UNIVERSITY OF PATRAS
DEPARTMENT OF MECHANICAL ENGINEERING AND AERONAYTICS
SECTOR OF APPLIED ENGINEERING, MATERIALS TECHNOLOGY AND BIOMECHANICS

ULTRASOUND PROPAGATION THROUGH 3D PRINTED SCAFFOLDS FOR OSTEOPOROSIS DIAGNOSIS

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OBJECTIVE

This thesis examines the effect of the characteristics of ultrasound and in particular the backscatter factor on the architecture and material of the cancellous bone, using 3D-printed trabecular bone models which is a useful tool in evaluating properties of samples with the same architecture but with different BV/TV. The backscatter factor as a function of density was measured with focus and unfocus transducers and then compared, in order to draw conclusions in regards to the accuracy and possible uses of the focus transducers.

METHODOLOGY

•Trabecular bone models with 21% BV/TV, 34% BV/TV and 40% BV/TV were printed

•The 3D printer used was Ultimaker 2+

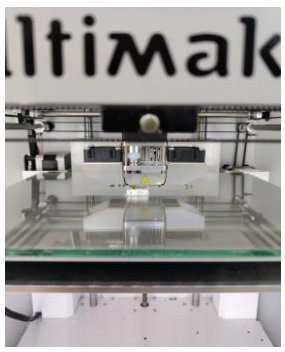
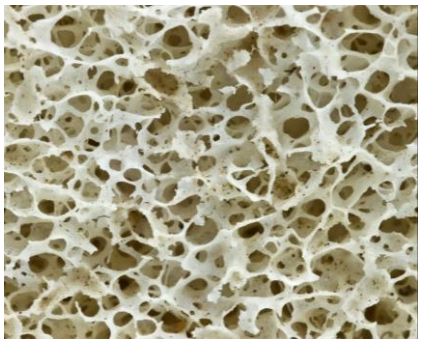
•PLA and TPU-95A were used as printing materials

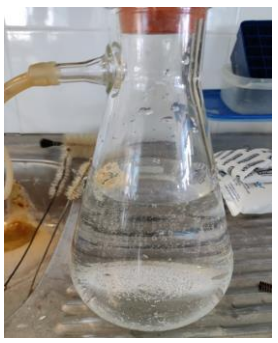
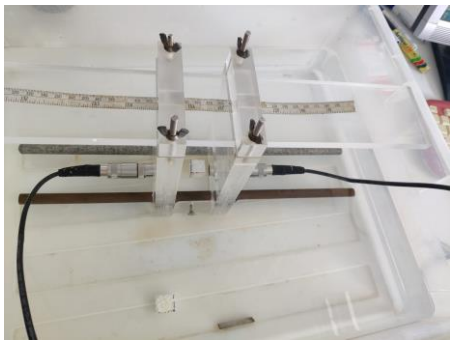
•Ultrasound propagation experiments were then conducted to draw conclusions about the structure of the specimens.

EXPERIMENT

In a number of six 3D printed trabecular bone specimens, measurements were conducted in three directions perpendicular to each other. Unfocused immersion transducers and focused immersion transducers were used connected to an ultrasonic pulse receiver.

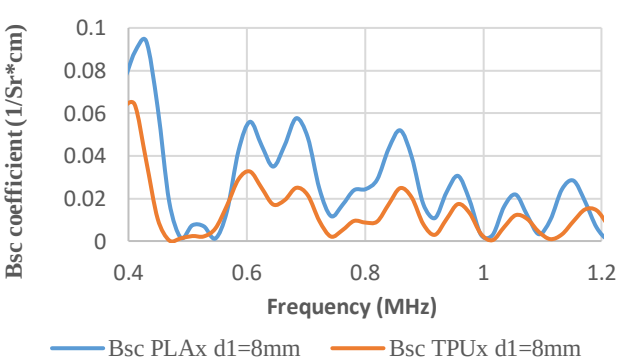
The through-transmission method was used to measure ultrasound speed (SOS) and attenuation (BUA) and the pulse-echo method was used for the measurements of the differential scattering cross section 180°.

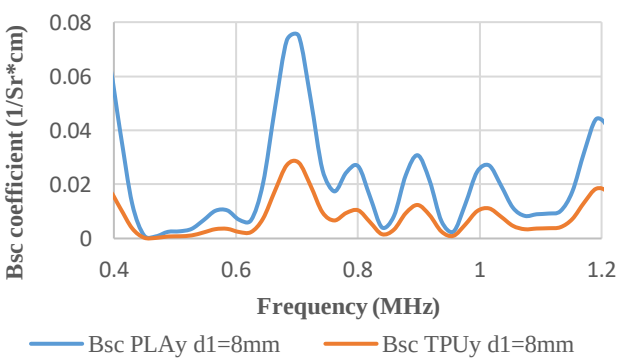



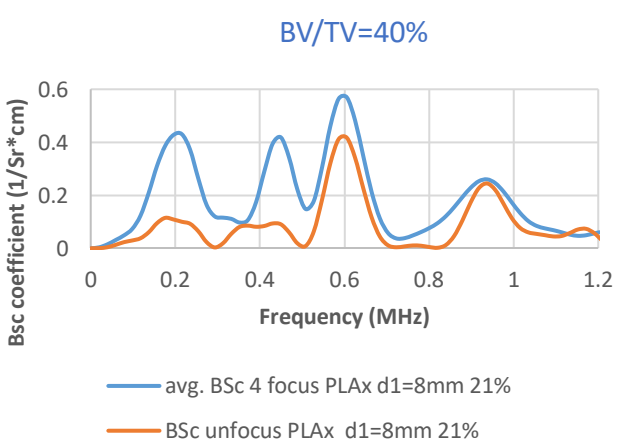
RESULTS

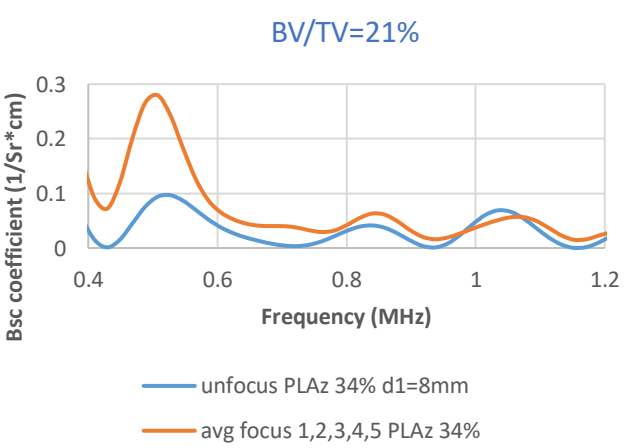
1. Influence of material properties on ultrasound propagation





2. Measurements with focused transducers and comparisons with Unfocused





CONCLUSIONS

The ultrasound measurements indicate that material properties, such as density and stiffness, influence the magnitude of the backscatter spectrum, whereas the shape of backscatter coefficient as a function of frequency depends on the bone structure. The fact that material properties influence the magnitude of the backscatter spectrum is verified by the results occurred from bone replicas with the same material but different density.

Also the correlation of the measurements with focal and non-focal mutants was quite satisfactory which leads us to the conclusion that the combination of measurements in these two ways could give reliable results, as the addition of measurements with focal mutants makes it possible to focus on specific areas. which due to architectural structure would be impossible to obtain with non-focal. It is this observation that becomes particularly critical in in vivo measurements as the morphology of the human body and the architecture of the bones create difficulties in measurement with non-focal mutants.