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Bladder tumor ablation with 980-nm and 980-/1470-nm diode lasers: a retrospective study

Farooq Hameed[1] and Adeel Anwaar[2*]

Abstract

Purpose This study evaluated the safety and feasibility of ablation of both non-muscle invasive and muscle invasive bladder tumors using single- and dual-wavelength diode lasers (980 nm and 980/1470 nm).

Methods We retrospectively examined 151 patients with bladder tumors of any type from 2009 to 2021 who underwent V-LABT (visual laser ablation of bladder tumor) with both single- and dual-wavelength diode lasers at Shalamar Hospital Lahore, Pakistan. All procedures were performed by the same surgeon. Shalamar Medical and Dental College review board approved this retrospective cohort study (IRB No. -623-2023). The collected clinical data were consolidated into a single group, encompassing various variables such as the patients' age, tumor size, number of tumors, tumor location, tumor grade, ablation duration, postoperative catheterization time, bladder discomfort, obturator nerve reflex, intraoperative and postoperative complications, and recurrence of tumors at the ablation sites. The patients were monitored for a minimum of 12 months to observe recurrence at the ablation sites through cystoscopy performed postoperatively every three months. The data were analyzed using Chi-square test, and p value < 0.05 was considered significant.

Results The average age of the 151 patients was found to be 64.72 ± 13.85 years. The size of the tumors was 4.88 ± 2.16 cm, with 48/151 (31.7%) patients having tumors larger than 3 cm. Among the cases studied, 117/151 (77.4%) patients had a single tumor, while the remaining patients had multiple tumors ranging in size from 5 to 7 cm in aggregate. Ablation took 1.57 ± 0.73 h to complete on average. None of the patients required a conversion to TURBT in 151 patients. No obturator reflexes or bladder perforations were observed in any case. Postoperatively, histopathology results showed 53/151 (35%) and 92/151 (60.9%) high- and low-grade tumors. The average catheterization duration was 6.58 ± 1.47 days. Tumors located on difficult sites, such as the anterior wall, lateral wall, and bladder neck, were ablated with ease. There was no recurrence seen on previously tumor ablated sites till 12-month follow-up.

Conclusion Ablation of bladder tumors of any type using single- or dual-wavelength diode laser (980 nm and 980/1470 nm) is safe and feasible. These lasers possess the capability to effectively ablate/coagulate bladder tumors in challenging anatomical locations including diverticular tumors with minimal difficulty.

Keywords Diode laser, Ablation of tumor, Carcinoma of bladder, Laser urology

1 Background

In 2023, the American Cancer Society estimates that there will be approximately 82,290 new cases of bladder cancer in the USA, with approximately 62,420 occurring in men and 19,870 in women. Furthermore, it is projected that there will be about 16,710 deaths resulting from

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bladder cancer, including roughly 12,160 in men and 4550 in women [1]. An estimated 74,000 new bladder cancer patients were diagnosed in 2015, of which approximately 75% were non-muscle invasive types, with a higher incidence among younger patients [2]. Endourological treatments such as transurethral resection of bladder tumors are often prescribed based on the guidelines set forth by several countries [3]. The efficacy of diode laser technology, such as the 980-nm and 980-/1470-nm systems, in bladder tumor ablation is of considerable interest because of its capacity to minimize complications compared with conventional TURBT. Previous studies have suggested that laser en bloc resection may be superior to conventional TURBT in terms of diminished complication and recurrence rates. Moreover, the precise tumor stage and grade obtained through laser en bloc resection can provide further insight into the effectiveness of this form of treatment [4, 5]. The use of true holmium (Ho:YAG) or thulium (Tm:YAG) lasers has also been reported to be safe, effective, and minimally invasive for treating bladder tumors [6]. The 1470-nm/980-nm dual-wavelength laser technique is a relatively new development that offers a wealth of benefits [7]. Resection and vaporization can be carried out quickly with the 1470-nm section, while hemostasis may be achieved efficiently and without contact via the 980-nm component [8]. As such, this technology is very attractive for medical applications. A study has recently demonstrated that it can also be employed safely and effectively for vascular lesions [9]. A diode laser with a wavelength of 980 nm has demonstrated good results in hemostasis and ablation [10].

