MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2024.7.454.458

Holmium: Yag Versus Thulium Fiber Laser Lithotripsy in Retrograde Intrarenal Surgery for Renal Calculi: A Single Centre Comparative Study

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Abstract

Holmium laser lithotripsy, introduced in 1993, is widely used for its efficiency in stone fragmentation but is limited by a fiber diameter of 200 micrometers. The Thulium Fiber Laser (TFL), first studied in 2005, offers high power output through smaller fibers (as small as 50 micrometers), providing better irrigation flow and enhanced instrument deflection. TFL demonstrates a significantly higher stone ablation rate and less stone retropulsion compared to Holmium: YAG laser. This study aimed to evaluate the safety and efficacy of TFL compared to Holmium: YAG laser lithotripsy for renal calculi during retrograde intrarenal surgery (RIRS). A retrospective analysis was conducted on 70 patients with renal calculi (0.5 to 2 cm) treated between July 1, 2019 July 31, 2022, at Mamata Medical College, Khammam. Patients were divided into two groups: Thulium Fiber Laser Lithotripsy (Group T) and Holmium: YAG Laser Lithotripsy (Group H). Data were analyzed using SPSS with $p<0.05$ considered significant. No significant differences were observed between the groups in baseline characteristics. Stone disintegration time was significantly shorter in Group T (15.4 ± 3.1 minutes) compared to Group H (26.8±4.7 minutes) ($p = 0.04$). Group T also had lower stone retropulsion (5.7% vs. 22.8%, $p = 0.04$) and shorter overall procedure duration (41.5±7.5 minutes vs. 66.7±8.6 minutes, $p = 0.03$). Stone-free rates, hospital stay postoperative complications were comparable, though renal mucosal abrasions were higher in Group T (11.4% vs. 2.8%, $p = 0.163$). TFL demonstrated shorter stone disintegration time, reduced stone retropulsion shorter procedure duration compared to Holmium: YAG laser, with no significant differences in stone-free rates, hospital stay, or postoperative complications. However, TFL was associated with a higher incidence of renal mucosal abrasions.

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Key Words

Holmium laser lithotripsy, thulium fiber laser lithotripsy, retrograde intrarenal surgery, renal calculi

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Received: 20 April 2024
Accepted: 19 June 2024
Published: 23 June 2024

Citation: P. Reshma, J. Sasi Kumar, Y. Anil Reddy, C.H. Vamsheedhar, A. Jagadeeswar and S. Sagar, 2024. Holmium: Yag Versus Thulium Fiber Laser Lithotripsy in Retrograde Intrarenal Surgery for Renal Calculi: A Single Centre Comparative Study. Res. J. Med. Sci., 18: 454-458, doi: 10.36478/makrjms.2024.7.454.458

INTRODUCTION

Holmium laser lithotripsy, which was first introduced in 1993, rapidly became the standard among urologists due to its significant advantages. These benefits include limited loss of energy, less tissue damage highly efficient stone fragmentation. However, the Holmium: YAG laser is constrained by a fiber diameter limited to 200 micrometers. This limitation arises from the physical properties of flash lamp-generated multimode laser generators. These generators release a considerable amount of energy and therefore require an adequate water-cooling system, which contributes to their large size[1].

The Thulium Fiber Laser (TFL) has recently emerged as a promising alternative, with the first experimental lithotripsy study conducted in 2005. TFL operates differently from the Holmium laser as it is generated and pumped by diodes into a silica fiber. This method allows for the delivery of high power output through very small fibers, as small as 50 micrometers. The use of smaller fibers offers several procedural advantages, including better irrigation flow and enhanced instrument deflection, which are critical during lithotripsy procedures[2,3].

When comparing the TFL to the Holmium laser, the TFL demonstrates a significantly higher stone ablation rate, estimated to be 1.5-4 times faster. This increased efficiency is a major benefit for urologists as it can lead to shorter procedure times and potentially better outcomes for patients[4,5]. Moreover, TFL produces less stone retropulsion. This is due to the smaller bubbles generated by TFL, which results from differences in bubble dynamics and lower peak power compared to the Holmium laser. Reduced stone retropulsion is advantageous as it can minimize the movement of stone fragments during the procedure, thereby increasing the precision and effectiveness of the lithotripsy[6,7].

Despite these promising attributes and extensive in vivo studies, TFL has only been the subject of a few clinical studies. This limited clinical data means that while the theoretical and experimental benefits of TFL are well-documented, its practical efficacy and safety in a clinical setting remain to be fully validated. Further clinical research is necessary to establish the role of TFL in routine urological practice and to confirm its advantages over the traditional Holmium laser lithotripsy. The present aim of the study was to evaluate the safety and efficacy of TFL with holmium: YAG laser lithotripsy for renal calculi during RIRS.

