

Imaging distortion and quantification bias of parotid ADC measurements in EP-DWI and fast spin-echo PROPELLER-DWI

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Introduction: Accurate measurement of the parotid ADC is clinically important not only for distinguishing pathologies but also for inter-experiment comparison. Although single-shot spin-echo echoplanar diffusion-weighted imaging (EP-DWI) has been increasingly applied to investigate the parotid gland pathologies, the parotid ADC values measured by EP-DWI are quite discrepant even in healthy volunteers, ranging from $0.28 \times 10^{-3} \text{ mm}^2/\text{s}$ (1) to $2.46 \times 10^{-3} \text{ mm}^2/\text{s}$ (2). Whether DWI pulse sequences contribute to the discrepancy of parotid ADC has not been documented yet. The aim of this prospective study was to investigate the severity of DWI distortion and the ADC measurement of parotid glands using EP-DWI and PROPELLER-DWI (PROP-DWI).

Materials and Methods: This study was of the approval of the Institutional Review Board at our hospital. A total of 35 healthy volunteers were recruited (15 men & 20 women; 36.1 ± 11.5 years). All MR scans were performed at a 1.5 T whole-body scanner (GE Healthcare, Signa HDx, US) (maximum gradient of 50mT/m; 8NV head and neck array coil). For anatomic correlation, axial fast spin-echo (FSE) T1-weighted images (T1WI) (TR/TE/Nex/ETL: 750ms/11ms/1/4) or T2-weighted images (T2WI) (3150ms/87ms/2/22) were acquired with field of view (FOV) of $240 \times 240 \text{ mm}$, matrix size of 128×128 , slice thickness of 5 mm and slice spacing of 1.0 mm. DW-MRI were obtained with motion-probing diffusion gradient ($b = 0$ and 1000 s/mm^2) being applied on each of three orthogonal directions. The geometry, FOV, matrix size, slice thickness and slice spacing were identical to that used with the FSE T1WI/T2WI. For PROP-DWI, FSE sequences (7000ms/122 ms/1.8/24) as described by Pipe et al. (3) were undergone with and without fat saturation. For EP-DWI, single shot spin-echo EPI acquisitions (7000ms/ 73.3ms/4) were performed with and without being accelerated by an array spatial sensitivity encoding technique (ASSET) with an accelerating factor of 2, respectively. Distortion of DW-MRI was evaluated independently by two experienced neuroradiologists by comparing the DW-MRI ($b = 0 \text{ s/mm}^2$) to the T2WI using a four-point grading score (0 = severe distortion: whole image was distorted; 1 = moderate distortion: distortion involving the parotid glands; 2 = mild distortion: distortion involving the oral cavity, oropharynx, or maxillary sinuses; 3 = no distortion) (Fig. 1). ADC maps were generated on personal computer by using a pixel-by-pixel computation according to the logarithmic equation: $\text{ADC} = \ln[S_0/SI_{1000}]/(b_{1000}-b_0)$, where S_0 and SI_{1000} was the signal intensity of DW images corresponding to the b value of 0 and 1000 s/mm^2 , respectively. The ADC of parotid glands and gray matter of cervical cord were analyzed using a region of interest (ROI) method. Interobserver reliability for imaging distortion was evaluated by weighted kappa statistics (4). Analysis of imaging distortion scores for DW-MRI was performed using nonparametric statistics, Wilcoxon Signed rank test. Student t test was used for group comparisons of ADC. A P value of less than .05 was considered as statistically significant.

Results: Non-ASSET EP-DWI demonstrated severe imaging distortions, followed by ASSET EP-DWI, FS PROP-DWI and NFS PROP-DWI. The mean distortion scores were 1.80 ± 0.64 , 1.97 ± 0.73 , 2.94 ± 0.24 and 2.94 ± 0.24 for NASSET EP-DWI, ASSET EP-DWI, PROP-DWI and NFS PROP-DWI with a weighted kappa of 0.705, 0.775, 1 and 1, respectively.

