SHIMADZU
Excellence in Science

Application News

No.N118

Industrial X-ray Inspection System

Observation of a Mouse Femur Using an X-Ray CT System

Introduction

At universities, pharmaceutical manufacturing companies and in other research fields, a variety of research using experimental animals is being conducted, including research into bone diseases, as well as drug administration evaluations, and fat measurements for metabolic research. The main experimental animals are rats, mice, and rabbits. In this context, X-ray CT systems are often used to observe and analyze the bones of small animals, and for research on the teeth of humans and small animals. Observations of small animals consists of in vivo CT imaging of living animals, and in vitro CT imaging of dead animals and excised parts.
This article introduces imaging (in vitro) CT data from mouse femurs, taken using the inspeXio SMX-100CT, as well as analytical results from 3-dimensional analysis software utilizing the CT data.

Fig. 1 Overview of the inspeXio SMX-100CT Micro Focus X-Ray CT System

Observation of a Mouse Femur

The inspeXio SMX-100CT Micro Focus X-ray CT system (Fig. 1) was used to take the images. This CT system is equipped with a sealed tube type micro focus X-ray generator with a maximum output of 100 kV, as well as a high sensitivity image intensifier, enabling 3-dimensional observations of resins, pharmaceuticals, bones, and other soft materials at high magnification.
Fig. 2 shows an actual image of a mouse femur. The portion enclosed by the red rectangle is the femur, and the portion to the right of the red rectangle is the tibia. A schematic of the mouse femur is shown in Fig. 3.
The femur consists of three parts: the proximal extremity, the femur itself, and the distal extremity. The proximal extremity together with the coxal bone forms the hip joint. The distal extremity together with the tibia forms the knee joint. This sample observation is an example in vitro imaging of the distal extremity of the femur.

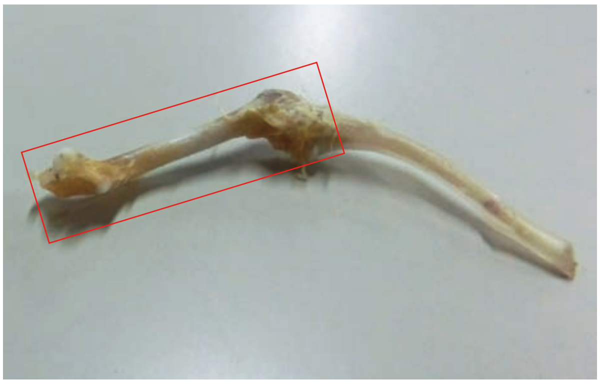

Fig. 2 Overview of a Mouse Femur

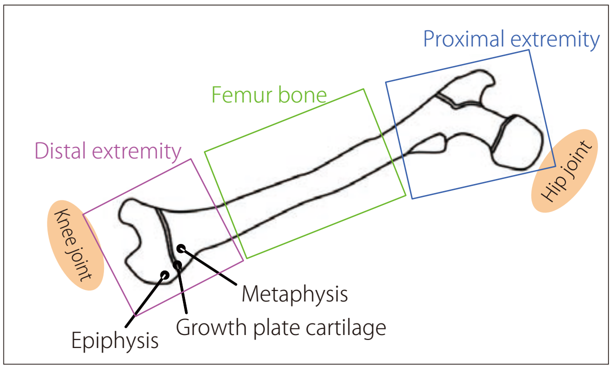

Fig. 3 Schematic Drawing of a Mouse Femur

Fig. 4 shows a cross sectional image of the epiphysis. Similarly, Fig. 5 shows a cross sectional image of the epiphysis and metaphysis, and Fig. 6 shows a cross sectional image of the metaphysis. In the cross section of the metaphysis, the circular bone region is the cortical bone, and the mesh like region inside it is the cancellous bone.
By performing a cone beam CT scan using the inspeXio SMX-100CT, these cross sectional images can be obtained with a single scan, and consecutive cross sectional observations are also possible.
Fig. 7 shows the MPR (Multi Planar Reconstruction) image. In an MPR display, multiple CT images are stacked up in a virtual space, so as to line up four images: a CT image (1); mutually orthogonal longitudinal images (2) and (3); and an arbitrary cross sectional image orthogonal to the longitudinal cross sectional image (4).
In the MPR image, the top left image (1) shows the cross section at right angles to the rotation axis (cross section of the femur). In the top left image (1), the leaf like shape extending in four directions from the central part is the metaphysis. Images (2) and (3) are longitudinal cross sections. The left side of image (2) and the top of image (3) show the epiphysis. The growth plate cartilage is found between the epiphysis and the metaphysis.
Next, Fig. 8 shows a 3-dimensional display of this data. The 3-dimensional display makes it easy to observe the positional relationship between the epiphysis and the metaphysis.

