Increased oscillation rate may improve morcellation efficiency in HoLEP

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ABSTRACT

Introduction: Tissue morcellation has become increasingly efficient, yet remains a rate limiting step in holmium enucleation of the prostate (HoLEP). Limited data exists on how the rate of oscillation by the morcellator blades affects morcellation efficiency (ME).
Methods: We undertook a retrospective review of HoLEP procedures performed by two surgeons from July 1, 2019 to August 25, 2022. All morcellation was performed with the Wolf Piranha device and enucleation was performed with Moses 2.0 technology. Surgeon 1 routinely uses 1500 oscillations/min (low rate [LR]) and Surgeon 2 uses a rate of 6000 oscillations/min (high rate [HR]). These rates were confirmed upon EMR review of each case. The primary endpoint was ME (g/minute). Secondary endpoints included enucleation efficiency (EE), mean tissue specimen weight, and preoperative prostate volume.
Results: A total of 894 HoLEPs were analyzed, 592 by Surgeon 1 and 302 by Surgeon 2. Surgeon 1 had larger preoperative prostate volumes (126 vs. 101, p<0.001) and specimen tissue weights (86.0 vs, 61.1, p<0.001). EE was higher in the LR group (1.67 vs. 1.33 g/min, p<0.001). Morcellation time was longer in the LR group (11.3 vs. 6.09 min, p<0.001) and ME was lower in

KEY MESSAGES

- Tissue morcellation was more efficient when using a higher rate of oscillation.
- The difference in morcellation efficiency was inversely proportional to specimen weight.
- Our subgroup analysis revealed a difference in efficiency up to a resected tissue weight of 150 g.
- This study helps expand the possibilities of one aspect of HoLEP and refine mechanical morcellation techniques.

the LR group (9.26 vs. 12.1 g/min, p<0.001). The difference in ME was inversely proportional to specimen weight.
Conclusions: Increased oscillation rate during morcellation may lead to decrease in morcellation time and increased ME during prostate enucleation. The primary limitation of this paper is the inclusion of only two surgeons. Future studies will serve to evaluate this finding across a larger number of institutions, and evaluate ways to increase ME in large prostate cohorts.

INTRODUCTION

Holmium laser enucleation of the prostate (HoLEP) is a size independent surgical treatment for patients with symptomatic benign prostatic hyperplasia (BPH)[1]. The procedure provides advantages to transurethral resection of prostate (TURP) in prostates above 80 grams and proves to be the single most cost-effective surgical treatment of BPH at 5 years post-operatively [2,3]. As such, HoLEP offers an appealing option to patients who desire surgical management of BPH with successful and durable outcomes.

HoLEP has further demonstrated superiority to TURP in terms of post-operative catheterization time and hospitalization duration [4]. However, when compared to TURP, HoLEP operative times are 16 minutes longer in preoperative size-matched prostates[5]. This increase in time can translate into increased operative costs. A study of over 300 facilities by Childers and colleagues estimated the average operative room (OR) costs to be 36-37 dollars/minute for acute care hospitals in FY2014[6]. Furthermore, the reported operating room costs of a tertiary care center for urolithiasis, estimated their OR costs to be anywhere from 64-115 dollars/minute [7]. With these significant costs in mind, any incremental changes in the operative flow of HoLEP procedures would be a welcomed value enhancement.

HoLEP can be divided into enucleation and morcellation phases. Significant efforts have been employed to improve enucleation time since the advent of HoLEP. Improvement in laser technology with the advent of the MOSES™ pulsed modulation has enhanced operative efficiency[8]. Additionally, evolving operative technique with en bloc resection has sought to decrease enucleation times[9]. However, different enucleation power settings have been shown to have no significant effect on intra or post operative variables like operative efficiency, bleeding rates, and other complication rates[10]. While much focus has been placed on enucleation, the literature on morcellation efficiency has been sparse.

Following enucleation of the prostatic adenoma, morcellation is performed to remove the benign tissue from the bladder and urethral space[11]. Currently, the safest and most efficient morcellator device is the Wolf Piranha[12]. In practice, morcellation oscillation rates can range from 0-6000 oscillations per minutes. Currently there is minimal guidance on ideal morcellator settings to maximize efficiency of morcellation. Oscillating techniques have already been shown to be superior to reciprocating blades in the mechanical morcellation of enucleated tissue[13].

Previous studies have demonstrated optimal morcellator device design while characterizing the efficiencies at base oscillation rates and size-dependent factors affecting morcellation. The current manufacturer's recommendation for the Piranha (Wolf) morcellators is up to 1500 rpm[14,15]. However, no data exists on the limits of morcellator oscillation speed and clinical safety profiles at high rates.

