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Clinical outcomes of 20-W versus 100-W holmium:YAG laser systems in retrograde intrarenal surgery: Implications for resource-constrained practice

Nikhil Vasan Arulmany

nikhil.arulmany@gmail.com

Amrita Institute of Medical Sciences and Research Centre

Rohan Rajendran

Amrita Institute of Medical Sciences and Research Centre

Georgie Mathew

Amrita Institute of Medical Sciences and Research Centre

Research Article

Keywords: holmium:YAG laser, kidney calculi, laser lithotripsy, retrograde intrarenal surgery, ureteroscopy

Posted Date: November 3rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11353672/v1

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Additional Declarations: No competing interests reported.

Abstract

High-power holmium:yttrium-aluminium-garnet (Ho:YAG) systems offer a wider operating range for laser lithotripsy, but the additional capability may be difficult to justify in resource-constrained practice. We compared outcomes after retrograde intrarenal surgery (RIRS) performed with 20-W and 100-W Ho:YAG systems. This retrospective cohort included 125 consecutive adults treated between March 2023 and June 2025 with a Lumenis 100-W (n = 87) or 20-W (n = 38) Ho:YAG system. Operative time was the primary outcome, and stone clearance was assessed by computed tomography of the abdomen at 4 weeks. Stones were larger in the 100-W group (1.62 ± 0.55 vs 1.16 ± 0.31 cm; P < 0.001). Mean operative time was 47.50 ± 20.51 versus 40.21 ± 20.24 minutes (P = 0.069). Complete clearance was achieved in 59/87 (67.8%) and 30/38 (78.9%) patients, respectively (P = 0.283). The need for ancillary procedures, Clavien-Dindo grade I-II complications, and total laser energy were also similar; no grade III or higher complication occurred. In this cohort, the 100-W platform did not show a clear clinical advantage over the 20-W platform. Because treatment allocation was non-random and larger stones were preferentially treated with the 100-W system, these data do not establish equivalence. They do, however, suggest that a 20-W Ho:YAG system remains a reasonable option for appropriately selected RIRS cases in centres where high-power equipment is difficult to justify.

Introduction

Retrograde intrarenal surgery (RIRS) is now a well-established minimally invasive treatment for renal calculi. The choice between RIRS and other stone treatments depends on stone size and location, renal anatomy, patient factors, and local expertise [1, 2]. Holmium:yttrium-aluminium-garnet (Ho:YAG) laser lithotripsy remains widely used because it is effective across common stone compositions and can be tailored for either fragmentation or dusting.

High-power Ho:YAG generators are attractive because they permit a broader range of pulse energy and frequency settings. Whether that technical flexibility translates into better patient-level outcomes is less certain, particularly because the rated power of a generator is not the same as the power actually delivered throughout a procedure. Available clinical series generally report similar stone-free and complication rates with high- and low-power platforms, although higher-power systems may shorten lasing or fragmentation time [3, 4]. In a direct RIRS comparison, a 60-W strategy shortened operative and stone-disintegration times compared with a 20-W strategy, but the stone-free rate was unchanged [5].

We therefore compared RIRS performed with 20-W and 100-W Ho:YAG systems in routine clinical practice. Our primary outcome was operative time. We also compared stone clearance, the need for ancillary procedures, perioperative complications, and total laser energy. A further aim was to consider whether the 20-W platform remains a practical option for peripheral or resource-constrained centres in which the cost and infrastructure requirements of a high-power laser may be difficult to justify.

Materials and methods

We retrospectively compared consecutive adults who underwent RIRS for renal calculi at the Department of Urology, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham, Kochi, Kerala, India, between March 2023 and June 2025. Patients were eligible if they were aged 18 years or older and underwent RIRS for a renal stone. We excluded patients with active urinary tract infection, uncorrected coagulopathy, pregnancy, an untreated ureteric stricture, or a non-functioning kidney.

Preoperative assessment included clinical evaluation, complete blood count, renal function tests, urine culture, ultrasonography, and non-contrast computed tomography of the kidneys, ureters, and bladder to assess stone size, location, and attenuation. All procedures were performed under general anaesthesia by experienced surgeons according to departmental practice. Use of a ureteral access sheath and ureteric stenting was recorded. Patients were grouped according to the Lumenis Ho:YAG system used: 100 W or 20 W. During the study period, lithotripsy was performed with pulse energies of 0.3–1.5 J and frequencies of 5–20 Hz, using short-pulse mode and a SlimLine SIS 200 laser fibre (Lumenis). Exact pulse duration and laser-on time were not available for analysis. The comparison therefore reflects the two generator platforms rather than a fixed wattage delivered throughout each case.

Operative time, measured from scope insertion to removal, was the primary endpoint. Stone clearance was assessed by computed tomography of the abdomen at 4 weeks and recorded as complete, near-complete, or partial. The study records did not contain a numerical residual-fragment threshold for these categories, so we retained the original classifications rather than applying a new definition retrospectively. This is relevant because reported stone-free rates after ureteroscopy vary with the residual-fragment threshold, imaging modality, and timing of follow-up [6]. Other analysed outcomes were the need for an ancillary procedure, Clavien-Dindo complications, total laser energy, and stone attenuation in Hounsfield units.