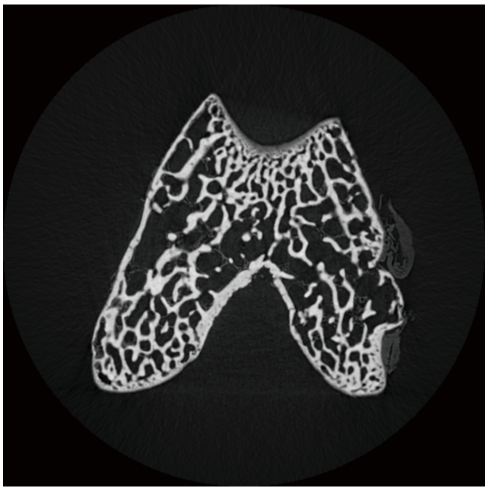

Fig. 4 CT Image of an Epiphysis

Fig. 5 CT Image of Epiphysis and Metaphysis

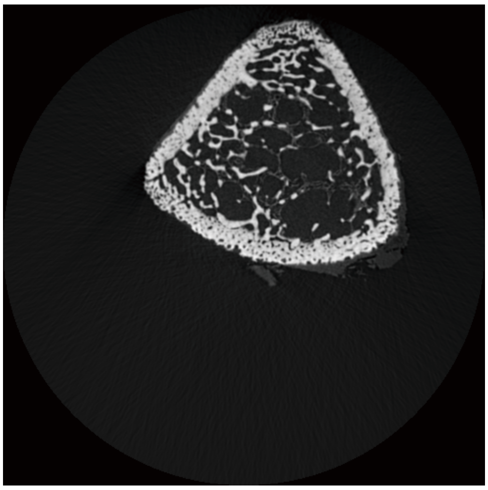

Fig. 6 CT Image of Metaphysis

Fig. 7 MPR Images of a Mouse Femur

Fig. 8 3D Images of a Mouse Femur

Sample Analysis of a Mouse Femur

Obtaining images with the X-ray CT system not only enables cross sectional and 3-dimensional observations, but also enables each region to be extracted for observation, and measurements to be taken of bone thickness. Figs. 10 to 14 show the actual results of scans of mouse femur cortical bone, cancellous bone, and extracted blood vessels within the cortical bone colored for display, utilizing the TRI/3D-BON bone structure analysis software from Ratoc System Engineering Co., Ltd. In Figs. 10 and 11, the portion shown in white is the cortical bone and cancellous bone. In Fig. 10, the cortical bone is made semitransparent in appearance. The red portion shows the blood vessels within the cortical bone, and the green portion shows the growth plate cartilage between the epiphysis and the metaphysis. Fig. 13 is an image with this growth plate cartilage extracted. Fig. 14 shows the results of measurements of the thickness of the extracted cortical bone and cancellous bone. The thin to thick portions vary in appearance from blue to red.

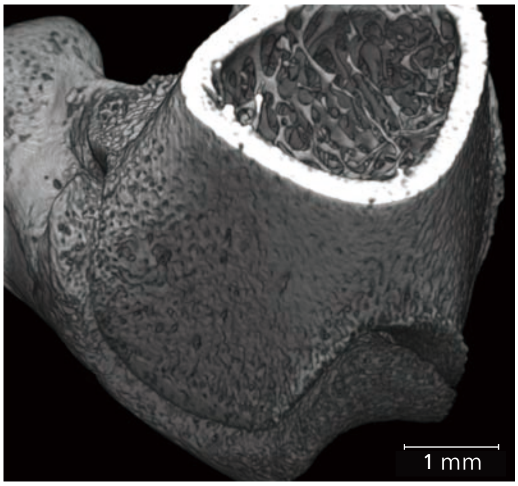

Fig. 9 3D Image of a Mouse Femur

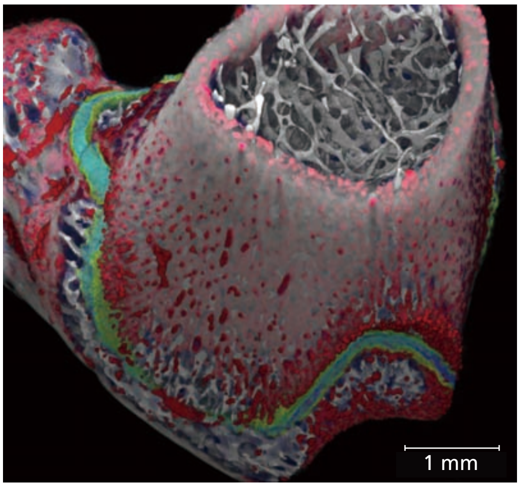

Fig. 10 White : Cortical Bone and Cancellous Bone
Red : Blood Vessels in Cortical Bone
Green : Growth Plate Cartilage

