Clinical Trial/Experimental Study

Medicine

OPEN

Comparative study between thulium laser and cold knife visual urethrotomy for treatment of short bulbomembranous urethral stricture

Mohamed Rehan, MD[a,*], Esam A. Elnady, MD[a], Saed Khater, MD[a], Ahmed Fawzi Arafat Elsayed, MD[a], Ahmed M. Abdel Gawad, MD[a], Mohamed Abdel Hafeez Aly Freeg, MD[a], Alaa R. Mahmoud, MD[a]

Abstract

Introduction: The classical way to treat urethral stricture is the direct vision cold knife internal urethrotomy (DVIU). Along with advances in laser technology, laser urethrotomy is widely used, such as neodymium-doped yttrium aluminum garnet, argon, potassium titanyl phosphate, and thulium laser. We aimed to compare thulium laser urethrotomy (TLU) and cold knife visual urethrotomy (CKVU) in terms of short bulbomembranous urethral stricture management.

Materials and methods: This prospective interventional study was conducted for 24 months, from January 2018 to January 2020, on 60 patients with primary short bulbo-membranous urethral stricture who came to the Department of Urology of Al-Azhar University Hospital, New Damietta, Egypt. We divided these patients into 2 age-matched groups; 30 patients treated with CKVU and 30 patients with TLU.

Results: Regarding efficacy, postvoid residual urine volume (PVR) was reduced significantly in both groups ($P < .001$) after 6 months of follow-up; however, the reduction in TLU was greater than CKVU ($P = .008$). The improvement of Qmax after 6 months was significant and comparable in both groups. Regarding the quality of life, both groups showed a significant (<0.05) improvement in international prostate symptom score (IPSS) and the Male Sexual Health Questionnaire (MSHQ) scale, without no significant difference between both groups (>0.05). TLU showed a significantly ($P = .038$) shorter operative duration (24 ± 4.17 min) than CKVU duration (33 ± 4.86 min). Compared with CKVU, TLU was associated with less blood loss during surgery ($P = .001$), lower recurrence rate (46.7% vs. 19.97%, respectively), and lower frequencies of urethral dilatation ($P = .001$).

Conclusion: TLU is an effective and safe therapy for managing bulbomembranous urethral strictures, with a relatively low recurrence rate. Further investigations of other techniques are recommended to look for the most appropriate procedure to combat the urethral stricture problem.

Abbreviations: CKVU = cold knife visual urethrotomy, DVIU = direct vision cold knife internal urethrotomy, IIEF = international index of erectile function, IPSS = international prostate symptom score, MSHQ = male sexual health questionnaire, PVR = postvoid residual urine volume, SD = standard deviation, TLU = thulium laser urethrotomy.

Keywords: direct vision internal urethrotomy, Thulium laser, urethral stricture

1. Introduction

Urethral stricture is a narrowing of the urethra due to many causes including, ischaemic spongiofibrosis, inflammation, and sexually transmitted gonococcal infections, resulting in scar tissue in the corpus spongiosum.[1] It can occur at any point on the male urethra and can be caused by a wide variety of causes.[2] In the United States, it was estimated that the urethral stricture incidence range between 200 and 1200 cases per 100,000 individuals.[3] People aged above 55 years are associated with a higher incidence.[4] Bladder stones, recurrent urinary tract infection, and complete retention are the main complications related to urethral stricture, which are linked to the contraction of the scarring tissue and reducing the urethral caliber from ~30 french (F) to less than 16F, leading to voiding dysfunction.[5] There are 2 types of urethral stricture; anterior and posterior; both types differ in terms of location, causes, and management.[6]

Regarding urethral stricture management, many researchers and surgeons have proposed and evaluated several methods,

Written and verbal informed consent was obtained from the patients.

The authors have no funding or conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

The ethical approval was obtained from the ethical committee of our hospital (IRB00012367-17-10-003).

Supplemental Digital Content is available for this article.

[a] *Urology Department, Faculty of Medicine, Al-Azhar University, Damietta, Egypt*

**Correspondence: Mohamed Rehan, Urology Department, Faculty of Medicine, Al- Azhar University, New Damietta, Egypt 34511, Egypt (e-mail: mrehan4040@gmail.com).*

How to cite this article: Rehan M, Elnady EA, Khater S, Elsayed AFA, Abdel Gawad AM, Freeg MAHA, Mahmoud AR. Comparative study between thulium laser and cold knife visual urethrotomy for treatment of short bulbomembranous urethral stricture. Medicine 2022;101:35(e30235).