The study was approved by the Institutional Ethics Committee, Amrita Institute of Medical Sciences (ECASM-AIMS-2025-153; 16 April 2025), and was performed in accordance with the Declaration of Helsinki and its later amendments. Written informed consent was obtained from the included participants.

Continuous variables are reported as mean±standard deviation and categorical variables as number (percentage). Continuous outcomes were compared with independent-samples t tests and are presented with mean differences and 95% confidence intervals (CIs). Fisher's exact test was used for complete versus non-complete clearance, ancillary procedures, and any versus no complication. All tests were two-sided, with $P < 0.05$ considered statistically significant.

Results

The study included 125 patients with a mean age of 49.33 ± 13.21 years; 81 (64.8%) were men. Thirty-three patients (26.4%) had been pre-stented, and a ureteral access sheath was used in 93 procedures (74.4%). Overall cohort characteristics are shown in Table 1.

Table 1
Overall cohort characteristics

Characteristic	Value
Age, years	49.33 ± 13.21
Male sex	81 (64.8)
Female sex	44 (35.2)
Prior ureteric stent	33 (26.4)
No hydronephrosis	95 (76.0)
Mild hydronephrosis	23 (18.4)
Moderate hydronephrosis	7 (5.6)
Ureteral access sheath used	93 (74.4)
Values are mean±standard deviation or n (%).	

Eighty-seven patients underwent RIRS with the 100-W system and 38 with the 20-W system. Mean stone attenuation was similar between groups (979.54 ± 304.09 vs 1005.52 ± 297.88 Hounsfield units; P = 0.659). Stone size, however, differed substantially: stones treated with the 100-W system measured 1.62 ± 0.55 cm compared with 1.16 ± 0.31 cm in the 20-W group (mean difference 0.46 cm, 95% CI 0.31–0.61; P < 0.001). This baseline imbalance is important when interpreting the unadjusted outcome comparisons.

Mean operative time was 47.50 ± 20.51 minutes with the 100-W system and 40.21 ± 20.24 minutes with the 20-W system (mean difference 7.29 minutes, 95% CI -0.59 to 15.17; P = 0.069). Total laser energy was also similar (16.33 ± 9.90 vs 14.46 ± 10.95 kJ; P = 0.349).

Complete clearance was recorded in 59/87 (67.8%) patients in the 100-W group and 30/38 (78.9%) in the 20-W group (P = 0.283). Near-complete clearance occurred in 26 and eight patients, respectively; partial clearance was recorded in two patients in the 100-W group and none in the 20-W group. Ancillary procedures were required in 32/87 (36.8%) and 12/38 (31.6%) patients (P = 0.685). Clavien-Dindo grade I-II complications occurred in 18/87 (20.7%) and 4/38 (10.5%) patients (P = 0.208). No grade III or higher complication was recorded. The between-group outcomes are summarised in Table 2.

Table 2
Comparison of stone characteristics and clinical outcomes by laser platform

Variable	100-W platform	20-W platform	P value
Patients, n	87	38	-
Stone size, cm	1.62 ± 0.55	1.16 ± 0.31	< 0.001
Stone attenuation, HU	979.54 ± 304.09	1005.52 ± 297.88	0.659
Operative time, min	47.50 ± 20.51	40.21 ± 20.24	0.069
Total laser energy, kJ	16.33 ± 9.90	14.46 ± 10.95	0.349
Complete clearance	59 (67.8)	30 (78.9)	0.283*
Near-complete clearance	26 (29.9)	8 (21.1)	-
Partial clearance	2 (2.3)	0	-
Ancillary procedure	32 (36.8)	12 (31.6)	0.685*
Any Clavien-Dindo I-II complication	18 (20.7)	4 (10.5)	0.208*
Clavien-Dindo grade III or higher	0	0	-

Values are mean±standard deviation or n (%). HU, Hounsfield unit. *Fisher's exact test for the binary comparison; continuous variables were compared using independent-samples t tests. Clearance categories were assigned on computed tomography of the abdomen at 4 weeks; a numerical residual-fragment threshold separating categories was not available.

Discussion

In this cohort, use of the 100-W Ho:YAG platform did not translate into shorter overall operative time, higher complete clearance, fewer ancillary procedures, lower total laser energy, or fewer complications. This is clinically relevant for centres where the capital and infrastructure requirements of a high-power laser may restrict access to RIRS. The finding should, however, be read with two important cautions. First, this was not an equivalence or non-inferiority study. Second, stones treated with the 100-W system were on average 4.6 mm larger. Our data therefore show comparable observed outcomes between the two platforms in this cohort; they do not prove that the systems are equivalent.