This study aims to assess how operative times differ across various morcellation settings, to evaluate the upper and lower limits that optimizes performance, and to determine the range of ideal morcellator settings that maximize both safety and efficiency in HoLEP procedures. Ideally, this inquiry serves to decrease the costs associated with HoLEP procedures and would serve the interests of both urologic providers and BPH patient cohorts alike.

METHODS

After obtaining institutional board review approval, we carried out a retrospective review of HoLEP procedures by two surgeons from 7/1/2019 to 8/25/2022. This timeframe was chosen to represent the most modern cohort available and ensure consistency in equipment. All morcellation was performed with the Wolf Piranha device and disposable morcellation blades. For enucleation, MOSES 1.0 and above technology was used at 1-2J and 20-60Hz. MOSES 2.0 was used from 2020 onward. Sheath size was 28 French in both groups. All surgeons were fellowship trained in endourology and surpassed the learning curve by the beginning of this study. From our existing dataset of 2482 patients, we identified 1083 patients for analysis based on available oscillation rate data. 189 were excluded due to insufficient morcellation/enucleation data or insufficient documentation, leaving a total of 894 patients (Figure 1). Surgeon 1 routinely uses 1500 oscillations/min (low rate), and Surgeon 2 uses a higher rate of oscillations/min, starting at 6000 and transitioning to 4000 and 2000 for denser tissue.

The primary endpoint was morcellation efficiency (grams/minute). Secondary endpoints included enucleation efficiency (grams/minute), mean tissue specimen weight (grams), and preoperative prostate volume (grams). Data was collected from multiple perioperative EMR documents including intraoperative notes and immediate post-operative notes. Morcellation time started explicitly when the morcellator engaged the enucleated prostatic tissue. All sensitive patient information was extracted from Cerner (Cerner Corporation, Kansas City, MO) and stored on institutionally approved software programs. Enucleation efficiency was calculated as enucleation time divided by specimen weight in grams for each subject. The tissues weights were reported on the same immediate post operative note. The preoperative prostate volumes were extracted from H&P notes from the surgeon performing the respective patient's HoLEP. All continuous variables were presented as mean values with standard deviations. They were then divided into LR and HR populations and compared using two-tailed T-tests assuming equal variance.

The data was also sub-grouped into small, medium, and large resected tissue weights (<80 grams, 80-150 grams and >150 grams) to delineate any differences in the different patient cohorts. Statistics were performed with Microsoft excel (version 16.74) and graphs were organized using GraphPad-Prism (Version 9).

RESULTS

894 HoLEPs were analyzed, 592 by Surgeon 1 and 302 by Surgeon 2. Between the LR and HR morcellation groups, there was a difference in pre-operative prostate volume (125.67 ± 65.6 vs 100.81 ± 57.3 grams; p<0.001). Enucleation efficiency was higher in the LR group (1.67 ± 1.04 vs 1.33 ± 0.87 grams/min; p<0.001). Morcellation time was longer in the LR group (11.28 ± 10.96 vs 6.09 ± 6.81 min, p<0.001) and morcellation efficiency was lower in the LR group (9.26 ± 4.50 vs 12.13 ± 5.60 grams/min; p<0.001) (Table 1). The difference in morcellation efficiency was inversely proportional to specimen weight (Figure 2).

When the data was sub-grouped by intraoperative resected tissue weight (≤150 grams and >150 grams), there was a significant difference below 150 grams (9.36 ± 4.71 vs 12.30 ± 5.68; p<0.001) in ME, yet no significant difference in the large tissue group (8.66 ± 2.71 vs 9.36 ± 2.78; p=0.34) (Figure 3). The data was further subgrouped to <80 grams, 80-150 grams, and >150 grams. There was a significant difference below 80 grams (9.63 ± 5.37 vs 12.81 ± 6.19 g/min, p<0.001) and between 80-150 grams (8.90 ± 3.25 vs 10.60 ± 2.90, p<0.001); however, no significant difference remained above 150 grams (8.66 ± 2.71 vs 9.36 ± 2.78, p=0.34).

