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Synchrotron-based 4D-X-ray Phase Tomography of fresh chordae tendineae of mitral valve

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Background: Mechanical properties of chordae tendineae of mitral valve (MV) are still not fully investigated. Synchrotron-based X-ray phase tomography (XPCT) is a powerful tool to measure biological soft tissues. Recently, we have developed dynamic X-ray phase tomography (4D-XPCT) to discuss the dynamic phenomena of biological samples quantitatively and applied to chordae tendineae of MV (MVCT).

Purpose: This study evaluated 4-dimensional changes of MVCT and clarified structural changes of MVCT during cardiac cycles.

Methods: The X-ray energy for 4D XPCT was set to 20keV. The effective pixel size was 7.8 μ m. Fresh MVCT extracted from a pig heart were measured in the specially designed container filled with normal cold saline. MVCT installed on the sample stage was stretched and released with a continuous oscillation of 0.5Hz during a phase tomographic measurement. The amount of stretch was 400 μ m where a mechanical load caused by stretching was approximately 1N. In this measurement, projection images

were acquired with a frame rate of 20Hz during a single sawtooth wave. Therefore, apparent frame rate of 20Hz is expected in 4D phase tomography. Cross section was determined by simple thresholding based on the density. In this case, the threshold was set to 1.018g/cm³.

Results: X-ray phase tomographic images of MVCT at the released (A) and stretched (B) conditions are shown in Fig. 1a. The load applied to the sample and change of the cross section obtained from tomography during stretching and releasing are shown in Fig. 1b and 1c, respectively. The diameter of chordae tendineae were changed approximately 2.5% during stretching and returned to initial diameter during releasing.

Conclusions: This result demonstrated that the 4D-XPCT had a capability to trace the detail of deformation process in the biological soft tissues during continuous oscillation. Even chordae tendineae are mainly consisted of collagen fibers, diameter of the chordae was changed according to stretching and releasing.

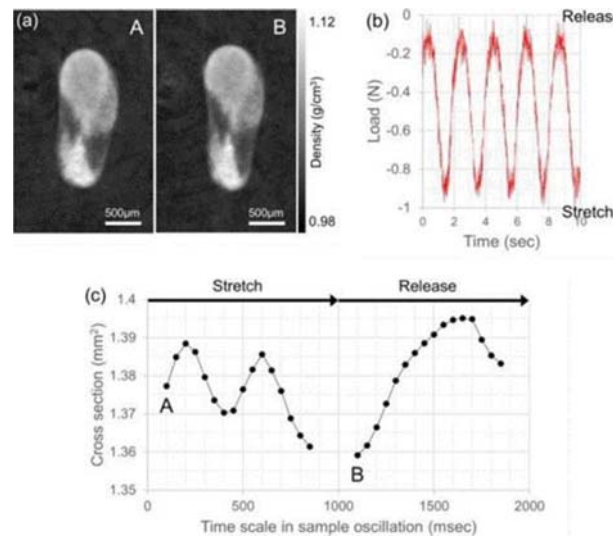


Figure 1