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Research Article

A Comparative Study between Dusting and Fragmentation in Intracorporeal Laser Lithotripsy in Distal Ureteric Stone

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Abstract

Background: Ureteric stones commonly have an impact on the quality of life of the patient. There are many treatment choices for the condition, including medical treatment, extra-corporeal shock wave lithotripsy (ESWL), endoscopic intervention by ureteroscope (URS), or surgery (open or laparoscopic). Semi-rigid URS with laser lithotripsy is used to fragment ureteric stones, especially those in the distal ureter.

Objectives: To assess the efficacy and complications of the dusting versus the fragmentation method for lower ureteric stones using holmium laser lithotripsy by analyzing intra-operative and post-operative variables.

Methods: One hundred and twenty patients with distal ureteric stones were included in the current study conducted in Ghazi AL-Hariri Teaching Hospital for Surgical Specialties from December 2020 to July 2022. The cases were divided into two groups: The first is the dusting group and the second is the fragmentation group. Both groups are further subdivided into the 10-15 mm and < 10 mm stone groups. The time of the operation, the rate of being stone-free, stone size, the rate of Double-J stents (*DJS*), and intraoperative complications were compared for the study groups.

Results: the operative time was more among Group A (dusting) than Group B (fragmentation) with a statistically significant association, stone-free rate more in Group A (dusting) than Group B (fragmentation) without a statically significant Need for DJ in Group b (fragmentation) than group a (dusting) with statically significant association Regard intraoperative complication (mucosal injury, stone migration, perforation) more in group b (fragmentation) a (dusting) without any significant association.

Conclusion: The dusting method resulted in fewer intraoperative complications (mucosal injury, stone migration, perforation) and a lower need for DJ insertion than the fragmentation method. However, it needed a longer operative time than the fragmentation method.

Keywords: Dusting; fragmentation; Laser lithotripsy; lower ureteric stone.

Introduction

Ureteroscopy (URS) was first introduced in 1912 when a pediatric cystoscope was accidentally inserted into a child's dilated ureter reaching into the pelvis of the kidney. This was published by Young and McKay in 1929 (1). Recent research found that the prevalence of ureteric stones has increased over the past years both in developed and developing countries. This may be explained by the change in lifestyle such as the type of diet, the decrease in physical activity, and hot weather (2). According to the modified Satava classification system the intraoperative complicationsuretcopy Is classified (3) into:

Grade 1 complications (need no intervention): Mild mucosal tear and stone migration proximally.

Grade 2 complications (require intervention endoscopically):
Migration of stone proximally that needs DJ insertion with or without ESWL, migration of stone proximally that needs to be treated with fle xible URS of PCNL, injury of the mucosa by thermal injury of false passage that needs DJ insertion,

Grade 3 complications (require laparoscopic or open surgery): Severe bleeding requiring termination of the procedure, inability to access ureter or reach stone requiring conversion to open surgery, ureteral perforation, ureteral intussusception, and ureteral avulsion.

The Holmium laser is very effective in treating ureteric stones irrelevant of their location (4). Holmium laser lithotripsy is currently one of the methods urologists employ the most since it causes few complications and lowers the risk of stone migration (4). By using the energy produced when the laser fibers come into contact with the stone, the holmium laser breaks apart the stone. The low-energy, high-frequency setting is referred to as the dusting mode, whereas the high-energy, low-frequency setting is referred to as the fragmentation mode (5). During ureteroscopy, lithotripsy can be performed using a variety of energy sources, including laser, electrohydraulic, pneumatic, and

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ultrasound (6, 7, and 8). At present, holmium laser lithotripsy is one of the most extensively used techniques by urologists as it results in fewer complications and decreases the incidence of stone migration (9, 10).

Holmium laser causes the fragmentation of stones by absorbing energy directly from the stone. The laser fiber transmits energy to the surface of the stone during the activation of the laser (11, 12).

The settings of energy of the Holmium laser range from 0.2 to 2.0 Joule depending on the producer and laser version. Lower energy causes small stone fragments and decreased risk of stone retropulsion (12). Higher energy leads to an increase in the size of stone pieces and increases the chance of stone retropulsion. The setting frequency of the Holmium laser ranges from 4 to 80Hz based on the model of laser used and corresponds to the number of pulses from the laser delivered to the stone (12).

