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TOPIC PAPER

Bladder neck incision using a 70 W 2 micron continuous wave laser (RevoLix)

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Abstract Postoperative bladder neck contracture continues to be a frequently occurring problem. Bladder neck incision (BNI) continues to be the standard mode of treatment. However, the recurrence rate appears to be high. Therefore alternative treatment options are still needed. We report about initial experience with the RevoLix 2 micron continuous wave laser for BNI after a 1-year follow-up. Fourteen patients with a second or third recurrence of bladder neck contracture after primary surgery were included into the trial. All patients reported high-grade obstruction and residual urine. BNI was performed using a 70 W 2-micron continuous wave laser (RevoLix). This laser utilizes the thulium as an active ion. Laser incisions were applied in 5 and 7o'clock lithotomy position. Remaining tissue was vaporized. Assessed outcomes were improvement in AUA-symptom-score, quality of life index and uroflowmetry, measured preoperatively, after 2 and 12 months postoperatively. Mean operating time was 7 min, mean catheterization time was 6.5 h. The mean maximum uroflow-rate improved from 9 ml/s preoperatively to 23 ml/s. AUA-symptom score improved from 22 to 8 points and quality of life index improved from four to one. Two patients developed restenosis so far. Although longer follow-up and larger sample size are needed, BNI with the RevoLix laser is a fast, safe and promising procedure in recurrent bladder neck sclerosis.

Keywords Bladder neck contracture · Revolix laser · 2-Micron continuous wave laser

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Introduction

Although known for almost a century [1] postoperative bladder neck contracture (BNC) following transurethral resection of the prostate (TUR-P) or radical retropubic prostatectomy (RRP) continues to be an unsolved problem [2]. BNC occurs in 3.6–17.9% of the patients after RRP or TUR-P [3–6]. A variety of solutions have been advocated for these strictures. The treatment-options range from balloon dilatation with a recurrence rate around 50% [7, 8], cold-knife incision [7], TUR of the bladder neck to stent placement [9]. However, bladder neck incision (BNI), first described by Sachse in 1974 [10], remains to be the standard mode of treatment for bladder outflow obstruction in men with BNC. Existing treatment modalities do cause bleeding, haematoma and scar formation with subsequent recurrent strictures [11, 12]. Therefore, alternative, less traumatic treatment options have to be developed.

To overcome the above-mentioned problems different lasers including the Neodymium:YAG laser, Argon laser, KTP-532 and holmium:Yag laser have been introduced with various success rates [13–16]. However all proposed lasers showed limitations in endourological soft tissue surgery. We report initial results of BNI after a 1-year follow-up with a 2-micron continuous wave laser (RevoLix) for the treatment of BNC.

Methods

A total of 14 patients were included in the trial. Medical history reported second recurrence in ten patients and third recurrence in four patients of bladder neck sclerosis after primary treatment. The patients were not specifically selected for laser treatment. Further characteristics were high-grade obstruction measured by uroflowmetry and residual urine. AUA symptom score and quality of life index were recorded. The diagnosis of BNC was confirmed with urethroscopy in all patients. All patients were treated by the same surgeon.

The BNI was performed using a 70-W 2-micron continuous wave laser (RevoLix, LISA laser products, Katlenburg, Germany). The delivery system was a bare-ended laser fibre with 365-µm optical core diameter (PercuFib, LISA laser products, Katlenburg, Germany). The laser incisions were placed at 5 and 7o'clock in lithotomy position. Remaining tissue was vaporized using the same laser and the same delivery system. Laser treatment of BNC was performed in normal saline. Once the bladder neck was wide open (Figs. 1, 2) and the sclerotic scar tissue was vaporized, a 24 French Foley catheter was inserted into the bladder and kept in place until the patient was ready for discharge. For pain control and reduction of postoperative swelling 50 mg Diclofenac suppositories were administered postoperatively. The assessed outcomes were operating and catheter time as well as improvement in AUA symptom score and in quality of life index. Maximum urinary flow rates were measured at baseline preoperatively, after 2 and 12 months postoperatively.

