Thulium laser enucleation of the prostate plus thulium fiber laser therapy for benign prostatic hyperplasia combined with bladder stones

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Thulium laser enucleation of the prostate plus thulium fiber laser therapy for benign prostatic hyperplasia combined with bladder stones

Running title: ThuLEP + TFL to Treat BPH Combined with Bladder Stones

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Abstract: This work explored the feasibility, safety, and efficacy of using Thulium laser enucleation of the prostate (ThuLEP) and thulium fiber laser (TFL) on a single-energy platform to treat benign prostatic hyperplasia (BPH) combined with bladder stones (BS). Thirty-one patients with BPH complicated by BSs who underwent ThuLEP+TFL treatment at our institution between October 2020 and September 2022 were included in the observation group, while 31 patients undergoing transurethral enucleation of the prostate (TUEP) plus bladder lithotomy during the same period constituted the control group. Data collection involved assessing differences in International Prostate Symptom Score (IPSS), hemoglobin (Hb) levels, maximum urinary flow rate (Qmax), and quality of life (QOL) scores before and after surgery, along with collecting follow-up results. The results indicated that compared to the control group, patients in the observation group exhibited significantly lower surgical duration, postoperative decrease in Hb levels, duration of postoperative indwelling catheterization, and proportion of
ASA II patients, with a higher proportion of ASA I patients ($P<0.05$). Additionally, compared to the control group, patients in the observation group had lower postoperative IPSS scores and higher levels of Hb, Qmax, and QOL scores ($P<0.05$). There was no significant difference in the postoperative stone clearance rate between the two groups ($P>0.05$); however, the postoperative length of hospital stay was significantly shorter in the observation group compared to the control group ($P<0.05$), with a significantly higher incidence of complications in the control group than in the observation group ($P<0.05$). In summary, ThuLEP + TFL surgery was safe and feasible in treating BPH + BS, relieved the symptoms, improved QOL of patients.

**Key words:** Thulium laser enucleation of the prostate; Thulium fiber laser; Benign prostatic hyperplasia; bladder stone

**Introduction**

With the exacerbation of population aging in China, the incidence of benign prostatic hyperplasia (BPH) among middle-aged and elderly men is increasing annually, making it a common condition in urology outpatient clinics [1]. Patients with BPH typically present with symptoms such as nocturia, urgency, hesitancy, and altered urine stream [2]. These symptoms not only affect the quality of life but may also lead to complications such as hemorrhoids and inguinal hernias. In severe cases, they can cause bladder dysfunction, hydronephrosis, and renal failure [3,4]. Due to prostatic enlargement causing urethral obstruction and bladder dysfunction, BPH patients often develop bladder stones (BSs). Clinical statistics suggest that approximately 10% of BPH patients have concurrent BSs, presenting mainly with symptoms such as frequency, urgency, dysuria, hematuria, and interrupted urination [5,6]. The presence of BSs in BPH patients exacerbates the risk of urinary retention and urinary tract infections, further complicating treatment. Currently, research has been conducted utilizing transurethral
enucleation of the prostate (TUEP) plus bladder lithotomy for the treatment of BPH complicated by BSs, yielding favorable outcomes [7]. However, open surgery is associated with higher blood loss, larger incisions, prolonged operative time, and may impede patient recovery. Traditional treatment methods for BPH include medication and surgical intervention. While medication can alleviate symptoms, its efficacy is limited for patients with concurrent BSs. In terms of surgical treatment, transurethral resection of the prostate (TURP) has been historically effective for BPH management; however, it has certain limitations when addressing concurrent BSs, such as prolonged operative time, significant bleeding, and slow postoperative recovery, thereby restricting its clinical applicability. With ongoing advancements in medical technology, laser therapy has gained widespread adoption in the treatment of BPH. Holmium laser enucleation of the prostate (HoLEP) or holmium laser enucleation of the prostate vaporization (ThuVEP), since 2016, has been recommended by the European Association of Urology (EAU) guidelines as an alternative to TURP and holmium laser enucleation of the prostate (HoLEP) for transurethral prostatectomy [8]. Since 2018, the EAU guidelines have directly recommended ThuLEP and HoLEP as first-line treatments for large-volume BPH [9]. Our hospital has also been performing ThuLEP surgery since 2020 with satisfactory results. BS is a common comorbidity in BPH patients and usually requires simultaneous surgical treatment of both conditions. Holmium:yttrium-aluminum-garnet (Ho:YAG) laser is considered the gold standard for ureteroscopy (URS) lithotripsy [10]. Recently, thulium fiber laser (TFL) has been introduced as a novel technology for BS treatment, demonstrating its ability to challenge the preferred laser status of Ho:YAG for BS therapy [11]. TFL offers higher energy density and shorter pulse width, enabling more effective stone fragmentation and tissue cutting. Compared to traditional holmium laser, TFL presents significant advantages in terms of energy transmission, surgical efficiency, and tissue preservation. Despite numerous studies on the individual applications of ThuLEP and TFL in prostate and
urinary system lithotripsy, there is a scarcity of clinical research reporting on the concurrent use of ThuLEP combined with TFL for the treatment of BPH complicated by BSs in real-world clinical settings. Therefore, this study retrospectively analyzed the clinical efficacy and safety of utilizing ThuLEP combined with TFL technology for the treatment of BPH complicated by BSs at our institution from 2020 to 2022. It aimed to explore the advantages and limitations of this novel technique in clinical practice, providing scientific evidence and guidance for the treatment of similar patients in the future.