This study aimed to explore the safety and feasibility of both single- and dual-wavelength diode lasers (980 nm and 980/1470 nm) in the ablation of bladder tumors of any type followed for minimum of 12 months.

2 Methods

2.1 Data collection

A retrospective cohort study of 151 Pakistani patients who were diagnosed with bladder tumors of any types between June 2009 and October 2021 at Shalamar Hospital Lahore Pakistan was conducted. The patients were treated with both 970-nm and 980-/1470-nm diode lasers (Evolve®, Biolitec, Germany) with ablation/coagulation (vapo-resection) technique. The same surgeon performed the procedures. Shalamar Medical and dental college review board approved this retrospective cohort study (IRB No. -623-2023).

The inclusion criteria were: (a) fresh and recurrent bladder tumors, (b) bladder tumors of any type, (c) tumors of any size, and (d) diverticular bladder tumors.

The exclusion criteria were patients unwilling to participate or give consent for the procedure.

2.2 Study protocol

The purpose of the study was to investigate the safety and viability of both single-wavelength and dual-wavelength diode lasers for ablating/coagulating bladder tumors, either primary NMIBC or muscle invasive. When a patient was presented to us with bladder tumor in the outpatient department, they were offered this procedure (V-LABT), those who agreed underwent V-LABT, and during which biopsy was also taken. The data collected were on patients' age, gender, bladder tumor size, number and location of tumors, and tumor type and grade after ablation and biopsy. Post-ablation, patients were monitored for at least 12 months for any recurrences at the ablation sites. Large tumors > 3cm and the tumors on difficult sites were also included into the study for ablation/coagulation. The data of all patients were included into one group and later analyzed. No patient was lost to follow-up till 12 months. Tumors in bladder diverticula were also ablated in this study.

In addition to a detailed history and physical examination, a complete blood picture, a complete urine examination, urine culture and sensitivity, serum electrolytes, a coagulation profile, and a CT urogram were performed before the procedure. All patients were given informed consent before procedure. Cystoscopy was performed immediately before ablation to determine the location, the volume, and the number of multiple tumors.

2.3 Surgical technique

Ablations were undertaken in the lithotomy position, with either regional or general anesthesia, without blocking the obturator nerve. Initially, a complete cystoscopic examination of the bladder was carried out; then, a 26 Fr continuous irrigation resectoscope with a laser bridge (custom-built), utilizing a side-firing laser fiber, was deployed; further to this, a twister fiber (Evolve®, Biolitec Diode Laser, Germany) was employed later on, but had no effect on outcomes. Laser energy settings ranged between 5 and 50 W, and 0.9% normal saline was used for irrigation in all cases.

Whenever if possible, it is important to get at the base of the tumor and identify its stalk and irradiate/coagulate the vessels supplying to the tumor. Bleeding occurred at any point before coagulation of the stalk or tumor was stopped by coagulating the bleeder first at 5W–10W. Once the surgeon was satisfied, the entire tumor was ablated/coagulated. Figure 1a, b shows small and huge bladder tumor being ablated. Tissue for biopsy was obtained using a resectoscope or a cup biopsy. After collecting the sample, the sites were again irradiated with laser at low voltage. Growth in diverticula is being ablated in Fig. 1c. Depth of penetration of laser into tissue is

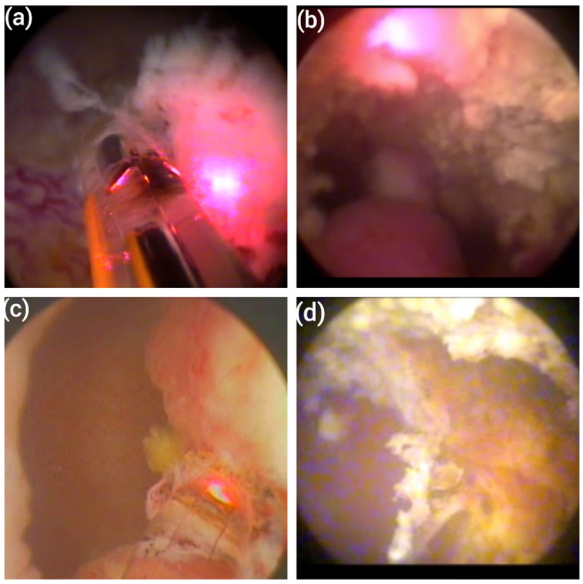

Fig. 1 **a** A growth being ablated, **b** the ease of ablating a huge growth, **c** dealing with diverticular growths, **d** showing depth of penetration

shown in Fig. 1d. Both single- and dual-wavelength lasers were used. In our 970-/1470-nm system, 1470 nm wavelength works after 40 W.

