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Clinical Studies : Images in Nephrology

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Label-free Serial Optical Coherence Tomography for Volumetric Visualization of Kidney Structure

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Background: One of chronic renal diseases, Ureter Obstruction (UO), occurs due to the blockage of the flow of urine out of the body, which mainly induce a progressive process of renal tubulo-interstitial fibrosis by increasing the production of extracellular matrix. It brings about severe loss in renal function over a period of time. Thus far, the principal method to research whether the damage in microcirculation occurred has been mainly proceeded by physiological analytic technique. However, there has been no optimal imaging tool to quantify the morphological change of inner-structure of progressive UUO model. In this study, we developed the serial sectioning Optical Coherence Tomography which offers high resolution, cross-sectional tissue structure similar to histology, non-invasively. Since OCT uses the back scattering signal from tissue, it does not require any labeling technique. OCT delivers high contrast to blood vessel network, while visualizing micro renal structure up to resolution of 10um. Our system is based on the spectral domain OCT at 1310 nm central wavelength having 70 nm full width half maximum. Our results shows stronger visualization and quantification of whole empty parts which cannot be provided from existing imaging tool mentioned above. Through this experiment, it is expected that our imaging system would be used as a versatile tool for implication and quantification of renal disease pathology.

Methods: Male C57BL/6 mice aged 8 weeks were used for experiment. To develop the mice UUO model, the ureter was ligated to the kidney with 5-0 black silk. Mice were sacrificed. Spectral Domain OCT system used for this study was supported by the center wavelength of 1310 nm and full-width-at-half-maximum of 75 nm. The sample unit achieves both axial resolution and lateral resolution of 10um each, and field of view (FOV) of 8 × 8 mm².

Results: By combining optical coherence tomography with serial sectioning technique, we were able to reconstruct the entire kidney structure in high resolution of 10um in lateral and axial both. Quantitatively computed volume of each kidney portion of whole structure and empty hole in each day of UO has been demonstrated as a hall maker to analyze the stage of UO.

Conclusion: In this study, we show some new approaches to renal fibrosis that have been known as major causes to elucidate its pathogenesis. In order to evaluate the possibility as a tool for kidney study, we prepared kidney samples subjected to urinary obstruction, and obtained the images of volumetric structure. Accordingly, we have demonstrated a new method enabling to investigate suspicious area in the kidney to make sure if the uriniferous tubules around cortex got injured by urinary obstruction. Through this experiment, it is expected

that our imaging system would be used as a versatile tool for implication and quantification of renal disease pathology.

Keywords: CKD (Chronic Kidney Disease), High-resolution imaging, SD-OCT