Aim

The aim is to explore the feasibility, safety, and efficacy of using Thulium laser enucleation of the prostate (ThuLEP) and thulium fiber laser (TFL) on a single-energy platform to treat BPH combined with BSs (BS)

Material and Methods

Research objects

This study was a retrospective single-center case series, which collected data from 31 patients with BPH complicated by BSs who underwent concurrent treatment with ThuLEP+TFL at our institution from October 2020 to September 2022. This group was designated as the observation group. Simultaneously, 31 patients treated during the same period with TUEP plus bladder lithotomy were selected as the control group. The patients were evaluated by the attending physician to determine if they met the surgical criteria and conditions for transurethral BS fragmentation and ThuLEP during the same period. All patients voluntarily signed an informed consent form, and this study obtained ethical approval from the institution.

The patients enrolled had to satisfy the following conditions: I. patients who meet the basic requirements for surgical anesthesia assessment, with anesthesia risk rating of grade I to II
(according to the ASA scoring system [12]); II. patients who underwent preoperative PSA, ultrasound, or MRI, and if necessary, underwent biopsy to rule out prostate cancer; III. IPSS ≥ 12 points and accompanied by QOL ≥ 4 points, or accompanied by Qmax ≤ 15 mL/s, or poor response to medical treatment [13,14]; IV. patients with no anesthesia or surgical contraindications; and V. patients with normal behavioral abilities who consent to the surgery.

The patients had to be excluded if they had any of below conditions: I. patients with uncontrolled diabetes, hypertension, cardiovascular or cerebrovascular diseases, and severe liver or kidney dysfunction or coagulation disorders; II. patients with uncontrolled urinary tract infection, or urethral stricture that prevents completion of transurethral surgery; III. those with unconfirmed prostate cancer or neurogenic bladder or neurological disorders that affect urinary function; and IV. patients with history of previous lower abdominal surgery.

**Surgery methods**

In the control group, patients underwent treatment with TUEPplus bladder lithotomy. This procedure was performed under combined spinal-epidural anesthesia with continuous monitoring of vital signs. During BS extraction, a resectoscope was inserted through the urethra to visualize the BSs and assess the extent of prostatic enlargement. Upon confirming the inability to retrieve the stones transurethrally, TUEP was conducted using continuous irrigation and flushing. Following completion of the resection, a triple-lumen urinary catheter was left in place, and the bladder was continuously irrigated with 0.9% saline solution. During the procedure, a midline abdominal incision was made approximately 12 cm above the symphysis pubis, with a length of 34 cm. The incision sequentially traversed the skin, subcutaneous tissue, anterior sheath of the rectus abdominis muscle, and separation of the rectus abdominis muscle. The peritoneum was then reflected upwards, exposing the bladder. The anterior bladder wall was incised, and stones were directly retrieved under direct vision. After ensuring no residual blood clots or significant bleeding in the bladder, the bladder was sutured. Intermittent plasma
Drainage was performed anteriorly to the bladder without the need for cystostomy. The incision was closed layer by layer, and a triple-lumen urinary catheter was left in place postoperatively, with continuous bladder irrigation.

