High SNR, Microscopic Imaging of Skin Lesions

S. Maderwald[1], S. C. Ladd[1], M. E. Ladd[1], F. Stock[1], T. Paul[1], A. Liffers[2], J. Barkhausen[1], T. Gambichler[3], H. H. Quick[1]

[1]Department of Diagnostic and Interventional Radiology and Neuroradiology, University Hospital Essen, Essen, Germany, [2]Institute of High Frequency Engineering, Ruhr-University Bochum, Bochum, Germany, [3]Department of Dermatology, Ruhr-University Bochum, Bochum, Germany

Introduction:

There is large dermatological interest in noninvasive imaging and characterization of healthy skin, inflammatory skin diseases, and differentiation of skin tumors. For imaging microscopic structures within the human skin, an in-plane resolution of about 40-100 µm is required. Therefore, surface radiofrequency (RF) receive coils that provide high signal-to-noise ratio (SNR) are a prerequisite when reducing voxel sizes to the order of 10^{-2} mm^3. A small diameter, high SNR surface RF receive coil for microscopic imaging of the human skin has already been introduced in another study [1], but its application to a variety of skin tumors was limited by a rather small imaging field-of-view (FOV). The purpose of the present study thus was to design a high SNR surface coil with extended FOV and to apply it in a clinically feasible protocol for assessing skin tumors with high-resolution MR imaging.

Methods and Materials:

A very low noise, linear, 2-turn loop receive only surface coil was constructed. It has an 18 mm diameter (vs. 9 mm [1]) (Figure 1) and was implemented on a 1.5 Tesla scanner (Magnetom Sonata, Siemens Medical Solutions, Erlangen, Germany) equipped with a gradient system capable of 40 mT/m maximum amplitude and a slew rate of 200 mT/m/ms. The gradient performance facilitates obtaining small FOVs and accelerating the acquisition speed. The sagittally-oriented pulse sequences for in vivo imaging were a T1-weighted 2D spin echo sequence (TR/TE = 400/19 ms , FOV 36 x 36 mm^2, BW 50 Hz/pixel, 10 slices, matrix 512 x 256 interpolated to 1024 x 512, slice thickness 1.5 mm, in-plane 0.07 x 0.14 mm^2, TA 1:50 min), and a 3D spoiled gradient-echo sequence (TR/TE = 12/5.12 ms , FOV 75 x 50 mm^2, flip 25°, BW 150 Hz/pixel, 48 slices, matrix 512 x 512 interpolated to 1024 x 1024, slice thickness 0.34 mm, in-plane 0.2 x 0.2 mm^2, TA 1 min). The coil was placed directly on top of the region of interest (healthy skin, birthmark, tumor) and fixed with a Velcro® fastener. T1-weighted images were acquired before and starting 1 min after i.v. administration of a Gadolinium-based contrast agent with a dose of 0.2 mmol/kg body weight. In vivo measurements were performed and evaluated regarding qualitative image quality and SNR in ten healthy volunteers and in six patients with skin tumors (malignant melanoma n = 4, basal cell carcinoma n = 2).

Fig. 1: The coil was attached with a Velcro® fastener over a birthmark on the thigh of a volunteer.

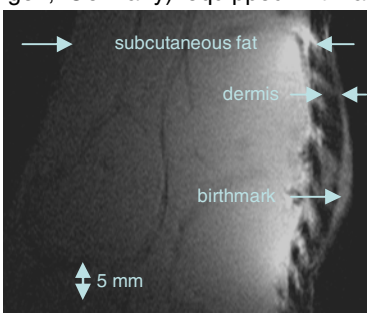

Fig. 2: In vivo MRI of the birthmark (native 2D T1-weighted).

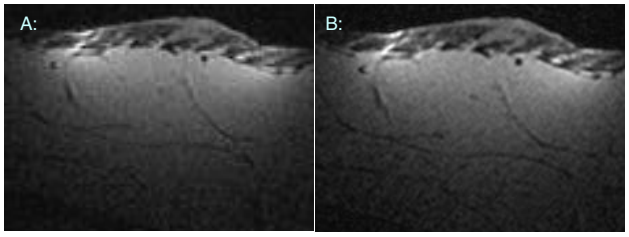

Fig. 3: In vivo MRI of the birthmark using the surface coil. T1-weighted 3D spoiled gradient-echo (200 x 200 x 340 μm^3):
A) without contrast agent
B) with contrast agent (no enhancement).

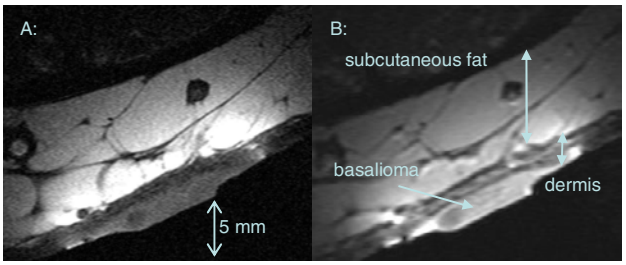

Fig. 4: In vivo MRI of a basalioma over the tibia using the surface coil. T1-weighted 2D spin-echo:
A) without contrast agent (70 x 140 μm^2)
B) with contrast agent (lower resolution 140 x 280 μm^2).

Results:

The RF coil provided sufficient SNR for high-resolution in vivo imaging of healthy and diseased human skin in all volunteers and patients with microscopic resolution. The examination was well tolerated with regard to examination time and coil positioning. High-resolution in vivo MR images of healthy skin (legs and arms, forehead and neck), of birthmarks (Figure 2 and Figure 3) and of tumors (Figure 4) show excellent detail of the epidermis, dermis and the subcutaneous fat, as well as of the lesions themselves. Contrast enhancement was not visible within birthmarks, but all basaliomas and melanomas demonstrated marked enhancement.

Discussion:

These results demonstrate that a dedicated, small-diameter surface-coil is able to achieve sufficient SNR for high-resolution in vivo imaging of healthy skin as well as of benign and malignant skin lesions with microscopic resolution at 1.5T. This imaging concept together with the use of contrast agents might provide the potential to differentiate between benign and malignant lesions. One limitation of this surface coil approach is that only skin lesions, which do not exceed the geometry of the sensitive volume of the small surface coil, can be fully assessed. The proposed imaging concept is currently being used to gain further diagnostic information 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