MINERAL MOBILIZATION NEAR THE LACUNAR AND CANAL NETWORK IN LACTATION

Michael Sieverts (1), Cristal Yee (2), Minali Nemani (2), Tamara Alliston (2), and Claire Acevedo (1, 3)

1. Department of Mechanical Engineering, University of Utah, USA;
2. Department of Orthopedic Surgery, University of California, San Francisco, USA;
3. Department of Biomedical Engineering, University of Utah, USA

Introduction

Bones constantly remodel to maintain their structural integrity. Additionally, the skeleton is a mineral source to satisfy metabolic demands, such as milk production during lactation. Calcium for the milk is mobilized by resorbing the skeleton. The bone must balance the competing mechanical and metabolic demands during this process. It must quickly supply sufficient minerals to milk while maintaining its structural integrity [1]. Osteocytes are responsible for directing this remodeling process.

Osteocytes are the most abundant bone cell. These cells coordinate remodeling within the bone and directly remodel their surrounding tissue through perilacunar/canalicular remodeling (PLR) [2-3]. PLR is an essential process that has been well-documented in lactation studies. However, the spatial preferences of PLR in the bone are still unclear. In this work, we use images from synchrotron X-ray radiation micro-tomography (SRμCT) to analyze changes in murine bone microstructure during lactation. Specifically, we analyze the spatial distribution of minerals and the distribution of osteocyte lacunae.

Methods

Tibia from age-matched virgin and lactating mice (n=5/group) were used for this study. Mice from both groups were sacrificed at 16 weeks of age.

The tibias were scanned at the Advanced Light Source (ALS) beamline 8.3.2 with an image voxel size was 1.3 um/voxel. The SRμCT scans were reconstructed using the Python package Tomopy. Paganin phase retrieval was applied during reconstruction to minimize interface intensity peaks and enable local mineralization analysis. SRμCT images were analyzed and visualized using a combination of Python and Dragonfly. Volumetric measurements confirmed that lactation had the expected effect on bone. Microstructural segmentation and distance maps were used to perform an in-depth analysis of bone's spatial control of minerals.

Results

Lacunar volume measurements showed that the lactating group had significantly larger lacunae than the virgin group ($p<0.05$). This increase in lacunar volume is expected because lactation induces PLR to mobilize mineral [2]. We measured the spatial distribution of lacunae throughout the bone with respect to the bone's vasculature and found that larger lacunae tend to be closer to the bone's vasculature, especially in the lactating group (Figure 1).

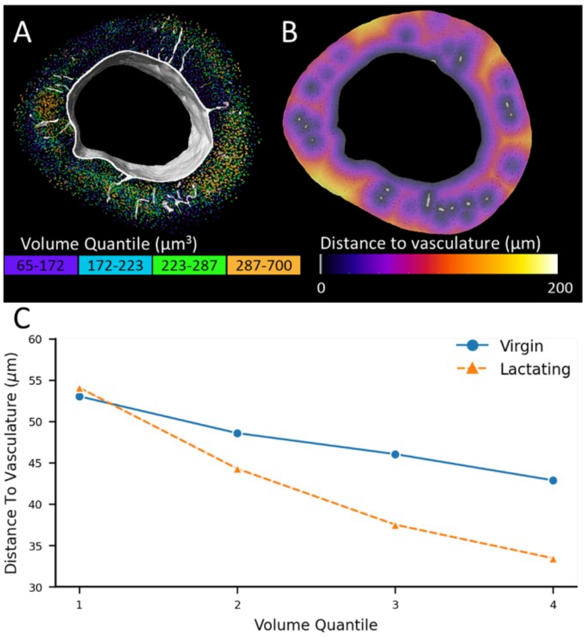

Figure 1: Example of SRμCT images and analysis. A) 3D visualization of the distribution of lacunae through the bone colored by volume quantile. B) 2D slice showing the computed distance from the bone's vasculature. C) Line graph showing the average distance away from the vasculature for lacunae of a particular volume (n=5).

Discussion

Our finding that larger lacunae tend to be closer to the vasculature, especially in the lactating group could suggest that PLR has a preference to occur near the bone's transport system. This could be

References

1. Liu et al. Osteoporors Reports, 17, 375-386, 2019
2. Qing et al. JBMR, 27(5), 1018-1029, 2012
3. Mazur et al. Bone Res. 7: 34, 2015