Patients in the observation group were treated with ThuLEP+TFL. The patient was placed in lithotomy position and administered general anesthesia or epidural anesthesia. A fiber-optic holmium laser (RevoLix, Shanghai, China) was used with cutting or vaporization power settings of 60 - 120W and hemostasis power settings of 20 - 40W. The fragmentation mode is set according to the hardness of the stone, with energy ranging from 0.1 - 2.0 J and power from 30 - 60 W. A Fr26 laser resection sheath with a continuous flushing system and a reusable fiber with a diameter of 550 µm are used for stone fragmentation and tissue vaporization. Physiological saline was employed for continuous irrigation during the procedure, with a flow rate of 50 - 100 mL/min through the resection sheath. The surgery was performed by a surgeon with the same professional title. Stone fragmentation was performed first using a powdering strategy, and the stone powder was continuously flushed out through the lens body. When the remaining stone volume was smaller than the sheath, it was washed out through the sheath. After the fragmentation, the mucosa of the urethra was cut open in an “Ω” shape in front of the verumontanum, and the surgical capsule plane of the prostate was found using the “push and pull” technique with the resection sheath. The entire prostate adenoma was then completely peeled off along the surgical capsule plane under direct visualization of the laser resection sheath. The holmium laser was utilized to sever the connection between the prostate adenoma and the urethral mucosa at the bladder neck and apex of the prostate, to vaporize the prostate nodules on the surgical capsule plane, and to fully stop bleeding at bleeding points on the surgical capsule plane and bladder neck. The excised adenoma was pushed into the bladder, and the external sphincter and bladder neck were completely preserved. Finally, a tissue pulverizer was utilized to crush the glandular tissue, which was then removed from the body, and the tissue
A sample was saved for pathological examination. A Fr20 three-chamber balloon catheter was left in place.

**Evaluation indicators**

Before surgery, it should collect the general information of all patients, including age, comorbidities, number of stones, serum PSA level, prostate volume (PV), stone burden (calculated based on the widest diameter of the stone, if multiple stones existed, the stone burden was calculated as the sum of the widest diameters of all stones), average stone density (determined by CT scan), preoperative blood routine (Hb and white blood cell count (WBC)), preoperative International Prostate Symptom Score (IPSS), QOL score, and maximum flow rate (Qmax).

The Perioperative indicators were collected, including operation time, duration of lithotripsy (DOL), duration of bladder irrigation (DBI), Hb decrease value, postoperative duration of catheterization (DOC), and ASA classification.

The therapeutic efficacy was assessed by evaluating the difference in IPSS score, Hb level, Qmax, and QOL score before and after surgery.

Furthermore, the postoperative follow-up indicators included length of hospital stay (LOS), maintaining daily phone, or internet follow-up within one week after discharge, instructing the patient to undergo regular check-ups, and evaluating the patient’s stone clearance, bleeding, infection, urinary retention, perforation, postoperative urethral stricture, and other complications based on CT scans.

**Methods for statistics**

The data was analyzed using SPSS 23.0. For normally distributed quantitative data, the mean ± standard deviation (\( \bar{x} \pm s \)) was adopted to represent the data, while non-normally distributed data were expressed as a percentage (%). The Wilcoxon rank-sum test was utilized to compare functional data before and after surgery, with a significance level of \( P < 0.05 \).
indicating statistical significance.

**Research results**

**General data of patients**

The study collected general clinical data of patients in both the control and observation groups prior to treatment, including age, comorbidities, number of stones, serum prostate-specific antigen (PSA) level, prostate volume (PV), stone burden, mean stone density, Hb, white blood cell count, IPSS, quality of life (QOL), and maximum flow rate (Qmax) (Table 1). Upon comparison, there were no statistically significant differences in the aforementioned general clinical indicators between the two groups before surgery ($P>0.05$).

**3.2 Comparison of perioperative conditions between the two groups of patients**

The study collected data on surgical duration, stone fragmentation/extraction time, postoperative decrease in Hb levels, bladder irrigation time, duration of postoperative urinary catheterization, and ASA score grading for the two groups of patients (Table 2). Upon analysis, compared to the control group, patients in the observation group exhibited significantly lower surgical duration, postoperative decrease in Hb levels, duration of postoperative urinary catheterization, and proportion of ASA II patients, with a higher proportion of ASA I patients ($P<0.05$). However, there were no significant differences in stone fragmentation/extraction time or bladder irrigation time between the two groups ($P>0.05$).