Received: 20 November 2021 / Received in final form: 9 July 2022 / Accepted: 12 July 2022

http://dx.doi.org/10.1097/MD.0000000000030235

including urethral dilation, direct vision internal urethrotomy (DVIU), and laser urethrotomy.[7,8] To incise the scared tissue, increase the urethral lumen's size and allow tissue healing, DVIU is conducted using a cold-knife transurethral incision urethrotomy (CKVU).[9] The internal urethrotomy's overall success rate was estimated to be between 8 to 80%; however, the reported long-term success rate was only 30%.[10] Besides, a meta-analysis reported that CKVU was associated with erectile dysfunction, extravasation, urinary retention, haematuria, and recurrence.[11] Therefore, many researchers suggested using laser urethrotomy as an alternative to CKVU, as it has a similar success rate with a lower complication rate.

Thulium laser (TLU) is one of the laser urethrotomy techniques that has been proposed for short urethral stricture as its waves can achieve a shallow tissue penetration of less than 0.4 nm.[12] In comparison to holmium, TLU has a lower mechanical effect but produces more continuous heat.[13] Moreover, TLU has many advantages, including rapid vaporization, efficient coagulation, a clear visual field, and less thermal damage.[14] A previous study found that TLU was associated with a significant improvement in the maximum flow rate (Q-max) postoperatively, with few postoperative complications and low recurrence rates.[15] This study aimed to compare TLU and CKVU in terms of the treatment of short bulbomembranous urethral stricture.

2. Patients and Methods

2.1. Study design

This prospective, nonrandomized study was conducted for 24 months, from January 2018 to January 2020, on 60 patients with primary short bulbomembranous urethral stricture who came to the Department of Urology of Al-Azhar University Hospital, New Damietta, Egypt. We divided these patients into 2 age-matched groups; 30 patients treated with CKVU and 30 patients with TLU. No sample size calculation was done; we included all patients who met our criteria during the study period. During reporting this study, we followed the CONSORT statement.[16]

2.2. Inclusion and exclusion criteria

We included all patients with bulbomembranous stricture, de novo, less than 1 cm who presented to our center. We excluded those who had a history of an internal urethrotomy or recurrent urethral strictures. Moreover, patients with bladder tumor or calculi, penile urethral stricture, suprapubic cystostomy, and those with a more than 1-centimeter stricture length were excluded.

2.3. Study endpoints

The primary endpoint of this study was the efficacy of both methods in terms of caliber dilation assessed by PVR and Q_{max}. The secondary endpoint was the sexual function and quality of life of the included patients in both groups assessed by the international prostate symptom score (IPSS), International Index of Erectile Function (IIEF) score, and the Male Sexual Health Questionnaire (MSHQ) scale. Moreover, the early (up to 3 months postoperatively) and late recurrence (6 months postoperatively) and the complications of both techniques, including blood loss, fluid extravasation, and dysuria, were assessed as secondary endpoints.

2.4. Investigations

All patients were evaluated using abdominal-pelvic ultrasound, retrograde urethrography, and uroflowmetry. Moreover, urinalysis, biochemistry panel, and complete blood count were assessed in all patients. In patients with urinary tract infection, antibiotics were adjusted, and sterile urine was reached before the operation.

2.5. Pre- and postoperative measures

Patients were evaluated with IPSS and quality of life preoperatively and at the 1st, 3rd, and 6th months postoperatively. We considered the procedure successful when the maximum flow rate (Q_{max}) was >12 mL/s, and the patient did not complain of any persistent subjective and objective symptoms; otherwise, we performed the diagnostic urethroscopy.

2.6. Procedure

All procedures were done by 3 expert surgeons with more than 15 years of experience. Under anesthesia, and after administration of a prophylactic intravenous broad-spectrum antibiotic was given, the guidewire (Boston Scientific, USA) was inserted into the urethra via the stricture, with the help of a 7.5 French (Fr) Karl Storz ureterorenoscope (Karl Storz, Germany). The lithotomy position was used for all operations.

