H112 The Contribution of Nuclear Magnetic Resonance to the Study of Bone

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After attending this presentation, attendees will have a better understanding of the use of Nuclear Magnetic Resonance (NMR) spectroscopy in forensic science contexts and particularly forensic anthropology and archaeology. The application of NMR is original for these purposes and gives new information about bone composition and its changes during postmortem decomposition.

This presentation will impact the forensic science community by introducing a novel methodology to human bone study by the analysis of carbon ^{13}C and hydrogen ^{1}H atoms contained in bone, and by the observation of differential modifications in bone chemical components over time.

NMR, well known in medicine thanks to Magnetic Resonance Imaging (MRI), can also make possible quantitative studies of different materials from atomic or molecular viewpoints. NMR has been widely used for *in vitro* biological tissues analysis and provides access to fats, molecular conformation, membranes lipid metabolism, and metabolomic analysis as a diagnostic technique to assess the severity of coronary heart disease by the analysis of human serum. However, NMR spectroscopy has been weakly used for bone analysis. It can indeed provide quantitative information on bones, such as composition of the mineral or organic part, hydroxyapatite characterization, identification of amino acids in collagen, presence of citrate, presence of lipids, etc. For this technique, only 80 – 150mg of bone are required for non-invasive analysis, and no chemical treatment is required. With all these advantages, NMR is a tool that should be investigated in physical anthropology and forensic sciences.

Experimental optimization is accomplished on a Bruker Avance 500 spectrometer (protons and hydrogen isotopes are detected at 500MHz, whereas ^{13}C, one of the observable carbon isotopes, is detected at 125.75MHz) under Magic Angle Sample Spinning at 10kHz. Cross polarization with protons is performed to enhance ^{13}C detectivity. Different samples were used in order to choose the better technical parameters according to each sample: fresh human bone (n=4); pig bone with a Postmortem Interval (PMI) of one year (n=4); forensic human bone (PMI=15 years; PMI=30 years; and PMI=60 years).

Using the optimized conditions, NMR bone spectra provided comparative information among samples, such as the presence of citrate or lipids in modern bones, the differential preservation of citrate and lipids in dry bone according to PMI, the presence of exogenous calcite in archaeological bones, the degradation of collagen and its amino acids as a function of time since death, etc. Collagen was found in all samples whatever the PMI. Bio-hydroxyapatite, the main component of the mineral fraction of bone, evolved with time since death toward the chemical structure of pure hydroxyapatite. Similarly, the fats and lipids component of bone are rapidly lost. Such information could lead to use NMR as an alternative method for bone aging, or at least to discriminate between archaeological samples and forensic samples.

More generally, the use of NMR as a complementary tool in forensic anthropology and archaeology opens up new prospects for the study of bone composition and its implications.

Forensic Anthropology, NMR Spectroscopy, Time-Since-Death

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