Comparing to PROP-DWI, both NASSET EP-DWI and ASSET EP-DWI showed severer imaging distortion with statistical significance ($P < .001$). The parotid ADC measured by FS PROP-DWI ($1.27 \pm 0.21 \text{ mm}^2/\text{s}$) was significantly higher than the ADC measured by ASSET EP-DWI ($1.08 \pm 0.13 \text{ mm}^2/\text{s}$; $P < .001$), NASSET EP-DWI ($0.87 \pm 0.13 \text{ mm}^2/\text{s}$; $P < .001$) and NFS PROP-DWI ($0.667 \pm 0.148 \text{ mm}^2/\text{s}$; $P < .001$). The ADC of cervical cord measured by FS PROP-DWI ($1.16 \pm 0.11 \text{ mm}^2/\text{s}$) did not differ from that measured by NFS PROP-DWI ($1.148 \pm 0.142 \text{ mm}^2/\text{s}$; $P = .362$) but was significantly higher than the ADC measured by ASSET EP-DWI ($0.81 \pm 0.06 \text{ mm}^2/\text{s}$; $P < .001$) and NASSET EP-DWI ($0.75 \pm 0.06 \text{ mm}^2/\text{s}$; $P < .001$) (Fig. 2).

Discussion & Conclusion: In head and neck, the abundant air in the aerodigestive tract usually lead to severe inhomogeneity of local magnetic susceptibility and imaging distortion on EP-DWI. Our results show that EP-DWI is susceptible to the susceptibility-induced imaging distortion, which is significantly reduced by PROP-DWI (Fig. 1). In addition to perceptible geometric distortion, the susceptibility-induced artifacts also lead to inaccurate ADC measurements of parotid glands. By acquiring non-accelerated EP-DWI, accelerated EP-DWI and PROP-DWI in a single study, our results clearly show that the parotid ADC varies dependent on DW-MRI techniques. The parotid ADC measured by NASSET EP-DWI is significantly lower than that measured by ASSET EP-DWI by 23.0% ($P < .001$) and FS PROP-DWI by 35.8% ($P < .001$). The parotid ADC measured by NFS PROP-DWI is significantly lower than that measured by FS PROP-DWI by 48.0% ($P < .001$). In conclusion, parotid ADC measurements are apparently biased by the DWI pulse sequences. According to our results, we suggest that researchers should pay attention to the sequence-related biases and be careful especially when inter-experiment comparison of parotid ADC values are performed. **Reference:** 1. Sumi M. AJR 2002;178:959; 2. Zhang L. JMIR 2001;14:223-229; 3. Pipe JG. MRM 2002; 47:42; 4. Sim J. Phys Ther 2005; 85:257.

Fig. 2. ADC (mean \pm SD) of the parotid glands and grey matter of the cervical cord measured on FS PROP-DWI, ASSET EP-DWI and NASSET EP-DWI.

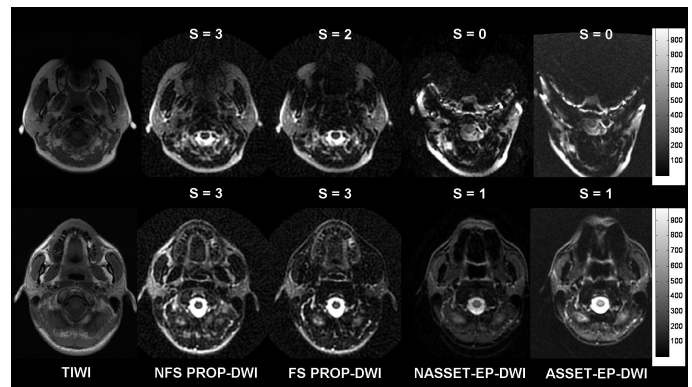


Fig. 1. Image demonstration and imaging distortion scores of DWI ($b = 0 \text{ mm}^2/\text{s}$) of NFS PROP-DWI, FS PROP-DWI, NASSET EP-DWI and ASSET EP-DWI.

