IMAGING MOUSE SPINE

Application Note

Abstract

Finding non-invasive, in vivo methods for imaging the spine is of great importance to improving surgery techniques and monitoring spinal injuries without causing further neurological damage. Photoacoustic imaging (PAI) has proven to be a low cost, safe, and highly informative modality for imaging the spine due to its ability to scan through bone tissue without using ionizing radiation. In this application note, the spine of a post-mortem, nu/nu nude mouse was scanned using the PhotoSound® TriTom™ at a laser wavelength of 850 nm. Features of the vertebral body and spinal column are labeled in PAI images and compared to similar MRI anatomical images.

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Introduction

Conventional MRI of a mouse's spine (Figure 1) provides clear images of internal anatomy. The benefits of a photoacoustic imaging (PAI) approach are a wide variety of commercial contrasts and lower costs [1]. Using the TriTom™ imaging platform, PAI data can be acquired and used to reconstruct 3D volumes of mouse anatomy.

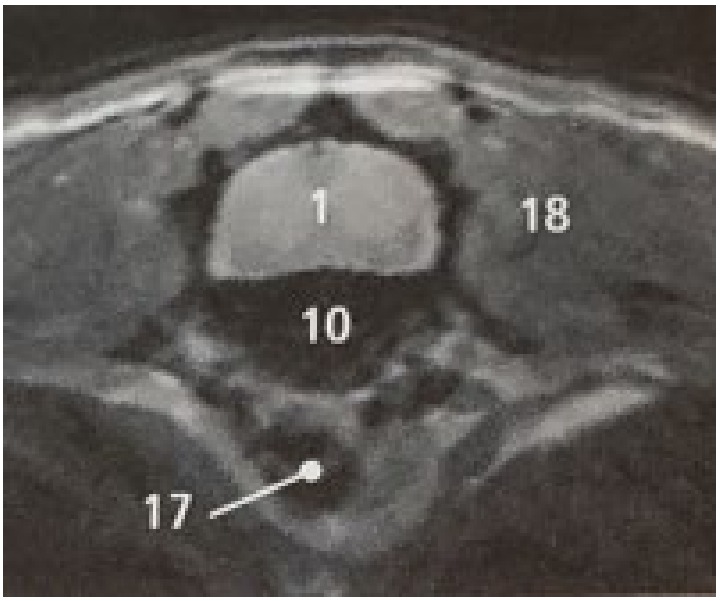

Figure 1: Axial view MRI of a mouse's spine. (1) Thoracic part of spinal cord; (10) vertebral body; (17) thoracic aorta; (18) M. spinalis et semispinalis thoracis [3].

Materials and Methods

Mouse Model

A post-mortem female nu/nu nude mouse (Charles River Laboratories, Wilmington, MA) was scanned. The mouse was previously used in a cancer metastasis study; thus, there is a primary tumor at the right 4th mammary fat pad with malignant cells in the lymphatic system.

Imaging

The imaging platform was filled with water in the imaging chamber at temperature $T = 25.0 \pm 0.5\ °C$. The mouse subject was placed into a mouse restrainer. The mouse holder was then mounted onto the rotational stage. Several 3D PAI scans were initiated, each rotating the mouse 360° while acquiring 360±5 frames of PA data at the excitation wavelength of 850 nm.

PAT Reconstruction

The acquired PA data was reconstructed into 10x10x30 mm volumes with a voxel size of 0.02 mm using a filtered back projection method [2].

Results

3D PAT

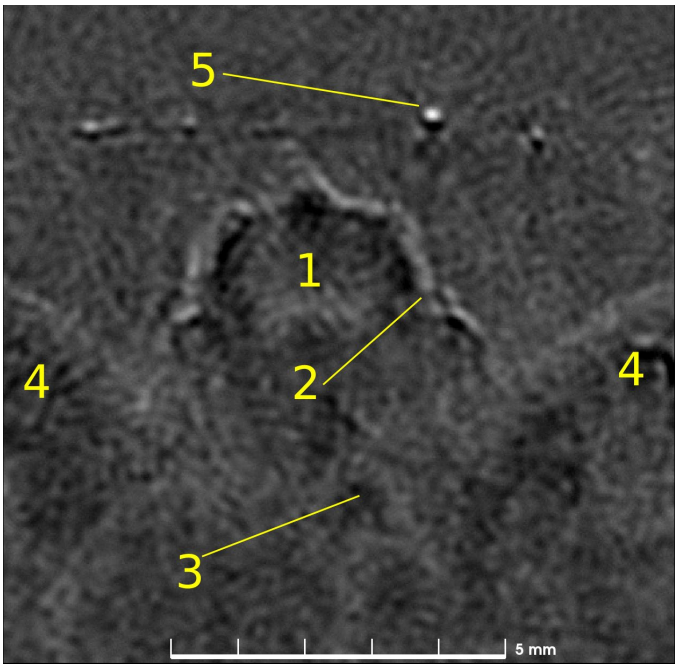

Figure 2: PAT 2D slice, axial view, excited by 850 nm. (1) Lumbar part of spinal cord; (2) vertebral body; (3) abdominal aorta; (4) lower portion of kidneys; (5) superficial vessel.

The 2D PAT reconstruction slice in Figure 2 shows comparable anatomical structures to the MRI slice in Figure 1 (Note: these scans are not from the same mouse). The spinal cord's grey/white matter (Figure 2:1) is detected inside the vertebral column. A lumbar vertebra (Figure 2:2) is distinctly visible and matches the shape of an electron microscopy image (Figure 3). The aorta has poor PA sensitivity (Figure 2:3), likely because there is no blood flow in the post-mortem subject.

