Millimeter Isotropic Resolution Volumetric Pediatric Abdominal MRI with a Dedicated 32 Channel Phased Array Coil

S. S. Vasanawala[1], T. Grafendorfer[2], P. Calderon[3], G. Scott[4], M. T. Alley[1], M. Lustig[5], A. C. Brau[6], A. Sonik[1], P. Lai[6], V. Alagappan[7], and B. A. Hargreaves[1]
[1]Radiology, Stanford University, Stanford, CA, United States, [2]ATD Coils, GE Healthare, Stanford, CA, United States, [3]MR Hardware Engineering, GE Healthcare, Fremont, CA, United States, [4]Electrical Engineering, Stanford University, Stanford, CA, United States, [5]Electrical Engineering & CS, UC Berkeley, Berkeley, CA, United States, [6]Global Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, [7]ATD Coils, GE Healthcare, Aurora, OH, United States

INTRODUCTION: Pediatric MRI is challenged by small anatomic structures and limited patient cooperation. This work investigates whether a phased array torso coil designed for highly accelerated parallel imaging of the pediatric torso enables submillimeter resolution.

METHODS: *Coil:* A 32 channel phased array was designed and constructed to fit the torso of an average 7 year old child (Fig 1), with 16 anterior 4x4 elements and 16 posterior 4x4 elements. Coil elements were slightly overlapped, and kept small (8 cm) for high SNR. Preamplifier oscillation was prevented with feedback compensation [1].

Subjects and MRI protocol: Phantom tests assessed SNR and coil element decoupling. 8 consecutive patients referred for pediatric abdominal imaging on a 3T GE MR750 with submillimeter resolution volumetric T1 and T2 acquisitions were retrospectively identified with IRB approval. Ages ranged from 2 to 5 years (mean 3.4 years). Patients had undergone a 3D FSE sequence with flip angle modulation (CUBE) and T2 weighting, with parameters: ETL 60, TE 70-90 ms, respiratory triggering, slice thickness 0.8 mm except one case at 0.6 mm and one case at 1 mm, 320x320 matrix, outer acceleration factor 8, FOV 22-30 cm, coronal plane. Post-gadolinium 3D SPGR with intermittent fat suppression and Poisson-disc [2] k-space variable density sampling had parameters of flip angle 15, slice thickness 0.8 mm (5 cases) or 1 mm (3 cases), acceleration 7.2 – 8 (mean of 7.8), matrix 288 x 288, FOV 24-30 cm, coronal plane. Routine clinical axial 2D FSE T2 imaging and axial volumetric navigated post contrast dual-echo SPGR were also obtained.

Image evaluation: The following were evaluated by consensus of two radiologists on a five point scale (Table 1): SNR of 3D acquisitions at source slice thickness (0.6 – 1 mm), SNR of 3D acquisitions at 3 mm slice thickness, aliasing artifacts of 3D sequences, sharpness of axial reformats from 3D T2 images versus conventional 2D axial T2, adequacy of spatial resolution of axial reformats of 3D T1, and sharpness of axial reformats of 3D T1 relative to navigated axial T1.

RESULTS: *Phantoms:* Improved SNR (Fig 2), coil decoupling, and g-factor (not shown) relative to adult sized coil was noted.

Volumetric T2: All cases had diagnostically acceptable SNR for thin source images as well as 3 mm slices (Figs. 3-5). Mild aliasing artifacts were noted in 7/8 cases and no aliasing artifact in 1/8. Sharpness of reformats was slightly inferior to 2D T2 in 2/8 cases, equivalent in 3/8, and superior in 3/8.

Volumetric T1: SNR of thin source images was slightly limited in 2 cases on thin images but of diagnostic quality on 3 mm thick slices for all cases. No coherent aliasing artifacts were noted. Axial reformats were of diagnostic quality in all cases. Mildly inferior sharpness of reformats compared with direct axial images was noted in 3/8 cases.

CONCLUSION: This preliminary work suggests true isotropic millimeter resolution volumetric T1 and T2 imaging with a dedicated pediatric abdominal phased array can be obtained with adequate SNR and with diagnostic quality reformats.

REFERENCES: **[1]**: T. Grafendorfer et al ISMRM 2010, p. 650. **[2]**: H. Tulleken et al., Poisson Disk Sampling Tutorial, Dev. Mag. Magazine 2008; **21**:21-25 (devmag.org.za). Research funded in part by NIH RR09794-15, NIH R01 EB009690, Tashia & John Morgridge Foundation, and GE Healthcare.

