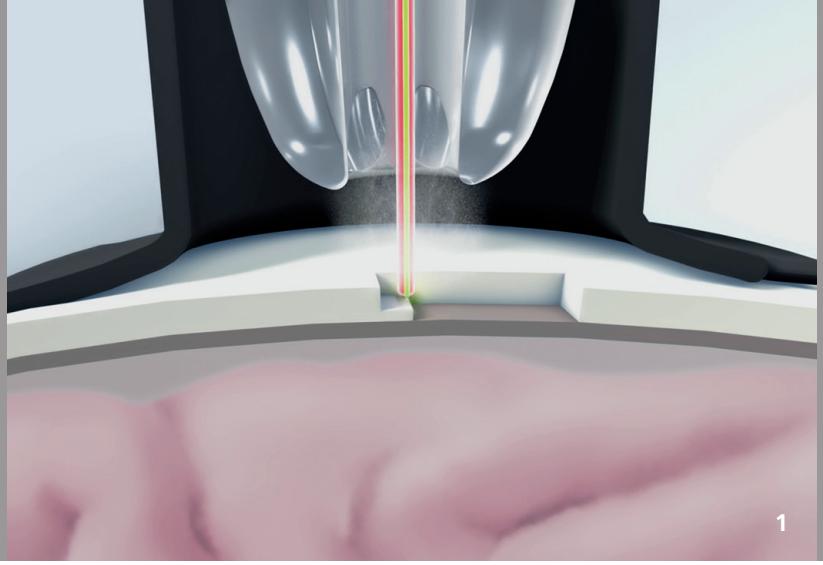

LASER OSTEOTOME FOR AWAKE BRAIN SURGERY

Task

For neurosurgery, researchers have developed novel therapeutic methods that not only significantly improve the quality of life, but also the survival rate of critically ill patients. These methods require, however, that the patient be operated on while awake since complex functions such as speech must be tested during awake brain surgery, yet removing bone from the skull with drills and burrs causes the patient extreme stress. For this reason, a laser osteotome is being developed at Fraunhofer ILT in close collaboration with experts in neurosurgery. This laser osteotome can be used to open the skull bone without vibration or noise, thus significantly reducing the psychological stress as well as the risk of injury for the patient.

Method

For a safe, vibration-free and low-noise ablation process, the drill and cutter are replaced by a MIR (Mid-Infrared) laser beam source, which emits nanosecond pulses with pulse energies in the millijoule range. To ensure that the cutting process is efficient and does not cause any thermal tissue damage, the laser pulses with kilohertz frequencies must be distributed along the cutting line in such a way that a continuous deep kerf is created. This cutting function is made possible by an applicator with an integrated 2D mini-scanner for beam guidance, focusing optics with adjustable focus position and a spray nozzle for wetting the bone surface. Synchronized with the cutting process, an OCT (optical coherence tomography) measuring beam determines the local cutting depth and residual thickness of the bone to control and stop the cutting process shortly before the bone is cut through. In this way, the cutting depth control protects the structures of the brain located under the skull bone.

Results

Process parameters for an efficient laser cutting process were determined in systematic ablation experiments on bovine bone samples. The ablation rates achieved were above $dV/dt = 4\ mm^3/s$. The maximum cutting depth was 7 mm with a cutting width of 2 mm. In addition, Fraunhofer ILT has developed a digital model of the laser osteotome, which can be used to simulate the entire operation sequence and develop a hardware control system.

Applications

Fields of application for the laser osteotome are awake operations for the treatment of complex movement disorders. Awake operations are also becoming increasingly important in the surgical treatment of low-grade gliomas (brain tumors).

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1 Applicator for implementing the laser cutting process on the skull bone.
2 Laser cut on a bovine bone with an aspect ratio of 16:1.