The high resolution 3D Rat Spine diffusion study by Utilizing Wideband MRI Technique

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Target Audience

Investigator who has interests in the high resolution 3D diffusion weighted imaging (DWI) of rat spine and the applications using simultaneous multi-slice MRI technique.

Introduction

Diffusion tensor imaging or diffusion weighted imaging are used to study fiber orientation and its diffusivity properties[1]. To have better fiber tracking effect, scientists have acquired higher resolution DTI or using high angular resolution HARDI to investigate the neural fiber in details. However, the long imaging time of 3D DTI has limits its clinical applications. In this study, we aims to solve the time consuming problem by using W=5 Wideband MRI technique on high resolution 3D isotropic diffusion rat spine imaging. Wideband MRI was introduced by Wu et. al. o accelerate the scan time with Wideband factor W by applying broader bandwidth to receive image from multiple locations [2][3]. In 2013 spine studies, 12X MR *WonderScan* imaging sequences by AMA Medical Inc. has significantly reduced acquisition time from 5 hour to 24 min for this long geometry shape tissue. In this preliminary study, we apply 5X DWI imaging sequences again to study its ADC, FA and 3D visualization model of rat spine.

Materials and Methods

3D Isotropic 200μm^3 Rat spine DWI imaging was acquired on a 7T Biospec 70/30 system (Bruker, Ettlingen, Germany) using the rat heart/spine coil with TR/TE as 750/21.43 ms and total coverage volume as 2 x 1.5 x 6 cm^3, 2 null DWI images and 6 directions including [+x ,+y, 0], [+x, -y, 0], [0, +y, +z], [0, -y, +z], [+x, 0,+z] and [-x, 0, +z], Δ/δ = 10/5ms, b-value:1200s/mm^2. Wideband MRI with factor W=5 are able to acquire 5 slabs simultaneously and reduce the imaging time from 22.5 hr to 4hr and 28min. The SCWB DWI images reconstruction and DTI analysis were implemented in Matlab (MathWorks, Natick, U.S.A.).

Results & Discussions

Figure 1 shows the results of raw image and diffusion properties of spinal cord in the axial view. The null DWI image, DWI image with direction (1, 1, 0), ADC map and FA map are demonstrated. By using W=5 3D Wideband MRI diffusion technique, the high resolution isotropic image could be acquired in a reasonable scan time 4.5 hours rather than a long Ta as 22.5 hours. Figure 2 demonstrate the 3D maximum intensity projection (MIP) results in different rotation angle. The MIP would reconstruct the 3D spine model and display the view from arbitrary angle and depth using isotropic resolution 3D imaging. Our method has first demonstrated the capability to build up an *in vivo* 3D model of the rat spinal and associated nerves. Figure 3 has the comparison between the *in vivo* spinal nerve and sciatic nerve obtained by Wideband MRI diffusion imaging technique and anatomical autopsy. The MIP spinal nerve covered from L4, L5, L6 and sciatic nerves are consistent with the anatomical imaging. Moreover, the common peroneal, Tibia and Sural can be observed clearly.

Conclusions

In our preliminary result, we first reveal the capability to acquire the *in vivo* 3D diffusion weighted scanning of rat spine by using W=5 accelerated Wideband MRI technique. The scan time was reduced from 22.5 hours to 4.5 hours significantly. Right now, we are looking into higher acceleration ratio and higher imaging resolution rat spinal diffusion study. Clinical trial for both normal and diseased spine cases will also be studied in the near future.

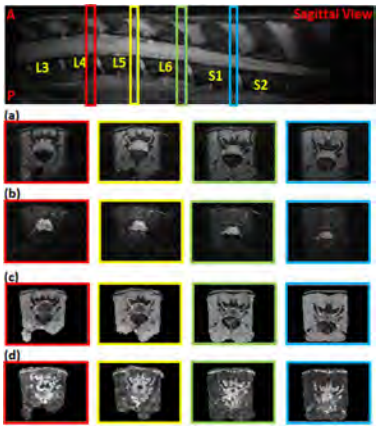

Figure 1. The upper row is the sagittal view of rat spine, red, yellow, green, blue blocks demonstrated the location from L4 to S1 of selected 4 slices. Row a) shows the null-DWI image. Row b) is the DWI image with diffusion gradient along direction (1, 1, 0). Row c) demonstrates the ADC map and Row d) demonstrates FA map.

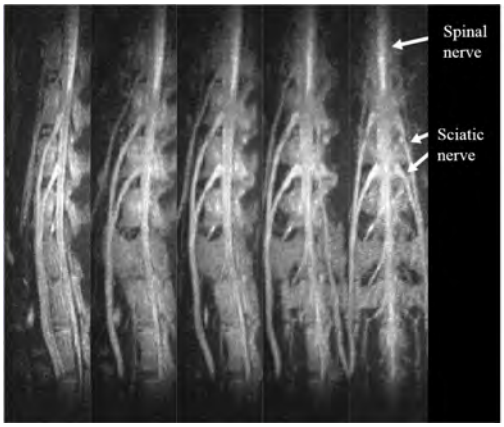

Figure 2. The figure shows the result of 3D spinal model from 0 to 90 degree, from L4 to S2 level. Both spinal nerve and sciatic nerve can be seen clearly. By reconstructing the diffusion weighted image with maximum intensity projection to a 3D model, one can rotate or stack-up the image to arbitrary orientation and arbitrary depth.

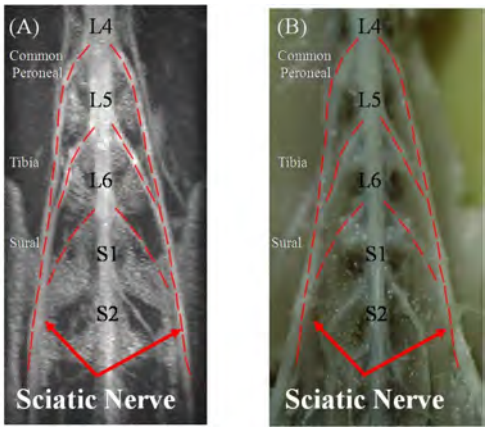

Figure 3. Virtual MR Autopsy vs. Post Mortem Autopsy. (A) The demonstration of spinal nerve and sciatic nerve from 3D maximum intensity projection. the spine was covered from L4-L6 to S1-S2.The fiber common peroneal, tibia, and sural can be observed and they are combined to sciatic nerve. (B) The demonstration of autopsy anatomical image of the same rat. The distribution of sciatic nerve and spinal nerve is consistent to the image (A) by using Wideband MRI diffusion imaging technique.

References

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