Available online at www.sciencedirect.com
SCIENCE DIRECT®
Medical Laser Application 21 (2006) 45–51
Medical Laser Application
www.elsevier.de/mla

200µm glass fibres for minimally invasive laser procedures in paranasal sinus surgery

Justus Ilgner[a,*], Martin Wehner[b], Andreas Donner[c], Philip Düwel[a], Reinhart Poprawe[b], Martin Westhofen[a]

[a]Department of Otorhinolaryngology, Plastic Head and Neck Surgery, Aachen University RWTH, Pauwelsstrasse 30, 52057 Aachen, Germany
[b]Fraunhofer Institute for Lasertechnology (ILT), Steinbachstrasse 15, 52074 Aachen, Germany
[c]Institute of Pathology, Aachen University RWTH, Pauwelsstrasse 30, 52057 Aachen, Germany

Received 25 October 2005; accepted 17 November 2005

Abstract

Objective: To investigate the suitability and power capacity of thin (200 µm) quartz glass fibres in contrast to conventional fibres (400–600 µm) for laser resection of recurrent nasal polyps.

Material and methods: Different quartz glass laser fibres (200 µm, new; 200 µm, re-used and 600 µm, new) were coupled to a Neodymium:YAG laser emitting at 1064 nm in continuous wave (cw) mode. We compared the nominal power (W) with the actual output at the fibre tip by a laser power meter. We resected nasal polyps in patients using both 200 and 600 µm fibres with rigid and flexible applicators.

Results: For 200 µm fibres, power settings of 14 W resulted in carbonisation of the superficial cladding. The laser power measured at the fibre tip corresponded to the nominal settings for the new 200 and 600 µm fibres. Fifty percent power loss due to inhomogeneous beam geometry was recorded with the re-used fibre. Histology revealed a deeper coagulation zone for the 600 µm compared to the 200 µm fibre.

Conclusion: 200µm quartz glass fibres display reliable transmission properties for power settings up to 10 W in cw mode. Their greater flexibility reduces the risk of unnoticed power loss or fibre breakage at small bending radius.

Keywords: Lasers; Surgical procedures; Minimally invasive; Paranasal sinus diseases; Endoscopy; Nasal polyps

Introduction

The increasing demand for minimally invasive surgery in Otorhinolaryngology heralds a constant challenge for the development of purpose-built instruments and new operative techniques. Especially in areas which are difficult to access, laser technology can complement mechanical instruments for tissue resection and coagulation [1]. As flexible endoscopes with an outer diameter in the millimetre- and submillimetre range have entered clinical routine, laser technology has to focus on the safe transmission of laser energy to the target area. Laser fibres with an outer diameter of 400–600 µm offer a power transmission capacity of up to 60 W, depending on wavelength [2], but the transmission loss rises exponentially with decreasing bending radius. This applies for large diameter fibres in particular compared to small diameter fibres. In the same way the danger of

*Corresponding author. Tel.: +49 241 80 88946; fax: +49 241 80 82523.
E-mail address: jilgner@ukaachen.de (J. Ilgner).

1615-1615/$ - see front matter
doi:10.1016/j.mla.2005.11.001

fibre breakage is greater with large diameter fibres. Furthermore, the minimal bending radius of flexible endoscopes decreases markedly with the introduction of large diameter laser fibres [3]. While 200 µm glass fibres have been used predominantly with pulsed laser systems emitting within the visible light range or near infrared, ablative surgery with continuous wave (cw) laser systems can strain laser fibres to a much greater extent [1]. The motivation for this study was to determine the power capacity and transmission characteristics of 200 µm laser fibres compared to conventional 600 µm fibres and to compare their ablation and handling characteristics for endonasal sinus surgery.