MATERIAL AND METHODS

This study was designed as a retrospective analysis to evaluate and compare the efficacy and outcomes of Thulium fiber laser lithotripsy and Holmium: YAG laser lithotripsy in the treatment of renal calculi. The study was conducted in the Urology Outpatient Department (OPD) at Mamata Medical College, Khammam. This setting provided a diverse patient population suitable for evaluating the effectiveness of the two laser treatments. Prior to the study, written informed consent was obtained from all participants. The study protocol was reviewed and approved by the institutional ethics committee, ensuring adherence to ethical standards in research involving human subjects. The study spanned from July 1, 2019, to July 31, 2022, covering a comprehensive period of 24 months. This time frame allowed for a robust collection of data and outcomes. The study population consisted of patients diagnosed with renal calculi ranging from 0.5-2 cm in size. This specific range was chosen to ensure uniformity in the treatment comparisons.

Sample Size: A total of 70 patients met the inclusion criteria and were selected for the study. These patients were systematically divided into two equal groups:

Group T: Received Thulium fiber laser lithotripsy in retrograde intrarenal surgery for renal calculi.

Group H: Received Holmium: YAG laser lithotripsy in retrograde intrarenal surgery for renal calculi.

Sampling Design: Patients were selected using a systematic random sampling method. This approach ensured that the sample was representative of the broader patient population and minimized selection bias.

Inclusion Criteria:

- Patients diagnosed with renal calculi measuring between 0.5-2 cm.
- Age between 16 and 75 years.
- Patients who provided written informed consent to participate in the study.

Exclusion Criteria:

- Stone density greater than 1400 HU (Hounsfield Units).
- Presence of multiple renal calculi.
- Patients under the age of 16 years or over the age of 75 years.
- Patients who did not provide written informed consent.

Study Procedure
Laser Equipment:

- Thulium Fiber Laser (UROLAS SP+).
- Holmium: YAG Laser (AURIGA, 30 watt, Starmedtec) with a fiber diameter of 200 µm.

Laser Settings:

- **Holmium: YAG Laser:** Fragmentation settings were 1.5-2J at 5 Hz frequency, with a power output of 7.5-10 watts.
- **Thulium Fiber Laser (TFL):** Fragmentation settings were 1.5J at 7 Hz frequency, with a power output of 10 watts.

Procedure: Both laser types were used in fragmentation mode to break down the renal calculi. A flexible ureteroscope of 7.5 Fr, with an up-and-down deflection capability of 270 degrees, was employed in all cases to access and treat the calculi effectively.

Statistical Analysis: The collected data were analyzed using SPSS software (trial version 23.0). Statistical significance was determined with a p-value threshold of less than 0.05. This analysis included a comparison of stone fragmentation efficiency, procedure duration, complication rates overall treatment outcomes between the two groups.

RESULTS AND DISCUSSIONS

The (Table 1) provides a comparative analysis of independent factors between two groups: Group T (Thulium Fiber Laser Lithotripsy) and Group H (Holmium: YAG Laser Lithotripsy). In terms of gender distribution, Group T had 28 males (70%), while Group H had 27 males (67.5%), showing no statistically significant difference (p = 0.771). The mean age of patients in Group T was 42.4 years (±6.7), compared to 44.7 years (±5.3) in Group H, also with no significant difference (p = 0.788). Regarding the prior history of renal calculi, 11 patients (27.5%) in Group T and 13 patients (32.5%) in Group H had such a history, which was not significantly different (p = 0.614). The average stone size was 1.1 cm (±0.5) in Group T and 1.3 cm (±0.6) in Group H, again showing no significant difference (p = 0.798). The distribution of stone locations was similar across both groups, with stones primarily located in the lower calyx (48.6% in Group T and 54.3% in Group H) no significant differences were found in the stone locations (p = 0.891). Overall, these demographic and clinical characteristics indicate that the two groups were well-matched, providing a solid foundation for comparing the outcomes of the two lithotripsy methods.

The table 2 provides a comparative analysis of various stone treatment characteristics between Group T (Thulium Fiber Laser Lithotripsy) and Group H (Holmium: YAG Laser Lithotripsy). The average stone density was similar between the groups, with Group T showing 1010±84 Hounsfield Units (HU) and Group H showing 950±95 HU, which was not statistically significant (p = 0.637). However, significant differences were observed in other parameters. The stone disintegration time was significantly shorter in Group T (15.4±3.1 minutes) compared to Group H (26.8±4.7 minutes), with a p-value of 0.04, indicating a statistically significant difference. Additionally, stone retropulsion was notably lower in Group T, with only 2 cases (5.7%), compared to 8 cases (22.8%) in Group H, also showing a statistically significant difference (p = 0.04). Furthermore, the overall procedure duration was significantly reduced in Group T (41.5±7.5 minutes) compared to Group H (66.7±8.6 minutes), with a p-value of 0.03. In summary, the Thulium Fiber Laser Lithotripsy demonstrated significant advantages over the Holmium: YAG Laser Lithotripsy, including shorter stone disintegration time, lower incidence of stone retropulsion reduced overall procedure duration, while maintaining comparable stone densities between the groups.

