DTI and fiber tracking of the median nerve using an adjustable wrist coil array

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Introduction

Diffusion Tensor Imaging (DTI) is a popular non-invasive method for studying bundles of nerve fibers in vivo [1]. This technique is widely used for investigating the central nervous system, but very rarely for peripheral nerve applications. Since these bundles of nerve fibers are much smaller than in the central nervous system, signal-to-noise ratio (SNR) has to be significantly increased to achieve optimal results. Recent publications [2-4] studied peripheral nerves like the sciatic nerve in the leg or the median, ulnar and radial nerve in the wrist. Meek et al. [2] reported DTI of the median nerve using a head coil array for imaging. Significantly higher sensitivity can be achieved with a close-fitting array of smaller receive coils. The aim of this study was to demonstrate the benefits of this approach. Here we present DTI of the median nerve and its branches in the hand using an adjustable 8-channel wrist array that adapts to the individual hand and wrist size and shape [5] for maximum SNR efficiency.

Materials and Methods

Anatomical and DTI images of a healthy volunteer's hand were acquired on a 3T Achieva system (Philips Medical Systems, Best, NL), using a custom-built adjustable 8-channel wrist coil (Fig. 1). All data were obtained in transverse orientation at the level of the metacarpus. High- and low-resolution anatomical data were collected with a 2D gradient echo sequence (High resolution: acq. matrix=384x307, rec. matrix=512x512, FOV=100x100 mm^2, 20 slices, thickness=4 mm. Low resolution: matrix=80x80, FOV=150x150 mm^2, 40 slices, thickness=2 mm). For DTI a single-shot spin-echo EPI sequence was used with the same geometry and resolution as the lower-resolution anatomy data (TE=44ms, NSA=6, SENSE factor=2, b-factor=800s/mm^2, 6 encoding directions). All post-processing was done offline. After co-registering the low resolution anatomical and DTI images with in-house software, fiber reconstruction of the median nerve was done using a line propagation algorithm [6]. The start region in the proximal metacarpus was identified from the high resolution anatomical images.

Results

Figure 2 shows the resulting fiber bundles of the median nerve in the hand, extending from the start region (right) towards the distal metacarpus. In Figure 3 a proximal slice of the high-resolution data set is shown which was used to identify the starting region for the tracking algorithm. The enlarged view of that region displayed in Figure 4 clearly shows the two branches of the median nerve after splitting at the level of the metacarpal bones. The tracking algorithm readily succeeded in resolving both branches.

Discussion

Due to the particular sensitivity of the small, close-fitting array elements the DTI data readily permitted tracking the fiber bundles of the median nerve. These bundles were identified as the two branches of the median nerve which lead into the index and the middle finger as expected in a normal hand. These findings indicate that DTI may be a valuable complement to conventional high-resolution imaging for peripheral nerve exams. Potential clinical applications include supporting therapeutic decisions after peripheral nerve injury and monitoring nerve repair.

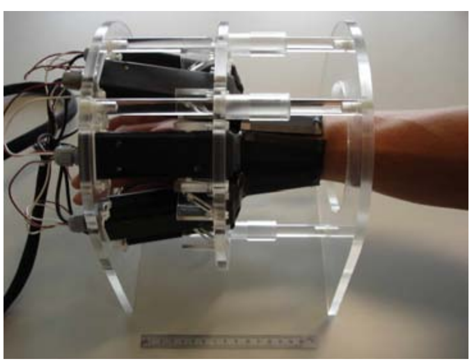

Fig.1: 8-channel wrist array. It is adjusted to the individual wrist's or hand's shape and size by moving the acrylic disk in the middle towards the forearm. The coil elements are made of flexible circuit board to accommodate anatomic variation.

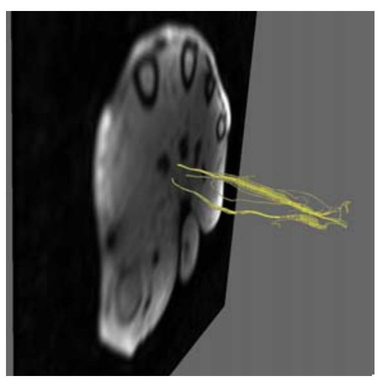

Fig.2: DTI-tracked fiber bundles of the median nerve in the hand showing two main branches that continue to the index and the middle finger. The tracking was seeded in the proximal metacarpus (right).

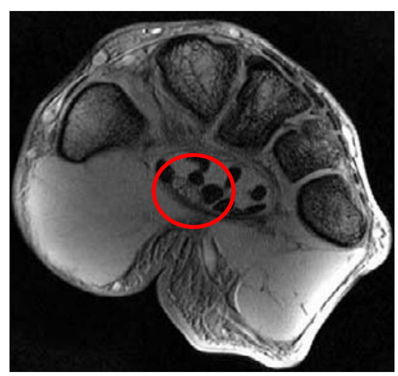

Fig.3: High-resolution (260x325μm^2) transverse image of the hand, serving for selecting the starting region (red circle) for the tracking algorithm.

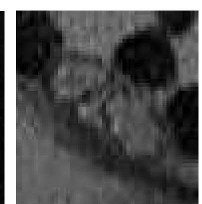

Fig.4: Enlarged view of the starting region from Fig. 3 (red circle). Two tracts of the median nerve are visible in the middle of the image, next to tendons depicted in black.

References

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