3T Skin Imaging

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Introduction: Skin imaging is challenging: a very high resolution over a FOV of a few cm^3 is desirable and images needs to be acquired with adequate SNR in clinically feasible scan times. Furthermore, if the epidermis or the dermis is under investigation, a short TE is necessary. *In vivo* skin imaging has been mainly investigated at 1.5 T. A 4.87 nL resolution was obtained with a 10.3 ms TE in 11 min, using dedicated receive/transmit coils [1]. A shorter TE (5 ms) was possible with 100 mT/m gradients on a small bore magnet [2]. Recently, a 1 nL resolution at 1.5 T was obtained in 13 min 7 s with a 1.3 cm diameter HTS surface coil [3]. This work investigates, on a 3 T system, three pulse sequences that satisfy the challenges of clinical skin imaging.

Methods: Three 3D pulse sequences (Figure 1) were implemented: spoiled GRE, balanced SSFP with 180° phase alternation of the RF excitation, and FLASE. The FLASE sequence has been designed as a 3D Cartesian trajectory with the shortest possible TE [4]. The experiments were performed on a 3T whole body scanner with a maximum gradient amplitude of 40 mT/m and a maximum slew rate of 150 mT/m/ms, using a customized 2.5 cm diameter receive coil. The calf of a normal volunteer was imaged. To reduce spurious motion, the subject's leg was immobilized using a plastic walker boot glued on a heavy wood plank, and all images were obtained in less than 6 min. All sequences offered 119*119*500 μm^3 (7 nL) resolution and used a 32 kHz readout bandwidth. Specific parameters are summarized in Table 1. For each sequence, the flip angle was optimized for the epidermis (assuming a long T1 and a short T2). For FLASE, water and fat images were acquired separately by shifting the center frequency of the excitation.

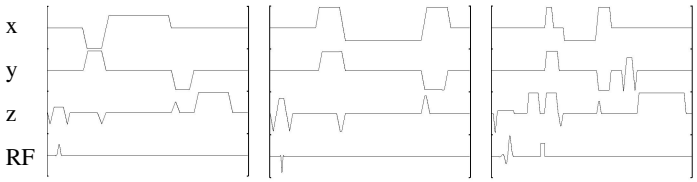

Figure 1: Pulse sequences, Left: GRE, Middle: alternated balanced SSFP, Right: FLASE. Since FLASE has a longer TR, it is amenable to navigators (alternating between axes, here on y) but this information was not used for this work.

	FOV	Matrix size	TE	TR	FA	Time
GRE	6*6 cm²	512*512*16	11 ms	28 ms	12°	3'50
Alt SSFP	6*6 cm²	512*512*16	11 ms	22 ms	7°	3'
FLASE water	6*3 cm²	512*256*16	13 ms	80 ms	160°	5'34
FLASE fat	6*3 cm²	512*256*12	16 ms	80 ms	160°	4'30

Table 1: Imaging parameters

Results: Figure 2 shows that we were able to resolve the main skin layers with all sequences. It is interesting to notice that across the entire 3D volume, SSFP did not suffer from banding artifacts despite the relatively long TR. The appearance of the dermis in GRE images was not consistent across experiments since it is affected by off-resonance at the skin/air interface. It should also be reported that a high variability of skin characteristics was found between healthy subjects and between skin areas across the body.

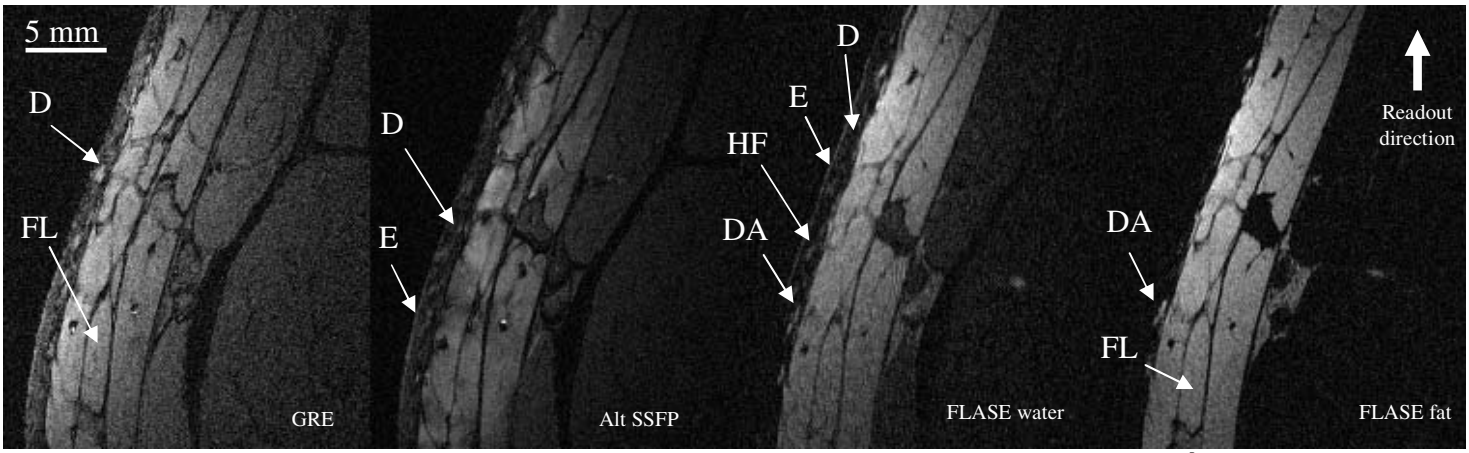

*Figure 2: In vivo images of calf skin of a normal volunteer obtained at 3 T using a 2.5 cm diameter receive coil. 119*119*500μm^3 resolution was obtained in less than 6 minutes. The following structures can be recognized [5]: E: epidermis – D: dermis – FL: fat lobule – HF: hair follicle – DA: dermis appendage.*

Conclusion: We have demonstrated that high resolution 3D skin imaging is feasible at 3T without complicated hardware and in clinically realistic scan times. The FLASE fat image offers a sharp depiction of the capillaries but the epidermis and dermis are invisible. The FLASE water image is immune to off-resonance and provides a good delineation of the epidermis. SSFP and GRE require a shorter scan time. The dermis is visible, but GRE images are sensitive to off-resonance whereas SSFP images did not seem to be. The specific clinical needs and constraints would trigger the choice of one sequence over the others.

References :

1. Song, H.K., *et al.*, Magn Reson Med, 1997. **37**(2): p. 185 - 191.
2. Ablett, S., *et al.,* Magn Reson Imag, 1996. **14**(4): p. 357 - 360.
3. Laistler, E., *et al.,* in *ISMRM*. 2007. Berlin, Germany, p. 326.
4. Ma, J., *et al.*, Magn Reson Med, 1996. **35**(6): p. 903-10.
5. Bittoun, J., *et al.*, NMR Biomed, 2006. **19**(7): p. 723-30.