World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:12, No:08, 2018

In vitro Characterization of Mice Bone Microstructural Changes by Low-Field and High-Field Nuclear Magnetic Resonance

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Abstract : The objective of this study is to develop Nuclear Magnetic Resonance (NMR) techniques to enhance bone related research applied on normal and disuse (Biglycan knockout) mice bone in vitro by using both low-field and high-field NMR simultaneously. It is known that the total amplitude of T_2 relaxation envelopes, measured by the Carr-Purcell-Meiboom-Gill NMR spin echo train (CPMG), is a representation of the liquid phase inside the pores. Therefore, the NMR CPMG magnetization amplitude can be transferred to the volume of water after calibration with the NMR signal amplitude of the known volume of the selected water. In this study, the distribution of mobile water, porosity that can be determined by using low-field (20 MHz) CPMG relaxation technique, and the pore size distributions can be determined by a computational inversion relaxation method. It is also known that the total proton intensity of magnetization from the NMR free induction decay (FID) signal is due to the water present inside the pores (mobile water), the water that has undergone hydration with the bone (bound water), and the protons in the collagen and mineral matter (solid-like protons). Therefore, the components of total mobile and bound water within bone that can be determined by low-field NMR free induction decay technique. Furthermore, the bound water in solid phase (mineral and organic constituents), especially, the dominated component of calcium hydroxyapatite ($Ca_{10}(OH)_2(PO_4)_6$) can be determined by using high-field (400 MHz) magic angle spinning (MAS) NMR. With MAS technique reducing NMR spectral linewidth inhomogeneous broadening and susceptibility broadening of liquid-solid mix, in particular, we can conduct further research into the ^1H and ^{31}P elements and environments of bone materials to identify the locations of bound water such as OH- group within minerals and bone architecture. We hypothesize that with low-field and high-field magic angle spinning NMR can provide a more complete interpretation of water distribution, particularly, in bound water, and these data are important to access bone quality and predict the mechanical behavior of bone.

Keywords : bone, mice bone, NMR, water in bone
Conference Title : ICBET 2018 : International Conference on Biomedical Engineering and Technology
Conference Location : Vancouver, Canada
Conference Dates : August 09-10, 2018