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Comparisons of HR-MRI with μ CT arthrography (μ CTA) for the morphological assessment of non-human primate models of osteoarthritis

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Introduction

Osteoarthritis (OA) that closely resembles to the human condition occurs naturally in primate and these animals could be used to model the human disease. Non-invasive techniques to measure and qualify in-vivo the cartilage thickness in animal model of OA have been developed. Established reproducibility confirmed that 3D HR-MRI could directly assess the cartilage thickness on guinea pigs (1) and recent instrumental developments demonstrated that volume quantification in the different compartments of the cartilage can be achieved on rat models of OA (2). Nonetheless, spatial resolution is limited compared to CT scanner. The aim of this work was (i) to develop a dedicated protocol for knee joint examination of cynomolgus primates at 1.5T and with μ -CT arthroscanner (μ CTA); (ii) to compare morphological parameters assessed based on MRI and μ CTA acquisitions on a group of 10 old primates with spontaneous OA.

Material and Method

The MRI experiments were performed on a 1.5T Siemens Sonata system. A pair of two-channel array coil was built on a thermoformable plastic support with about 32 mm outer diameter. Each element consists in a rectangular loop (30 x 35 mm² internal dimensions with 5 mm width and 35 μ m thickness copper track) etched on a flexible 508 μ m thick substrate. The decoupling between the two channels was achieved with optimal coil overlapping to minimize coupling between the two elements. The ethical guidelines for experimental investigations with animals were followed, and the experimental protocol was approved by the Animal Ethics Committee of our institution. Ten female primates between 12 and 18 years old (mean 13.8 \pm 1.8) were examined. The primates were placed in supine position with both dual array coils was placed on top of patella to encompass the whole knee joint. A minimum distance of 100 mm between both knees was kept to insure at least 20dB decoupling between internal coil elements located at medial sides. HR-MRI was performed in the sagittal plane using a 3D water excitation FLASH sequence. A total of 120 partitions (220 μ m thick) were acquired with an in-plane pixel of 112 x 131 μ m². The scan time was 20 min. μ CTAs were performed on a GE Locus μ -CT at standard voltage and amperage parameters with an isotropic resolution of 90 μ m. The scan time was 15 min. For each animal, both knees were sequentially scanned. 3D thicknesses of the tibial plateau cartilage layers were assessed both on lateral and medial sides of the knee by using the same image processing protocol for each kind of acquisitions (MRI and μ CTA). This protocol consisted in a double segmentation procedure: a first rough and manually handled contour segmentation to isolate the cartilage regions of interest (ROI) and avoid any divergence of the second region automatic global segmentation procedure which accurately extracts the morphology of both medial and lateral cartilage ROIs. Parameters of the second segmentation procedure were adapted for MRI or μ CTA acquisitions. Inside the cartilage ROIs, the quantification of cartilage thicknesses was performed following the method previously described (3).

Results

In vivo images acquired with the array coil associated with the HR-MRI protocol nicely depicted the cartilage. Such acquisitions were suitable to apply the segmentation procedure leading to articular cartilage volumes and thickness distributions. In the examined group of old female primates, a coherent description with both imaging modalities was observed with superimpose 3D thickness distributions measured on the same animals. Both imaging approaches gave similar normalized cartilage thickness distributions on the same animals. The presence of spontaneous OA was established (narrower thickness distribution) among the animals.

Conclusion

Both imaging modalities appear valuable to measure cartilage morphology (volume and thickness). The choice of one on the other could be done based on imaging systems available or on additional information needs such as indirect cartilage structure (T2, T1rho...) for MRI or subchondral bone density for μ CTA.

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