DISCUSSION

The difference in preoperative prostate volumes was significantly different across the two morcellation groups (126 vs. 101 mL). Previous studies have shown morcellation efficiency worsens above 80 grams, which would affect both groups in our current study [16]. In contrast to previous studies of low rate morcellation (6.7-8.6 g/min), our LR group had a mean morcellation efficiency of 9.26 grams/minute[13,14]. Morcellation of 9.26 grams/minute exceeded efficiency elsewhere, despite the relatively large prostate volumes. This finding may be due to the relatively larger case density (CD) of HoLEP at 38.67 average cases per month. If physicians on the learning curve perform superiorly above a monthly CD of 3, then Surgeons 1 and 2 should intuitively have baseline efficiencies above average [17].

A point of contention lies in the difference between the two surgeons' resected tissue weight. Assmus et al. identified an equation (y=-0.3338x+10.012) to calculate expected morcellation efficiency based on resected weight from Surgeon 1 and another provider (Assmus, 2021). X is equivalent to resected tissue weight in intervals of 25 grams. The predicted difference in morcellation efficiency should only be around 0.34 grams/minute (9.20 - 8.86 g/minute) based on findings of previous literature. This lies in contrast to the difference of 2.87 grams/minute in our current study. Therefore, the difference in prostate size and resected weight can only partially explain the variations in efficiency, both for morcellation and enucleation. One of the main findings of our study is this difference in efficiency of multiple grams/minute between morcellator speeds. The cost of operating room time in tertiary urologic centers can be upwards of 64-115 dollars per minute; therefore, even a difference of a few minutes per case can accumulate significant savings over the course of a month, year, or career of surgeons.

The data was further sub-grouped into groups based on resected tissue weight to evaluate if there was an identifiable difference between small (<80 grams), medium (80-150 grams), and large (>150 grams). There was a significant difference for LR and HR groups below 80 grams (9.63 vs 12.81 g/min; $p<0.001$) and between 80-150 grams (8.90 vs 10.60 g/min, $p<0.001$); however, this did not remain the same above 150 grams (8.66 vs 9.36 g/min; $p=0.339$). There was still a sub-statistical difference in the raw data that will need a higher-powered sample size to fully identify any differences. Our N values for the above prostate groups were only 80 for LR and 17 for the HR group. A future study could explore the use of varying morcellation speeds in the large tissue group beyond our single-center study design. HoLEP has proven to be effective and clinically safe in subgroups of men with "massive" prostates above 150 grams, yet the operative efficiency of these sub-groups has been sparingly explored[18].

The inclusion of nearly 900 patients is by far the most by any paper specifically looking into morcellations speeds[14]. The primary limitation of this paper is the inclusion of only two surgeons in a retrospective single center study. Future studies would include patent-matched, randomized control trials that would explore the differences in perioperative times and patient outcomes. Additionally, there are aspects of each patient's prostate that allow for inter-patient variability as well as inter-provider differences. To account for one of these common factors, the EMR details were meticulously combed to exclude any cases of reported dense prostatic tissue ("beach ball" prostates) that would have positively skewed the data in a non-representative manner. In cases with beach ball prostates, the morcellation time averaged around 51.4 minutes [19]. This study did not control for history of UTI's and/or intermittent catheterization, which can negatively affect morcellation times as well [19]. Other factors include where providers lie on the learning curve, trainee involvement, meticulousness of hemostasis, resectoscope type, PSA density, and prostatic calcifications [20]. These demographic factors did not necessarily affect our data; however, future multicenter studies may have to control for a wide variety of morcellation brands, resectoscope types, and other patient demographics [21].

A common concern with HoLEP and increased oscillation rates is the potential for damage to the bladder wall [22]. An acceptable endoscopic view, continuous irrigation, and well-trained OR staff are all mainstay ways to ensure safe morcellation [23]. However, there have been reports in the literature of bladder neck injury and associated bleeding [24]. This can be managed by morcellating in proper right to left motions with careful advancement in addition to the safeguards [25]. We did not observe a single bladder injury with the LR or HR morcellator settings. This study serves to solidify the efficiency of HR morcellation, yet further work needs to be done to establish this approach as potential HoLEP standard of care. The respective results for operative pathology outcomes were not collected for this study.

In assigning surgeons to each respective morcellation setting groups, this adds limitations. All cases were truly morcellated at either 6000 or 1500 rpms, with the exception to particularly difficult prostate tissue where Surgeon 2 was forced to transiently adjust with slower oscillating speeds (i.e. 4000 and below). This naturally adds a limitation, as there is no way to adjust for these changes under the current methodologic design.

One final limitation pertains to how preoperative prostate volumes were estimated. In a small minority of cases, preoperative prostate volumes were estimated based on digital rectal exam (DRE). These values have been shown to be commonly underestimated above TRUS-calculated volumes of 30 grams [26]. Preoperative MRI could further evaluate lobar anatomy, phenotypic classification systems of BPH, and inform treatment if patient do not follow through with surgery [27].

