

Feasibility study of high resolution PDw imaging of cartilage of the thumb at 7Tesla MRI

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Introduction:

The first carpometacarpal (CMC1) joint is commonly affected in patients with osteoarthritis (OA) of the hand and is a common cause of pain and disability^{1,2}. The first metacarpophalangeal (MCP1) joint is also often affected. Currently plain radiographs and CT-scans are the imaging method to diagnose CMC1 OA. Both imaging modalities however fail to depict the articular cartilage itself, which is the initial location where changes occur in OA. Additionally there is poor interobserver agreement between radiologists and/or hand surgeons concerning the degree of CMC1 OA as well as for the choice of treatment between different patients with CMC1 OA³. Treatment protocols however, rely on the imaging based disease staging for defining therapeutic strategies. Another discrepancy in currently used imaging methods is that nearly half of patients with radiographic signs of OA have no symptoms which can be attributed to the disease⁴. Also, a considerable amount of patients have symptoms attributable to OA without radiographic evidence to support the diagnosis, suggesting another important discrepancy between clinical and radiological features in these patients with early OA. Conventional MRI scanners do not provide enough spatial resolution to accurately depict the thin cartilage layer of the thumb, which in healthy individuals measures 0.6-1.4 mm approximately. Therefore, the objective of this study is to enhance the quality of the information on which treatment strategies in CMC1 OA are based by visualizing the cartilage in the CMC1 joint at ultra high resolution using 7T MRI to yield consistent staging of CMC1 OA.

The preferred sequence contrast for the assessment of articular cartilage is a PD weighted TSE (PDw-TSE) with or without fat suppression⁵. At 7T MRI it can provide optimal Signal-to-Noise (SNR), efficiency and shorter scan times at high resolution. Previously it has been shown that with the use of a high density receive array it is feasible to image ankle cartilage with high resolution PDw-TSE at 7T MRI⁶.

The aim of the present study is to image cartilage of the CMC1 and MCP1 joint by means of a sub-millimeter resolution multislice PDw-TSE sequence with optimal image contrast for depicting cartilage while covering the CMC1 and MCP1 joint.

Methods:

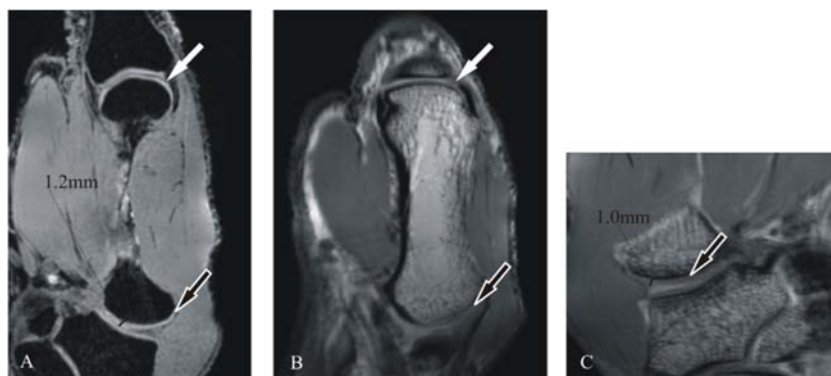
Imaging was performed on a 7T scanner (Philips Healthcare) using a flexible 32 (2x16) channel high density micro loop array⁷ for receive combined with a single channel volume coil for transmit (Nova Medical). Patients were carefully positioned in a prone, superman position. The thumb and the hand were stabilized and weighted down by cushions, to minimize motion. A coronal multi slice PDw-TSE sequence covering the CMC1 joint was implemented with the following scan parameters; acquisition pixel size of 0.25x0.25 mm², 14 slices of 1mm slice thickness, FOV 90x90x27 mm³, TR/TE 3538/15 ms, turbo factor 3, linear k-space order, echo spacing 7.3 ms, total scan time 10:15 min. Standard refocusing pulse angle sweep was used consisting of a 1800 followed by two 1600 refocusing pulses for optimal image contrast between cartilage and synovial fluid. Two signal averages (NSA) were used to reduce FID artifacts by alternating the phase between first and second average. Homogeneity correction was applied based on the receive coil sensitivity. To stay within the very conservative chosen SAR limits a repetition time of 3538 ms was selected. The coil sensitivity reference scan was made at relative high resolution of 3.0mm³. In addition a 3D T1-FFE with water selective excitation scan (WATS) was implemented, TR/TE 20/4.0, FOV 90x90x40 mm³, 0.25 mm isotropic resolution, flip angle 15 degrees, scan time 9:25 min. Three volunteers (age range; 25-35 years) were scanned. All volunteers gave written informed consent as approved by the institutional review board.

Results:

A multi slice PDw-TSE sequence and a WATS sequence are successfully implemented on a 7T scanner for the thumb. The in-vivo experiments show high quality images with exquisite detail of the thin cartilage layer of the CMC1 and MCP1 joint (Fig. 1), which cannot be detected with other non-invasive imaging techniques. The SNR at the CMC1 and MCP1 are sufficient at this resolution, while image contrast between soft tissues, synovial fluids and articular cartilage is rated as good, thus potentially yielding interpretation of diseased cartilage in OA patients. The artifact level is acceptable even though some of the images show mild motion artifacts due to the relative long scan times of around 10 minutes and the ultra high in-plane resolution. In the three healthy volunteers cartilage thickness of the base of the first metacarpal was 1.0, 1.2 and 1.2mm respectively and at the head of the first metacarpal of 0.8, 0.9 and 1.0 mm respectively, with an error margin of 0.25 mm.

Conclusion:

The present study shows that a routine clinical PDw-TSE and WATS sequence is well feasible at 7Tesla for the depiction of the thin layer of articular cartilage of the first metacarpal. The combination of the high SNR at 7Tesla and 32 channel high density flexible receive array has the potential to make the next step toward



cartilage imaging of the thumb in OA patients and therefore possibly providing an important staging tool for the disease extent and treatment planning of CMC1 and MCP1 joint OA.

Figure 1. High resolution water selective excitation sequence (A) and a proton density spin echo sequence (B and C) of the right thumb, depicting the first carpometacarpal (CMC1) and the first metacarpophalangeal (MCP1) joint in a coronal view. Black arrows indicate the articular cartilage of the CMC1 joint of the metacarpal, white arrows indicate the articular cartilage of the MCP1 joint of the metacarpal. Articular cartilage thickness of the CMC1 joint at the base of the first metacarpal measures 1.2 and 1.0mm respectively and is visualized well.

References

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