Results

The patients' mean age was 67 years (55–78 years). Five patients presented bladder neck sclerosis post RRP and nine

Fig. 1 Patient with recurrent bladder neck sclerosis after TUR-P. The picture compares the pre- and postoperative situs

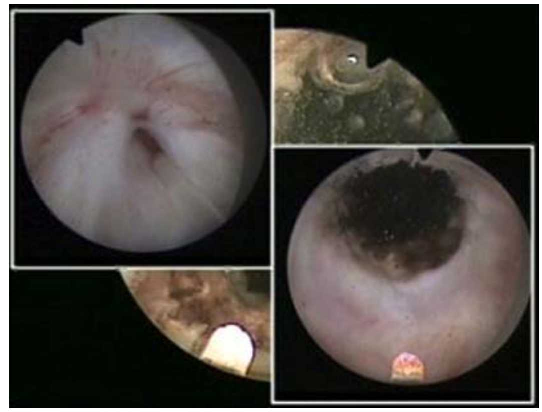

Fig. 2 Patient with recurrent bladder neck sclerosis after radical retropubic prostatectomy. The picture compares the pre- and postoperative situs

patients post TUR-P. Surgery could be carried out successfully in all 14 patients (Figs. 1, 2). Mean operating time was 7 min (5–21 min), catheterization time was 6.5 h (0–7.5 h). The preoperative uroflow rate was 9 ml/s (3–14 ml/s) and improved to 25 ml/s (19–28 ml/s) after 2 months and 23 ml/s (17–30 ml/s) after 12 months. AUA-symptom score improved from 22 (19–28) preoperatively to 8 points (7–12) postoperatively. Quality of life score improved as well from four (3–5) to one (1–2) (Table 1). Two patients developed restenosis (14.3%) and needed re-treatment.

Discussion

Recurrent BNC after primary treatment remains to be a frequent problem in patients after RRP or TUR-P, occurring in up to 18% of the patients [3–6].

All treatment options introduced earlier, e.g., cold-knife incision, electrocautery of the bladder neck or mechanical dilation of the stenosis, result in high failure rates since either the scarred tissue is not resected or thermal and mechanical tissue damage cause recurrent scarring [17].

Because of the above-mentioned problems encountered in recurrent BNC, specific requirements need to be accomplished by a new therapeutic procedure. The ideal procedure has to be quick and as atraumatic as possible to reduce hospitalization to a minimum for this frequently pretreated group of patients. The surgical effect has to be efficient and

Table 1 Results

	Preoperatively	After 2 months	After 12 months
Uroflow (ml/s)	9 (3–14)	25 (19–28)	23 (17–30)
AUA-SS (points)	22 (19–28)	8 (7–12)	8 (6–11)
QoL-index (points)	4 (3–5)	1 (1–2)	1 (1–2)

equivalent in vascular (e.g., prostate, “red tissue”) and avascular tissue (scars, “white tissue”). For good control on the extent of the tissue damage, the device needs to have a shallow, but sufficient penetration to provide coagulation and excellent hemostasis at the same time. A smooth incision with no trauma and no residual necrotic or fibrotic tissue is necessary.

In the attempt to fulfil these requirements different types of lasers have been introduced [13–16]. However all previously introduced laser systems have their limitations, which are mainly due to their operational mode and their wavelength. The related damage zone is suspected to cause recurrent strictures [18].

At this point we will review these lasers proposed earlier with respect to their wavelength, tissue target chromophore and the absorption length in this chromophore (Table 2). The data will be compared to the laser used for this work and compared with the clinical results published so far.

The Neodymium:YAG laser was introduced for the treatment of strictures since it became available for endourological surgery. This laser operates in the continuous wave (cw) mode and the emission wavelength is 1,064 nm. Due to lack of other chromophors in tissue at this wavelength (Fig. 3) laser radiation is mainly absorbed by water, which is an acceptable theoretical model for the absorption of light in white or avascular tissue. However the absorption coefficient in pure water at this wavelength is 0.13 cm^{-1} only. In water a laser beam travels 7.7 cm before it is attenuated by 63% (Table 2). Compared to the extent of urethral mucosa or sclerotic bladder neck tissue the absorption length is long and the likelihood of deep penetration and risk of uncontrolled necrosis caused by this wavelength is high. Therefore it is understandable why the Nd:YAG laser has not proven to be suitable for BNI [19]. The Neodymium:YAG laser is known to have a theoretical thermal damage zone of 2,000–3,000 µm and a success rate of 33–36% [13, 20].

Another laser system introduced for therapy of strictures is the KTP laser with a wavelength of 532 nm. Other than the Nd:YAG laser the KTP laser receives no significant absorption in water (absorption length 3,000 cm) meaning that white tissue is almost transparent for this laser. The chromophore of hemoglobin at this wavelength has an

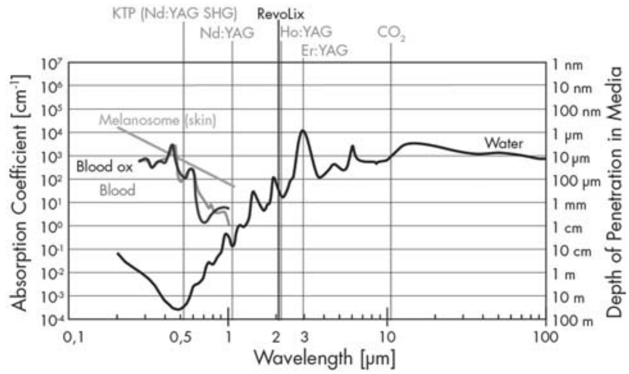

Fig. 3 Absorption coefficient and chromophores in different laser types and wavelengths. The absorption coefficient of water is 2.5 times higher in the RevoLix 2 micron laser than in the holmium:Yag 2.12 micron laser

extremely strong absorption for the KTP laser and the absorption length is only 80 nm [21]. However, there is uncertainty with this laser target:

1. The hemoglobin concentration in tissue varies dramatically between well-circulated tissue like kidney or prostate and white tissue like scars as in bladder neck sclerosis. Without hemoglobin scar tissue is white and no significant absorption of KTP laser radiation will occur. Instead the radiation will travel through the sclerotic tissue, receive scattering at microscopic structures and finally will be absorbed in structures which are out of sight with risk of deep penetration and uncontrolled necrosis.
2. Hemoglobin is thermally unstable. The molecule denaturizes at around 65°C, looses its red color and the ability to absorb green light. This may impair the cutting efficiency if the hemoglobin was denaturized during a first laser pass and lost its color to absorb the laser for the next cut.

The holmium:YAG laser operates in the pulsed mode at 2,123 nm. The absorption length in water is 400 µm. Due to the pulsed operational mode and strong absorption in water rapidly expanding steam bubbles are created with every laser pulse. The pressure waves created by these bubbles are audible and cause trauma to the tissue under treatment. The surface of a cut performed by a holmium:YAG laser is

Table 2 Absorption length of different laser types

	Absorption length		Cw/pulsed	Thermally stable chromophore	Success rate (%)
	H_2O	HbO			
Nd:YAG 1,064 nm	7.7 cm	–	Cw	Yes	33–36
KTP 532 nm	–	80 nm[a]	Cw	No	59–68
Ho:YAG 2,123 nm	400 µm		Pulsed	Yes	69–76
2 Micron cw 2,013 nm	180 µm		Cw	Yes	85.7

[a] Depending on concentration

torn, fibrotic and has a cotton wool appearance. Haemostasis of the holmium:YAG laser is excellent due to absorption length, which is in the range of blood vessel diameter.

The success rate of this laser is reported to be between 69 and 76% [22, 23]. Therefore the holmium:YAG laser is suggested to be favorable for the treatment of urethral or bladder neck strictures [23]. This laser has the potential to cut and coagulate tissue with good haemostasis and flexible optical fibre delivery systems are available [18].

The limitation of the holmium:Yag laser is the pulsed operational mode, which causes a torn surface, which is not ideal for the precise cutting of fine structures.

This study reports the initial results with a new 2-micron 70-W cw laser (RevoLix), which enables cutting and simultaneous coagulation of either perfused, avascular or hardly vascularized tissue, such as in scars. The wavelength of this laser is 2,013 nm. At this wavelength the chromophore is water and the absorption length is 180 μm. Accordingly the laser tissue interaction is very similar to the holmium:YAG laser with the exception of the continuous wave operational mode which eliminates the only disadvantage of the Ho:YAG laser. The surgical effect of the 2-micron cw laser is entirely independent of vascularization or tissue color, since the laser energy is absorbed by the interstitial water, which is ubiquitous in all tissues. Since the wavelength of the RevoLix laser is closer to the 2-micron peak of the absorption spectrum of water than that of the holmium:YAG laser, the absorption is stronger by a factor of 2.5 (Fig. 3). This leads to a reduced zone of thermal damage [24] and to even more precise cutting performance. Since the 2-micron cw laser operates in a continuous wave mode, movement of the laser probe can increase the vaporizing effect while the heat penetration is reduced [25]. The opposite bladder wall is protected from the laser radiation due to the opaqueness of the irrigation fluid at this laser wavelength.

Table 2 summarizes the data compiled in this section. Accordingly the Ho:YAG laser offered the most suitable modality for BNI since the introduction of lasers into endourology. The pulsed operational mode is the only shortfall of this laser causing rough cuts, complicating surgery of fine structures and may be the reason for the recurrence of stenosis. With the 2-micron cw-laser almost duplicating the features of the Ho:YAG laser in a continuous wave operational mode instead of the pulsed mode, this new laser may be the ideal endourological laser for soft-tissue surgery.

Conclusion

BNI with the RevoLix 2-micron cw laser is a safe, rapid and promising procedure in patients with recurrent BNC. Reviewing our initial results the 2-micron continuous wave laser offers promising treatment options in recurrent bladder neck sclerosis due to reduced scaring and its ability to work in perfused as well as in avascular tissues. Larger prospective randomized studies and a longer follow-up will be needed to confirm the promising preliminary results.

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