CONCLUSIONS

This paper provides preliminary evidence into the usage of higher oscillation rates when morcellating prostate tissue. The existing literature has proven the safety and efficacy of low oscillation rates; however, this study explores an expanded range of oscillation rates and how they impact operative efficiency. Increased oscillation rates during morcellation may lead to decrease in morcellation time and increased morcellation efficiency during HoLEP. As the scope of HoLEP usage increases, the need for efficient operative techniques becomes increasingly imperative. This study helps expand the possibilities of one aspect of HoLEP and refine mechanical morcellation techniques. Future studies will serve to evaluate this finding across a larger number of institutions and evaluate ways to increase morcellation efficiency in large prostate cohorts (I.e., above 150 grams).

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Competing Interests: *Marcelino Rivera is a consultant for Boston Scientific and Cook Medical. Austen Slade is a consultant for Cook Medical. The other authors have no relevant financial or non-financial interests to disclose.*

FIGURES AND TABLES

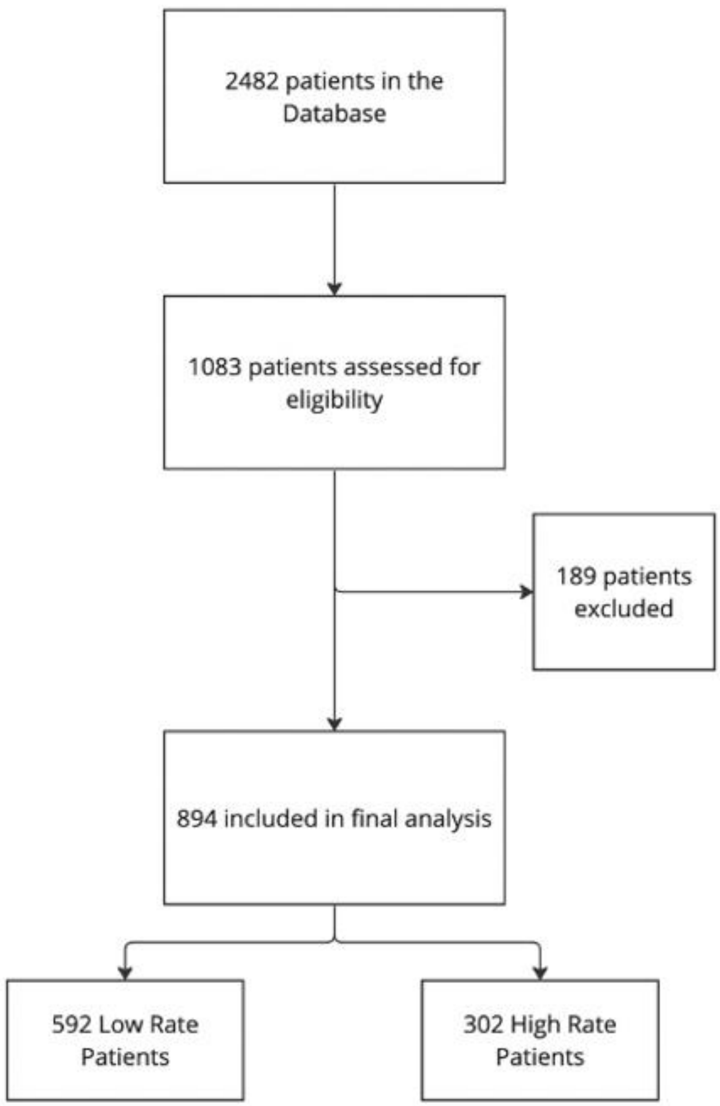

Figure 1. Flowchart depicting selection process for patients.

Figure 2. Morcellation efficiency categorized by specimen weight between low rate and high rate groups.