2.4 Statistical analysis

With SPSS software, categorical data were analyzed using Fisher's exact or Chi-square tests, and continuous variables were summarized as mean + standard deviation. $P < 0.05$ was considered significant.

3 Results

The mean age of 151 (male = 115 and female = 36) patients was 64.72 ± 13.85 years with 65/151 (43%) above age of 75 years. The mean size of the tumors was 4.88 ± 2.16 cm (Table 1). Among 151 patients, 31 (20.52%) had diabetes mellitus, 19 (12.58%) had hypertension, and 49% had tumors on the left lateral wall of the bladder (Figs. 2, 3). Furthermore, 115/151 (76%) and 31/151 (20.5%) patients experienced mild and moderate discomfort postoperatively, respectively, and no blood transfusions were necessary during the procedure in any case. Postoperatively, histopathology showed 92/151 (60.9%) low-grade and 53/151 (35%) high-grade tumors, and 06/151 (4%) were not recognized. The procedure was also a success, with no conversions required to TURBT, as well as an ablation/coagulation time of 1.57 ± 0.73 h, 15.33 ± 3.93 h's irrigation and 6.58 ± 1.47 days of catheterization in all 151 patients post-surgery.

Table 1 Patient characteristics in 980-nm and 980-/1470-nm diode laser group

Variables	n = 151 (35–94)
Age (years) ± SD	64.72 ± 13.85
< 35	03 (1.9%)
36–45	09 (5.9%)
46–55	09 (5.9%)
56–65	42 (27.8%)
66–75	26 (17.2%)
> 75	65 (43.0%)
Sex	
Male	115 (76.1%)
Female	36 (23.8%)
Tumor	
Single	117 (77.4%)
Multiple	34 (22.6%)
Tumor size (cm) including multiple tumor	
< 3 cm	103 (68.2%)
> 5 cm	48 (31.8%)
Tumor grade	
LG	92 (60.9%)
HG	53 (35%)
Not recognized	06 (4%)
Risk category	
Low	36 (23.8%)
Intermediate	56 (37%)
High	59 (39%)

In 3/151 (2.98%) patients, secondary bleeding was reported. After surgery, 09/151 (5.96%) patients' urine color was not clear and they were managed conservatively. There were no cases of recurrence reported at ablation sites in the following 12-month postoperative follow-up in both muscle invasive or non-muscle invasive bladder tumors. However, growths were seen at margins of previously ablated sites in 12/151 (7.94%). Twenty-one out of 151 patients (13.90%) developed urinary tract infections after surgery (Table 2). Overall, diode lasers with ablation technique have proved to be highly beneficial for tumors located in difficult sites including diverticula bladder tumors, with little to no difficulty.

4 Discussion

TURBT, the conventional method of treating NMIBCs, is associated with a heightened risk of possible complications, such as obturator nerve reflex and postoperative bleeding, in turn increasing the odds of malignancy and recurrence [11, 12]. The same issue has yet to be addressed using V-LABT. While some reported

