european urology 52 (2007) 1723–1728

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Benign Prostatic Obstruction

980-nm Diode Laser: A Novel Laser Technology for Vaporization of the Prostate

Gunnar Wendt-Nordahl, Stephanie Huckele, Patrick Honeck, Peter Alken, Thomas Knoll, Maurice Stephan Michel, Axel Häcker*

Department of Urology, University Hospital Mannheim, Mannheim, Germany

Article info

Article history:
Accepted June 18, 2007
Published online ahead of print on June 26, 2007

Keywords:
Benign prostatic enlargement
Bleeding
KTP laser
Tissue ablation
Transurethral resection of the prostate

Abstract

Objective: The wavelength 980 nm of a recently introduced diode laser system for treatment of benign prostatic enlargement offers a high simultaneous absorption in water and haemoglobin, and is postulated to combine high tissue ablative properties with a good haemostasis.

Methods: The Ceralas HPD150 diode laser system was evaluated in the well-established ex vivo model of the isolated blood-perfused porcine kidney to evaluate tissue ablation capacity and haemostatic properties at different generator settings. A histological examination of the ablated renal tissue followed. The results were compared with the reference standards transurethral resection of the prostate (TURP) and potassium-titanyl-phosphate (KTP) laser.

Results: The diode laser displays a higher tissue ablation capacity, reaching 7.24 ± 1.48 g after 10 min, compared with the KTP laser (3.99 ± 0.48 g; $p < 0.05$), whereas only 30 s are needed to resect the tissue in the same surface area using TURP, resulting in 8.28 ± 0.38 g of tissue removal. With a bleeding rate of 0.14 ± 0.07 g/min, the diode laser offers haemostatic properties equivalent to the KTP laser (0.21 ± 0.07 g/min) and a significantly reduced bleeding compared with TURP (20.14 ± 2.03 g/min; $p < 0.05$). The corresponding depths of the coagulation zones are 290.1 ± 46.9 μm for the diode laser, 666.9 ± 64.0 μm for the KTP laser ($p < 0.05$), and 287.1 ± 27.5 μm for TURP.

Conclusions: In the standardised ex vivo investigation, the 980-nm diode laser offers a higher tissue ablation capacity and similar haemostasis compared with the KTP laser. In comparison with TURP, both tissue ablation and bleeding are significantly reduced. The promising ex vivo results warrant further clinical investigation.

* Corresponding author. Department of Urology, University Hospital Mannheim, Theodor-Kutzer-Ufer 1–3, 68135 Mannheim, Germany. Tel. +49 621 383 3349; Fax: +49 621 383 4001.
E-mail address: gunnar.wendt-nordahl@uro.ma.uni-heidelberg.de (G. Wendt-Nordahl).

0302-2838/$ – see back matter © 2007 European Association of Urology. Published by Elsevier B.V. All rights reserved. doi:10.1016/j.eururo.2007.06.029

1. Introduction

Although transurethral resection of the prostate (TURP) is still considered the reference standard in surgical therapy of benign prostatic enlargement (BPE), it has been challenged by several alternative treatment modalities that try to match the efficacy of TURP but do reduce perioperative morbidity [1]. In this context, several laser devices working on various wavelengths have been introduced in the last few decades [2,3].

The neodymium:yttrium-aluminum-garnet (Nd: YAG) laser (wavelength, 1064 nm) has a low absorption coefficient in tissue, and displays a deep penetration and a low energy density, resulting in coagulation necrosis without immediate ablative effects. In contrast, the holmium:YAG (Ho:YAG) laser (wavelength, 2140 nm) is highly absorbed in prostatic tissue, and has a short penetration depth and a high-energy density. It heats the tissue above the boiling point and produces instant removal by vaporization. The physical properties of the lately introduced potassium-titanyl-phosphate laser (KTP laser), operating on a wavelength of 532 nm, offer an excellent haemostasis because the laser is highly absorbed by haemoglobin [4]. Its ablative properties are rather slow because the absorption in water is minimal, resulting in prolonged operation times [5,6].

