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# Ex-vivo evaluation of new 980nm diode laser device for treatment of benign prostatic enlargement

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## Abstract

Various laser techniques offer an alternative to transurethral resection of the prostate (TURP) in surgical treatment of benign prostatic enlargement. We evaluated a lately introduced diode laser system working on a wavelength of 980nm. As this wavelength offers a high absorption in water as well as in haemoglobin, the laser combines high tissue ablation with good haemostasis.

The well established ex-vivo model of the isolated blood-perfused porcine kidney was used to evaluate the Ceralas HPD150 Laser system (Biolitec AG, Jena, Germany) using different output power parameters (30, 50, 60, 80, 100, 120 Watt) in the continuous wave and pulsed mode. The results were compared to the reference standard 80 Watt potassium-titanyl-phosphate (KTP)-Laser (Laserscope, USA) and conventional TURP. N=5 experiments were carried out per parameter. Porcine kidneys were weighed before and after 10 minutes of laser ablation in an area of 3x3cm; the weight difference marked the amount of ablated tissue. Bleeding was determined by the weight difference of a swab before and after it was placed on bleeding surface for 60 seconds after ablating an area of 9cm$^2$. Samples of the ablated area were taken and processed for histological determination of the coagulation zone.

The diode laser displayed increasing tissue ablation capacity at higher output powers. The tissue ablation at 100 Watt reached 6.06±1.54g after 10 minutes. The KTP-Laser offered a significantly lower ablation of 3.99±0.48g after 10 minutes ($p<0.05$), whereas only 30 seconds were needed to resect the tissue in the same surface area using TURP, resulting in 8.28±0.38g of tissue ablation.

The bleeding rate at 100 Watt was 0.09±0.03g/min for the diode laser compared to 0.21±0.07g/min for the KTP-Laser and 20.14±2.03g/min for TURP ($p<0.05$). The corresponding depths of the coagulation zones were 255.1±28.3µm for the diode laser, 666.9±64.0µm for the KTP-Laser ($p<0.05$) and 287.1±27.5µm for TURP.

Using the pulsed mode (5 Hz), at 100 Watt tissue ablation was slightly reduced to 5.21±1.06g compared to 6.06±1.54g for the continuous-wave mode. In contrast bleeding was significantly higher in the pulsed mode (0.54±0.56g/min vs. 0.09±0.03g/min; $p<0.05$), whereas the depth of the coagulation zone was similar (208.8±30.8µm vs. 255.1±28.3µm). However, the coagulation zone using the continuous-wave mode appeared much denser.

In our standardized ex-vivo investigation, the Ceralas HPD150 Laser offers a higher ablation capacity and similar haemostasis compared to the KTP-Laser. Compared to TURP both tissue ablation and bleeding rate are significantly lower. The promising ex-vivo results warrant further clinical investigation.

## Introduction

Although standard transurethral resection of the prostate (TURP) is still considered as the reference standard in surgical therapy of benign prostatic enlargement, it has been challenged by several alternative treatment options, trying to match the efficacy of TURP but reduce the perioperative morbidity. In this context, several laser devices working on various wavelengths have been introduced in the last decades. The Ceralas HPD150 (Biolitec AG, Jena, Germany) is a lately introduced diode laser device and operates on a wavelength of 980nm. As this wavelength offers the highest simultaneous absorption in water and haemoglobin, it combines high tissue ablative properties with a good haemostasis. This study was performed to evaluate the tissue ablation capacity and bleeding rate of the new diode laser in an ex-vivo model and compare it with standard TUR-P and the KTP-Laser.

## Results

**Fig.A.** The Ceralas HPD150 Laser generator (Biolitec AG, Jena, Germany) working on a wavelength of 980nm.

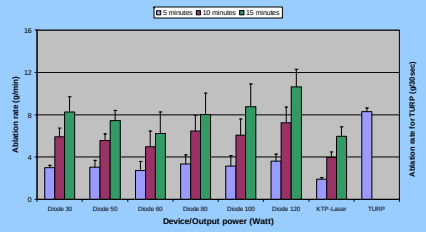


**Fig. B.** Ablation capacity of the 980nm Diode Laser at different output powers in the continuous-wave mode, the 80 Watt KTP-Laser and standard TURP. Increasing output power resulted in higher tissue ablation. Using higher output powers, tissue ablation was higher compared to KTP-Laser. With conventional TURP only 30seconds were needed to resect the same surface area of the kidney.