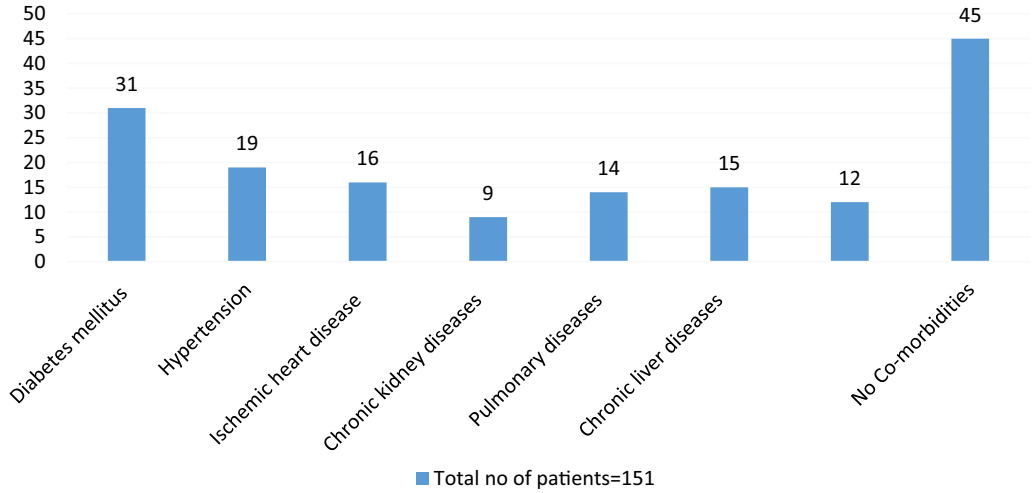

Fig. 2 Comorbidities of the patients

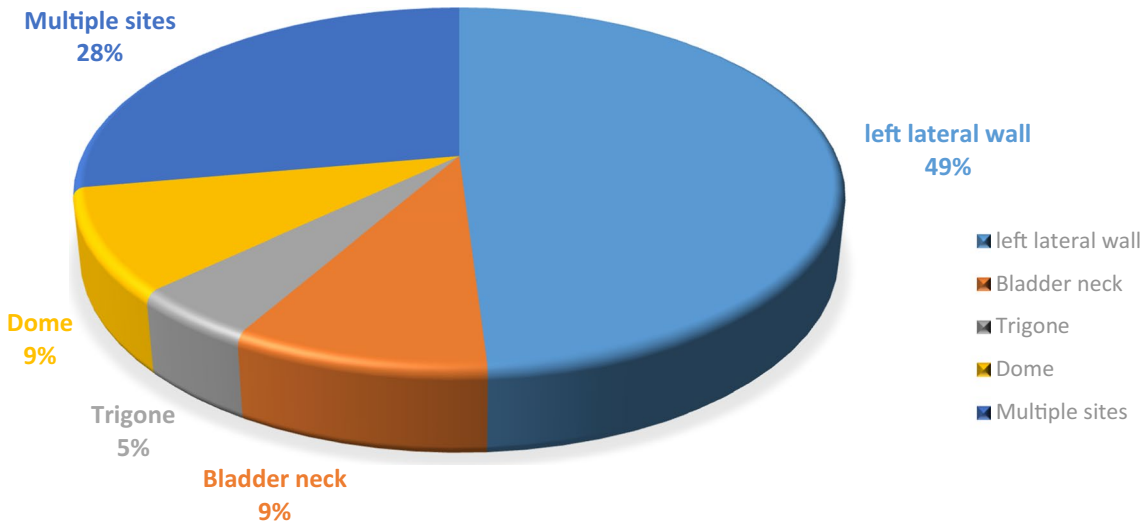

Fig. 3 Tumor sites

outcomes suggest that bipolar resection may lessen the complications risk compared with resection of bladder tumors with monopolar, these results are inconclusive [13, 14]. In our cases, we discovered a reduced possibility of recurrence on ablation sites and complications.

Staehler et al. first reported the use of lasers for urological surgery, and since then, it has become popular for prostate and bladder procedures. Tey described a technique of transurethral ablation of bladder tumors using an Nd:YAG laser [15, 16]. A 980-nm diode laser was tested and found to be effective in treating NMIBC in vitro [17]. In clinical practice, other lasers, such as the thulium laser, the holmium laser, the 2-µm laser, and the 1.9-µm vela laser, have all been proved safe and effective [18–21]. While resecting tumors from the lateral walls of the bladder, an electric current can flow through the obturator nerve, causing a potential bladder perforation and OBR during TURBT [22]. However, in our cases, no obturator reflex was observed, as no current was used directly. With Holmium lasers, cutting is reported to be precise with efficient hemostasis [23]. In our series, we observed that diode lasers have much better hemostatic properties than holmium lasers. Moreover, in cases of brisk bleeding from a spurter, we had to help with the ball electrode. Only one patient with a huge tumor required post-op clot evacuation. It has been suggested that around 30% of individuals cannot receive ERBT due to the size, shape, or location of their tumors [24]. Tumors