Patients and Methods

Settings and Design

This is a comparative interventional study that was conducted on a total of 120 Iraqi patients, between the ages 18-70 years old with lower ureteric stones at the Department of Urology/ Ghazi AL-Hariri Teaching Hospital for Surgical Specialties during the period from July 2020 to Oct 2022.

Inclusion Criteria

Single distal ureteric stone with a size of less than 15 mm with failed medical treatment.

Exclusion Criteria

Active urinary tract infection, pregnancy, previous ureteric surgery, and urinary tract abnormality.

The following assessments were done for all cases:

- Preoperative history,
- Physical examination,
- Routine laboratory tests including a complete blood cell count, serum electrolytes, and urine culture,
- Renal ultrasonography,
- Non-contrast computerized tomography (NCCT) to determine the definitive stone sizes, localization, Hounsfield unit density (HUD), and renal tract assessment. The stone burden was calculated using NCCT and measured as the largest single-dimensional stone diameter.

Ethical Consideration

Before data collection, each patient's signed consent was obtained after being informed of the study purpose. Every patient had the full, unconditional right to withdraw at any stage. Patients were given the assurance that their information would only be utilized for research purposes throughout the study, which guaranteed the confidentiality of their data.

Study Groups

The cases were divided randomly into two groups: The first group, the dusting method group, included 60 patients and was subdivided into 34 patients with a stone size of 10-15 mm (group 1a) and 26 patients with a stone size of less than 10 mm (group 2a). They were treated by URS with the setting of laser (low pulse energy, high frequency). The second group, the fragmentation method group, included 60 patients and was subdivided into 35 patients with a stone size of 10-15 mm (group 1b) and 25 patients with stone of less than 10 mm (group 2b). They were treated by URS with the setting of laser (high pulse energy, low frequency).

Operative Technique

The patients were anesthetized by spinal or general anesthesia. Each patient was given a single dose of ceftriaxone at the time of aesthesia induction. Antibiotics were continued for two days through the parenteral route and 5 - 7 days orally. Standard ureteroscopy with laser lithotripsy was carried out using: The Holmium YAG laser lithotripsy system (Quanta system) {a wavelength of 2100 nm, power of 35 watts, pulse duration 95-1500, and a 600 µm quartz end fiber}. In the dusting mode, a high frequency (12-20Hz) with a low energy (0.3-0.5J) was used while in the fragmentation mode, a high energy (0.6-1J) with a low frequency (6-10Hz) was used.

Follow-up: During the early postoperative period, monitoring of vital signs and urine output was done. A postoperative KUB X-ray was obtained to ensure the positioning of the DJ stent and any radiopaque residual fragments.

The follow-up continued for 1 month, and if there was no residual stone documented by NCCT, the DJ was removed. Stone-free status was defined as having no remaining stones larger than 3 millimeters in the ureter one month after surgery. (13)

Data Analysis

1. SPSS (Statistical Package for Social Science) Version 26 was used.
2. Categorical variables were presented using numbers and percentages and associations were tested using Pearson's chi-square test.
3. Continuous variables were presented using mean, standard deviation (SD), and range. The comparison between means was tested using the independent t-test.
4. The P-value was considered significant at level <0.05.

Results

The mean age of the 120 patients included in the study was 48.1±19.35 years with a range of 18 - 70 years. There were 78 (65%) males and 42 (35%) females with a male-to-female ratio of 1.85:1, table 1.

The number of stones managed in the current study was 120, 55.8% of which were 10-15 mm in size and 44.2% were less than 10 mm. There were more stones on the left side (54.2%) than on the right (45.8%), Table 1.

Table 1: Distribution by stone and site

Characteristics	Result
Number of stones	120
Size (mm) No. (%)	
10-15 mm	67 (55.8)
<10 mm	53 (44.2)
Site	
Right	55 (45.8)
Left	65 (54.2)

For patients who had stones between 10-15 mm in size, table 2 shows the results of the treatment outcomes for the 34 cases treated by the dusting method (group 1a) were compared with those of the 35 cases treated by the fragmentation method (group 1b). The operation time was significantly longer for group 1a than group 1b (47.7±2.23 versus 39.7±2.27 respectively), (p=0.001).

More cases had stone freedom from a single session among group 1a (91%) than group 1b (74%) but was not statistically significant (p=0.064). More patients from group 1b needed DJ stent than patients from group 1a (68.6% versus 29.4% respectively), (p=0.001). There was no significant difference between the two treatment groups in terms of HUD (p=0.079).