**3.3 Analysis of surgical treatment efficacy**

The study compared the post-treatment IPSS, Hb levels, maximum urinary flow rate, and QOL scores between the two groups of patients before and after treatment. Preoperative IPSS scores, Hb levels, maximum urinary flow rates, and QOL scores for both the control and
observation groups are presented in Table 1. Postoperatively, the IPSS score, Hb level, maximum urinary flow rate, and QOL score for the control group were (11.2±3.2) points, (111.4±10.8) g/dL, (14.6±9.3) mL/s, and (3.7±0.4) points, respectively, while for the observation group, they were (8.5±2.4) points, (126.4±15.9) g/dL, (21.2±13.7) mL/s, and (4.8±0.4) points, respectively. Compared to preoperative values, postoperatively, both groups showed a decrease in IPSS score and Hb levels, and an increase in maximum urinary flow rate and QOL score ($P<0.05$). Postoperatively, compared to the control group, patients in the observation group exhibited lower IPSS scores and higher Hb levels, maximum urinary flow rate, and QOL scores ($P<0.05$) (Figures 1-4).

3.4 Postoperative follow-up results

All patients underwent postoperative abdominal radiography follow-up, with a 100% stone clearance rate observed in both the control and observation groups. The average postoperative hospital stay was (9.3±3.25) days for the control group and (6.7±2.5) days for the observation group. Upon comparison, there was no significant difference in the postoperative stone clearance rate between the two groups ($P>0.05$), while the postoperative hospital stay was significantly shorter in the observation group compared to the control group ($P<0.05$) (Figure 5). During the follow-up period, patients in the observation group did not exhibit any significant complications postoperatively, whereas in the control group, 4 cases (12.90%) experienced infections and 5 cases (16.13%) developed postoperative urethral strictures and other complications, significantly higher than the observation group ($P<0.05$).

4. Discussion
Based on the study results, it can be concluded that compared to TUEP combined with bladder lithotomy, ThuLEP combined with TFL demonstrated superior surgical outcomes in the treatment of BPH complicated by BSs. Additionally, patients in the observation group experienced shorter postoperative hospital stays and no occurrence of severe complications. Therefore, ThuLEP combined with TFL can be considered as an effective and safe surgical approach for the treatment of BPH complicated by BSs.

Firstly, the study found that the postoperative stone clearance rate was 100% in both the control and observation groups, indicating that TUEP combined with bladder lithotomy and ThuLEP combined with TFL are highly effective in clearing BSs. This may be attributed to the high-energy and precise cutting and fragmentation capabilities of thulium laser technology, which effectively clears stones from the bladder. Traditional surgical methods involve directly incising the bladder wall, allowing for the removal of all stones under clear visualization. These findings are consistent with previous research[15]. The study also found no significant difference in stone fragmentation/extraction time between the two groups, suggesting that TFL achieves similar efficiency in stone fragmentation as bladder wall incision for stone extraction. This is because TFL fragmentation not only induces a photothermal effect but also triggers a water explosion effect around the stones. Moreover, TFL pulse waves are square waves, allowing for more uniform energy transfer to the stones, leading to efficient stone fragmentation. Research showed that TFL-induced stone displacement is minimal, reducing the probability of interrupted stone fragmentation, thus reducing procedure time while achieving precise stone fragmentation [16,17]. Therefore, patients in the observation group did not experience significant complications that would affect subsequent ThuLEP surgery.
ThuLEP utilizes the blunted dissection effect of the laser sheath to mimic the surgical plane of anatomical dissection performed by fingers during open prostatectomy, aiming to completely detach the hypertrophic adenoma from the surgical capsule, thus maximizing the relief of bladder outlet obstruction, alleviating lower urinary tract symptoms, and effectively preventing long-term recurrence of BPH [18]. The TFL used in this study, unlike conventional solid-state holmium lasers, employs a fusion wave technology that combines continuous and pulse waves, ensuring that tissue temperature remains below 100 degrees Celsius throughout laser application, thereby further minimizing thermal stimulation to the bladder mucosa and prostate bed [19]. Additionally, it can generate a larger area of umbrella-like hemostasis, leading to faster hemostasis and contributing to improved surgical efficiency in ThuLEP procedures. This study also found that patients in the observation group had shorter surgical durations and lower postoperative decreases in Hb levels.

