Beaming Your Attention towards Lasers in ENT

OPMI® Application Tip #3

Every surgeon experiences situations in which he wishes to restore the natural function of an organ without contacting and injuring the surrounding tissue. This is one of the main reasons for the use of lasers as a surgical instrument in many different specialties of medicine.

Fig. 1: A laser micromanipulator integrated into the surgical microscope.

At low pulse energies, the laser allows surgery on very fine tissue structures. It is precisely for this reason that laser systems have been used in medicine for some time now. By integrating the surgical microscope into the laser platform, surgeons are able to effectively perform microsurgery on minute anatomical structures. The surgical microscope with a magnification of up to 20x allows laser surgery on fine, mobile structures such as the tympanic membrane or the ossicle, without injury to adjacent, healthy tissue.

About spot size

The active and aiming beams are delivered to the surgical field via a micromanipulator (Fig. 1). Today's state-of-the-art micromanipulators have minimum spot sizes of approximately 0.1 to 0.2 mm. To use the exact spot diameter for the respective application, there are some points to consider:

In laser treatment, the most important beam parameter is the power density at the treatment area (e.g., the applied laser energy divided by the area of the laser spot). This definition implies that when the spot diameter is reduced at the place of treatment, the laser pulse energy regime has to be reduced accordingly if a constant physiological effect is to be achieved.

The minimization of the pulse energy to an appropriate setting for the respective application is essential for the safety of the device. (CO_2 lasers may be equipped with a computer-assisted optical scanning system that helps to reduce tissue carbonization and thermal necrosis, since the laser beam is swept over the tissue area and dwells for a minimum duration on each tissue point.)

The microscope's focus has to correspond to the focus setting on the micromanipulator to obtain a laser spot aimed precisely on the working plane. This way, a maximum effect at the intended treatment area is obtained.

Mechanical attachment of the micromanipulator

The different micromanipulator models available today require specific attachment procedures to the microscope's body. The following recommendations are intended to facilitate an optimized solution in your individual case:

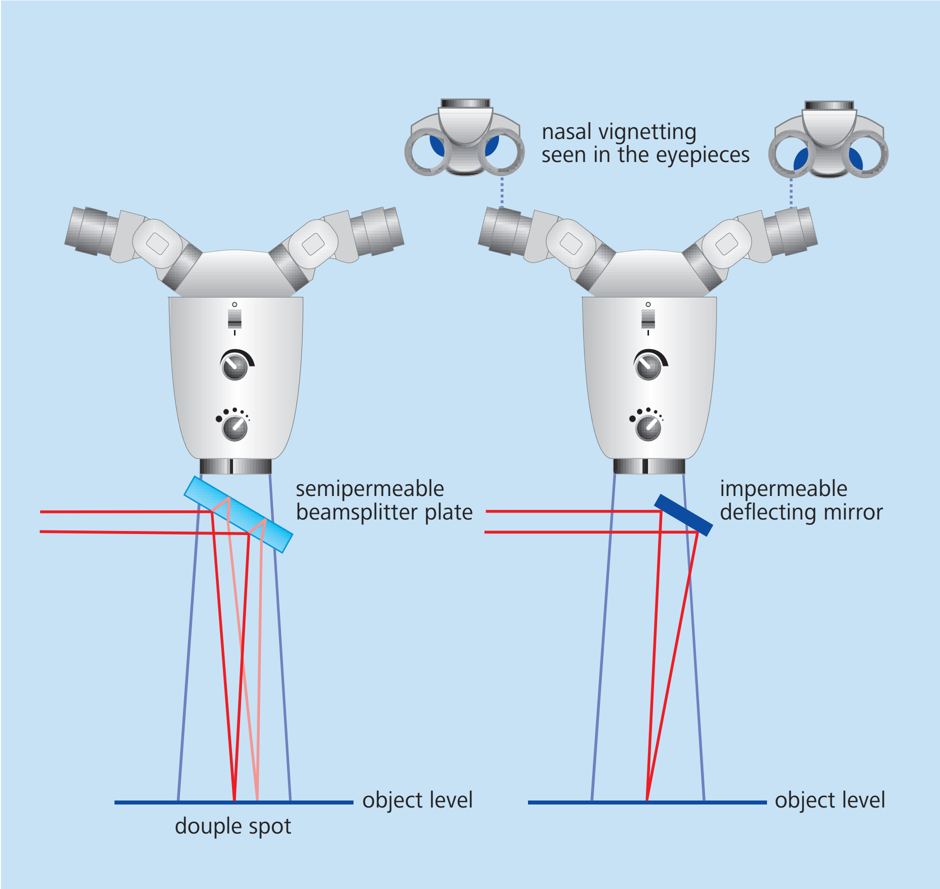

Fig. 2: Optical resctrictions when using the surgical microscope in combination with a laser micromanipulator. A double spot may be produced by the aiming beam when using a semipermeable beamsplitter plate (left). Nasal vignetting appears in the eyepieces when using an impermeable deflecting mirror (right).

