Ultrasound transmission through human hair

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Background, Motivation and Objective

Therapeutic transcranial focused ultrasound (TcFUS) protocols include patient's head shaving to facilitate the transducer acoustic coupling. However, little is known to what degree ultrasound (US) transmission is affected by the hair presence. Avoiding hair shaving could improve patient's comfort and potential psychological burden, especially during repeated sessions. In this study, we investigated the influence of the acoustic frequency and the level of dissolved oxygen (O_2) in the coupling medium on the ultrasound transmission through the human hair.

Statement of Contribution/Methods

Strands of different types of human hair were immersed in a non-degassed water bath. Then, the acoustic transmission factor through the hair was consecutively measured using a broadband transducer centered at 600kHz and a hydrophone while the dissolved O_2 level was gradually decreased from values above 90% to levels lower than 15%. Seventeen measurement points were defined along the degassing procedure. For each degassing water level, the transmission factors for frequencies ranging from 300kHz to 1MHz were measured with a 25kHz-step. Pressure measurements in free water (no hair) were used as reference.

Results/Discussion

Pressure measurements in free water were found independent of the degassing level. At the beginning of the experiments, millimeter-sized bubbles were trapped in the hair and progressively disappeared as the water bath was degassed. Samples with initial 0_2 level above 90% presented US transmission between 0.25 and 0.40 according to the frequency. The degassing of samples to levels lower than 15% increased US transmission factor, leading to values between 0.65 and 0.90 according to the frequency. At high 0_2 levels, increasing the frequency was associated with a rise of US transmission whereas the opposite trend was observed for lower O_2 levels. The transmission loss could be explained by the US reflection caused by large bubbles trapped in the hair as it was more affected at lower frequencies. A reasonable transmission factor through the hair (up to 0.9) was reached for sufficient degassing water levels (<15%). This study demonstrates that TcFUS treatments could be achieved without head shaving with a compensation of ultrasound power.

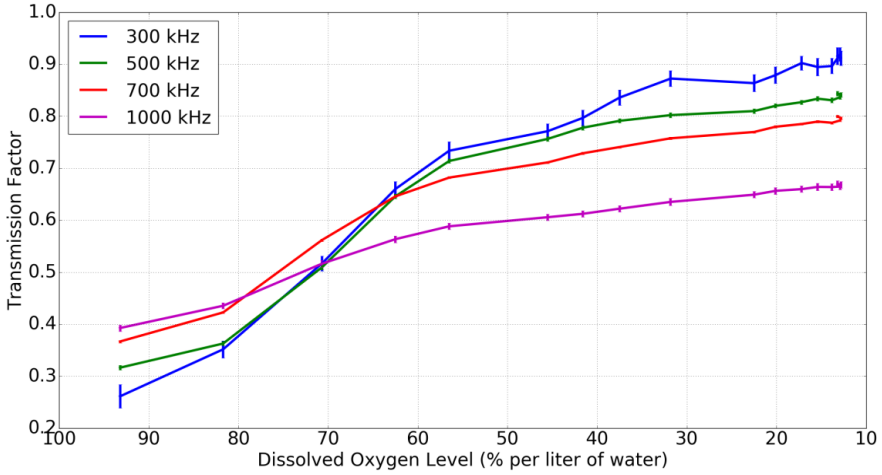

Fig.1 Acoustic transmission factors through one hair sample as a function of dissolved oxygen level and frequency