In the first group, CKVU was done with a straight type urethrotomy knife inserted through a 21 Charrière Storz urethrotome (Karl Storz, Germany). TLU was conducted towards the endoscopic targets in the second group using a diode-pumped solid-state thulium laser emitting light at a wavelength of 2.0 μm (Revolix LISA Laser Products, Katlenburg, Germany) transmitted through a silica fiber. After that, using a 365 m core diameter bare-ended silica fiber (PercuFib; LISA Laser Products), we incised the stricture at the 6 o'clock position. In both continuous and pulsed modes, the energy used for this purpose was controlled at a power level of 10 W.

Areas with severe stricture were defined first. In a word, the stricture region must be completely treated while healthy mucosa is preserved. In both groups, an indwelling 16Fr silicone urethral catheter was left in place for about 5 days. Patients were followed after 1, 3, and 6 months using the urethrogram. The early recurrence was defined as any subjective or objective complaint after 1 month postoperatively, while the delayed recurrence was defined as any subjective or objective complaint after 6 months postoperatively. Blood loss was calculated by assessing the pre- and postoperative hemoglobin.

2.7. Statistics

We used the Statistical Package of Social Science (SPSS; Windows version 22) to analyze our data. Data were expressed as the mean and standard deviation (SD), and all statistical tests were 2-tailed. chi-square tests (χ^2), paired *t* test, and ANOVA test were used to assess the differences between groups. A *P value of* <.05 was considered to indicate statistical significance.

3. Results

The demographic and clinical characteristics of included patients are presented in Table 1. The time of catheter removal was the same in both groups (5 days). The most common cause of stricture in both groups was iatrogenic, followed by inflammatory and traumatic.

Regarding the number of strictures, bulbar urethra strictures, membranous urethra strictures, and bulbomembranous strictures were reduced significantly after the operation in both groups, as presented in Table 2.

Table 3 shows that in terms of PVR, both groups showed a significant ($P < .001$) reduction after 6 months of follow-up; however, the reduction in TLU was greater than CKVU ($P = .008$).

Table 1

Demographic and clinical characteristics of the studied groups.

Parameters		CKVU (n=30)	TLU (n=30)	*P* value
Age (y)		43 ± 11	44 ± 10.59	.147
Causes of Stricture	Iatrogenic (cathertarization, and endoscopic surgires)	13 (43.33%)	15 (50%)	.693
	Inflammatory	10 (33.33%)	7 (23.34%)	
	Traumatic	5 (16.67%)	4 (13.33%)	
	Idiopathic	2 (6.67%)	4 (13.33%)	
Patients with benign prostatic hyperplasia		2 (6.67%)	2 (6.67%)	1.000

CKVU = cold knife visual urethrotomy, TLU = thulium laser urethrotomy.
P > .05= not significant, *P* < .001 = highly significant.

Table 2

Urethral stricture appearance by retrograde urethrogram of the 2 studied groups.

	CKVU		TLU		
Stricture site before surgery	**N**	**%**	**N**	**%**	***P* value**
Bulbar urethra	16	53.3	25	83.3	.004*
Membranous urethra	7	23.3	3	10.0	<.001*
Bulbomembranous	7	23.3	2	6.67	<.001*
Stricture site after surgery	**N**	**%**	**N**	**%**	*P* value
Bulbar urethra	7	23.3	4	13.3	.024*
Membranous urethra	3	10.0	0	0.00	<.001*
No stricture	20	66.7	26	86.7	.009*

CKVU = cold knife visual urethrotomy, TLU = thulium laser urethrotomy.
**P* < .05 = significant.

Table 3

Comparison of postvoid residual urine volume of the 2 studied groups after 6 months of follow-up.

	Before surgery (mL)		After surgery (mL)		
Group of surgery (PVR)	**Mean ±SD**	**Range**	**Mean ±SD**	**Range**	***P* value***
CKVU	79 ± 17.2	50–110	10 ± 14.5	0–40	<.001
TLU	67 ± 17.8	40–110	6 ± 13.0	0–40	<.001
P value**	.061		.008		

CKVU = cold knife visual urethrotomy, PVR = postvoid residual urine volume, SD = standard deviation, TLU = thulium laser urethrotomy.
**P* value between pre- and postoperation.
***P* value between CKVU and TLU.

Table 4

Comparison of Q-max score of CKVU and TLU before and postoperative.

	Q-max before surgery		Q-max after 6 months		
Parameters	**Mean ± SD**	**Range**	**Mean ±SD**	**Range**	***P* value**
CKVU	7 ± 1.82	5–10	16 ± 1.26	12–20	.005*
TLU	8 ± 1.96	6–11	18 ± 1.70	12–22	.001*

CKVU = cold knife visual urethrotomy, TLU = thulium laser urethrotomy.