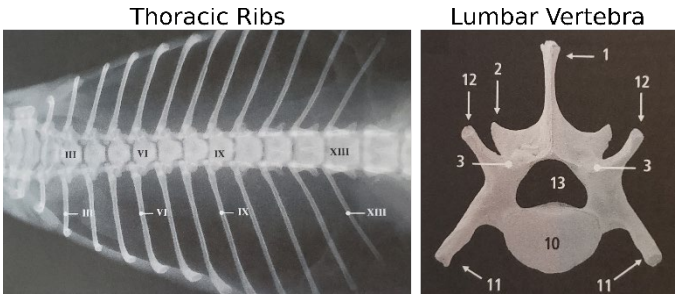

Figure 3: (Left) Ribs attached to thoracic vertebrae, radiography. (Right) Lumbar vertebra, electron microscopy [3].

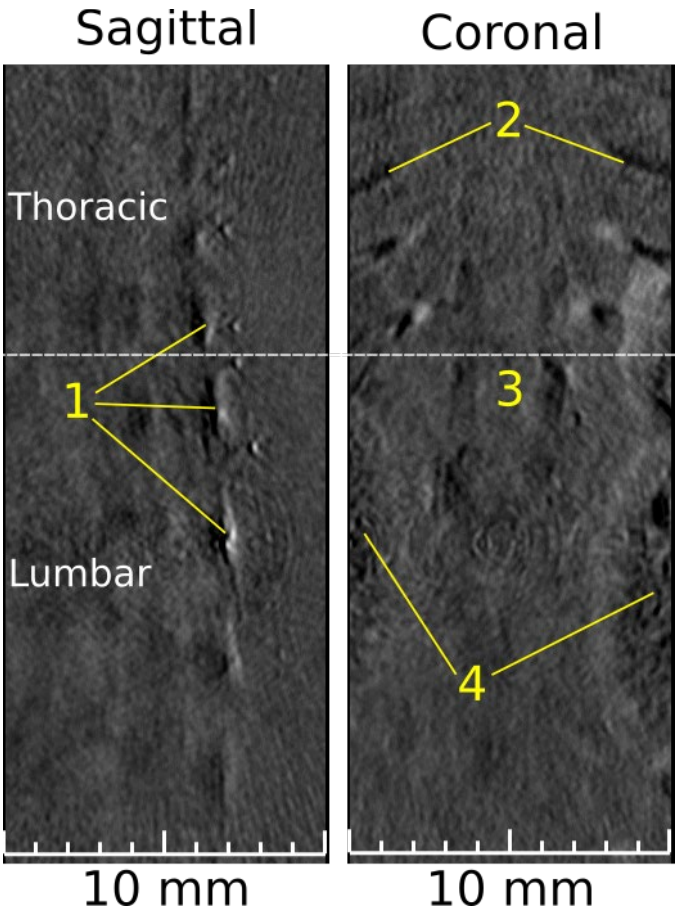

Figure 4: PAT 2D slices, sagittal and coronal views, excited by 850 nm. (1) Multiple thoracic and lumbar vertebrae; (2) ribs; (3) grey/white matter; (4) kidneys. Thoracic and lumbar sections are separated by the dotted-white line.

Figure 4 shows both sagittal and coronal views of the PAT volume. The sagittal slice visualizes vertebra (Figure 4:1) from the thoracic and lumbar sections of the spine, the sections are distinguished by the end of the ribs (Figure 4:2). The grey/white matter (Figure 4:3) of the spinal cord is visible inside the vertebral body.

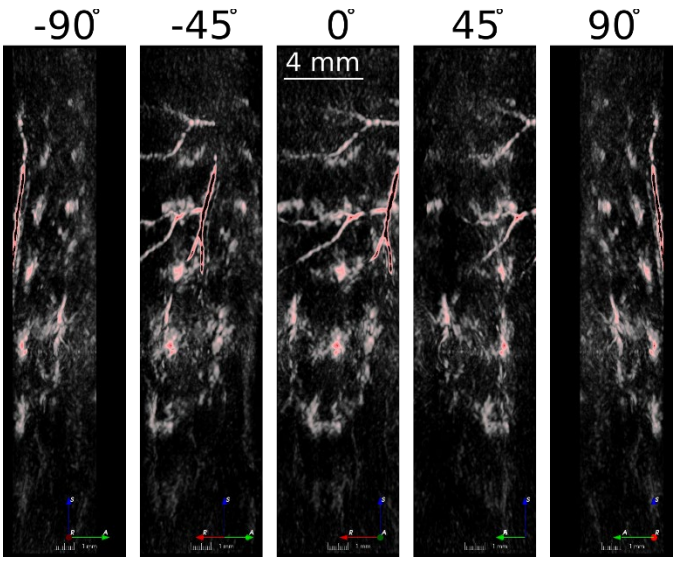

Figure 5: 3D rendering of the PAT volume. Red colormap indicates high PA amplitude, white indicates medium PA amplitude, black indicates low PA amplitude. Five views are displayed in 45° rotation steps.

The 3D rendered images in Figure 5 prominently show the vertebra of the mouse whereas the spinal cord is visible at lower constrast.

References

[1] Steinberg, Idan et al. "Photoacoustic clinical imaging." *Photoacoustics* vol. 14 77-98. 8 Jun. 2019, doi:10.1016/j.pacs.2019.05.001

[2] Minghua Xu and L. V. Wang, "Time-domain reconstruction for thermoacoustic tomography in a spherical geometry," in *IEEE Transactions on Medical Imaging*, vol. 21, no. 7, pp. 814-822, July 2002, doi: 10.1109/TMI.2002.801176.

[3] Ruberte, Jesus, et al. *Morphological Mouse Phenotyping: Anatomy, Histology and Imaging*. Elsevier/Academic Press, 2017.