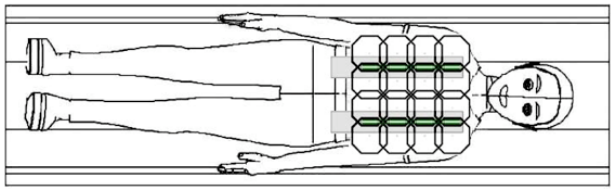

Fig 1. Diagram of coil to scale on a 7 year old.

SNR scale	Reformat sharpness scale	Score
More than adequate SNR for all structures	Clearly sharper margins on reformats	5
More than adequate SNR for most structures	Mildly preferred reformats	4
Adequate SNR for most structures	Equivalent	3
SNR somewhat limiting	Mildly preferred direct axials	2
Nondiagnostic SNR	Clearly worse margins on reformats	1
Artifact scale	**T1 Sharpness**	
No perceptible coherent artifacts	High quality	5
Minimal	Good quality	4
Mildly limiting	Less than expected from direct axials	3
Significantly limiting	Significantly limiting	2
Nondiagnostic	Nondiagnostic	1

Table 1. Evaluation scale of volumetric image quality.

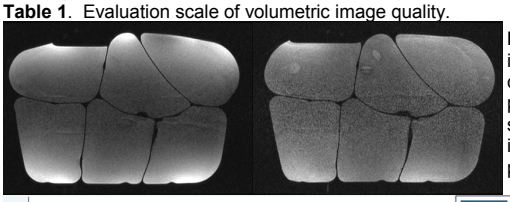

Fig 2. Left: phantom image with pediatric coil. Right: Same phantom with adult sized coil. Note improved SNR with pediatric coil.

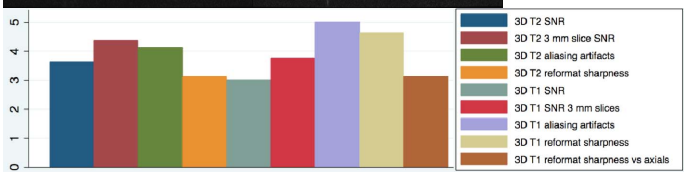

Fig 3. Mean scores for image quality evaluations.

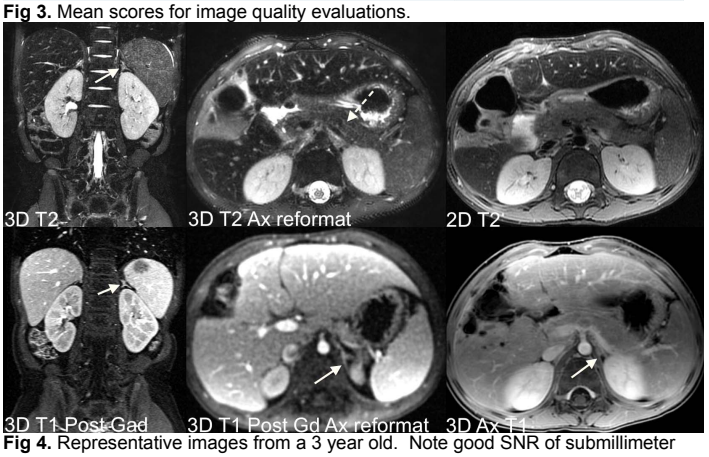

Fig 4. Representative images from a 3 year old. Note good SNR of submillimeter thickness slices (left), and good quality T2 and T1 reformats (middle) compared with directly obtained axial images (right). Sharp delineation of left adrenal gland (arrow) and pancreatic duct (dashed arrow) are unusual for such a small child.

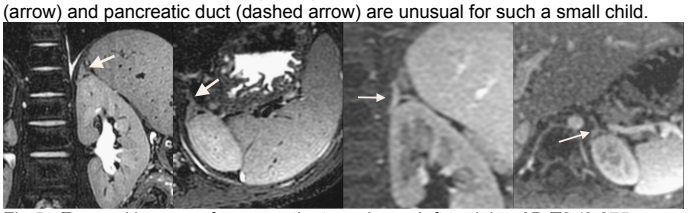

Fig 5. Zoomed images of same patient as above, left to right: 3D T2 (0.875 x 0.875 x 0.8 mm voxels, 8x acceleration), 3D T2 axial reformat, 3D T1 post gadolinium 0.97 x 0.97 x 0.8 mm voxels, 8x acceleration), and 3D T1 axial reformat. Note high SNR delineation of left adrenal gland (arrow).