Q_{max} was improved significantly after 6 months of operation in both groups, as shown in Table 4. However, when we compared both techniques, we found no significant difference between TLU and CKVU in terms of Qmax and Q-average before and after 1, 3, & 6 months (*P* > .05) shown in (Table A, Supplemental Digital Content, http://links.lww.com/MD/H99).

The same results were found in the comparison of the IPSS, IIEF score, and the MSHQ scale of the 2 studied groups. Intergroup comparison between IPSS and MSHQ scores before and after surgery showed a statistically significant difference (*P* < .05), as shown in (Table B, Supplemental Digital Content, http://links.lww.com/MD/H99). However, a comparison of MSHQ EJ before and after surgery between the 2 studied groups showed a statistically non-significant difference (*P* > .05), as in (Table C, Supplemental Digital Content, http://links.lww.com/MD/H99). Concerning the operative time, TLU showed a shorter operative duration (24 ± 4.17 min) than

Table 5

Complications of the 2 procedures.

Complication	CKVU	TLU	*P* value
Time of surgery (min)	33 ± 4.86	24 ± 4.17	.038*
Blood loss during surgery (mL)	65.9 ± 3.48	23.5 ± 1.62	.001*
Fluid extravasation (mL)	2 ± 0.49	2 ± 0.00	.912
Urethral dilatation: N (%)	8 (26.7%)	4 (13.3%)	.001*
Recurrence:			
Early: N (%)	8 (26.7%)	4 (13.3%)	.001*
Delayed: N (%)	6 (20.0%)	2 (6.67%)	.013*
Dysuria VAS after 2 weeks	7 ± 1.36	7 ± 1.67	.998
Dysuria VAS after 1 month	2 ± 2.16	1 ± 1.55	.041*

Visual analog scale.

*$P < .05$= significant.

CKVU duration (33 ± 4.86 min), with a statistically significant difference ($P = .038$).

As regards complications, Table 5 shows that early recurrence was observed in 8 patients (26.7%) in the CKVU group compared to 4 (13.3%) in the TLU group, ($P = .001$). Patients who experienced early recurrence were all subjected to urethral dilatation. Delayed recurrence was observed in 6 patients (20%) and 2 patients (6.67%), in the CKVU and TLU groups, respectively, ($P = .013$). Out of the patients who experienced recurrence, 2 patients required another session of TLU, 3 patients required another CKVU session, and 3 patients required open urethroplasty. In terms of blood loss during surgery, TLU was associated with a lower amount of blood loss ($P = .001$). After 1 month, the dysuria visual analog scale (VAS) was 2 ± 2.16 in the CKVU group compared to 1 ± 1.55 in the TLU group ($P = .041$).

The correlation coefficient (r) between the MSHQ score of the CKVU group before and after surgery showed a statistically significant difference ($r = 0.1435$, $P = .041$), and in the TLU group, it showed a statistically highly significant difference ($r = 0.3692$, $P = .001$) as shown in (File 1, Supplemental Digital Content, http://links.lww.com/MD/H99), Figs. 1 and 2, respectively.

4. Discussion

Although open urethroplasty is a reliable treatment for any stricture including those at the first diagnosis and recurrent strictures, the ideal management for short bulbar stricture is yet to be determined. Therefore, many researchers suggested the endoscopic treatment for the following advantages, clear vision during incision, less scar tissue, shorter hospital stay, and less bleeding.[17] However, it was reported that many patients require several endoscopic treatments to achieve improved quality of life, functionality, and lower-urinary-tract function. Moreover, stricture recurrence is commonplace when managing strictures through endoscopic approaches.[18] Several studies have compared the holmium laser and CKVU in managing short-segment urethral stricture. They have concluded that both techniques are safe and equally effective in treating short-segment urethral strictures in terms of outcome and complication rate.[7,19,20] Another study showed that holmium laser has a higher success rate than CKVU for urethral strictures ≤1.5 cm with significantly higher Qmax; however, both are easy to perform, low invasive, and safe.[21]

In the present study, both groups had a postoperative catheter size of 16 Fr. These findings were similar to Razzaghi et al, who had the same catheter removal time.[22] In patients with primary urethral strictures (<1.5 cm), DVIU entails the best surgical outcome, with an overall success rate of 80%. With longer strictures, the success rate of DVIU decreases to approximately 20%.[23] Moreover, every additional centimeter in the stricture length is associated with an increased risk of recurrence (RR: 1.22).[24]