The (table 3) compares post-treatment outcomes between Group T (Thulium Fiber Laser Lithotripsy) and Group H (Holmium: YAG Laser Lithotripsy). The stone-free rate was slightly higher in Group T, with 34 patients (97.2%) achieving stone-free status compared to 32 patients (91.4%) in Group H, though this difference was not statistically significant (p = 0.303). The mean duration of hospital stay was comparable between the two groups, with Group T having an average stay of 2.4±1.2 days and Group H having an average stay of 2.8±1.4 days, with no significant difference (p = 0.828).

Both groups had no residual stones at the 30-day follow-up, indicating complete stone clearance in all cases, which rendered statistical comparison not applicable (NA). The incidence of renal mucosal abrasions was higher in Group T, with 4 cases (11.4%) compared to 1 case (2.8%) in Group H, but this difference was not statistically significant (p = 0.163).

Overall, the post-treatment outcomes were largely similar between the two groups, with both showing high stone-free rates and minimal hospital stays. The slightly higher incidence of renal mucosal abrasions in the Thulium Fiber Laser group did not reach statistical significance.

This study evaluated the safety and efficacy of TFL compared to HO: YAG laser in RIRS All patients were successfully treated .The stent was placed post procedure in all the patients. Operative time was the time from insertion of scope to stent placement. Stone disintegration time is the total time taken by laser to fragment the stone. Retropulsion scoring using Likert scale: 0-no retropulsion, 1-retropulsion, do not effect stone ablation, 2-retropulsion that interfere with stone ablation. All the patients underwent post operative xray kub on POD 1 and after one month for residual stones. There was no significant difference statistically between the two groups regarding age, gender ,prior

Table 1: Association between Baseline characteristics and type of laser used for RIRS

Sl. No	Independent factors		Group T	Group H	p-value
1	Male		28 (70%)	27 (67.5%)	0.771# [NS]
2	Age (years)		42.4 ± 6.7	44.7 ± 5.3	0. 788* [NS]
3	Prior history of renal calculi		11 (27.5%)	13 (32.5%)	0.614# [NS]
4	Average size of the stone (cms)		1.1 ± 0.5	1.3 ± 0.6	0.798* [NS]
5	Stone location	Upper calyx	8 (22.8%)	7 (20%)	0. 891#[NS]
		Middle calyx	10 (28.6%)	9 (25.7%)	
		Lower calyx	17 (48.6%)	19 (54.3%)	

#Chi-square test, *unpaired t-test

Table 2: Comparative Analysis of Stone Treatment Characteristics Between Thulium Fiber Laser and Holmium: YAG Laser Lithotripsy

Sl. No	Independent factors	Group T	Group H	p-value
1	Stone density (HU)	1010 ± 84	950 ± 95	0. 637 [NS]
2	Stone disintegrating time	15.4 ± 3.1	26.8 ± 4.7	0.04* [Sig.]
3	Stone Retropulsion	2 [5.7%]	8 [22.8]	0.04# [Sig.]
4	Procedure's overall duration	41.5 ± 7.5	66.7 ± 8.6	0.03* [Sig.]

Table 3: Comparative Analysis of Post-Treatment Outcomes Between Thulium Fiber Laser and Holmium: YAG Laser Lithotripsy

Sl. No	Independent factors	Group T	Group H	p-value
1	Stone free rate	34 (97.2%)	32 (91.4%)	0.303# [NS]
2	Mean duration of hospital stay	2.4 ± 1.2	2.8 ± 1.4	0. 828* [NS]
3	Residual stones at 30-day follow-up	Nill	Nill	NA
4	Renal mucosal abrasions	4 (11.4%)	1 (2.8%)	0.163* [NS]

history of stone disease, average size of the stone and location, stone density, stone free rate , post operative complications (fever, Hematuria), duration of hospital stay, except for stone distentigration time which was shorter for TFL. Kronenberg[8] summarized TFL stone ablation was faster by two times and four times for fragmentation and dusting mode respectively when compared to Ho: YAG laser lithotripsy.

Mahajan AD, Mahajan SA *et al*, In terms of stone disintegration time (11 min 19 s vs. 20 min 45s) TFL was highly effective, hospital stay was less in TFL group slightly better stone-free rate was reported in TFL group[9]. Panthier F, Doizi[10] and Gao B, Bobrowski A, Lee[11] concluded that the efficiency of TFL is better than Ho: YAG laser (low power or Moses technology),in ablation of stone, using the similar pulse energy and frequency settings during stone lithotripsy.

