High resolution T1ρ-mapping of articular cartilage in the wrist at 3T

Joep van Oorschot[1], Mark Gosselink[1], Fredy Visser[2], Alexandra de Rotte[1], Peter Luijten[1], and Dennis Klomp[1]
[1]*University Medical Center Utrecht, Utrecht, Utrecht, Netherlands,* [2]*Philips Healthcare, Best, Noord-Brabant, Netherlands*

Purpose

Perform high resolution $T_{1\rho}$-mapping of articular cartilage in the wrist at 3T.

Background

$T_{1\rho}$-mapping is a promising quantitative technique to detect cartilage damage at an early stage, at which tissue damage might be reversible. The $T_{1\rho}$ relaxation is sensitive to the slow motion interactions between macromolecular protons and bulk water, and describes relaxation while the magnetization is in the rotating frame, in the presence of a so-called spin-lock pulse. It has been shown that $T_{1\rho}$ is sensitive to changes in proteoglycan content in cartilage[1]. Several studies have shown that the $T_{1\rho}$ relaxation time enables early detection of cartilage damage in the knee[2,3]. Where the cartilage layer in the knee is 2-3 millimeters thick, the articular cartilage layer in the wrist is thinner and therefore more difficult to image this small cartilage layer. Here we test the feasibility of high resolution $T_{1\rho}$-mapping mapping of articular cartilage at 3T.

Methods

Three healthy subjects (23±2 years) were scanned on a 3T Philips scanner (Achieva TX, Philips Healthcare, Best, The Netherlands). Subjects were placed feet first in a supine position with the eight element SENSE phased array receive coil alongside the body.

A high resolution anatomical image was acquired using a multi-slice turbo spin-echo sequence to obtain contrast between bone, cartilage and synovial fluids: TE/TR = 44/5000 ms, resolution = 0.2 x 0.2 mm, slice thickness = 1 mm, FOV = 90x90 mm^2, flip angle = 90 degrees, NSA = 2, SENSE = 2.5. $T_{1\rho}$-mapping was performed using a $T_{1\rho}$-prepared 3D FFE sequence. 4 images with different spin-lock (SL) preparation times with an amplitude of 500 Hz were acquired (SL = 1, 12, 24, 48 ms). Each SL pulse consists of 2 continuous RF pulses with opposite phase to compensate for B1 variations, and a refocusing pulse between the spin-locking halves to compensate for B0 errors[4]. Other parameters were: TE/TR = 5.3/10 ms, resolution = 0.25x0.25 mm, slice thickness = 1 mm, FOV = 90x90x47 mm^3, flip angle = 8 degrees, 99 TFE shots, NSA = 1, SENSE = 4, scan time 4 min. per scan. Analysis: $T_{1\rho}$-maps were calculated by pixelwise fitting of a mono-exponential decay function in Matlab.

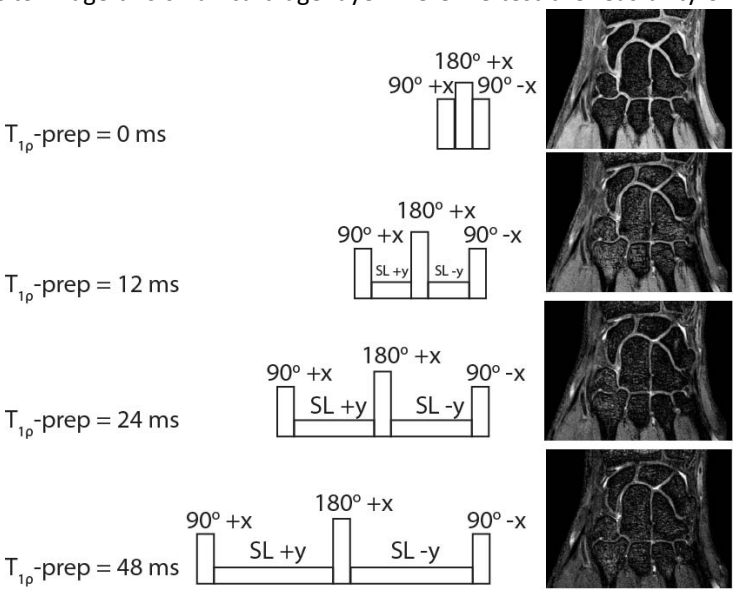

Fig. 1: $T_{1\rho}$-mapping method: 4 images were acquired with increasing SL preparation pulse length

Results

High resolution anatomical images and $T_{1\rho}$-maps were acquired at 3T (figure 2). The $T_{1\rho}$-relaxation time in the articular cartilage in healthy subjects was 57 ± 2 ms.

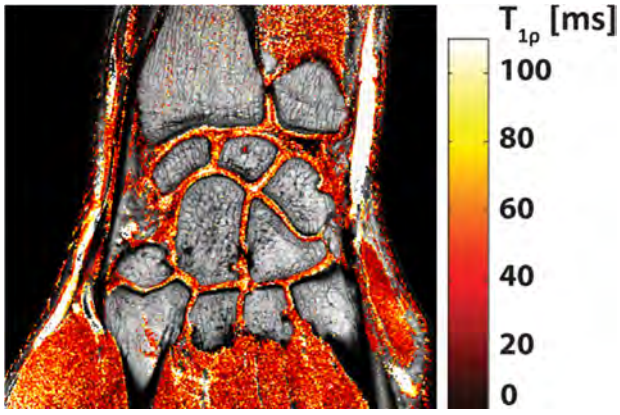

Fig. 2: High resolution anatomical image with an overlay $T_{1\rho}$-map in a healthy subject at 3T

Discussion

Currently $T_{1\rho}$-mapping is mainly applied to assess cartilage degeneration in the knee. However, here we have shown the feasibility of high resolution $T_{1\rho}$-mapping of articular cartilage in the wrist. Despite the fact that $T_{1\rho}$-mapping requires long spin-lock pulses that require a high specific absorption rate (SAR), the proposed protocol is applicable on a standard clinical 3T scanner. This method could easily be incorporated in standard clinical practice, and is a promising technique to detect cartilage damage at an early stage, at which tissue damage might be reversible.

Conclusion

High resolution $T_{1\rho}$-mapping of the wrist at 3T is feasible, and a promising technique to assess early cartilage damage in the wrist.

References

[1]Akella S. et al. MRM 2001 [2]Menezes et al. MRM 2004 [3]Peers S et al. Clin.J.Sports.Med. 2014 [4]Borthakur et al. MRM 2007