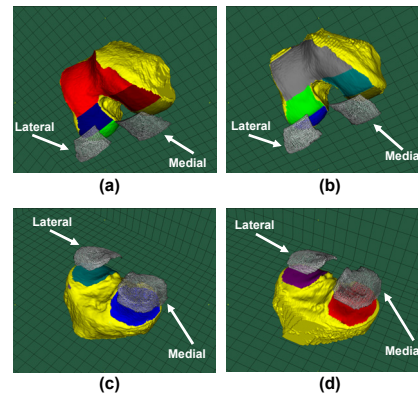
- The quantification of morphological parameters of the knee cartilage is a promising technique to evaluate osteoarthritis (OA) progression.
- The MRI FLASH sequence has been validated as a reproducible and accurate MRI sequence for doing morphology analysis of cartilage tissue[1]. FLASH offers a very good contrast between cartilage and bone tissue. However, the high bone-cartilage contrast is paid off by a lack of contrast in the inter-cartilage structure and a low contrast between the cartilage and the adjacent soft tissues.
- Although the contrast between bone and cartilage is not as good as the FLASH sequence, the Double Echo Steady State (DESS) sequence offers a better view of the inter-cartilage structure and has a very good contrast between the cartilage and the adjacent soft tissue structures. As a result, the DESS sequence was chosen as the MRI modality for the Osteoarthritis Initiative (OAI) study.

## Scope:

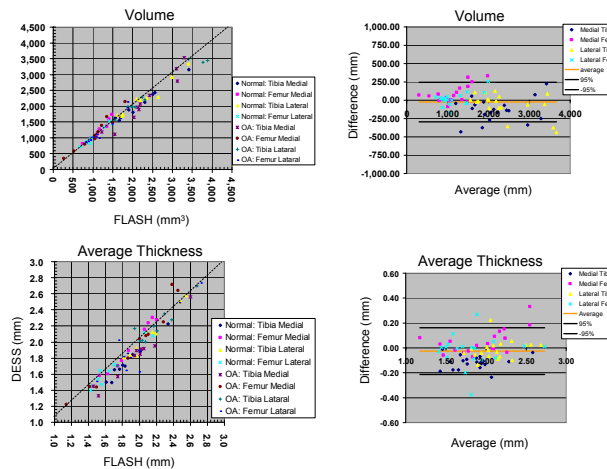
- This work presents the results of the OAI pilot study aimed to confirm the DESS sequences as a valid MRI sequence for doing cartilage quantification. The validation was completed by doing a direct comparison of the quantitative results for the medial and lateral tibia and the medial and lateral central portions of the femoral cartilage analyzed from the coronal FLASH and sagittal DESS sequences.

## Materials and Methods:

- Nineteen subjects (7 men and 12 women; 9 control and 10 with self-reported knee OA) with a mean age of 51 years underwent two knee MR exams as part of the pilot MR study for the Osteoarthritis Initiative (OAI). A Siemens 3T scanner was used to acquire a high resolution (0.3646 x 0.3646mm and 0.7mm slice thickness) Sagittal 3D DESS images in a scan-rescan fashion. Similarly, the same scanner was used to acquire the 3D FLASH sequence (0.3125 x 0.3125mm and 1.5mm slice thickness) in the same scan-rescan fashion.
- All 76 scans were randomized and a supervised-computerized system was used to extract the articulating bones and the cartilage plates [2].
- The volume, average thickness, and the bone-cartilage-interface (BCI) area were calculated for the medial and the lateral tibia cartilage as well as the central medial and the central lateral femur regions. These regions are illustrated in Figure 1 for the DESS sequences in (a) and (c) and for the coronal FLASH sequence in (b) and (d).



**Figure 1:** 3D rendering of the central femur cartilage regions for the sagittal DESS sequence (a) and the coronal FLASH sequence (b). 3D rendering of the tibia cartilage regions for the sagittal DESS sequence (c) and the coronal FLASH sequence (d).



**Figure 2:** Scatter plots (right) and Bland-Altman plots (left) for volume measurements (top) and average thickness measurements (bottom).

Biomarker DESS vs. FLASH	Bias	P value	95% CI	Correlation
Volume (μl)	-24	0.18	-60 to 12	0.98
BCI (mm <sup>2</sup> )	18	0.01	6 to 29	0.99
Thickness (mm)	-0.03	0.04	-0.05 to 0	0.95

**Table 1:** Summary statistics of the paired analysis after comparing the pooled tibia cartilage biomarkers for the DESS and FLASH sequences.

ROI/Sequence	Reproducibility		
	Volume	BCI	Thickness
Tibia Medial	FLASH 3.5%	2.6%	1.8%
Tibia Lateral	FLASH 4.1%	3.4%	2.3%
Femur Medial	FLASH 5.1%	4.3%	3.5%
Femur Lateral	FLASH 4.8%	3.7%	3.4%
Tibia Medial	DESS 4.2%	4.0%	2.9%
Tibia Lateral	DESS 4.7%	5.3%	2.0%
Femur Medial	DESS 3.5%	4.4%	1.8%
Femur Lateral	DESS 3.8%	4.4%	2.6%

**Table 2:** DESS and FLASH reproducibility.

## Statistical Analysis:

- For both DESS and FLASH sequences, the randomized analysis was un-blinded and the scan-rescan results were averaged.
- The average volume and thickness measurements between DESS and FLASH were plotted in Figure 2. Bland-Altman plots were also generated (Figure 2).
- The population values for volume, thickness, and bone-cartilage interface area were compared using a pair analysis. 95% confidence intervals were computed.

## Results:

- The pooled average volume was 1712 μl with a population standard deviation of 539 μl.
- The pooled BCI area was 806 mm<sup>2</sup> with a population standard deviation of 161 mm<sup>2</sup>.
- The pooled average thickness was 1.93mm with a population standard deviation of 0.32mm<sup>2</sup>.
- Table 1 shows the results of the paired analysis.
- The 95% limits of agreement include the zero bias for all measurements.
- FLASH and DESS have very similar reproducibility (Table 2).
- No bias exists between FLASH and DESS sequences in cartilage volume.
- A small significant difference exists between bone-cartilage interface measurements (2%, p=0.01).
- A small significant bias was found between the thickness measurements (1%, p=0.04)

## Conclusion:

- The morphological cartilage quantification of the tibia and central femur cartilage from the MRI DESS sequences is as accurate and reproducible as that of the FLASH sequences for volume and thickness.
- The differences in the BCI area and thickness are small and within the measurement error of the FLASH sequence.
- This represents the first step in the validation of DESS sequences as an accurate and precise technique for the evaluation of OA progression.

## Acknowledgements:

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## References:

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