These results are consistent with much of the published literature. Ventimiglia et al pooled 22 retrospective series and found similar stone-free rates with low- and high-power Ho:YAG lithotripsy, although high-power systems were associated with shorter lithotripsy time; substantial heterogeneity and differences in stone burden limited the comparison [3]. The more recent EAU Endourology review reached a similar conclusion: fragmentation was generally faster at higher power, but the evidence remained heterogeneous and better randomised studies were needed [4]. Tsaturyan et al also reported the same stone-free rate with 60-W and 20-W strategies, despite shorter operative and stone-disintegration times in the higher-power arm [5]. In our series, preferential use of the 100-W system for

larger stones may have offset any gain in fragmentation efficiency when total operative time was considered.

Stone clearance also needs to be interpreted in context. A reported 'stone-free rate' is strongly influenced by how residual fragments are defined, which imaging test is used, and when that imaging is performed [6]. Registry data further suggest that stone size, lower-pole location, multiplicity, and attenuation influence residual fragments after RIRS independently of the laser platform [9]. The 0.46-cm difference in mean stone size between our groups is therefore clinically important and limits any simple unadjusted comparison of clearance.

Safety outcomes were acceptable in both groups, and all recorded complications were Clavien-Dindo grade I or II. Large international ureteroscopy series have likewise shown that major complications are uncommon, although overall rates vary with case mix and definitions [7, 8]. The use of higher-power laser systems still requires careful attention to irrigation and thermal load. Experimental studies show that intrarenal temperature can rise quickly during Ho:YAG activation when irrigation is interrupted [11]. Ureteral access sheaths, used in about three-quarters of our procedures, may improve access and outflow but can themselves cause ureteral wall injury [10]. In practice, safe RIRS depends on the interaction between laser settings, irrigation, access, anatomy, and surgical technique rather than on generator wattage alone.

Generator rating is also an imperfect measure of the laser exposure a stone actually receives. Fragmentation depends on pulse energy, frequency, pulse duration, fibre characteristics, contact with the stone, and the chosen lithotripsy strategy. In our cohort, the recorded setting range was 0.3–1.5 J and 5–20 Hz, delivered in short-pulse mode through a SlimLine SIS 200 fibre. Changes in pulse energy and frequency are known to alter both fragmentation and retropulsion [12]. Because exact pulse duration and laser-on time were not available, our results are best viewed as a comparison of two laser platforms, not as a direct comparison of continuously delivered 20 W versus 100 W.

Several limitations should be considered. The study was retrospective, non-randomised, single-centre, and the groups were unequal in size. The 100-W group had significantly larger stones, and group-level data for several potential confounders - including age, sex, prestenting, hydronephrosis, access-sheath use, and detailed stone location - were not available for adjusted modelling. Although the study-level laser setting range was known, exact pulse duration and laser-on time were not. Clearance was assessed by computed tomography at 4 weeks, but the records did not specify a numerical residual-fragment threshold for the clearance categories. Finally, the study had no prespecified equivalence or non-inferiority margin and did not collect acquisition, maintenance, or infrastructure costs. We therefore cannot claim formal equivalence or cost-effectiveness.

Even with these limitations, the resource question is worth considering. De Coninck et al argued that high-power, high-frequency Ho:YAG systems are not essential for RIRS and highlighted the practical appeal of a lower-power system that can operate from a standard electrical outlet [13]. Earlier prospective experience similarly found low-power Ho:YAG adequate for urinary stone fragmentation and

proposed it as a lower-cost option for centres that do not need high-power applications [14]. Our findings add a real-world clinical perspective: despite preferential use of the 100-W system for larger stones, we did not observe a clear advantage in overall operative time, clearance, ancillary procedures, or complications. For appropriately selected cases, this supports continued use of a 20-W system where the cost or infrastructure required for a high-power platform is difficult to justify. It does not mean that 20 W and 100 W perform identically in every setting; high-power systems may still offer faster fragmentation, particularly for larger or more complex stone burdens [3, 4]. A prospective non-inferiority study with a prespecified margin and a parallel economic analysis would be the most direct way to test this question.

Conclusions

In this retrospective cohort, the 100-W Ho:YAG system did not produce better overall clinical outcomes than the 20-W system, despite being used preferentially for larger stones. The study was not designed to establish equivalence. Still, for appropriately selected renal stones, the observed clearance, ancillary-procedure, and safety outcomes suggest that a 20-W Ho:YAG platform remains a practical option for centres where the acquisition or infrastructure burden of a high-power laser is prohibitive. High-power systems may retain an efficiency advantage for larger or more complex stones, and this should be considered when choosing equipment for local case mix.

Declarations

Ethics approval:

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Institutional Ethics Committee, Amrita Institute of Medical Sciences (16 April 2025; ECASM-AIMS-2025-153).

Funding:

No funding was received for conducting this study.

Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Prior presentation: This work has not been presented at any scientific forum or conference.

Author Contribution

N.V.A., R.R., G.M., contributed to the study conception and design. R.R. and G.M., contributed resources required for the study, including access to relevant patient data and clinical material. Data collection and

analysis was performed by N.V.A. The first draft of the manuscript was written by N.V.A., and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Artificial intelligence was used to assist with formatting and presentation of the manuscript content.

Data Availability

The de-identified data supporting the findings of this study are available from the corresponding author on reasonable request, subject to institutional and ethical requirements.

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