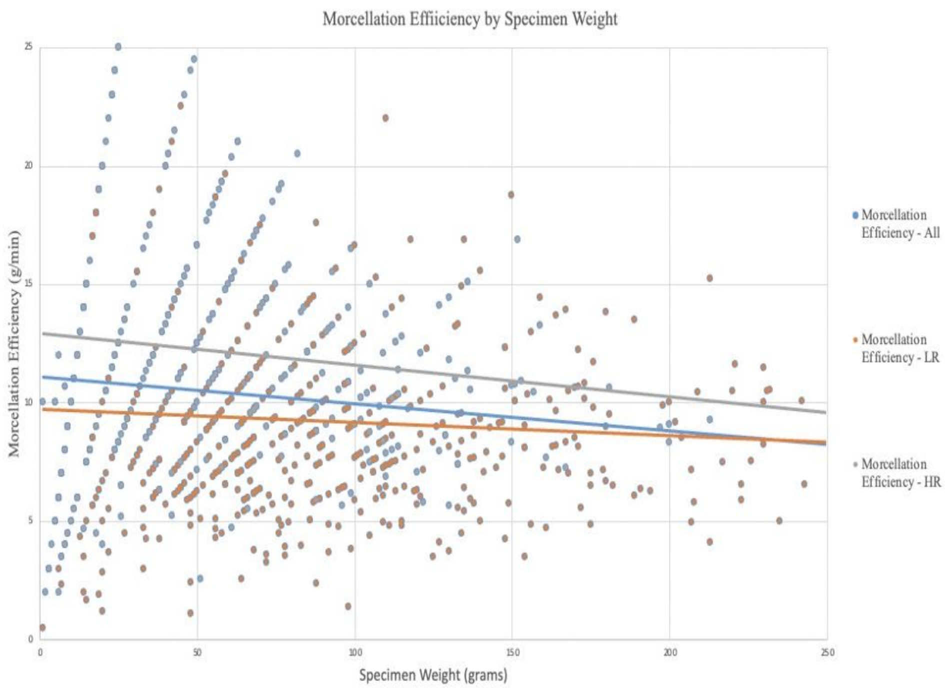

Figure 3. Morcellation efficiency subdivided by specimen weight. *Significant (p<0.05).

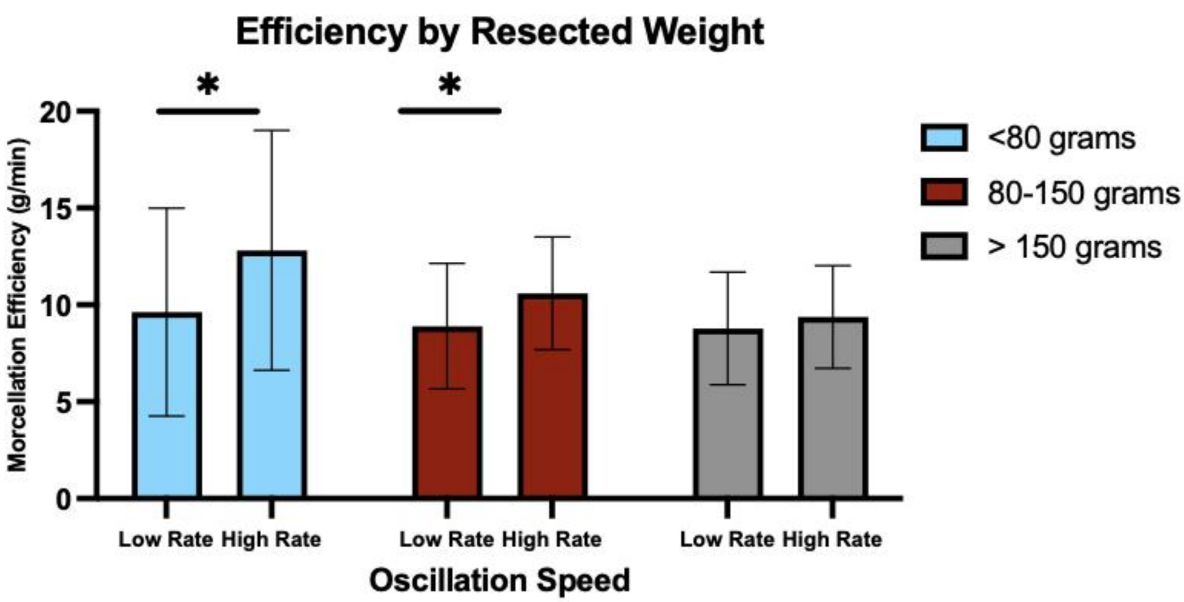

Table 1. Perioperative outcome means and standard deviations			
	Low rate (n=592)	**High rate (n=302)**	**p**
Resected tissue weight	85.98 (64.65)	61.08 (51.52)	<0.0001
Morcelllation time	11.28 (10.96)	6.09 (6.81)	<0.0001
Morcellation efficiency	9.26 (4.50)	12.13 (5.60)	<0.0001
Enucleation time	51.80 (23.68)	43.02 (18.07)	<0.0001
Enucleation efficiency	1.67 (1.04)	1.33 (0.87)	<0.0001