By evaluating the success rate, Q_{max} and Q-average before and after 1, 3, and 6 months after surgery showed a statistically insignificant difference between the 2 groups ($P > .05$). The same results were found in the comparison of the IPSS, IIEF score, and MSHQ scores of the 2 studied groups. Intergroup comparison between IPSS and MSHQ scores before and after surgery showed a statistically significant value ($P < .05$). A comparison of MSHQ EJ before and after surgery between the 2 studied groups showed a statistically non-significant difference ($P > .05$). Correlation coefficient (r) between MSHQ score of cold knife group[1] before and after surgery showed a statistically significant difference ($r = 0.1435$, $P = .041$) and in thulium laser group[2] showed very highly significant difference ($r = 0.3692$, $P = .001$).

In their studies, Cecen et al,[25] and Ozcan et al,[26] found that the intervention successes in the absence of any voiding difficulties and with the Q-max greater than 12 mL/s. However, other studies reported an effective operation with Q-max greater than 10 mL/s in patients without voiding difficulty. Tom et al demonstrated that the recurrence could be identified by the Q-max and IPSS.[27] However, developing highly sensitive tools to detect the recurrence of stricture is necessary. Yenice and his colleagues stated that the procedure was considered effective in the absence of any persistent symptoms and with a Q-max greater than12 mL/s.[7]

With an overall success rate of approximately 73.9% over a period of 1 year, Wang et al achieved good results with their patients. The results of TLU, including postoperative IPSS and quality of life after 12 months, were satisfactory for 17 patients (80.95%), according to their findings.[28] A meta-analysis based on 44 non-comparative observational studies showed that the success rate of TLU was significantly ($P = .004$) higher than the CKVU (74.9% vs. 68.5%), respectively.[29] On the other hand, in his review about the current management of urethral stricture, Smith T. claimed that, regardless of energy source, laser urethrotomy was not superior to the DVIU and had a higher complication rate.[30] However, this claim was not supported with enough evidence form reviewed studies or secondary analysis (meta-analysis), and can only be considered as an expert opinion.

In agreement with our findings, laser urethrotomy had a considerably shorter mean operative time of 16.4 ± 8.04 min compared to CKVU, which had a mean of 23.8 ± 5.47 min, according to Atak et al.[31] On the contrary, Jain et al showed that CKVU took a significantly shorter time than TLU (7.44 min vs. 19.8 min), respectively.[20] Likewise, the study by Yenice et al