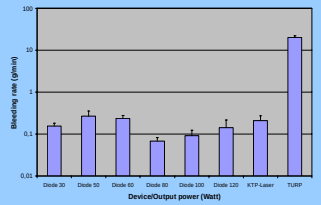


**Fig.C.** Bleeding rate of the 980nm diode laser at different output powers in the continuous-wave mode compared to KTP-Laser and TURP. Laser ablation with the diode laser displayed a similar haemostasis compared to the KTP-Laser, whereas TURP resulted in a much higher bleeding ($p<0.05$)

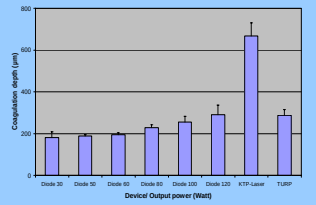


**Fig.D.** Coagulation depth of the 980nm diode laser at different output powers in the continuous-wave mode compared to KTP-Laser and TURP. The depths of the coagulation zones were comparable to those of TURP, whereas the KTP-Laser displayed deeper coagulation zones ($p<0.05$).

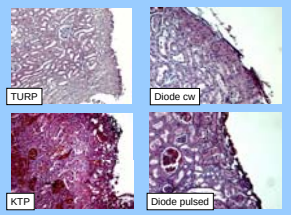


**Fig. E.** Histological images of the coagulation zones of TURP, KTP-laser, the diode laser at 100 Watt continuous wave (cw) and at 100 Watt pulsed (pulse length 0.1s/pulse pause 0.1s).

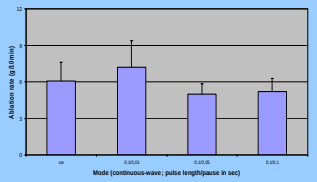


**Fig. F.** Ablation rate of the diode laser in the continuous-wave mode (cw) and in the pulsed modes. A pulse length of 0.1sec with varying pulse pauses resulted in similar tissue ablation compared to the cw-mode ($p>0.05$).

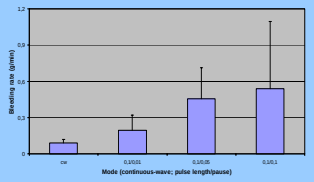


**Fig. G.** Bleeding rate of the diode laser in the continuous wave (cw) and pulsed modes. At a pulse length of 0.1sec, bleeding increases with higher pulse pauses.

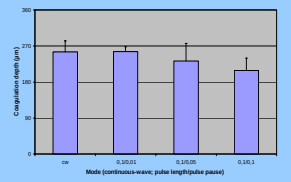


**Fig. H.** Coagulation depth in the continuous-wave (cw) and pulsed mode at 100 Watt. The dephts of the coagulation zones decrease slightly but not significantly with higher pulse pauses.

## Materials & Methods

The model of the isolated blood-perfused porcine kidney was used to determine tissue ablation capacity and haemostatic properties of the Ceralas HPD150 using an output power of 30, 50, 60, 80, 100 and 120 Watt in the continuous wave and pulsed mode. The results were compared to 80 Watt KTP-Laser and standard TURP. After catheterization of the renal artery and vein, porcine kidneys were perfused with 0.9% NaCl solution until the effluent was clear. Autologous blood was harvested and anticoagulized with sodium citrate. The trials were performed in an acryl basin containing 0.9% NaCl solution at a temperature of 37°C. Before commencing the experiments each kidney was put in the basin for 30 minutes to adapt to the temperature. To determine the ablation capacity, the kidneys were weighed before and after 10 minutes of laser ablation in an area of 3x3cm; the weight difference marked the amount of ablated tissue. To evaluate the haemostatic properties of the laser, the kidneys were perfused via the catheter in the renal artery with autologous blood by a roller pump. 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 80ml/minute. The bleeding rate was determined by the weight difference of a swab before and after it was placed on bleeding surface for 60 seconds after ablating an area of 9cm$^2$. Afterwards, samples of the ablated area were taken and processed for histological evaluation. The depths of the coagulation zones were measured after HE-staining.

## Conclusions

- **The Ceralas HPD150 980nm diode laser offers a higher tissue ablation capacity and similar haemostasis compared to the KTP-Laser.**
- **Compared to TURP both tissue ablation and bleeding rate are significantly lower.**
- **The promising ex-vivo results warrant further clinical investigation.**