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T_1 Correlates Age: A Short-*TE* MR Relaxometry Study *in vivo* on Human Cortical Bone Free Water at 1.5T

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Abstract. Large pores of human cortical bone (>30 µm) are filled with fluids, essentially consisting of water, suggesting that *cortical bone free water* can be considered as a reliable surrogate measure of cortical bone porosity and hence quality. Signal from such pores can be reliably captured using Short Echo Time (STE) pulse sequence with echo-time in the range of 1-1.5 msec (which should be judiciously selected correspond to T_2^* value of free water molecules). Furthermore, it is well-known that cortical bone T_1-relaxivity is a function of its geometry, suggesting that cortical bone free water increases with age. In this work, we quantified cortical bone free water longitudinal relaxation time (T_1) by a Dual-TR technique using STE pulse sequence. In the sequel, we investigated relationship between STE-derived cortical bone free water T_1-values and age in a group of healthy volunteers (thirty subjects covering the age range of 20-70 years) at 1.5T. Preliminary results showed that cortical bone free water T_1 highly correlates with age ($r^2 = 0.73$, $p < 0.0001$), representing cortical bone free water T_1 as a reliable indicator of cortical bone porosity and age-related deterioration. It can be concluded that STE-MRI can be utilized as proper alternative in quantifying cortical bone porosity parameters *in-vivo*, with the advantages of widespread clinical availability and being cost-effective.

Keywords: Relaxometry, Cortical Bone, Porosity, Bone Water, T_1 quantification

1. Introduction

Bone has a complex hierarchical structure which supports skeletal frame of the human body. This structure is responsible for the bone metabolic, synthetic and mechanical functions, and acts as a reservoir for calcium and phosphorous **(1)**. At the macroscopic level, bone is categorized as trabecular and cortical bone. Cortical bone constitutes about 80 percent of the bone skeleton and is more prone to fracture **(2)**. It consists of three different components; minerals (~42% by volume), organic matrix (~35% by volume) and water (~23% by volume) **(3)**, each with a different and particular role as follows: minerals are responsible for stiffness **(4)**, collagen contributes to energy absorption **(5-7)**, and water guarantees the poroelasticity of the cortical bone **(8)**.

Until now, scientists have mostly concentrated on minerals as a good predictor of bone quality; hence, commonly used bone assessment methodologies in clinics, i.e. Dual-Energy X-ray Absorptiometry (DEXA) and peripheral Quantitative Computed Tomography (pQCT) measure Bone

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