• If the surgical microscope is equipped with a varioscope system, choose a micromanipulator that enables an adjustable working distance to avoid a deviation in the focal planes for both the laser and the microscope.

• If an adapter plate is required for mounting the micromanipulator to the microscope's body, please note that the plate's size might cause dimming of parts of the laser beam and the microscope's illumination path.

• Micromanipulators designed specifically for small objective lenses should not be used with surgical microscopes equipped with objective lenses of larger diameters (e.g., varioscope optics), since mechanical collision and optical dimming would otherwise occur.

Optical adjustment and restrictions

Before using a surgical microscope for laser applications, a check should be made to ensure that the working distance of the microscope corresponds to the working distance for the laser micromanipulator:

1. Before every surgical procedure, please check the correspondence of the two working distances for both the microscope and the laser micromanipulator by directing a trial laser shot at a wooden spatula located in the focal plane.

2. If the alignment is correct, the laser is focused precisely on the working plane with the active beam set at its maximum effect. The wooden spatula must be sharply focused in this position. If this

is not the case, the working distance has to be corrected by focus adjustment.
3. After correctly matching the two focal planes, the focal distance of the surgical microscope should not be changed to avoid an unfocused laser beam.
4. Since varioscope optics allows the surgeon to move the focal plane up and down, these changes have to be synchronized with the focal plane of the laser beam. However, if the micromanipulator is not able to adjust its focal length automatically to the focal length of the microscope, the varioscope mechanism needs to be deactivated. In this case, an external module (mounted between the microscope's housing and the suspension system) can be used for fine focusing by simultaneously moving the surgical microscope and the micromanipulator. This synchronized adjustment ensures that the microscope and micromanipulator remain focused on the same focal plane.

The focused laser spot is generated by firstly enlarging the beam through a system of lenses and consequently beaming it towards the target area through a deflecting mirror. This mirror can be finely adjusted using a joystick to allow the exact positioning and movement of the laser spot. Since the deflecting mirror is attached directly beneath the objective lens of the surgical microscope, some restrictions may occur (Fig. 2): If the deflecting mirror is designed as a semi-permeable beam splitter plate, a double spot of the aiming beam may appear at the target (due to a second reflection of the beam inside the plate adjacent to the intended reflection on its surface). In contrast, if the deflecting mirror is designed as an impermeable mirror, dimming is seen in a part of the eyepieces (known as nasal vignetting) and also on the video image, if attached, since a part of the mirror is located inside the visual beam path. In addition, it can lead to a visible reflection of the illumination light. However, the dimming disappears with higher magnification. Reducing the diameter of the spot illumination helps to minimize reflections.

Safety requirements

When working with a laser system in combination with the surgical microscope, it is important to remember a number of safety requirements:

1. The treating physician must wear appropriate laser safety eyewear (when working with a CO_2 laser system, the treating physician is protected by the lens system of the microscope, which completely absorbs any deflecting laser radiation).
2. The OR team has to wear appropriate laser safety eyewear during the entire procedure.
3. The patient's eyes must also be properly protected during the entire procedure.
4. All objects within the area in which there is a possibility of exceeding the allowed limits of laser irradiation (known as laser hazard area), including the floor, must have diffusely reflecting surfaces or be covered with diffusely reflecting material. For example, endotracheal tubes must be able to resist the laser radiation.
5. Explosive or easily inflammable materials, liquids or gases can ignite fires. Materials which might explode should not be kept in the laser hazard area. Inflammable drapes, surgical gowns, gauze or other flammable materials must be kept out of the beam path.

Despite these required laser safety principles, laser technology opens up new clinical application possibilities in ENT surgery, specifically in larynx surgery. The microscope integrated laser facilitates many procedures, or indeed makes them possible in the first place. In the field of ENT, among others, lasers are already used for endolaryngeal laser surgery or for laser surgical treatments within the ear such as stapedotomy or cochlear implantations. In particular, transoral laser surgery for laryngeal malignancies represents an important approach for the organ and function-preserving treatment of head and neck cancer. Beside these applications, others will continue to emerge in the future as laser technology and its integration into the surgical microscope are further refined.