Subject to alterations in specifications and other technical information. 06/2022.

COLD LASER ABLATION FOR NON-CONTACT CRANIOTOMY DURING AWAKE SURGERY

Task

Recent successes in the therapy of movement disorders – e.g. in Parkinson's patients, as well as in the resection of tumors in eloquent regions of the brain – improve patients' quality of life and increase their survival rate. In these surgical procedures the skull must be opened while the patient is awake so that complex brain functions can be checked during the operation. During this procedure, the skull is opened mechanically with a drill or a burr, which causes extreme psychological stress in the affected patients.

Method

To reduce this stress, Fraunhofer ILT is developing an efficient and safe laser cutting process to replace conventional surgical drills and milling cutters. This cutting process features inline monitoring of the residual bone thickness based on optical coherence tomography (OCT). This real-time monitoring allows the laser process to be controlled and makes it impossible for the system to injure the brain tissue lying beneath the skull bone. The ablation is performed with a Q-switched CO_2 laser at repetition rates between 20 and 100 kHz. A water spray system ensures continuous wetting of the bone surface and thus prevents the bone from drying out during the cutting process. This guarantees that the hard tissue is removed efficiently and is free of carbonization.

Results

In laboratory experiments, parameter studies on the cutting process were carried out on bovine bone samples. A maximum removal rate of more than 5 mm³/s was achieved at a cutting width of 2 mm and a cutting depth of 3.7 mm. A maximum cutting depth of 7 mm was achieved with a cutting width of 2 mm. Defined residual bone thicknesses between 50 and 350 µm have been reliably measured with the OCT system while the bone surface was wetted.

Applications

Applications for laser craniotomy are stereotactic implantations of electrodes for deep brain stimulation for the treatment of complex movement disorders. Other applications include craniotomies on awake patients for removal of low-grade gliomas (brain tumors) in eloquent regions of the brain. Here, awake surgery assists operating doctors in making the crucial distinction between malignant and functional tissue.

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1 Laser cutting process on bone with Q-switched CO_2 laser.

2 Laser sections on a bovine bone specimen.

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