Ultrastructural Organization of Bone and Tendon – Novel Method for Musculoskeletal Imaging of extremely fast relaxing Spins

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PURPOSE

Short T2 signals such as those from cortical bone, tendons, ligaments, scar tissue, cartilage etc., are largely undetectable by conventional magnetic resonance imaging (MRI); this imposes limitations on clinical utility of MRI as ultrastructure and pathologies involving such tissues remain inaccessible. In addition, signals from areas affected by susceptibility gradients (e.g. adjacent to implants) are also undetectable due to ultrashort T2's.

METHOD AND MATERIALS

SWIFT, sweep imaging with Fourier transformation, was used to detect tissues of the musculoskeletal system, including those with extremely short T2 values. The effective TE in SWIFT is ~0, thus allowing imaging of spins with extremely fast transverse relaxation rates as well as long T2. The field gradient used for spatial-encoding is not pulsed on and off, but rather is stepped in orientation in an incremental manner, which results in low acoustic noise. Cortical bone, tendons and cartilage were imaged in vitro at 9.4 T and in vivo at 4T. SWIFT, conventional MR-imaging and histological methods were applied for comparative and validation studies.

RESULTS

Cortical bone and tendon are characterized by lack of signal in conventional imaging and appear "black". These structures yield detectable signals in the SWIFT approach due an effective TE of ~0, thus allowing for the first time the demonstration of the ultrastructural organization of bone (Fg.1). Results were correlated with histopathological slides of the same specimen (Fig.1). Furthermore, detail of the epiphyseal growth plate, tendons and cartilage were obtained. In vivo experiments with humans depicting the carpal tunnel and carpal bones of the wrist were acquired at 4T.

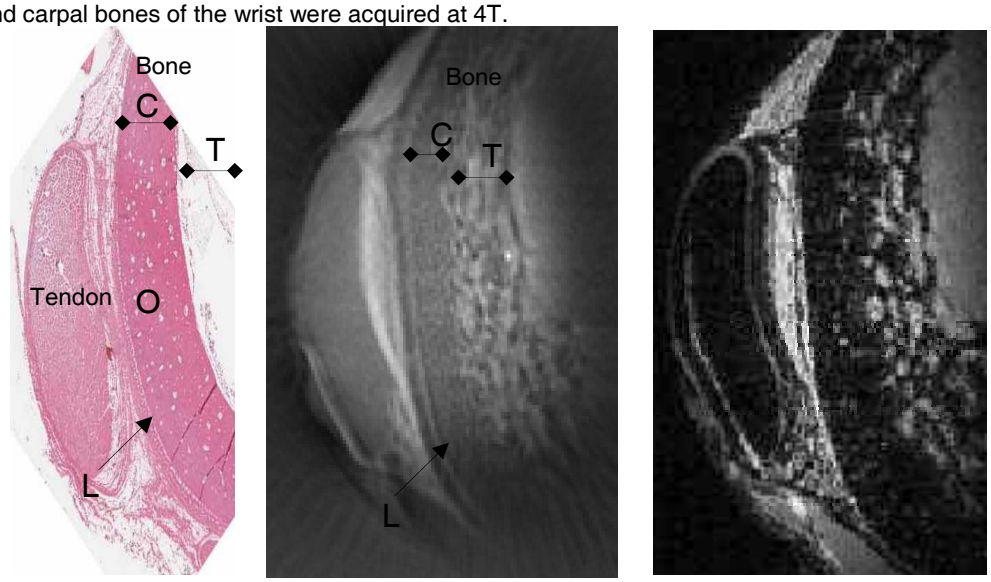

Fig 1 **a)** **b)** **c)**

a) Histology(lamb specimen, H&E Stain); Tibia: **C=Cortical Bone** consistent of Osteon and Interstitial (O) and Lamellar (L) Bone and **T=Trabecular Bone**; Achilles Tendon (T), **b)** SWIFT Imaging at 9.4 T, **c)** FLASH Imaging at 9.4 T

CONCLUSION

The SWIFT technique has many novel and beneficial properties for imaging the short T2 components, and thus creates new opportunities for Musculoskeletal Imaging of previously "MR-invisible" structures and pathologies, as demonstrated by visualizing the ultrastructural organization of bone for the first time. We acknowledge the support NIH Grants 5RO1CA092004 and 5P41RR008079.

References

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