超音波援用ドップラーＯＣＴを用いた
再生組織の力学特性マイクロ断層可視化システム

Micro-tomographic Visualizing System of Mechanical Properties inside Regenerated Tissue using UA-OCDV

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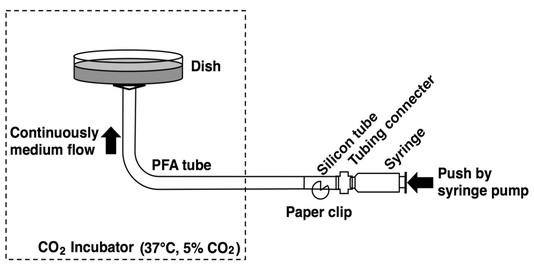
Introduction

Recently, the regenerative therapy of skin tissue and osteoarthritic cartilage has attracted attention due to clinical transplantation of autologous cultured tissue. However, a non-contact and invasive diagnosing method of **bio-mechanical functions**, e.g. **viscosity** and **elasticity**, has never been established yet. It is quite necessary to improve a non-contactly and tomographically quantitative measurement of functional characteristics every time the culture processing of regenerated tissue.

Autologous Cultured Cartilage



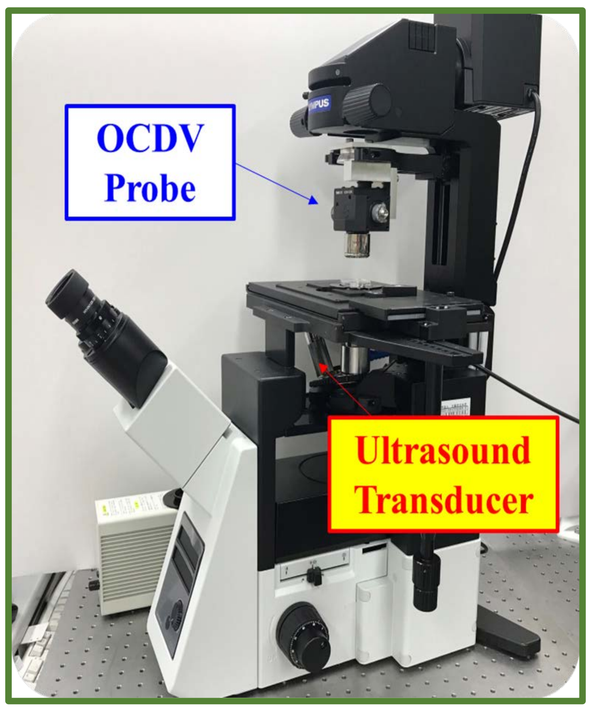
Dermal skin equivalent by Perfusion culture

Objectives of this study

The purpose of this study is to construct and validate **Ultrasonic-assisted Doppler OCT** system (**UA-OCDV**), which can provide **viscoelastic characteristics inside tissue tomographically and NON-CONTACTLY** using a high intensity focused ultrasound transducer as a loading devise.

Experiment & Method

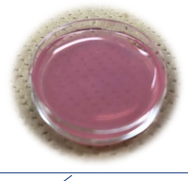
UA-OCDV = Acoustic Radiation Pressure + Doppler OCT (OCDV)

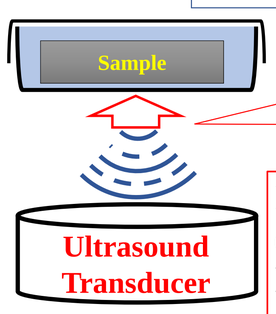


Acoustic Radiation Pressure

Sample: Dermal skin equivalent
- Control tissue
- Hyaluronidase digested tissue (0.5 [H])

Culture condition
- Collagen coated dish
- Culture period : 3days

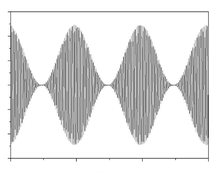




Acoustic radiation pressure is generated at the boundary of different acoustic impedance.