A recently introduced diode laser system operates on a wavelength of 980 nm. Because this wavelength offers a high simultaneous absorption in water and haemoglobin, it is postulated to combine high tissue ablative properties with good haemostasis.

In this study the diode laser was evaluated in an ex vivo model to determine its ablative and haemostatic properties systematically and to compare the results against TURP and KTP lasers as reference standard methods.

2. Methods

2.1. Equipment

The Ceralas HPD150 (Biolitec-AG, Jena, Germany) is a diode laser system emitting a wavelength of 980 nm. The light is transmitted via a flexible 600-μm side-fire fibre to vaporize the tissue in a noncontact mode. The laser was evaluated at output power levels of 30, 50, 60, 80, 100, and 120 W in the continuous wave (cw) mode. Furthermore, the pulsed mode was tested with a fixed pulse length of 0.1 s and pause lengths of 0.01, 0.05, and 0.1 s at an output power of 100 W. TURP was performed with the use of a standard monopolar resectoscope (Karl Storz, Tuttlingen, Germany) activated by a high-frequency generator (Autocon II, Karl Storz) and set to an output power of 160 W, coagulation degree 2. Mannitol/sorbitol solution (Purisole SM, Fresenius, Bad Homburg, Germany) was used for irrigation.

KTP laser ablation was performed with the use of the GreenLight PV laser generator (Laserscope, USA) and 600-μm side-fire fibres. An output power of 80 W was used in all experiments.

2.2. *Ex vivo experiments*

The well-established model of the isolated blood-perfused porcine kidney was used to determine tissue ablation and haemostatic properties of the diode laser, the KTP laser, and TURP as previously described [7,8].

Porcine kidneys were removed immediately after slaughtering (Mannheim city slaughterhouse). After catheterisation of the renal artery and vein with a 10F catheter, the kidneys were perfused with 0.9% sodium chloride solution until the effluent was clear. Autologous blood was harvested and anticoagulized with sodium citrate. The kidneys and the blood were stored at 4 °C until the experiments started.

The trials were performed in an acryl basin containing 0.9% sodium chloride solution at a temperature of 37 °C. All experiments were done by the same surgeon. Five experiments were performed per output power level and device; one kidney was used per experiment. Before commencing the experiments, each kidney was put in the basin for 30 min to adapt to the temperature. For the evaluation of tissue ablation, the catheters in the renal artery and vein were removed and the vessels were ligated. After removal of the capsule, the kidneys were weighed. Different output power levels were used to ablate the renal tissue in an area of 3×3 cm. The kidneys were weighed after 5, 10, and 15 min to determine the time-dependent amount of tissue ablation. Similarly, an area of 3×3 cm was resected with a drag speed of 1 cm/s to determine the amount of tissue removal by TURP.

To evaluate the haemostatic properties of the devices, we perfused the kidneys with autologous blood by a roller pump via the catheter in the renal artery. The blood was drained from the kidney through the catheter in the renal vein to ensure a clear vision in the basin. The perfusion rate was set to 80 ml/min, resulting in a pressure of 110–130 cm H_20. After removal of the renal capsule, a surface area of 9 cm^2 (3×3 cm) was ablated. The blood loss was quantified by the weight difference of a swab before and after it was placed on the bleeding surface for 60 s. The weight difference marked the amount of blood loss per minute. Afterwards, samples of the ablated renal tissue were taken and fixed in 4% formalin. After being embedded in paraffin at an interval of no longer than 2 wk after the experiments, the blocks were frozen at −19 °C, sectioned, and stained with haematoxylin-eosin. The depths of the coagulation zones induced by the lasers and TURP were determined under the microscope with the use of a calibrated calliper.

Statistical data are presented as mean ± standard deviation. Statistical significance was evaluated with the use of the unpaired Student *t* test. A p value < 0.05 was considered to be statistically significant.

3. Results

The ablation rates of the diode laser at different generator settings compared with the KTP laser and