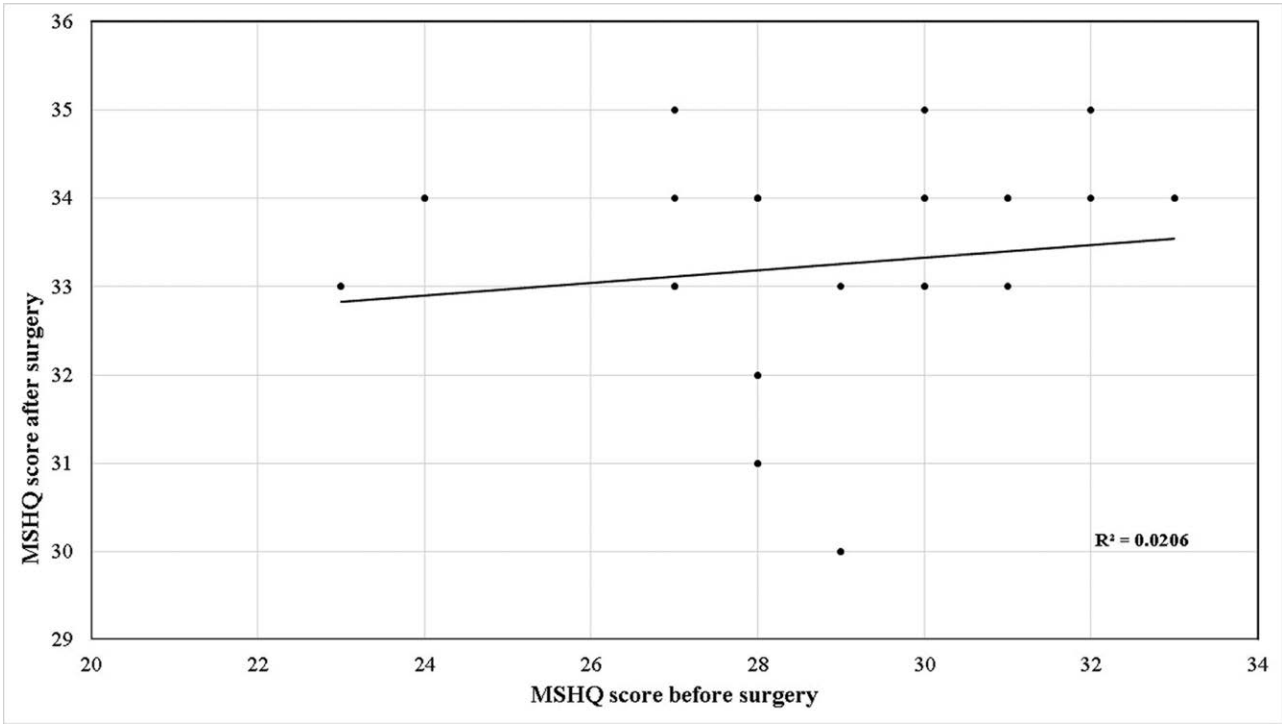

Figure 1. Correlation coefficient (r) between MSHQ score of CKVU before and after surgery (r = 0.1435, P = .041).

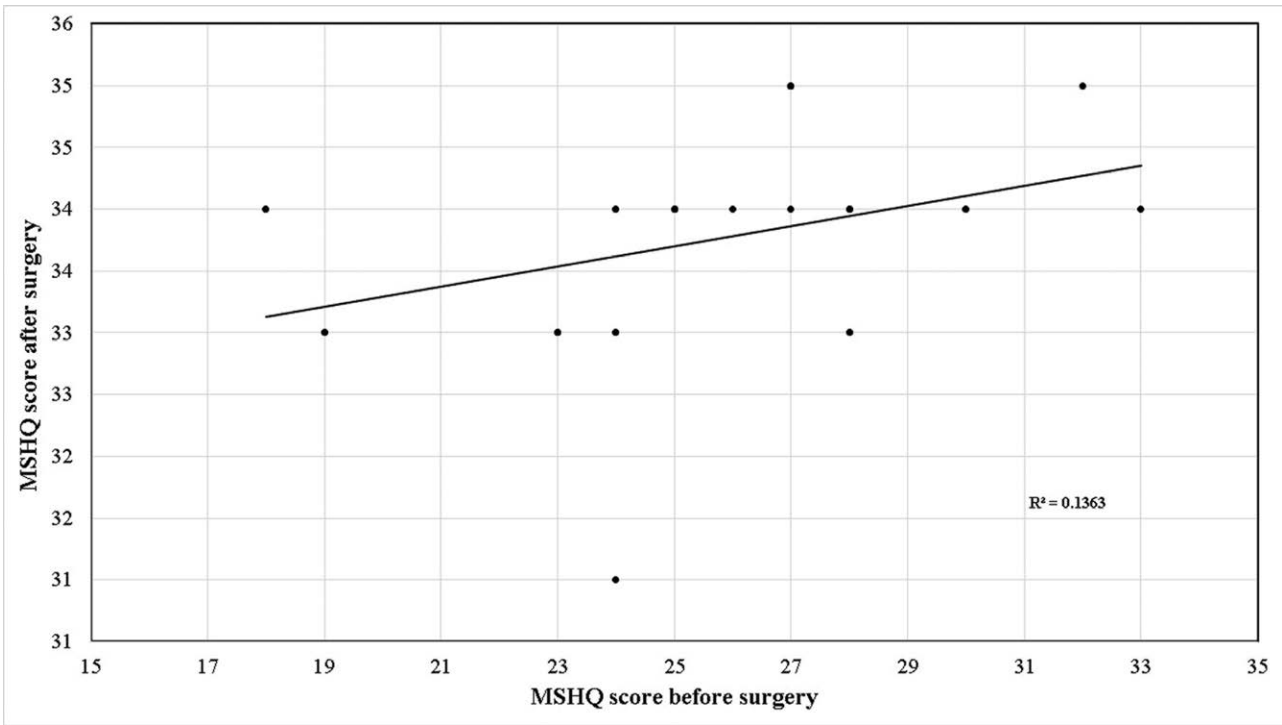

Figure 2. Correlation coefficient (r) between MSHQ score of TLU before and after surgery (r = 0.3692, P = .001).

demonstrated that the duration of the LU operation was longer than it in the CKVU group.[7] The discrepancy in these findings may be due to technical difficulties and a lack of laser treatment experience.

