HIGH FREQUENCY SONOGRAPHY FOR CHARACTERIZING INDIVIDUAL TISSUE IN PULLEY SYSTEM

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INTRODUCTION
Trigger finger is one of the most common complaints in a hand surgeon’s clinics. It was characterized by loss of normal gliding between tendon and pulley even with popping sensation or painful locking [1]. Sonography has been widely used to evaluate and diagnose the trigger finger for years by measuring the thickness and echogenicity of the A1 pulley, tendon thickness, fluid collection and other related parameters [2,3,4]. It also was used to assist release of A1 pulley [5]. For an average thickness of normal pulley around 0.5 mm, the resolution of clinical ultrasound scanners (frequency: 12 ~ 17 MHz) is inadequate to sensitively differentiate the complexity of tissues in the pulley system. Recently, ultrasounds with frequencies higher than 20 MHz have been used to measure the skin, the eye, and vasculature…etc. It can provide more detailed information and make imaging of soft tissues readily, so ultrasound signals can be utilized to further characterize properties of soft tissues quantitatively [6]. It is crucial to verify the quantitative acoustic properties of normal pulley system prior to they are further applied to clinical diagnosis. In this study, we used 31 MHz high-frequency ultrasound images incorporated with ultrasonic parameters to characterize the A1 pulley and adjacent soft tissues.

MATERIALS & METHODS
Normal A1 pulley, subcutaneous fat, and superficial flexor tendon (FDS) were individually harvested for in vitro experiments from 8 cadaveric hands. Those tissues were fixed on a custom-made plexiglass plate and placed in a saline tank. Then, the backscattering and attenuation properties of tissues were measured using 31 MHz ultrasound. Then ultrasonic parameters for analysis included the attenuation of saline solution and tissues were measured for compensating losses of echo signals associated with high-frequency ultrasound. Besides, the integrated backscatter (IB) and Nakagami parameter (m) were calculated offline from ultrasonic signals backscattered from the tissues.

RESULTS & DISCUSSiON
In this study, the textures of these B-mode images (individually from normal A1 pulley, adjacent subcutaneous fat and FDS) provide better resolution than clinical ultrasound. Furthermore, the linear regression of attenuation slope, integrated backscatter (IB) and Nakagami parameter (m) of subcutaneous fat, A1 pulley, and FDS were calculated. A1 pulley and FDS have a similar tendency of attenuation slopes due to these tissues consisted of collagen fibers. The IB values of the A1 pulleys and FDS were much larger than that of the subcutaneous fat. It demonstrated marked material property difference between hard and loose tissue. The m of FDS was much smaller than 1 indicating that the probability density function (PDF) of corresponding backscattering envelope to be pre-Rayleigh distributed. Although the main contents of A1 pulley and FDS are collagen fibers, the m of A1 pulleys was larger than that of FDS. This could be resulted from the orientation of collagen fibers in A1 pulley is perpendicular to those of in FDS. Overall, the conjunction of IB and m is feasible for differentiating the annular pulley, subcutaneous fat, and FDS.

CONCLUSIONS
The high-frequency ultrasound system with 31 MHz central frequency was developed and was applied to acquire B-mode images, to measure ultrasonic backscattered signals and ultrasonic parameters. These images have shown to provide a sufficient resolution for differentiating variations among each tissue structure. This study has demonstrated that high-frequency ultrasound image in conjunction with ultrasonic parameters are able to characterize the A1 pulley and surrounding tissues for further diagnosis on the syndrome of trigger finger.

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REFERENCES