3D High Resolution Skin Imaging

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Introduction Patients with diabetes have diseases in the skin that are currently diagnosed using biopsy. Besides the fact that the procedure is invasive, biopsy can only detect the disease in the localized region where the tissue sample is taken. Furthermore, it is difficult to monitor the progress. Due to these difficulties skin imaging using a non-invasive technology such as MRI is very attractive. The challenge in imaging skin using MRI is the extremely high resolution required. High resolution imaging in MRI is mainly a problem of SNR, since the MR signal is proportional to the voxel size. It also requires short enough scan times for in-vivo imaging since the slightest movement of the subject in a high resolution scan will lead to artifacts such as blurring. Skin imaging has been previously done by using customized coils with Cartesian trajectories [1]. In this work we address the challenge of MR skin imaging by using small surface coils to reduce the noise volume while using a fast spiral imaging sequence.

Theory The major difficulties in skin imaging include the fact that ultra-high resolution is required with short imaging time. The high resolution requirements lead to SNR deficiency which can be overcome by using customized small surface coils to reduce the noise volume. To achieve high resolution in the slice direction, 3D imaging is desirable. The short imaging time is required since even small motion can lead to degradation in image quality. Therefore, stack-of-spiral trajectories were chosen to decrease the scan time for a 3D acquisition. Spiral acquisition has the added advantage of enabling short TE for higher signal. Since skin contains a lot of fat components, to avoid blurring, fat and water need to be separated in spiral imaging. This is done by using spectral-spatial excitation pulses to selectively excite the water component.

Method The experiments were done using a GE 1.5 T whole-body scanner with a maximum gradient amplitude of 40 mT/m and maximum slew rate of 150 mT/m/ms. A custom-made surface coil with 1 inch radius was used. The stack-of-spirals trajectory was combined with a gradient recalled echo (GRE) sequence with a flip angle of 30°. The field-of-view was chosen to be 4 x 4 x 1 cm^3. The resolution was designed to be 78 x 78 x 500 μm. This resulted in 200-interleave spiral per phase encode location with 20 phase encode locations. Readout time was 16ms. TR was chosen to be 40ms which resulted in a total scan time of 2 min 40 sec. The spectral-spatial excitation pulse (Fig. 1) was designed to be short (5.6 ms) so that short T_2s could be imaged while robust lipid suppression is achieved.

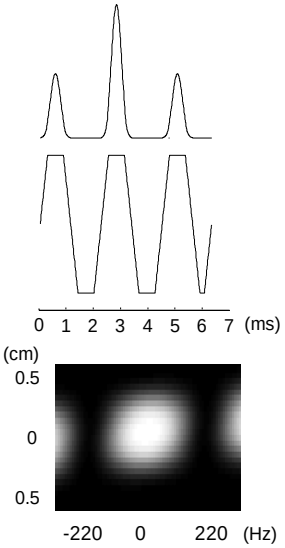

Figure 1 *Spectral-spatial excitation pulse. The RF excitation pulse and the corresponding z gradient are shown with the spectral-spatial profile.*

Result Skin images of the dorsal calf of a normal volunteer are shown in Fig 2. One of the single axial sections from a 3D scan is shown in the figures. Water images are shown in the upper row (Fig. 2 a, c) and fat images (Fig. 2 b, d) are shown on the bottom. The water and fat images were separately acquired by shifting the center frequency of the excitation to be at the water and fat resonance frequency. The left column (Fig. 2 a, b) shows images obtained with a single scan which lasts 2 min 40 sec. The right column (Fig. 2 c, d) shows images averaged from four consecutive scans. The averaged images clearly show higher SNR. In the water images, blood vessels in the dermis and in the subcutaneous fat region can be seen. The subcutaneous fat images also show blood vessel void. Note that there is no apparent off-resonance artifact despite the relatively long readout time of the spirals.

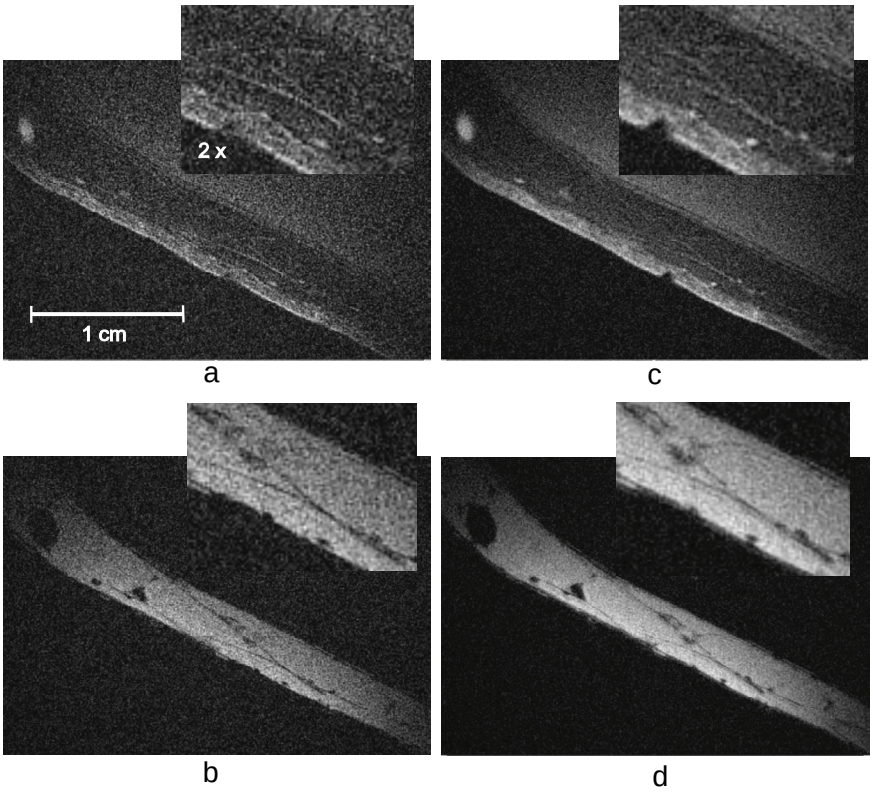

Figure 2 *Skin image of the dorsal calf. a) Water image and b) fat image from a single 3D scan. c) Water image and d) fat image with 4 scans averaged. On the right hand corner of each image, a 2x zoomed version of part of the image is displayed.*

Discussion This demonstrated the feasibility of skin imaging using a whole body 1.5 T system in a reasonably short scan time. Smaller surface coils will allow more SNR which can enable higher resolution imaging. The fast imaging methods will also allow skin perfusion studies [2] to augment this anatomic information.

Reference

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