As for the intra-operative complications, grade 1 mucosal injury was more frequent among group 1b (48.6%) than group 1a (29.4%), but not significantly associated, (p=0.103). Grade 2 mucosal injury was more frequent among group 1b than among group 1a (17.1% versus 14.7% respectively), but not significantly so (p= 0.782). Grade 1 and grade 2 migration was more frequent among group 1b (11.4%) than group 1a (2.9%), but not significantly so (p=0.174). Perforation was more frequent among group 1b (5.9%) than group 1a (2.9%), but not significantly so (p=0.572).

Table 2: Operative outcomes of group 1 (Stone size 10-15 mm)

Variables	Group 1a (Dusting method) No. cases = 34 No. stones = 34	Group 1b (Fragmentation method) No. of cases = 35 No. of stones = 35	*P* value
Operation time (minutes) (Mean±SD)	47.7±2.23	39.7± 2.27	0.001* €
Stone freedom from a single session	31 (91.2%) †	26 (74.3%) †	0.064 £
Need for DJ stent	10 (29.4%)	24 (68.6%)	0.001* £
HUD	845.0±125.52	787.6±140.90	0.079 €
Intra-operative complications			
Mucosal injury (grade 1)	10 (29.4%)	17 (48.6%)	0.103 £
Mucosal injury (grade 2)	5 (14.7%)	6 (17.1%)	0.782 £
Migration (grade 1)	1 (2.9%)	4 (11.4%)	0.174 £
Migration (grade 2)	1 (2.9%)	4 (11.4%)	0.174 £
Perforation	1 (2.9%)	2 (5.7%)	0.572 £

€: Independent samples t-test; £: Chi-square test

For patients who had stones less than 10 mm in size, table 3 shows the results of the treatment outcomes for the 26 cases treated by the dusting method (group 2a) compared with those of the 25 cases treated by the fragmentation method (group 2b). The operation time was significantly longer among group 2a than group 2b (38.1±2.16 and 34.3±2.74 respectively), (p=0.001).

There was slightly more stone freedom from a single session among group 2a (92.3%) than group 2b (88%) which was not significant, (p=0.605). The need for DJ stent was significantly higher among group 2b than group 2a (60% versus 19% respectively), (p=0.003). There was no significant difference between the two groups in relation to HUD (p=0.201).

As for the intra-operative complications, grade 1 mucosal injury was more frequent among group 2b (32%) than 2a (11.5%), but not significantly so (p=0.076).

Grade 2 mucosal injury was more frequent among group 2b than group 2a (20% and 3.8% respectively), but not significantly so (p= 0.073). Grade 1 and grade 2 migration was more frequent among group 2b than group 2a, but not significantly so, (p=0.30). There were no perforations among these groups.

Table 3: Operative outcomes of group 2 (stone size less than 10mm)

Variables	Group 2a (Dusting method) No. of cases = 26 No. of stones = 26	Group 2b (Fragmentation method) No. of cases = 25 No. of stones = 25	P value
Operation time (minutes) (Mean±SD)	38.1±2.16	34.3±2.74	0.001* €
Stone freedom from a single session	24 (92.3%)	22 (88.0%)	0.605 £
Need for DJ stent	5 (19.2%)	15 (60%)	0.003* £
HUD	856.3±135.56	805.8±142.47	0.201 €
Intra-operative complications			
Mucosal injury (grade 1)	4 (15,4%)	8 (32%)	0.076 £
Mucosal injury (grade 2)	1 (3.8%)	5 (20.0%)	0.073 £
Migration (grade 1)	2 (7.7%)	4 (16.0%)	0.357 £
Migration (grade 2)	0 (0.0%)	1 (4.0%)	0.305 £
Perforation	0 (0.0%)	0 (0.0%)	--

€: Independent samples t-test; £: Chi-square test

Discussion

The best technique for endoscopic lithotripsy of stones in the upper urinary tract is the Ho: YAG laser lithotripsy (14) which has a success rate of 90-100% (15)**.** Variables, such as pulse energy and pulse frequency aid the doctor in selecting various combinations that have effects on the fragmentation of stone during URS lithotripsy. Contact laser lithotripsy can be carried out using dusting or fragmentation settings (16). Some research hypothesized that employing the dusting mode might lower the likelihood of ureteral damage, whereas there isn't much proof that this is a better technique (17). Only a few research papers have examined the usage of fragmentation or dusting laser systems in a centralized location, despite past comparisons of the potency of various energy and frequency settings (18, 19). The current study addresses the effectiveness and results of such intense laser therapy options for ureteral stones.