TUEP involves the insertion of an electric resection loop through the urethra to excise hypertrophic prostatic tissue, thereby alleviating urinary obstruction symptoms, and is currently a mature technology [20]. However, TUEP is associated with relatively higher levels of bleeding, often necessitating stricter intraoperative and postoperative bleeding control measures. Moreover, due to the larger trauma incurred, longer postoperative recovery times and comparatively prolonged indwelling catheter durations are often required [21]. Additionally, studies noted that TUEP may pose a higher risk of postoperative complications such as urethral stricture and infection [22]. Therefore, patients in the control group were more likely to experience postoperative infections and urethral strictures, indirectly leading to lower maximum urinary flow rates in the control group compared to the observation group. Given that holmium laser technology entails less tissue trauma compared to
traditional incisional surgery, faster tissue healing, reduced postoperative bleeding, and decreased bladder irritation, these advantages facilitate patients’ postoperative recovery and catheter removal. Consequently, patients in the observation group had shorter postoperative hospital stays and indwelling catheter durations. The study also found that postoperatively, patients in the observation group had lower IPSS scores and higher QOL scores. IPSS score is widely used clinically to assess the severity of symptoms in patients with BPH, and a decrease in IPSS score indicates the effectiveness of the surgery in alleviating symptoms. This suggests that the ThuLEP combined with TFL surgical approach is more effective in improving patient symptoms. Specifically, it reduces the poor sleep, anxiety, embarrassment, and discomfort caused by BPH symptoms, thereby enhancing the quality of life for patients.

In summary, ThuLEP+TFL demonstrated advantages in treating BPH with concurrent BSs, including shorter surgical duration, faster postoperative recovery, reduced bleeding, significant treatment efficacy, and fewer complications. Moreover, it can better improve the quality of life for patients.

**Conclusion**

This work reported, for the first time, the real-world clinical application data of simultaneous ThuLEP and TFL surgery for treating BPH with concurrent BS. The preliminary results indicated that simultaneous ThuLEP and TFL surgery was a safe and feasible treatment for BPH + BS, which can effectively alleviate the symptoms of patients and improve their QOL. However, the sample size enrolled was relatively small, the follow-up time was short, and it was a single-center study, which may have certain biases in the research results. Therefore, further studies with increased sample size are needed to confirm these findings. In summary, the treatment approach of ThuLEP and TFL is worth promoting in hospitals with appropriate
conditions.

**Abbreviations**

ThuLEP  Thulium laser enucleation of the prostate  
TFL  thulium fiber laser  
BPH  benign prostatic hyperplasia  
BS  bladder stones  
IPSS  International Prostate Symptom Scale  
Hb  hemoglobin  
Qmax  maximum flow rate  
QOL  quality of life  
DOL  duration of lithotripsy  
DOC  duration of catheterization  
SCR  stone clearance rate  
EAU  European Association of Urology  
TURP  transurethral resection of the prostate  
HoLEP  holmium laser enucleation of the prostate  
TFL  Thulium fiber laser  
PV  prostate volume  
WBC  white blood cell count  
IPSS  International Prostate Symptom Score  
DBI  duration of bladder irrigation  
LOS  length of hospital stay

**Declarations**
Ethics approval and consent to participate

confirming that informed consent was obtained from all subjects and/or their legal guardian(s); this includes information regarding informed consent obtained from the study participant's parent or legal guardian for any participant below the age of consent. Confirmation that the guidelines outlined in the Declaration of Helsinki were followed.

Competing interests

The authors declare that they have no competing interests

Acknowledgement

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References

4. Wieczorek K, Braczkowski RS, Skrzypek M, et al.. The comparison between vitamin d concentration in upper silesia patients with prostate cancer and with benign prostatic


Figure 1. Comparison of IPSS scores between the two groups of patients before and after surgery (# indicates significant difference compared to preoperative values, \( P<0.05 \); * indicates significant difference compared to the control group, \( P<0.05 \).)
**Figure 2.** Comparison of Hb levels between the two groups of patients before and after surgery (# indicates significant difference compared to preoperative values, $P<0.05$; * indicates significant difference compared to the control group, $P<0.05$.)
Figure 3. Comparison of maximum urinary flow rates between the two groups of patients before and after surgery (# indicates significant difference compared to preoperative values, $P<0.05$; * indicates significant difference compared to the control group, $P<0.05$.)
**Figure 4.** Comparison of QOL scores between the two groups of patients before and after surgery (# indicates significant difference compared to preoperative values, $P<0.05$; * indicates significant difference compared to the control group, $P<0.05$.)
Figure 5. Comparison of postoperative stone clearance rate (A) and hospital stay (B) between the two groups of patients (* indicates significant difference compared to the control group, $P<0.05$.)
Table 1. Preoperative general information of patients