Table 2 Perioperative parameters

Variable	Results n = 151
Ablation/operation time (hours ± SD)	1.57 ± 0.73
Bladder perforation (n)	0
Obturator reflex (n)	0
Conversion to conventional TURBT (n)	0
Blood transfusion (n)	0
Duration of catheterization (days)	6.58 ± 1.47
Postoperative bladder irrigation (n)	151 (100%)
Postoperative bladder irrigation time (hours ± SD)	15.33 ± 3.93
Postoperative bladder discomfort (n)	
Mild	115 (76.15%)
Moderate	31 (20.5%)
Severe	05 (3.3%)
Duration of hospital stay in days (n)	1
Severe post-op bleeding requiring clot evacuation (n)	1 (0.66%)
Secondary bleeding (n)	3 (1.98%)
Secondary surgery (n)	0
Post-surgery urine color	
Clear	142 (94.03%)
Not clear	09 (5.96%)
Urinary tract infections	21 (13.90%)
Recathetrization	0
Growths seen at margins of previously ablated sites	12/151 (7.94%)

located at the anterior and posterior bladder walls, bladder neck, or exceeding 3 cm in size are usually avoided in such cases. This was not a factor for exclusion in this study; even though a majority of the tumors were on the lateral walls, there were 35 cases located on the dome and trigone as well as on the bladder neck. Despite this, all tumors were treated successfully with an ablation technique. It has been concluded that TULA with diode laser is a safe and well-tolerated procedure [25].

Currently, there exists a limited amount of research regarding the utilization of 980-nm and 980-/1470-nm diode lasers for the ablation of bladder tumors. However, in this particular study, a total of 151 patients who were diagnosed with bladder tumors of any type underwent an innovative procedure involving the ablation/coagulation of the bladder tumor using either 980-nm or 980-/1470-nm diode lasers. We did our best to avoid complications of heat injury, often beginning by coagulating the tumor stalk first before ablation or coagulation of the rest of its growth. Cases involving large or multiple tumors were ablated as much as possible and then waited for two months before performing another cystoscopy to determine whether fresh tissue had grown or the scab remained adherent to the site of ablation. This process was repeated, depending on the results.

Almost always after ablating/coagulating a tumor, we resect the tumor partially (more safe) and allow the necrotic tissue to shed itself in due course. As a result of the efficient hemostasis achieved by the diode laser, these benefits, namely low postoperative clot formation, reduced bladder irrigation requirements, and less postoperative bladder discomfort, are all related. As a result of its potent hemostatic property, the diode laser provides a bloodless surgical field.

Our study has certain limitations that should be considered. Firstly, its retrospective nature and small sample size reduce the generalizability of our findings. Additionally, our investigation solely focused on patients treated by a single surgeon, which may limit the applicability of our results to a broader population. The method in which patients were enrolled could have introduced selection bias, potentially affecting the validity of our conclusions. Moreover, since all patients' data were grouped together, we were unable to make a direct comparison between single-wavelength and dual-wavelength lasers. Consequently, it is crucial that future research includes a prospective design to address these limitations and provide more comprehensive insights into the topic.

5 Conclusion

The utilization of both the 980-nm and 980-/1470-nm diode lasers for transurethral ablation of bladder tumors through the ablation technique proves to be effective, efficient, and safe. The findings of using single- and dual-wavelength diode lasers for ablating bladder tumors are encouraging. These lasers demonstrate excellent hemostatic properties and have shown satisfactory postoperative outcomes followed for at least 1 year. This study opens up pathways for further research on the utilization of diode lasers through ablation technique in the future. In order to validate our promising short-term outcomes, it is imperative to conduct prospective randomized controlled trials that incorporate extensive long-term follow-up.

Abbreviations

V-LABT Visual laser ablation of prostate
TURBT Transurethral resection of bladder tumor
NMIBC Non-muscle-invasive bladder cancer
ERBT En-bloc resection of bladder tumor
OBR Obturator nerve reflex

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Author contributions
F.H. performed the procedures helped with study design, data collection, and manuscript editing and review. A.A. drafted the manuscript, acquisition, analysis, interpretation of data, and literature review. All authors approved the manuscript.

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Availability of data and materials
Data can be requested from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained for this study. Shalamar Medical and Dental College approved this study (IRB-635-2023). Written informed consent was obtained for anonymized information published in this article.

Consent for publication
Consent for publication is obtained from the patients.

Competing interests
The authors declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

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