High Frequency Ultrasound and Dual-Wavelength Photoacoustic Imaging of Skin – Comparison between Images Obtained with Single Concave Transducer and Annular Array Transducer

Yoshifumi Saijo[1], Taiichiro Ida[2], Hideaki Iwazaki[2], Shin-Ichiro Umemura[1], Jeffrey Ketterling[3], [1]Tohoku University, Sendai, Japan, [2]Advantest Corporation, Kazo, Japan, [3]Riverside Research, New York, USA

Background, Motivation and Objective

Skin aging has been drawing increasing attention in the aging societies. Besides the classical features of skin aging such as color, wrinkle and flexibility, skin vasculature is proposed as a novel biomarker. The volume, diameter and branching of the micro-vessels have shown close relationship to skin aging. In the present study, high frequency ultrasound microscope (HFUS) combined with dual-wavelength photoacoustic microscope (PAM) is developed to visualize both micro structure and vasculature of skin. Improvement of the image quality of the HFUS-PAM system by adoption of 4-ch annular array transducer is also discussed.

Statement of Contribution/Methods

Two Nd:YAG laser light sources with the wavelength of 532/556 nm, pulse width of 1.2/3.6 ns, pulse energy of 16 μJ/pulse and repetition rate of 1 kHz were equipped in the HFUS-PAM system. The optical fiber for laser irradiation was inserted through the center hole of the ultrasound transducer. The transducer was scanned by voice coil actuators to obtain 3D dataset of HFUS and PA signals. Two kinds of transducer were compared. One was P(VDF-TrFE) concave transducer with the central frequency of 80 MHz and the other was LN-composite 4-ch annular array transducer with the central frequency of 60 MHz. Human skin of 6.0 x 6.0 mm area in volunteers was visualized by the HFUS-PAM system with 30-μm scan step. The study was approved by the Institutional Review Board of Graduate School of Engineering, Tohoku University.

Results/Discussion

3D data sets of both HFUS and PAM were obtained in 70 sec. Skin micro structures such as hair follicle, sebaceous gland were clearly visualized by HFUS. Skin vasculature representing the oxygen saturation with the horizontal resolution of 24 μm was obtained by PAM. Figure shows the comparison of PAM images obtained with the 4-ch annular array transducer and the single concave transducer. The focus of the single concave transducer was set at 0.5 mm beneath the skin surface. The image quality of the en face view of PAM images at 0.5 mm depth is similar in the images with two transducers but image with the annular array transducer shows better image quality at 0.1 mm and 0.9 mm depth. HFUS-PAM with 4-ch annular array transducer will provide important information of skin morphology and microcirculation for assessment of skin aging.

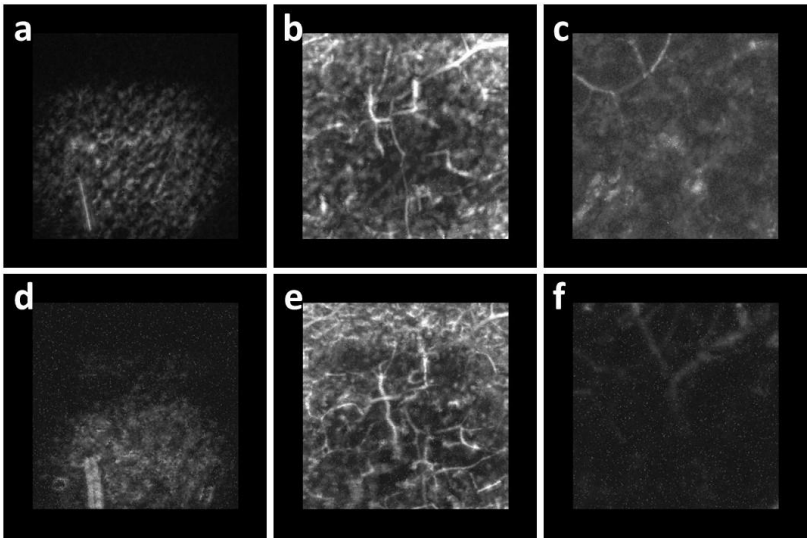

Figure. Comparison of PAM images obtained with 4-ch annular array at (a) 0.1 mm, (b) 0.5mm and (c) 0.9 mm, and single concave transducer at (d) 0.1 mm (e) 0.5 mm and (f) 0.9 mm imaging depth.