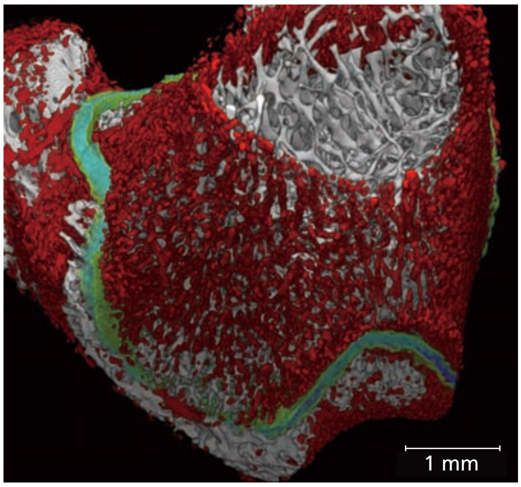

Fig. 11 White : Cancellous Bone
Red : Blood Vessels in Cortical Bone
Green : Growth Plate Cartilage

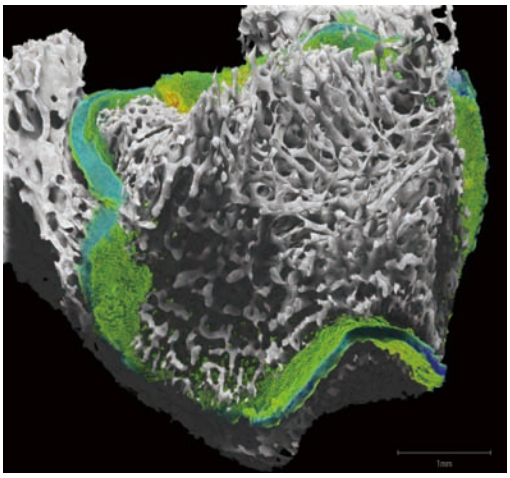

Fig. 12 Cancellous Bone and Growth Plate Cartilage

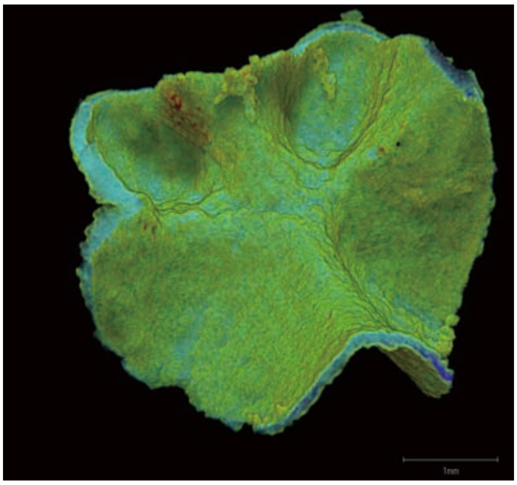

Fig. 13 Extracted Growth Plate Cartilage

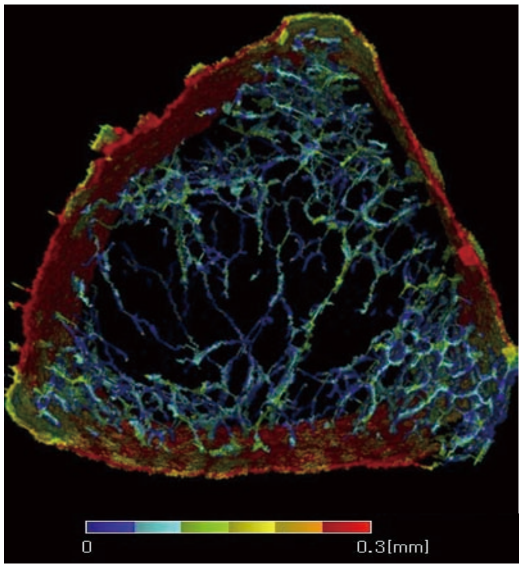

Fig.14 Thickness Measurements of Cortical Bone and Cancellous Bone

Conclusion

In this way, with the inspeXio SMX-100CT, not only is it possible to volumetrically observe the structure of a mouse femur but it is also possible to utilize analysis software to extract each region, and to measure and evaluate the thickness of cortical bone and cancellous bone.

In addition, by applying the BMD phantom (bone mineral quantification) and utilizing TRI/3DBON, it is possible to convert the imaging data brightness values to CT values and separate the cortical bone and cancellous bone, and then obtain the respective BMD values for the cortical bone and cancellous bone. It is also possible to create analysis standard data (calibration curves) by imaging using the BMD phantom instead of the bone after imaging the bone.

First Edition: Dec, 2012

Shimadzu Corporation
www.shimadzu.com/an/