21 Tesla Micro-MRI of Rat Skin

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Abstract: A rapid ultra high resolution ex vivo MRI imaging method was evaluated to visualize rat skin structure. The main objectives were: 1.qualitative assessment of viable epidermis, hair, oil and fat-rich skin features by multi-contrast approach; 2.achievement of spatial resolution up to 15 microns; 3. comparison of skin histology with MRI skin features obtained by 21 Tesla magnetic resonance imaging (MRI) imager.

Introduction: The ultrawide bore 900 MHz magnet has high resolution NMR magnet has a central field of 21.1 T. The high resolution MRI technique has potential for both quantitative and non-invasive morphological evaluation at micrometer level. The MRI signal is sensitive to water protons and glycolipid distribution in the skin. At 21 T, both contrast and resolution are enhanced utilizing thin slices up to 100 microns. Multiple contrast by magnetization transfer contrast (MTC), spin–lattice relaxation (T1-weighting), combination of T2 and magnetic field in-homogeneity (T2*-weighting) may provide resolution up to 15 microns with distinct proton-fat contrast.

Methods: On histology and MRI co-registered images, skin features of epidermis, dermis, hair, sebaceous glands were compared. For spin echo(SE) and gradient echo(GE) imaging utilized the MSME_Bio and GEFC (Bruker Biospin, Billerika) methods at short TE=8 ms and TR=100,200,500,1000 ms(for T1 weighted) and TE= 8,16, 24 ms, TR=1000 ms(for T2 weighted), matrix of 256 x 256 and 0.1-0.3 mm slice thickness, NEX=4. The MSME_MTR was used for MT images. The MRI visible skin features regions were identified for epidermis, dermis, hair follicles and oil glands. Distinct epidermis and intact hair and root thickness served as good skin quality.

Results: At high resolution 25 μm, SE T1-weighted images showed distinct epidermis, brighter brightest stratum corneum; bright-gray papillary (collagen) and reticular dermis (glycolipids). The hair follicles and sebaceous glands appeared gray(Figure 1). Signal intensity was proportional to TR. At TE=8 ms, water and lipids appeared distinct in the dermis. The T2-weighted images highlighted the stratum corneum (dark thin band at top), viable epidermis (white band below the stratum corneum), hair follicles/sebaceous glands (light channels running vertically through the skin), and dermis (dark regions between hair follicles)(Figure 1 and Table 1). Water-fat phantom showed distinct intensity(Figure1E). In plane resolution was 100 micron and contrast enhancement was achieved by multicontrast approach. Histology-MRI comparison: Epidermis, hair root, follicles, sebaceous gland were comparable.

Conclusion- High resolution SE short TE images demonstrate distinct contrast properties as preliminary data. High CNR and better morphology both require ultra high magnetic field using T2* weighted and magnetization transfer weighted MRI imaging to achieve high in-plane and spatial resolution.

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Table 1:Multicontrast approach by T1-, T2-, proton density, MT weighted images distinguish different skin features on images with different signal intensities.

Skin feature	T1-weighting	T2-weighting	PD weighting	MT
Stratum corneum	Brightest; ++++	Darker-gray	Iso-intense	Darker
Epidermis	Iso-intense	Brighter; +++	Brighter; ++	Bright
Dermis-Reticulum	Brighter; +++	Gray	Brighter; +	Gray
Dermis-papillary	Bright-Gray; ++	Dark gray	Brighter; +	Bright
Hair follicle	Gray	Brighter; ++	Dark	Dark
Sebaceous gland	Iso-intense +	Hyper-intense; +	Brighter; ++	Dark

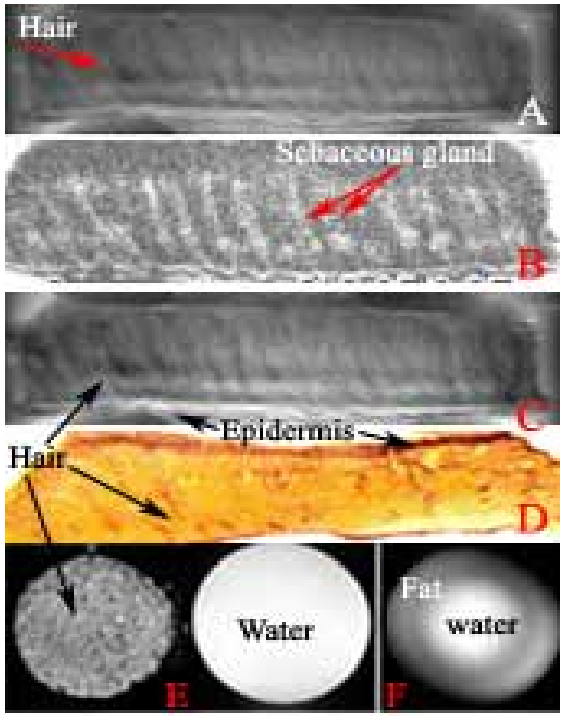

Figure 1 (right) shows SE image (A), GE image(B), MT image(C), histology(D) show comparable skin features with arrows. Axial image(E) shows hair on skin surface. Water-fat phantom(F) shows different MRI signal.