Microscopic Skin Imaging at 7T

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Introduction:

Noninvasive imaging with characterization of healthy skin, inflammatory skin diseases, and differentiation of skin tumors would be a valuable diagnostic tool for dermatologic purposes. For imaging such microscopic structures within the human skin, an in-plane resolution of about 40-100 µm is desired. Therefore, on 1.5T whole-body scanner systems, surface radiofrequency (RF) receive-only coils that provide high signal-to-noise ratio (SNR) are required when reducing voxel sizes to the order of 10^{-2} mm^3. Small diameter, high SNR surface RF receive coils for microscopic imaging of the human skin have already been introduced in other studies [1,2], but their application to a variety of skin tumors was limited by a rather small imaging field-of-view (FOV) of only 2 cm or even smaller. The purpose of the presented study was to adapt this knowledge to 7-Tesla MRI and to perform microscopic MR imaging in vivo in order to evaluate potential advantages and disadvantages specifically associated with imaging at this high field strength.

Methods and Materials:

A 10-cm-diameter single loop transmit/receive coil (Rapid Biomedical, Würzburg, Germany) was used on a 7-Tesla whole-body MRI system (Magnetom 7T, Siemens Medical Solutions, Erlangen, Germany) equipped with a gradient system capable of 45 mT/m maximum amplitude and a slew rate of 220 mT/m/ms. This gradient performance was mandatory to obtain small FOVs and accelerate the acquisition speed. The sagittally-oriented imaging sequences for in vivo imaging were a T1-weighted spoiled gradient-echo sequence (Volume interpolated 3D Flash (VIBE)) (TR/TE = 10.9/4.77 ms , FOV 100 x 100 mm^2, flip 10°, BW 150 Hz/pixel, 128 slices, matrix 512 x 512 interpolated to 1024 x 1024, slice thickness 0.2 mm, in-plane 0.2 x 0.2 mm^2, TA 7:14 min with and without fatsat) and a T1-weighted magnetization-prepared rapid gradient echo (MPRAGE) sequence (TR/TE = 2500/4.74 ms, FOV 100 x 100 mm^2, flip 10°, BW 130 Hz/pixel, 176 slices, matrix 512 x 512 interpolated to 1024 x 1024, slice thickness 0.4 mm, in-plane 0.2 x 0.2 mm^2, TA 16:00 min). The coil was placed directly on top of the region of interest (ROI) (healthy skin, birthmark) and fixed with a Velcro® fastener. Alternatively, the subject was placed on top of the coil. A nitro capsule was used to quickly find the ROI in the scout images. High-resolution in vivo measurements were performed in ten volunteers and evaluated regarding image quality and contrast properties.

Results:

The RF transmit/receive coil provided sufficient SNR and image contrast over the entire FOV for high-resolution in vivo imaging of healthy human skin in all volunteers with microscopic resolution. Coil positioning (even lying on top of the coil for imaging the back) (Fig.1A) and examination time were well tolerated by all subjects. Excellent details of the surrounding epidermis, dermis, and the subcutaneous fat, as well as of the birthmarks, were found in all high-resolution in vivo MR images (Fig.1 B / C).

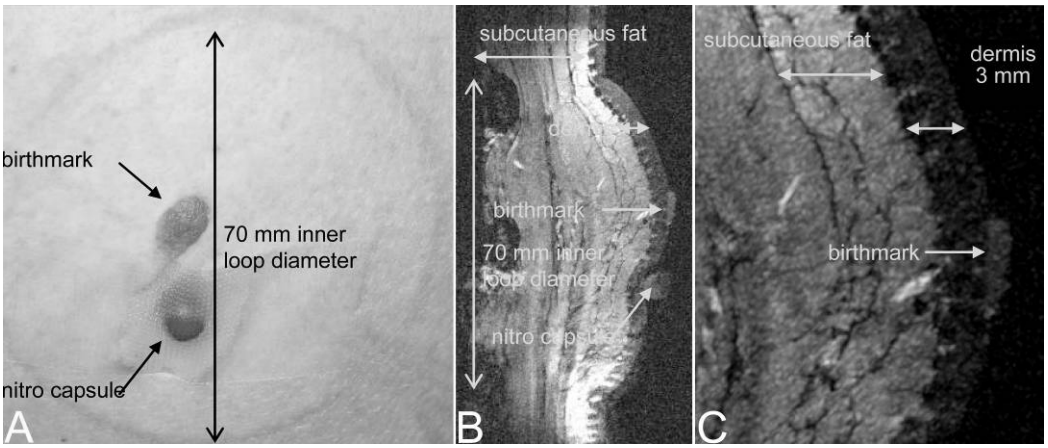

Fig. 1: (A) Photograph of a birthmark on the skin of the back of a volunteer. The birthmark is marked with a nitro capsule for fast localization in scout images. **(B)** Sagittal oriented VIBE image showing the full FOV of the coil. The birthmark can be identified directly above the nitro capsule. The dermis, the subcutaneous fat as well as ribs can be seen. **(C)** Zoomed image. A clear depiction of dermis, the subcutaneous fat, vessels in the skin, and the birthmark is achieved.

Discussion:

These results demonstrate that high-field MR imaging is capable of achieving sufficient SNR for high-resolution in-vivo imaging of healthy skin with microscopic resolution. This approach circumvents the limitation of measuring at 1.5T with very small surface coils to achieve adequate SNR, as these coils can only depict skin lesions which do not exceed the very small geometry of the sensitive volume (<2 cm). The proposed imaging concept is currently being used to gain further information on healthy skin and on cutaneous tumors.

References:

[1] Liffers, A. et al.: High Resolution in Vivo MRI of the Skin and Comparison to High Frequency Ultrasound, ISMRM 2000 Proc. p. 1400
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