

Focused Ultrasound for Functional Neurosurgery

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Historically, the first reported investigations into the use of focused ultrasound were performed by John G Lynn and Tracy J. Putnam in 1942. In early 1950, Lars Leksell designed a specially adapted frame and ultrasound transducer for the purpose of high intensity focused ultrasound. However, the major limitation for Leksell in treating human patients were the accuracy in targeting deep seated structures and the needs for a craniotomy. The major revolution in the development of modern focused ultrasound surgery came with the development of phased arrays of ultrasound transducers and the improvements in MRI.

Magnetic resonance image-guided focused ultrasound surgery (MRgFUS) has surfaced as a viable noninvasive image-guided therapeutic method that integrates focused ultrasound (FUS), the therapeutic component, with magnetic resonance imaging (MRI), the image guidance module, into a real-time therapy delivery system with closed-loop control of energy delivery. The main applications for MRgFUS of the brain are thermal ablations for brain tumors and functional neurosurgery, and nonthermal, nonablative uses for disruption of the blood brain barrier (BBB) or blood clot and hematoma dissolution by liquification. The disruption of the BBB by MRgFUS can be used for targeted delivery of chemotherapy and other therapeutic agents. MRI is used preoperatively for target definition and treatment planning, intraoperatively for procedure monitoring and control, and postoperatively for validating treatment success. Although challenges still remain, this integrated noninvasive therapy delivery system is anticipated to change current treatment paradigms in neurosurgery and the clinical neurosciences.

Recently, transcranial MRgFUS was introduced in Korea, and we have treated two patients with medically refractory essential tremor by using MRgFUS. Following the patients' focused ultrasound, the patient's hand became steady enough to resume every day activities, and the efficacy seemed to be better than previous neurosurgical treatment for medically refractory essential tremor.

Although challenges remain, high intensity focused ultrasound-mediated neurosurgery may offer the ability to target and treat central nervous system conditions that were previously extremely difficult to address.

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