The lesser operative and lasering time were noted by the A. G Martov *et al*.'s study[12]. probably due to the faster ablation speed of the TFL compared to the Ho: YAG, SFR showed no significant difference. Unlike the present study, Ulvik *et al* showed improved SFR of renal stones (86% vs 49%, P = .001) but like present study showed shorter operative times for the TFL when compared to the holmium laser[13]. Bertrand Delbarre et al stone free status was similar in both groups (p = 0.06). Complication rates were comparable. For stones of size 1-2 cm operative time was shorter, whereas its similar for stones <1 cm and >2 cm[14].

CONCLUSION

Over all there is no difference for stone free rate , hospital stay duration and post op complications. However TFL exhibits considerably shorter stone disintegration time thus less operating time and less retropulsion. It is important to note that TFL is associated with a higher occurrence of renal mucosal abrasions.

REFERENCES

1. Sayer, J.J.D., R.E. Price and D.M. Cromeens, 1993. Ureteral lithotripsy with Holmium :YAG laser. J. Clin. laser, med. surg. 11: 61-65.
2. Blackmon, R.L., T.C. Hutchens, L.A. Hardy, C.R. Wilson, P.B. Irby and N.M. Fried, 2014. Thulium fiber laser ablation of kidney stones using a 50-µm-core silica optical fiber. Optical Eng., Vol. 54 .10.1117/1.oe.54.1.011004.
3. Pasqui, F., 2004. Impact on active scope deflection and irrigation flow of all endoscopic working tools during flexible ureteroscopy. Eur. Urol., 45: 58-64.
4. Hardy, L.A., C.R. Wilson, P.B. Irby and N.M. Fried, 2014. Thulium fiber laser lithotripsy in anIn vitroUreter model. J. Biomed. Optics, Vol. 19 .10.1117/1.jbo.19.12.128001.
5. Blackmon, R.L., P.B. Irby and N.M. Fried, 2010. Holmium:yag (? = 2, 120 nm) versus thulium fiber (? = 1, 908 nm) laser lithotripsy. Lasers Surg. Med., 42: 232-236.
6. Blackmon, R.L., P.B. Irby and N.M. Fried, 2011. Comparison of holmium:yag and thulium fiber laser lithotripsy: Ablation thresholds, ablation rates, and retropulsion effects. J. Biomed. Optics, Vol. 16 .10.1117/1.3564884.
7. Hardy, L.A., J.D. Kennedy, C.R. Wilson, P.B. Irby and N.M. Fried, 2016. Analysis of thulium fiber laser induced bubble dynamics for ablation of kidney stones. J. Biophotonics, 10: 1240-1249.
8. Kronenberg, P., B.Z. Hameed and B. Somani, 2021. Outcomes of thulium fibre laser for treatment of urinary tract stones: Results of a systematic review. Curr. Opin. Urol., 31: 80-86.
9. Mahajan, A. and S. Mahajan, 2022. Thulium fiber laser versus holmium:yttrium aluminum garnet laser for stone lithotripsy during mini-percutaneous nephrolithotomy: A prospective randomized trial. Indian J. Urol., 38: 42-47.

10. Panthier, F., S. Doizi, P. Lapouge, C. Chaussain, N. Kogane, L. Berthe and O. Traxer, 2020. Comparison of the ablation rates, fissures and fragments produced with 150 µm and 272 µm laser fibers with superpulsed thulium fiber laser: An in vitro study. World J. Urol., 39: 1683-1691.
11. Gao, B., A. Bobrowski and J. Lee, 2020. A scoping review of the clinical efficacy and safety of the novel thulium fiber laser: the rising star of laser lithotripsy. Can. Urological Assoc. J., 15: 56-66.
12. Martov, A.G., D.V. Ergakov, M. Guseynov, A.S. Andronov and O.A. Plekhanova, 2021. Clinical comparison of super pulse thulium fiber laser and high-power holmium laser for ureteral stone management. J. Endourology, 35: 795-800.
13. Ulvik, Ø., M.S. Æsøy, P. Juliebø-Jones, P. Gjengstø and C. Beisland, 2022. Thulium fibre laser versus holmium:yag for ureteroscopic lithotripsy: Outcomes from a prospective randomised clinical trial. Eur. Urol., 82: 73-79.
14. Delbarre, B., F. Baowaidan, T. Culty, L. Khelfat and M. Brassier et al., 2023. Prospective comparison of thulium and holmium laser lithotripsy for the treatment of upper urinary tract lithiasis. Eur. Urol. Open Sci., 51: 7-12.