Use of acoustic Radiation Force in the bone characterization

Braz, G. A[*]*,P.M.Agnollitto*[**]*, Nogueira-Barbosa, M.H*[**]*.Carneiro, A. A. O*[*]*.*

[*] Universidade de São Paulo. Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, Departamento de Física, Ribeirão Preto, Brasil.

[**] Universidade de São Paulo. Faculdade de Medicina de Ribeirão Preto, Divisão de Radiologia, Ribeirão Preto, Brasil.

Introduction: The characterization of the bone conditions is very important, especially in newborns, where there are restrictions in the use of conventional densitometry. Current techniques used in the diagnosis of bone diseases include X-ray Absorptiometry (DEXA) and quantitative ultrasound (QUS). Although DEXA is currently the gold standard for the diagnosis of bone disease, exposure to ionizing radiation is a disadvantage, especially in its use in newborns and the QUS is not very precise due to the phase error caused by the surrounding tissue. The mechanical properties of the bone changes with its condition, and some techniques are based in this fact, in this work we used acoustic radiation force in order to extract quantitative information about the bone conditions. The technique we propose uses a single high-frequency pulse (MHz) to excite the medium. Non-linear interactions of this acoustic wave in the medium produces a lower frequency signal (kHz) which is then detected by a dedicated hydrophone. This signal carries information of mechanical and morphological properties of the region of interest, so it can be processed into images weighted in these properties.

Methods: A focused transducer with resonance frequency at 3.4 MHz and 5 cm of focus was placed in an acoustic tank by a 3D positioning system near the sample. Short duration and high intensity ultrasound pulses were emitted on femur bones extracted from mice and the acoustic signals from the interaction of this pulse with the sample were acquired by a hydrophone with frequency response band between 10 Hz and 100 kHz. The study was performed on 20 bones, 10 of which were asymptomatic animals and 10 of animals with suspected osteoporosis. With these signals, a spectral analysis was carried out trying to differentiate the groups of bones.

Results: When comparing the Fourier transform of these signals, we observed contrast in several frequencies, 55 kHz being the frequency where the highest contrast was observed. The amplitude at this frequency was 5.4 ± 0.5 V for asymptomatic bones and 2.6 ± 1.3 V for osteoporotic bones. A Student's t-test was performed and a descriptive level value (p-value) of less than 5% was obtained. Figure 1 shows a box plot containing the results of the two sets of bones.

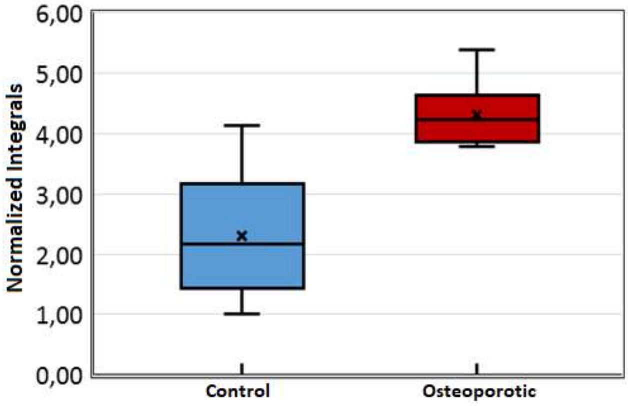

Figure 1. Box plot containing the results of the two groups of bones, in red the osteoporotic group and in blue the control group.

Conclusion: This result suggests that the technique was able to differentiate the two groups.

References: [1] CALLE, S.; REMENIERAS, J. P.; MATAR, O. B.; DEFONTAINE, M.; PATAT, F. Application of nonlinear phenomena induced by focused ultrasound to bone imaging. Ultr. Med. Biol., v. 29, n. 3, p. 465–472, abr. 2003.