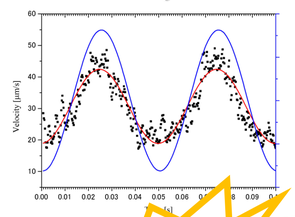
Non-invasive diagnosis of mechanical function can be completed by introducing a non-contact loading devise of a high intensity focused ultrasound transducer

Pressure Modulation of Acoustic radiation



Driving condition
- Central frequency : 1 [MHz]
- Modulated Frequency : 20 [Hz]
- Amplitude : 30 [Vp-p]
- Sinusoidal modulation

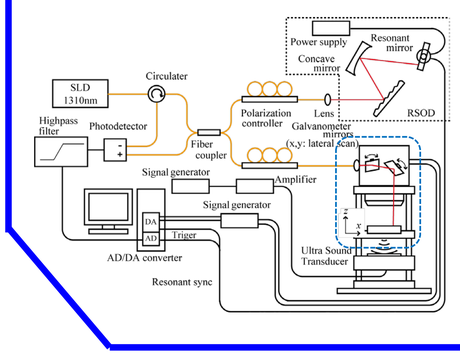
Phase analysis method



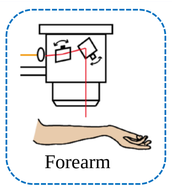
The **phase difference** between the acoustic radiation pressure and flow velocity can be calculated by nonlinear least square method .

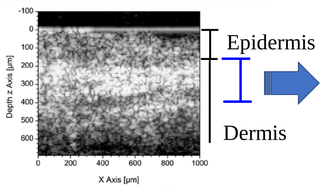
Plus

Doppler OCT (OCDV)



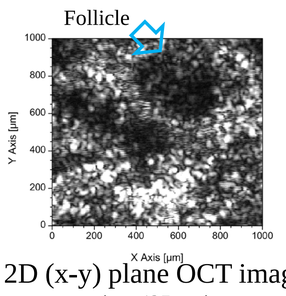
OCDV can visualize a micro-tomographic imaging of blood flow velocity of capillary vessels inside skin.



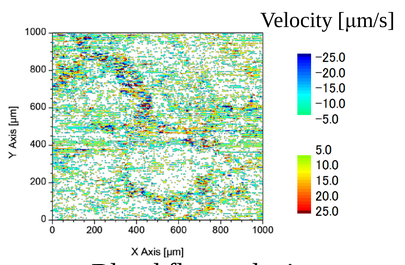


Cross-sectional image of human forearm

OCDV system was *in vivo* applied to forearm



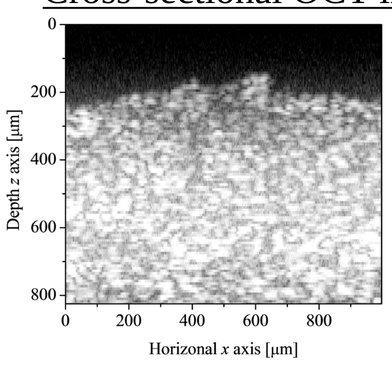
2D (x-y) plane OCT image
(z = 435 μm)

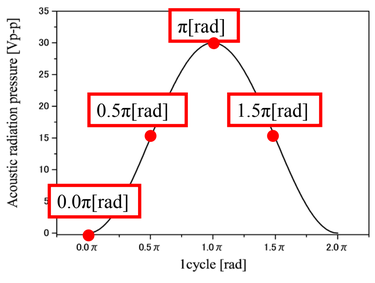


Blood flow velocity
(Maximum velocity map: z= 112.5～435 μm)