<table>
<thead>
<tr>
<th>Index</th>
<th>Observation group (n=31)</th>
<th>Control group (n=31)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>67.9±7.8</td>
<td>65.1±6.2</td>
<td>0.239</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td>0.162</td>
</tr>
<tr>
<td>Hypertension (cases)</td>
<td>13 (41.9%)</td>
<td>12 (38.71%)</td>
<td></td>
</tr>
<tr>
<td>Diabetes (cases)</td>
<td>5 (16.1%)</td>
<td>6 (19.35)</td>
<td></td>
</tr>
<tr>
<td>Coronary artery disease (cases)</td>
<td>4 (12.9%)</td>
<td>5 (16.13%)</td>
<td></td>
</tr>
<tr>
<td>Myocardial infarction (cases)</td>
<td>2 (6.5%)</td>
<td>3 (9.68%)</td>
<td></td>
</tr>
<tr>
<td>Cerebral infarction (cases)</td>
<td>2 (6.5%)</td>
<td>4 (12.90%)</td>
<td></td>
</tr>
<tr>
<td>Urinary tract infection (cases)</td>
<td>3 (9.7%)</td>
<td>2 (6.45%)</td>
<td></td>
</tr>
<tr>
<td>Other (cases)</td>
<td>12 (38.7%)</td>
<td>10 (32.26%)</td>
<td></td>
</tr>
<tr>
<td>Number of Stones</td>
<td></td>
<td></td>
<td>0.102</td>
</tr>
<tr>
<td>1 stone (cases)</td>
<td>11 (35.5%)</td>
<td>13 (41.94%)</td>
<td></td>
</tr>
<tr>
<td>2 stones (cases)</td>
<td>6 (19.4%)</td>
<td>5 (16.13%)</td>
<td></td>
</tr>
<tr>
<td>≥3 stones (cases)</td>
<td>14 (45.2%)</td>
<td>13 (41.94%)</td>
<td></td>
</tr>
<tr>
<td>Serum PSA (ng/ml)</td>
<td>5.5±5.2</td>
<td>5.3±5.0</td>
<td>0.092</td>
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<td>Prostate Volume (mL)</td>
<td>64.1±43.4</td>
<td>62.8±36.2</td>
<td>0.112</td>
</tr>
<tr>
<td>Stone Burden (mm)</td>
<td>21.9±11.6</td>
<td>22.6±9.2</td>
<td>0.193</td>
</tr>
<tr>
<td>Mean Stone Density (HU)</td>
<td>759.2±300</td>
<td>737.9±273.2</td>
<td>0.100</td>
</tr>
<tr>
<td>Preoperative Hb (g/L)</td>
<td>136.4±15.9</td>
<td>135.8±13.8</td>
<td>0.111</td>
</tr>
<tr>
<td>Preoperative White Blood Cell Count (×10^9/L)</td>
<td>7.6±3.3</td>
<td>7.2±3.4</td>
<td>0.072</td>
</tr>
</tbody>
</table>
Preoperative IPSS Score (points) | 14.2±3.8 | 13.9±3.2 | 0.074  
QOL Score (points) | 3.1±0.9 | 2.9±0.8 | 0.083  
Maximum Flow Rate (mL/s) | 8.8±6.2 | 8.3±5.3 | 0.114

**Table 2.** Perioperative characteristics of patients in two groups

<table>
<thead>
<tr>
<th>Index</th>
<th>Observation group (n=31)</th>
<th>Control group (n=31)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical duration (min)</td>
<td>109±29.1</td>
<td>130.4±20.3</td>
<td>0.017</td>
</tr>
<tr>
<td>Stone Fragmentation/Extraction time (min)</td>
<td>34.7±27.6</td>
<td>30.8±22.3</td>
<td>0.052</td>
</tr>
<tr>
<td>Postoperative decrease in Hb levels (g/dL)</td>
<td>0.1±0.2</td>
<td>0.3±0.1</td>
<td>0.001</td>
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<tr>
<td>Bladder irrigation time (days)</td>
<td>2.1±0.9</td>
<td>1.9±0.6</td>
<td>0.063</td>
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<tr>
<td>Duration of postoperative urinary catheterization (days)</td>
<td>5.5±1.3</td>
<td>7.3±1.0</td>
<td>0.018</td>
</tr>
<tr>
<td>ASA score grading</td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>Grade I (cases)</td>
<td>19 (32.3%)</td>
<td>13 (41.95%)</td>
<td></td>
</tr>
<tr>
<td>Grade II (cases)</td>
<td>12 (29%)</td>
<td>18 (58.06%)</td>
<td></td>
</tr>
</tbody>
</table>