

Could T1 and T2 Weighted Volumetric Imaging be used for Clinical Purposes in the Very Preterm Brain?

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Introduction:

T₁ and T₂ weighted (T₁w and T₂w) sequences are very important MRI modalities, routinely used for identifying pathologies and monitoring development in the neonatal brain^{1,2}. These modalities can also be used for segmentation of brain regions in developmental studies of morphology^{3,4}. Currently, however, clinical T₁w and T₂w sequences used for diagnostic and research purposes are frequently acquired using different imaging protocols and experimental settings. While low through-plane resolution conventional spin-echo (SE) T₁ and T₂ sequences are used to identify pathologies, high resolution 3D volume imaging is frequently used for clinical research^{1,4}. We compared these two neuroimaging approaches in very preterm neonates to determine whether rapid high resolution T₁w and T₂w sequences can provide both diagnostic and morphometric value.

Methods:

Subjects: The study cohort included 30 preterm neonates showing a range of pathologies born between 24 to 32 weeks gestational age (GA) (median, 29 weeks) and scanned between 26 to 34 weeks corrected GA (median, 30^{4/7} weeks). Informed, written consent was given by the infants' parents; the study was approved by the hospital's research ethics board. All but two were scanned without sedation.

MR Acquisition: MR scans were performed on a 1.5T GE Signa Excite HD scanner (GE, Milwaukee, WI, USA) using an MR-compatible incubator and neonatal head coil (Advanced Imaging Research, Inc. Cleveland, USA). Conventional clinical T₁w and T₂w images were obtained first: axial SE T₁w (TR/TE/FA=850ms/15ms/65°, BW=8.93kHz, FOV=14cm, matrix=256x192, 18 slices of 4mm), sagittal T₂w fast recovery fast SE (FRFSE) (TR/TE/ETL=5s/150ms/27°, BW=20.83kHz, FOV=14cm, matrix=288x288, 13 slices of 5mm, 1mm gap) and axial T₂w-FSE PROPELLER (TR/TE/ETL=6s/133.5ms/32°, BW=31.25kHz, FOV=14cm 18 slices of 4mm, matrix=256x256). High resolution axial T₁w and T₂w volumes were acquired using 3D spoiled gradient recalled (T₁w-SPGR) (TR/TE/FA=23ms/4ms/19°, BW=15.63kHz, FOV=12.8cm, matrix=128x128, 110 slices of 1mm) and multi-slice 2D FRFSE (T₂w-FRFSE) (TR/TE/ETL=4000/145ms/19°, BW=25kHz, FOV=12.8cm, matrix=128x128, 90 slices of 1mm), respectively.

Radiological Assessment: Three radiologists experienced in neonatal imaging independently evaluated each of the clinical and high resolution T₁w (SE and SPGR) and T₂w (sag. FRFSE, PROPELLER and high resolution FRFSE) images separately (T₁ evaluated by SM, JPSF; T₂ evaluated by JPSF, BT). The radiologists completed a questionnaire noting detected lesions by type, time taken to read the images and rating the sequences using a five-level Likert scale for diagnostic confidence, image quality and presence of motion artifacts. Finally, each radiologist compared the clinical and high resolution images.

Analysis: Spearman's rho (ρ) was calculated to test the correlation between the scores given by the raters for each type of scan. The Kolmogorov-Smirnov test was used to determine whether the distributions of the combined results for the clinical and high resolution sequences were significantly different. Statistical analyses were performed using the R statistical software (www.r-project.org).

Results:

According to the combined rating results (Fig. 1a) and K-S test, T₁w-SPGR was demonstrated to provide significantly ($p<0.001$) higher diagnostic confidence compared to the clinical T₁w-SE. The correlation, though, was not significant between the raters. The two T₁w sequences demonstrated similar rating distributions ($p>0.05$) for image quality and motion artifact with a high correlation between the raters ($\rho\geq 0.5$, $p<0.01$). Compared with sagittal T₂w-FRFSE and axial PROPELLER, high resolution T₂w-FRFSE did not differ significantly in the rating distributions ($p>0.05$) for diagnostic confidence, image quality or motion artifacts. Nevertheless, a trend showing higher frequencies of higher scores was observed in

diagnostic confidence for high resolution T₂w-FRFSE (Fig. 1b). Significant, strong correlation between raters was found for image quality in both clinical and research sequences and for motion artifact scores in high resolution T₂w-FRFSE. Two out of three radiologists reported longer time to read the clinical 2D T₁w and T₂w images compared to the high resolution 3D T₁w and T₂w volumes. All three radiologists noted an overall better delineation of myelination and sulcation in 3D images. Moreover, referring to high resolution sequences, T₁w-SPGR images provided better detection of cystic PVL and small ischemic foci, while T₂w-FRFSE images were found to be useful for detecting small haemorrhages.

Conclusions:

T₁w and T₂w high resolution images were compared to conventional SE-based images for diagnostic confidence, image quality and motion artifacts. Diagnostic confidence appeared to be improved for the high resolution scans, while no difference was observed for image quality and motion artifact. These results suggest that high resolution T₁w and T₂w sequences could be used in clinical imaging, thus providing both diagnostic and morphometric information.

References:

1. Barkovich AJ, *Neuroimaging Clin N Am.* 2006; 16(1):117-35. 2. Counsell SJ et al., *Am J Neuroradiol.* 2002; 23:872-81. 3. Anbeek P et al., *Pediatr Res.* 2008 ;63(2):158-63. 4. Conklin J et al., *Magn Reson Med.* 2008 ;59(5):1190-6.

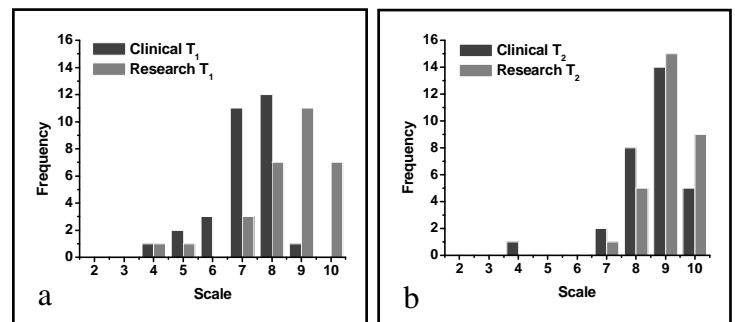


Fig. 1: T₁w (a) and T₂w (b) clinical vs. high resolution images: Histograms of total score among raters for diagnostic confidence.

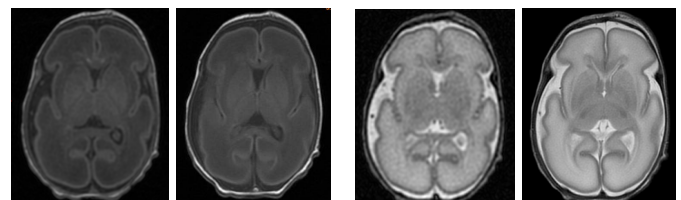


Fig. 2: T₁w-SPGR (a), T₁w-SE (b), T₂w-FRFSE (c), T₂w-PROPELLER(d).