Transcranial brain therapy

Transcranial brain therapy has recently emerged as a non-invasive strategy for the treatment of various neurological diseases, such as essential tremor or neurogenic pain. However, treatments require millimetre-scale accuracy. The use of high frequencies (typically ≥1 MHz) decreases the ultrasonic wavelength to the millimetre scale, thereby increasing the clinical accuracy and lowering the probability of cavitation, which improves the safety of the technique compared with the use of low-frequency devices that operate at 220 kHz. Nevertheless, the skull produces greater distortions of high-frequency waves relative to low-frequency waves. High-frequency waves require high-performance adaptive focusing techniques, based on modelling the wave propagation through the skull. This study sought to optimise the acoustical modelling of the skull based on computed tomography (CT) for a 1 MHz clinical brain therapy system. The best model tested in this article corresponded to a maximum speed of sound of 4000 m.s-1 in the skull bone, and it restored 86% of the optimal pressure amplitude on average in a collection of six human skulls. Compared with uncorrected focusing, the optimised non-invasive correction led to an average increase of 99% in the maximum pressure amplitude around the target and an average decrease of 48% in the distance between the peak pressure and the selected target. The attenuation through the skulls was also assessed within the bandwidth of the transducers, and it was found to vary in the range of 10 ± 3 dB at 800 kHz and 16 ± 3 dB at 1.3 MHz [1].

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Marsac L, Chauvet D, La Greca R, Boch AL, Chaumoitre K, Tanter M, Aubry JF. Ex vivo optimisation of a heterogeneous speed of sound model of the human skull for non-invasive transcranial focused ultrasound at 1 MHz. Int J Hyperthermia. 2017 Sep;33(6):635-645. doi: 10.1080/02656736.2017.1295322. Epub 2017 Mar 7. PubMed PMID: 28540778.