Er:YAG laser

An Er: YAG laser (erbium-doped yttrium aluminium garnet laser, erbium YAG laser) is a solid-state laser whose active laser medium is erbium-doped yttrium aluminium garnet (Er:Y3Al5O12). Er: YAG lasers typically emit light with a wavelength of 2940 nm, which is infrared light.

Erbium:yttrium-aluminum-garnet (Er:YAG) laser ablation can effectively resect water-bearing tissues. Application of Er:YAG resection in neurosurgery is complicated by unpredictable bleeding in the surgical field. An integrated theranostics system combining a dual-wavelength laser surgery system using a thulium (Tm) fiber-laser for coagulation and Er:YAG for resection, combined with optical coherence tomography (OCT) guidance was demonstrated for the in vivo resection of tumor tissue. However, lateral thermal spread in the range of 100 seconds of micrometers is common due to a lack of vascular specificity using a Tm fiber-laser for coagulation. In a study, a vascular-specific ytterbium (Yb) fiber laser is utilized for enhanced photocoagulation during in vivo neurosurgery improving the precision of Er:YAG tissue resection with minimal lateral thermal spread.

Mice underwent stereotactic laser surgery with the proposed Yb/Er:YAG dual wavelength vascular specific neurosurgery in vivo. An OCT system (wavelength range 1310 ± 70 nm) and OCT derived angiography images were used to record cortical images to confirm the coagulation of blood vessels and guide subsequent Er:YAG resection steps. After the laser surgery, mice were killed, and histological analysis was carried out using hematoxylin and eosin staining and Nissl staining to compare the lateral thermal spread with our previously reported Tm/Er:YAG neurosurgery where a continuous wave Tm fiber-laser was used for coagulation.

A coagulation scheme using a Yb fiber-laser allowed stoppage of blood flow in disparately sized blood vessels encountered in the mice brain. Histological analysis of murine brain slices post Yb/Er:YAG laser surgery yielded lower thermal spread compared with Tm/Er:YAG laser surgery, maximizing the efficiency in both hemostasis (blood flow stoppage) and maximizing tissue ablation efficiency with minimal residual thermal damage zone.

Katta et al. from the Beckman Laser Institute, the University of California at Irvine, East Irvine, California, and Department of Biomedical Engineering, the University of Texas at Austin, Texas, USA presented a vascular-specific coagulation scheme with Yb/Er:YAG dual-wavelength surgery for neurosurgery. Additionally, Yb/Er:YAG study results are compared with that of a tissue coagulation approach in Tm/Er:YAG surgery previously reported to highlight improved coagulation, reduced nonspecific thermal damage, and limited lateral thermal spread. Experimental results suggest that the developed dual-wavelength laser system can effectively resect neural tissues with high localization, and minimal lateral thermal spread at the micrometer level while maintaining a bloodless surgical field [1)].

Ha et al. created a total of 33 holes with an Er: YAG laser in human skull bones. They could demonstrate that the achievable radial tolerance concerning the guidance of a biopsy needle by a laser-created bone canal is within the range of the actual accuracy of a usual navigated device if the canal is at least 4 mm in length. Lateral mechanical loads applied to the biopsy needle had only a minor impact on the measurable radial tolerance. Furthermore, in contrast to mechanical drilling systems, laser technology enables the creation of bone canals at pointed angles to the skull bone

surface. The latter opens the perspective to sample biopsies in brain areas that are usually not or only hazardous to access [2].

1)
Katta N, Estrada AD, McElroy AB, Milner TE. Er:YAG laser brain surgery with vascular specific coagulation. Lasers Surg Med. 2022 Aug 10. doi: 10.1002/lsm.23591. Epub ahead of print. PMID: 35946396.
2)
Ha TT, Thieringer FM, Bammerlin M, Cordier D. High Precision Bone Cutting by Er: YAG Lasers Might Minimize the Invasiveness of Navigated Brain Biopsies. Front Oncol. 2022 Jan 3;11:690374. doi: 10.3389/fonc.2021.690374. PMID: 35047381; PMCID: PMC8762267.