Urethral hemorrhage, urinary tract infection, and sepsis are associated with single or repetitive dilations. Furthermore, patients with urinary tract infections should not be assigned to the urethra dilatation.[24] Our findings showed that early recurrence was observed in 8 patients (26.7%) in the TLU group compared to 4 (13.3%) in the CKVU group (P = .001), while delayed recurrence was observed in 6 patients (20%) and 2 patients (6.67%), respectively. Dysuria VAS after 1 month was 2 ± 2.16 in the CKVU group compared to 1 ± 1.55 in the TLU group showing a statistically significant difference (P = .041). Endoscopic therapy of urethral stricture was linked to increased recurrence rates, varying from 30% to 80%, prompting plenty

of studies evaluating the efficacy of various treatment options.[7] Up to this day, similar recurrence rates in the available techniques of urethral stricture therapy have been reported. In bulbar urethral strictures, Pansadoro and Emiliozzi found a 58% of recurrence rate after CKVU.[32]

Based on our experience, TLU was more precise and accurate than CKVU. The adjustment using TLU is much easier than CKVU. The management of intraoperative bleeding is better in the TLU as it helps maintain the hemostasis, which enhances the internal vision during the procedure. The vaporization of the scar edges is more manageable in the TLU. In addition, the time of surgery was significantly shorter in the TLU compared with CKVU. Moreover, the postoperative urethral dilation was less frequent in the TLU group. Regarding the early and delayed recurrence, TLU showed less recurrence rate compared with CKVU.

We acknowledge that our study has some limitations, including the small sample size and the short follow-up period. Moreover, we only investigated bulbar urethral strictures. Another limitation was that we could not perform an inter- & intraobserver analysis as the included measures were assessed by 1 investigator with more than 15 years of experience. We could not assess and compare the risk of recurrence between the 2 groups based on a time-dependent analysis due to the lack of required data. Long-term follow-up is required to assess the density of spongiofibrosis resulting from laser energy. Performing a postoperative MRI could reveal the extent of spongiofibrosis which may be used as a predictive factor for future recurrence. Therefore, MRI findings might favor one treatment over another, which should be considered in future studies.

In conclusion, TLU is an effective and safe therapy for managing bulbomembranous urethral strictures, with a relatively low recurrence rate. However, further randomized studies with a longer follow-up period and larger sample size are required to determine the clinical value of the TLU in the treatment of urethral strictures.

References

[1] Joshi P, Kaya C, Kulkarni S. Approach to bulbar urethral strictures: which technique and when? Turk J Urol. 2016;42:53–9.

[2] Hampson LA, McAninch JW, Breyer BN. Male urethral strictures and their management. Nat Rev Urol. 2014;11:43–50.

[3] Gallegos MA, Santucci RA. Advances in urethral stricture management. F1000Res. 2016;5:2913.

[4] Lazzeri M, Sansalone S, Guazzoni G, et al. Incidence, causes, and complications of urethral stricture disease. Eur Urol Suppl. 2015;15.

[5] Bergamin PA, Kiosoglous AJ. Surgical management of recurrent urinary tract infections: a review. Transl Androl Urol. 2017;6(Suppl 2):S153–62.

[6] Stein MJ, DeSouza RA. Anterior urethral stricture review. Transl Androl Urol. 2013;2:32–8.

[7] Yenice MG, Seker KG, Sam E, et al. Comparison of cold-knife optical internal urethrotomy and holmium:YAG laser internal urethrotomy in bulbar urethral strictures. Cent Eur J Urol. 2018;71:114–20.

[8] Pal D, Kumar S, Ghosh B. Direct visual internal urethrotomy: is it a durable treatment option? Urol Ann. 2017;9:18–22.

[9] Verla W, Hoebeke P, Spinoit A-F, et al. Excision and primary anastomosis for isolated, short, anastomotic strictures in transmen. Plast Reconstr surgery Glob open. 2020;8:e2641–e2641.

[10] Santucci R, Eisenberg L. Urethrotomy has a much lower success rate than previously reported. J Urol. 2010;183:1859–62.

