Quantitative and qualitative analysis of diffusion tensor imaging of the median nerve region at the carpal tunnel in various clinical settings

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Target audience

The scientific information derived from this study should be useful for future patient care.

Purpose

Recently, the median nerve at the carpal tunnel has been visualized with diffusion MRI such as diffusion tensor imaging (DTI) or diffusion tensor tractography (DTT) (1, 2). The so-called "Superman position", prone position with the wrist over the head at the center of magnet, can provide high S/N images and is ideal for MRI acquisition of the wrist. However, it is hard to keep that position, particularly for elderly people because of their limited range of motion in the shoulder. The purpose of this study was to demonstrate the clinical feasibility of diffusion tensor imaging of the median nerve region in supine position as well as prone position, to quantitatively investigate changes in diffusion values such as FA and ADC at different locations of the carpal tunnel, and to qualitatively visualize the median nerve in healthy volunteers on fiber tracking images.

Methods

We examined eight wrists from healthy volunteers (mean age 42.4 y/o). All DTIs were obtained using an 8-channel wrist coil at 3T (four from Achieva and four from Ingenia, Philips Healthcare) with following four settings; prone position (P, n=4) and supine position with the wrist at the side of the body (S1, n=8) with identical sequence parameters, supine position with increased pixel size (S2, n=8), and increased FOV (S3, n=8) assuming the need for more S/N and trade-off parameters in clinical settings. Sequence parameters are as follows; P and S1: TR/TE=4600-5258/79ms, flip angle=90, FOV=90mm, b-value=800s/mm^2, pixel size=1.07/1.02mm, slice thickness=4mm, S2: TR/TE=4600-4908/69-80ms and pixel size=1.18/1.12, and S3: TE=68ms and FOV=110mm. Scan time was 6 min 15-59 sec. As a qualitative evaluation, we created fiber tracking of the median nerve at first. "Zero point" (Z) was set at the level of the radial styloid tip, where was considered to be the proximal end of the carpal tunnel. Mean FA and ADC at the 12, 8, 4, 0mm proximal and 4, 8, 12, 16, 20, 24, 28, 32mm distal to the Z were measured by placing a region of interest in expected axial DTI (ROI method) and by calculating from the drawn fibers (fiber statistics (FS) method). Comparisons across the four settings (P, S1, S2, and S3) were performed by Scheffe post hoc test and regression analysis.

Results

On fiber tracking images, the median nerve including motor branch was well visualized morphological changes are appreciated around the carpal tunnel (Fig 1). With ROI method, FA and location of the median nerve demonstrated a strong negative linear correlation from the proximal to the distal wrist in all P, S1, S2, and S3 (r=-0.87 to -0.80)（Fig 2）, while ADC and median nerve location showed a weak to moderate positive linear correlation (r=0.01 to 0.72) (Fig 3). With FS method, FA and location of the median nerve with FS method demonstrated a strong to moderate negative linear correlation from the proximal to the distal wrist in all P, S1, S2, and S3 (r=-0.88 to -0.15), while ADC and median nerve location with ROI method showed a strong negative to moderate positive linear correlation (r=-0.95 to 0.53). There were no significant differences in FA and ADC among these methods at each measuring point except for ADC between S1 and S3 with FS method. Comparison of FA and ADC between ROI and FS methods in prone position showed no statistical differences at any measuring site.

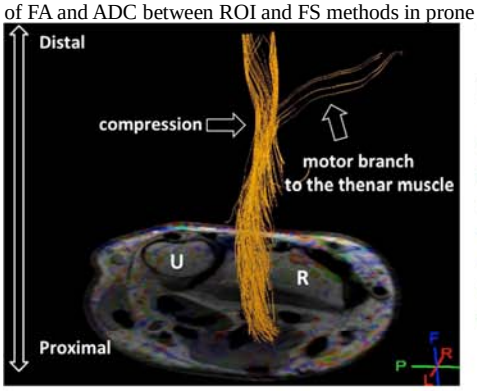

Fig 1: Fiber tracking image of the median nerve

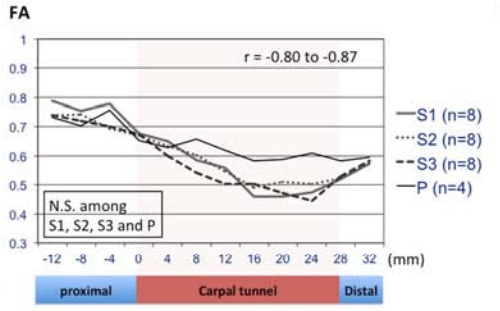

Fig 2: FA (P vs S1 vs S2 vs S3) with ROI method

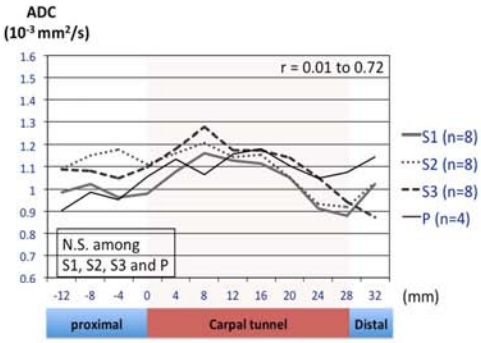

Fig 3: ADC (P vs S1 vs S2 vs S3) with ROI meth

Discussion

We could demonstrate comparable fiber tracking images of the median nerve and quantitative diffusion values in supine position to those in a "Superman position" and showed a potential for a clinical use of diffusion weighted MR imaging of the median nerve at the carpal tunnel. As to quantitative assessment, both ROI and FS methods showed similar single regression in FA and ADC, where FA decreased and ADC increased from proximal to distal. Although FA/ADC with FS method was measurable, the fiber tracking extended to adjacent several slices from the selected axial slice and the measured values were averaged from those slices. These results may not reflect the accurate FA/ADC at the point of interest. On the other hand, direct FA/ADC measurement at the point of interest on each axial slice with ROI method was not influenced by values on the adjacent slices. Therefore, ROI method for quantitation of FA and ADC appears more accurate than FS method.

Conclusion

The median nerve at the carpal tunnel, even a small nerve fiber such as a motor branch was well appreciated on fiber tracking images. We also could demonstrate comparable fiber tracking images and FA/ADC values in supine position to those in prone position without any statistical differences, and showed a potential for their clinical use.

References

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