IN VIVO MICRO CT SCANNING OF A RABBIT DISTAL FEMUR

[1,2]Boon H. Kam, [2]Shannon B. Antekeier, [1,2]Michael J. Voor, [1,2]Shuo Yang, [2]Seid W. Waddell and [2]Robert L. Burden Jr.
[1]University of Louisville Department of Mechanical Engineering,
[2]University of Louisville Department of Orthopaedic Surgery; email: bhkam002@gwise.louisville.edu

INTRODUCTION

High resolution computed tomography (micro-CT) is a powerful research tool for the study of the detailed structure of cancellous (trabecular) bone [1, 2]. In vivo scanning of only small animals such as rats has been described [3-5]. There are obvious advantages to scanning larger animals using similar techniques so that greater volumes of bone and larger implants can be studied. The objective of this investigation was to demonstrate the successful scanning of a live rabbit distal femur and obtaining accurate high-resolution micro-CT images of 3-D trabecular architecture. A volume fraction comparison was made from in vivo micro-CT images to in vitro micro-CT images on the same femurs after excision to ensure the in vivo scanning produced accurate results.

METHODS

Two six-month-old New Zealand White rabbits (weight: 4-5 kg) were used. All procedures were approved by the university institutional animal care and use committee. The rabbits were anaesthetized with 37.5 mg/ml of Ketamine and 5mg/ml of Xylazine). It took approximately 10 to 20 minutes for the rabbit to be sedated. A rabbit holder was custom made for this scanning procedure. It consists of three sections include the top column of 2.25 inches in length and 40.055 inches in diameter, the second column of 9.22 inches in length and 21.6 inches in diameter and the last column is similar to a tube which has 12.00 inches in length and 2 inches in diameter.

The rabbit was situated in the holder resting its front legs against the top column of the fixture. The right hind leg was resting in flexion and the left hind leg was extended into the transparent column and held in place with a strap. Fabric padding was placed around its head and neck to provide anatomical support in its seating position. The holder was then placed on the specimen manipulator in a custom open acrhitecture micro-CT scanner ((ACTIS 150/225 FFi-HR CT, BIR Inc., Chicago, IL) (Figure 1).

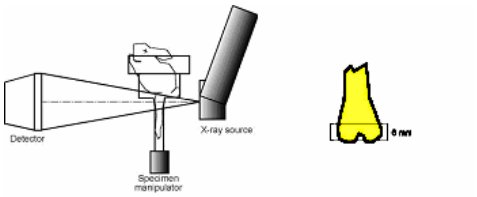

Figure 1: Scanning a live rabbit distal femur 28-micron nominal resolution. Scans were performed in two rotations with a total radiation exposure time of approximately six minutes.

The specimen manipulator is rotated around the z-axis and raised or lowered along the z-axis. The best nominal resolution obtained in scanning a live rabbit distal femur in this arrangement is a voxel size of 28 microns. After in vivo scanning, the femurs were excised and scanned again in vitro in a smaller specimen holder at 14-micron nominal resolution. These two sets of data were registered and compared using VG StudioMAX (Volume Graphics, Heidelberg, Germany) to allow direct comparison.

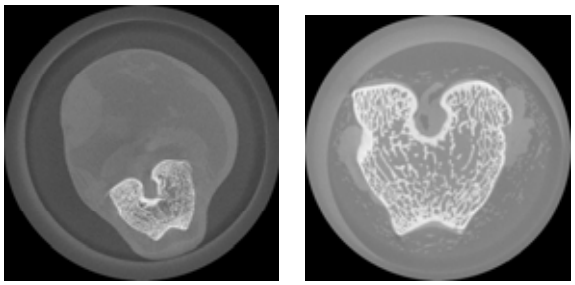

Figure 2: Examples of in vivo (28 micron) and in vitro (14 micon) slice images from the same rabbit femur.

RESULTS

The volume fractions calculated for these two rabbits are 0.25 vs. 0.262 and 0.37 vs. 0.374 (in vivo micro-CT scanning vs. in vitro micro-CT scanning) respectively. The accuracy of in vivo micro-CT scanning is well within 5% of the in vitro method.

DISCUSSION AND CONCLUSIONS

Our studies have demonstrated that the volume fraction from in vivo micro-CT images matches the in vitro micro-CT images. These accurate high-resolution images show the true trabecular architecture can be further utilized in obtaining other trabecular measurements such as trabecular thickness and in analyzing the changing mechanical properties of trabecular structure in micro-FEA on living animals.

REFERENCES

1. Hildebrand T, et al. CMBBE 1,15-23, 1997.
2. Mueller R, et al. Bone 23, 59-66, 1998.
3. Kinney JH, et al. J Bone Miner Res 10, 264-270, 1995.
4. Laib A, et al. Osteoporos Int, 12, 936-941, 2001.
5. Waarsing JH, et al. Bone 34, 163-169, 2004.

ACKNOWLEDGEMENTS

The study was made possible by grants from the NSF and NIH/NIA AG022299-01.