Material and methods

We employed a neodymium:yttrium–aluminium–garnet (Nd:YAG) laser system (Dornier Medilas 5060N, Dornier GmbH, Germering, Germany) emitting at 1064 nm in cw mode at different power settings. As the laser operates in the near infrared, the system is complemented with a Helium:Neon (He:Ne) guide laser operating at 630 nm with 5 mW output power. 600µm laser bare fibres are supplied by the same manufacturer and are coupled to the laser system via a purpose-built connector. In comparison we employed a 200 µm bare fibre with a single cladding layer of 10 µm thickness (Distributor: Alpha-Card X, Düsseldorf, Germany), which was coupled to the laser system by means of a LuerLock®-system. In a third setting, we re-used a 200 µm bare fibre which was re-sterilised and separated from its used tip with a ceramic cutter. The actual laser power emitted at the fibre tip was picked up and measured by a laser power meter (Scientech 365, Scientech, Boulder CO, USA) with a round planar sensor area of 25.4 mm diameter (1 in) (Figs. 1 and 2). As the laser power increased, the distance from the fibre tip to the sensor area had to be varied in order to avoid destruction of the sensor. The distance from the fibre tip to the sensor area is indicated as a black line with diamond dots in Fig. 3a–c. In addition, we recorded the spot size of the He:Ne guide laser for all three bare fibres (600, 200 and re-used 200 µm) at a fixed distance of 20 mm from the fibre tip. In all cases, the minimal bending radius for the 200 µm fibre was 20 mm and 80 mm for the 600 µm fibre, respectively. The experimental set-up is shown in Fig. 1. In an intraoperative setting, we employed both fibres for the resection of recurrent nasal polyps in a patient with chronic rhinosinusitis. Informed consent was obtained from the patient for this procedure which has been a standard operation for recurrent nasal polyps in our department since September 1st 1996 with more than 128 cases [1]. Both resections were performed with the Neodymium: YAG laser in contact mode, set at 10 W cw. A negative feedback loop integrated in the laser system, which is based on the light spectrum emitted by the vapourised tissue under laser irradiation, limits the thermal damage to surrounding structures. The 600 µm fibre was directed to the operative field with rigid applicators (Fig. 4b), angled 30° and 90°, while the 200 µm fibre was introduced into the 300 µm canal of a custom-built applicator (Fig. 4a) (EndoFlektor, Poly-Diagnost GmbH, Pfaffenhofen, Germany). Both procedures (Fig. 5a and b) were controlled under vision through a 70° angled Hopkins rod endoscope which was connected to a 3CCD Video camera (Lemke TC 804, Lemke GmbH, Gröbenzell, Germany) and recorded on digital video tape using the DV standard (Sony DSR 30, Sony Corp., German Division, Cologne, Germany). The resected polyps were fixed in 3.5% formaldehyde solution stained with haematoxylin–eosin and examined for coagulation and carbonisation margins.

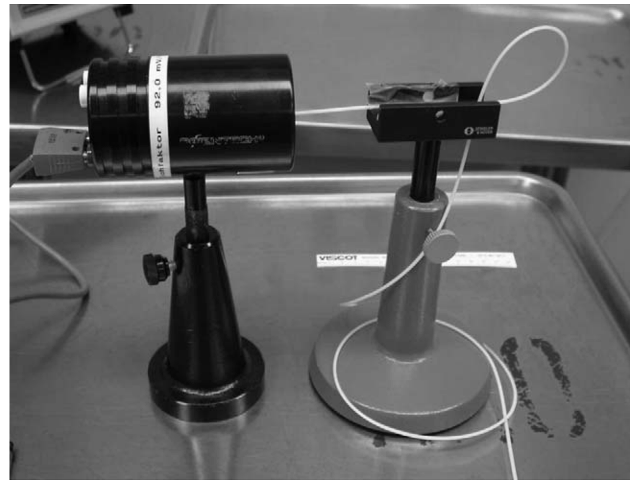

Fig. 1. Set-up consisting of a laser power meter (background) with a 25.4 mm (1 in) planar sensor area (left) and laser fibre mounting bracket (right).

Results

The results show that in relation to a 25.4 mm sensor area the difference between nominal laser power setting and actual laser power recorded at the fibre tip is most notable at low power settings for both 200 and 600 µm fibres (Fig. 3a–c). The maximum difference in relation to the nominal value set for the laser system (= 100%) is 15.5% for a 600 µm fibre (Fig. 3a) (nominal setting 2 W; actual output 2.31 W) while the minimal difference is 0.2% at 5 W (actual output 5.01 W). The spot size is 7 mm in 20 mm distance from the fibre tip (Fig. 2a). For a 200 µm fibre the maximum difference is 24% at 2 W (actual output 2.48 W) and the minimal difference 0.02% at 12 W (actual output 11.98 W). The spot size at 20 mm distance is 14% larger than with a 600 µm fibre (8 mm) (Fig. 2b). As for the re-used 200 µm fibre, the