[11] Haroun H, Eltatawy H, Soliman MG, et al. Evaluation of outcome of transurethral needle ablation for treating symptomatic benign prostatic hyperplasia: a 10-year experience. Urol Ann. 2019;11:198–203.

[12] Zeitels SM, Burns JA, Akst LM, et al. Office-based and microlaryngeal applications of a fiber-based thulium laser. Ann Otol Rhinol Laryngol. 2006;115:891–6.

[13] Lerner LB, Rajender A. Laser prostate enucleation techniques. Can J Urol. 2015;22(Suppl 1):53–9.

[14] Chang CH, Lin TP, Chang YH, et al. Vapoenucleation of the prostate using a high-power thulium laser: a one-year follow-up study. BMC Urol. 2015;15:40.

[15] Ebrahim MFA, Selmy GI, Elshal AM, et al. Efficacy and safety of thulium laser for treatment of short segment bulbomembranous urethral stricture. Egypt J Hosp Med. 2018;72:4826–30.

[16] Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. PLoS Med. 2010;7:e1000251.

[17] Bagley DH, Grasso M. Ureteroscopic laser treatment of upper urinary tract neoplasms. World J Urol. 2010;28:143–9.

[18] Tinaut-Ranera J, Arrabal-Polo MÁ, Merino-Salas S, et al. Outcome of urethral strictures treated by endoscopic urethrotomy and urethroplasty. Can Urol Assoc J. 2014;8(1–2):E16–9.

[19] Jhanwar A, Kumar M, Sankhwar SN, et al. Holmium laser vs. conventional (cold knife) direct visual internal urethrotomy for short-segment bulbar urethral stricture: outcome analysis. Can Urol Assoc J. 2016;10:E161–4.

[20] Jain SK, Kaza RCM, Singh BK. Evaluation of holmium laser versus cold knife in optical internal urethrotomy for the management of short segment urethral stricture. Urol Ann. 2014;6:328–33.

[21] Aboulela W, ElSheemy MS, Shoukry M, et al. Visual internal urethrotomy for management of urethral strictures in boys: a comparison of short-term outcome of holmium laser versus cold knife. Int Urol Nephrol. 2018;50:605–9.

[22] Razzaghi MR, Karkan MF, Ghiasy S, et al. Laser application in Iran urology: a narrative review. J Lasers Med Sci. 2018;9:1–6.

[23] Wong SSW, Aboumarzouk OM, Narahari R, et al. Simple urethral dilatation, endoscopic urethrotomy, and urethroplasty for urethral stricture disease in adult men. Cochrane Database Syst Rev. 2012;12:CD006934.

[24] Verla W, Oosterlinck W, Spinoit A-F, et al. A comprehensive review emphasizing anatomy, etiology, diagnosis, and treatment of male urethral stricture disease. Biomed Res Int. 2019;2019:9046430.

[25] Cecen K, Karadag MA, Demir A, et al. PlasmaKinetic™ versus cold knife internal urethrotomy in terms of recurrence rates: a prospective randomized study. Urol Int. 2014;93:460–3.

[26] Ozcan L, Polat EC, Otunctemur A, et al. Internal urethrotomy versus plasmakinetic energy for surgical treatment of urethral stricture. Arch Ital di Urol Androl. 2015;87:161–4.

[27] Tam CA, Elliott SP, Voelzke BB, et al. The international prostate symptom score (IPSS) is an inadequate tool to screen for urethral stricture recurrence after anterior urethroplasty. Urology. 2016;95:197–201.

[28] Wang L, Wang Z, Yang B, et al. Thulium laser urethrotomy for urethral stricture: a preliminary report. Lasers Surg Med. 2010;42:620–3.

[29] Jin T, Li H, Jiang L, et al. Safety and efficacy of laser and cold knife urethrotomy for urethral stricture. Chin Med J (Engl). 2010;123:1589–95.

[30] Smith TG 3rd. Current management of urethral stricture disease. Indian J Urol. 2016;32:27–33.

[31] Atak M, Tokgöz H, Akduman B, et al. Low-power holmium:YAG laser urethrotomy for urethral stricture disease: comparison of outcomes with the cold-knife technique. Kaohsiung J Med Sci. 2011;27:503–7.

[32] Pansadoro V, Emiliozzi P. Internal urethrotomy in the management of anterior urethral strictures: long-term followup. J Urol. 1996;156:73–5.