Tissue Scaffolds Characterization Using Synchrotron Radiation Micro-Computed Tomography with Helical Acquisition Mode

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Introduction

In the field of tissue engineering, hydrogel scaffolds have gained significant attention due to their unique properties, due to their unique properties. Accurate imaging techniques are essential for studying the internal structure and properties of these scaffolds. Hydrogel scaffolds have very low density and synchrotron radiation micro-computed tomography (SR-μCT) shows high contrast with three-dimensional and non-invasive characterization [1].

Despite many advantages, SR-μCT image quality for hydrogel still needs to be improved due to common ring artifacts resulted from systematic errors or defects on the scintillator, monochromator, or filters. Such artifacts usually reduce the accuracy when visualizing and charactering samples. Methods have been developed to reduce the ring artifacts, e.g., low-pass filtering algorithm, but these approaches suffer from limitations. This work integrates SR-μCT with the helical acquisition mode (SR-μHCT) to avoid the ring artifacts issues. SR-μHCT involves two motions, a horizontal rotation and a vertical motion which can spread the intensity of ring artifacts over larger regions in the vertical direction, therefore reducing the effects of artifacts.

Materials and Methods

4% w/v alginate were printed to scaffolds (dimension: 2 × 2 × 10 mm^3) with the needle's diameter of 100 μm. After 15-minute cross-linking, the alginate scaffolds were inserted into PCL tubes which can provide mechanical support [2]. The assembled conduits later were implanted into injured sciatic nerve of Sprague−Dawley rats. Euthanasia was conducted 2 days after surgery and the whole hindlimb was collected and was fixed with formalin for imaging (*ex vivo*).

The SR-μHCT imaging were performed at the BMIT-ID beamline, Canadian Light Source (CLS), Canada. All scans were performed at sample-to-detector distance of 1.5 m, photon energy of 30 keV, helical pitch of 1.5, and the pixel size of 13 μm.

Results and Discussion

Fig. 1 shows image quality comparisons of *ex vivo* scaffolds sample with SR-μCT and SR-μHCT. While SR-μCT exhibits adequate image contrast, it is susceptible to ring artifacts that affect the overall quality. Although these artifacts can be mitigated using a low-pass filtering method, it leads to the introduction of additional ring-like shadows. On the other hand, SR-μHCT effectively minimizes ring artifacts without introducing any further distortions or artifacts. Quantitative evaluation index, contrast-to-noise ratio (CNR) and signal-to-noise ratio (SNR) were also measured. These results illustrate a higher characterization accuracy of SR-μHCT compared with SR-μCT, which is essential for following quantitative analysis, e.g., segmentation.

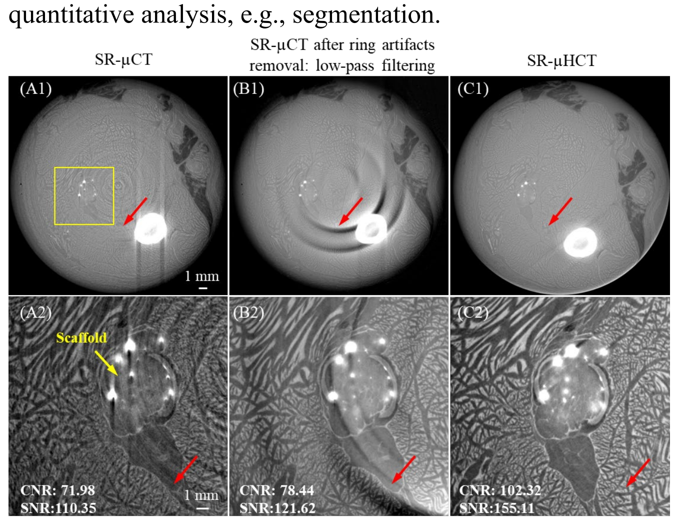

Fig. 1 *Ex vivo* hydrogel scaffolds imaging with SR-μCT and SR-μHCT; (A1-C1) SR-μCT image, SR-μCT image processed by a ring artifacts removal algorithm, and SR-μHCT image. (A2-C2) Corresponding enlarged regions of interest at positions indicated by yellow rectangular.

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References

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