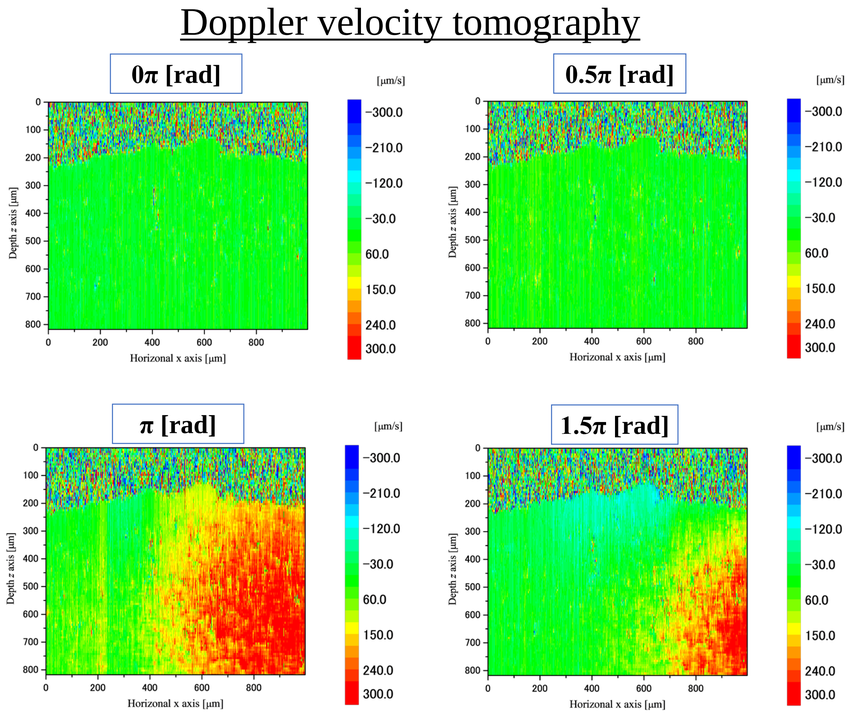
Result & Discussion

Cross-sectional OCT image



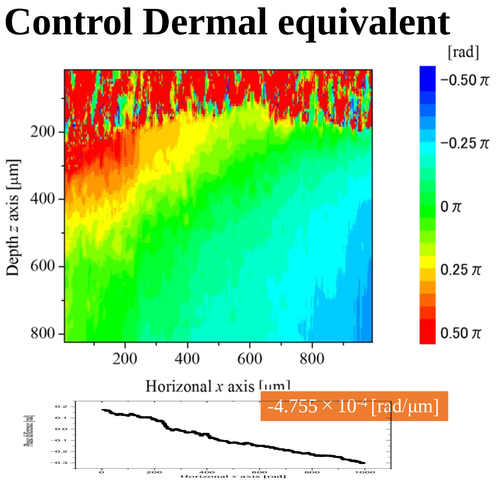


Doppler velocity tomography

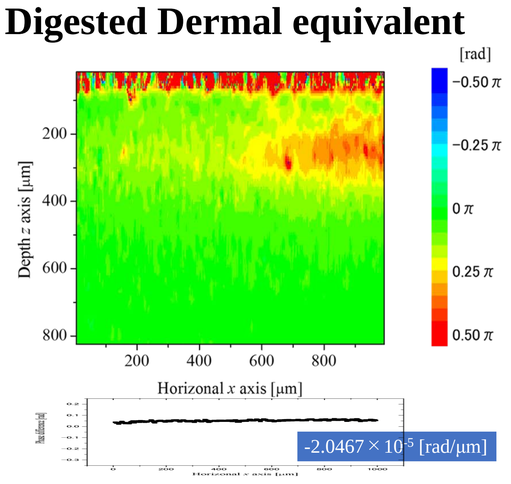


Cross-sectional color map of phase difference

Control Dermal equivalent



Digested Dermal equivalent



- ☑ **Diagnosis in microscale**
- ☑ **Tomographic diagnosis**
- ☑ **Non-invasive**
- ☑ **Non-contact**
- ☑ **Mechanical properties evaluation**

Conclusion

The cross-sectional color map of phase difference between the acoustic radiation pressure and flow velocity can be visualized by UA-OCDV. The phase gradient can discriminate the local degradation of regenerated tissue under culture processing. Consequently, It was proven that UA-OCDV was an effectively diagnostic method as a non-contact assessment of permeability and tissue visco-elasticity.