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► **To cite this version:**

Amadou Sall DIA, Quentin Grimal, Guillaume Renaud. Specular Beamforming and Refraction Correction Improve Ultrasound Imaging of the Bone Cortex Geometry in Vivo. International Ultrasound Symposium (IUS), IEEE, Sep 2023, Vancouver (CA), Canada. hal-04818427

HAL Id: hal-04818427

<https://hal.science/hal-04818427v1>

Submitted on 9 Dec 2024

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SPECULAR BEAMFORMING AND REFRACTION CORRECTION IMPROVE ULTRASOUND IMAGING OF THE BONE CORTEX GEOMETRY IN VIVO

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Background, Motivation and Objective

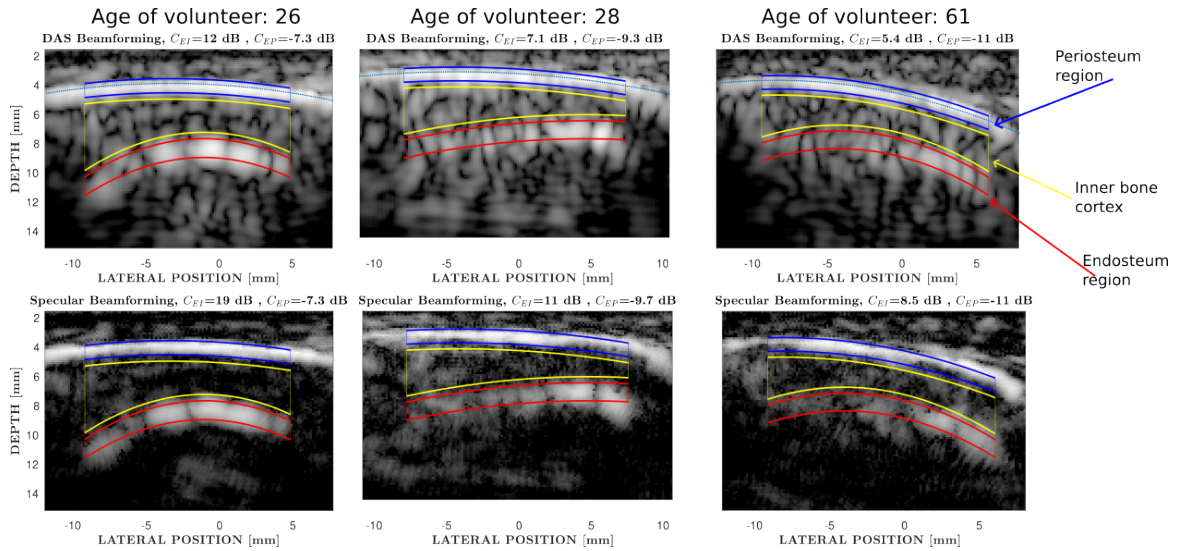
Ultrasound imaging of the cortex of long bones may enable the measurement of the cortical thickness and the ultrasound wave speed in cortical bone tissue [1]. These biomarkers can help assess bone mechanical strength, and hence the risk of fracture [2]. However, with bone loss, the cortical porosity and the size of the vascular pores increase, resulting in strong ultrasound diffuse scattering whose magnitude can exceed that of the specular reflection from the bone cortex-marrow (endosteal) interface [3]. In this study we adapt to bone a specular beamforming technique proposed to better image a needle in soft tissue [4]. Our approach takes into account both wave refraction and specular reflection physics [1,4] to enhance the contrast of bone surfaces and reduce speckle from intracortical pores.

Statement of Contribution/Methods

In vivo ultrasound data were acquired at the center of the human tibia in a plane normal to the bone axis. A single-element transmission synthetic aperture imaging sequence was implemented on a research ultrasound system with a 2.5MHz phased array transducer. Image reconstruction was performed using two different reconstruction methods: (A) a delay-and-sum (DAS) algorithm with optimized f-number, correction of refraction at the soft tissue-bone interface and subject-specific ultrasound wave speed[1] and (B) an adaptive algorithm using Snell's law of reflection to determine the optimal receive subaperture for each pixel [4]. The improvement of image quality was evaluated with contrast ratios of the average intensities: C_{EI} between the endosteal surface (red box in Figure) and the center of the cortex (yellow box in Figure), and C_{EP} between the endosteal surface and the periosteal surface(blue box in Figure).

Results/Discussion

Specular beamforming applied to 3 volunteers aged 26, 28 and 61 years improved the visibility of the endosteum (C_{EI}) by 3 to 7 dB (Figure) while maintaining the relative contrast between the outer and inner surfaces of the cortex (C_{EP}). These results suggest that the visualization of the intra-osseous anatomy can be enhanced if Snell's law and wave refraction are taken into account during image reconstruction.



References

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