Intra-session and Inter-session Repeatability of Diffusion Tensor Measurement in Normal Human Liver

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Target Audience: Researchers or clinicians interested in quantitative body diffusion imaging.

Purpose: There is growing interest in using liver diffusion tensor imaging (DTI) for characterizing disease [1]. Poor consistency of DTI metrics will reduce the confidence in assessment of disease progression or therapeutic efficacy. Choice of DT imaging parameters to stress SNR (through number of averages) and better tensor approximation through number of diffusion gradient directions (NGD) was assessed to better understand liver DTI repeatability. Specifically, we aimed to evaluate the effect of NGD on inter- and intra-session repeatability of liver DT metrics in healthy volunteers.

Materials and Methods: Liver imaging was done in 5 healthy volunteers using a 1.5T Siemens MR scanner (Espree, Siemens Medical Solutions, Erlangen, Germany). Eight axial diffusion images were acquired using respiratory triggering at end expiration (TE/TR = 86/2200ms, slice thickness = 10mm, 35cm FOV, 110x110 matrix, b-value = 300s/mm^2). Intra-session repeatability assessment was first performed with nine repeats of 5NEX/6 number of gradient directions (NGD) liver DTI. . Mean diffusivity (MD), fractional anisotropy (FA) and eigenvalues were calculated using the FDT plug-in (FSL, FMRIB, Oxford, UK) over the whole liver (WL), a small circular ROI of a venous vessel, right liver lobe (RL) and left liver lobe (LL). Intra-session repeatability of each metric was estimated using the percentage ratio of the standard deviation of intra-session measurement differences over mean of the corresponding metric (denoted as V_{intra}). The effect of varied NGD to inter-session repeatability, while maintaining acquisition scan time equivalence (STE), was then studied using 4 NEX/NGE combinations (1/30, 3/12, 3/10 and 5/6). For each volunteer, scanning was repeated three times over a two-week interval. Image acquisition and DT metrics calculation were performed using the same pipeline as that of intra-session repeatability assessment. Inter-session repeatability of each metric was estimated using the percentage ratio of standard deviation of inter-session measurement differences over mean of the corresponding metric (denoted as V_{inter}).

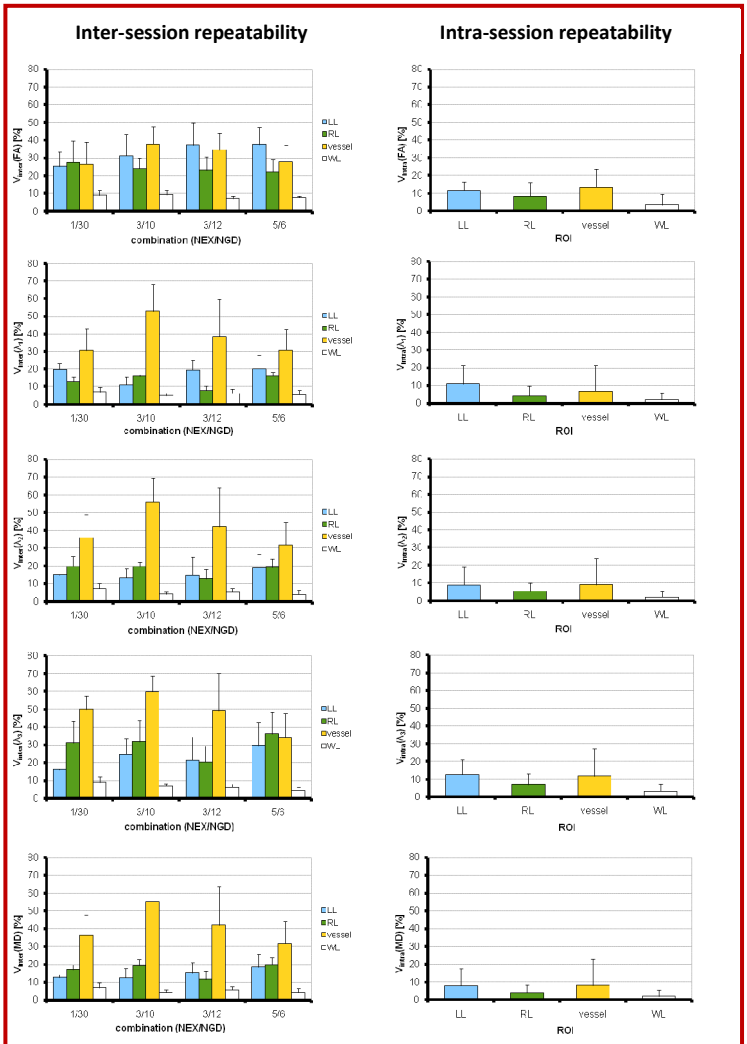

Figure 1: The left column corresponds to the inter-session repeatability of liver DT metrics (V_{inter}(FA), V_{inter} (λ_1), V_{inter} (λ_2), V_{inter} (λ_3) and V_{inter} (MD)) using 4 NEX/NGD combinations (1/30, 3/10, 3/12 and 5/6). The right column corresponds to the intra-session repeatability (V_{intra}) of the same liver DT metrics using NEX/NGD combination of 5/6. All analyses were performed using 4 choices of ROIs (left liver lobe (LL), right liver lobe (RL), vessel, and whole liver (WL).

Results: Acceptable intra-session and inter-session repeatability of MD, FA and eigenvalue estimates of the whole liver were achieved (V_{inter}< 10%) for all choices of acquisition combinations. The worst inter-session repeatability scores of MD, FA and eigenvalues were (not surprisingly) obtained inside blood vessels (V_{inter}> 30%). When comparing intra-session repeatability of all DT metrics with the corresponding inter-session repeatability (i.e. 5NEX/6NGD), better intra-session repeatability was observed for all choice of ROIs (V_{inter} = 4%-55% and V_{intra} = 2-13. Larger intra-session variation was also observed in the left liver lobe (V = 8-13%), when compared with the right liver lobe (V = 4-9%).

Discussion: As expected, intra-session repeatability was smaller than inter-session repeatability for all choice of ROIs. Although increased NGD was hypothesized to be of use in improving the inter-session repeatability [2], it was not the case. Pulsation and cardiac motion were not corrected in this study. This likely resulted in larger intra-session variation in the left liver lobe, compared with the right liver lobe, and larger inter-session variation and intra-session variation in the vessels, compared with other ROIs. When a large ROI was selected (i.e. ROI of the whole liver), the motion effect was averaged out. The best inter-session and intra-session repeatability were, expectedly, observed using whole liver ROI.

Conclusion: Based on our results, DT metrics are repeatable (for both intra-session and inter-session) when large ROIs are chosen. Additional gradient directions do not improve the measurement precision and repeatability in general.

Reference: [1] Erturk. Acta Radiologica. 2013; DOI: 10.1177/0284185113504916. [2] Song. NeuroImaging. 2002