The male-to-female ratio in the current study was close to other studies of 2:1, which reflects the fact that males are affected twice as frequently as women (19). Chen et al (20) reported a ratio of 1.45:1 with a mean age of 46.5 years. While Jodi et al (21) reported a ratio of 1.55:1 with a mean age of 46.08 years.

In the current study, the higher need for DJ stent in the fragmentation group agrees with the results of Ashmawy (22), while Chen et al study on 421 patients with ureteric stones showed that 81% of the dusting group and 79% of the fragmentation group needed DJ (20).

A recent study conducted by Elzayat et al showed that the stone-free rate was 90% and 75% in the dusting and fragmentation groups respectively, while post-operative complications were 15% and 20% in the dusting and fragmentation groups respectively (23). Ashmawy et al (22) showed that the stone-free rate was 91.66% while post-operative complications happened in 18.33% of the cases. Wael et al (24) reported postoperative complications in 86% of the dusting group and 89% of the fragmentation group. Ben et al showed that the complication rate was 8.69% and the stone-free rate was 60.9% (25).

Dusting has more advantages by minimizing the possibility of problems following surgery. Stone retropulsion is reduced after stone fragmentation when dusting mode is used (26), by reducing the need to "hunt" ureteral stones that have migrated proximally Additionally, some investigations have shown that stone retropulsion may enhance the requirement for follow-up treatments to address stone pieces that have moved from the distal ureter to the upper ureter or renal pelvis. (27)

According to Kortenberg and Traxer, "high-frequency, low voltage" choices are better suited for micro stone fragmentation, particularly in the case of impacted ureteric stones, which produce smaller stone fragments (dusting influence). Reduced mucosal damage is another advantage of "reduced voltage," albeit it prolongs surgery and may not be effective for harder stones (28). The same result was found in the current study among the two study groups. The mean time needed to operate in the current study was slightly longer than that needed by Ben et al (28) who had a mean operation time of (40.5±14.70 min) in the dusting group, and that done by Wael (27). The lower frequency of grade 1 and 2, of stone migration among the dusting and the very low frequency of perforation in the dusting group, are in agreement with the results of the study conducted by Jodi MR, et al (21) who reported less stone migration, and less mucosal injury in the dusting group than the fragmentation group. The minimal risk of perforation in the current study in both groups is very close to other studies which ranged from 2.6%-6% (29).

The current study showed that neither the stone-free rate nor the incidence of complications was significantly related to the stone size, while a significant relationship was found between operating time and stone size. These findings agree with those reported by Rana et al (30).

Conclusions

The dusting method resulted in fewer intraoperative complications (mucosal injury, stone migration, perforation) and a lower need for DJ insertion than the fragmentation method. However, it needed a longer operative time than the fragmentation method.

Authors' declaration

We hereby confirm that all the Figures and Tables in the manuscript are mine/ ours. Besides, the Figures and images, which are not mine /ours, have been given permission for re-publication attached with the manuscript.-Authors sign on ethical consideration's approval-Ethical Clearance: The project was approved by the local ethical committee **i**n the Medical City Complex according **to** the code number **(193/ 2022/12/7)**

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Authors' contribution: All authors contributed to the study conception or design, data gathering, analysis, and writing of the manuscript.

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تكسير حصاة أسفل الحالب باستخدام الليزر بتقنيه الطحن وتقنيه التكسير: دراسة مقارنة

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الخلاصة

حصاة الحالب واعراضها تؤثر على حياة المريض بصوره سلبيه، عدة علاجات متوفرة لعلاج حصاة الحالب من ضمنها مراقبه المريض، استخدام ادويه تفتيت الحصاة، استخدام موجات الفوق الصوتية تفتيت الحصاة بناظور الحالب، استخراج الحصاة جراحيا او بالناظور البطني, استخدام ناظور الحالب وتفتيت الحصاة بالليزر هي الطريقة المفضلة لعلاج حصاة اسفل الحالب.

الهدف من الدراسة:لمقارنه تأثير ومضاعفات استخدام تقنيه الطحن او تقنيه التكسير لحصاة أسفل الحالب باستخدام الليزر وذلك بمقارنه وقت العملية، معدل التخلص من الحصى، معدل احتياج وضع قسطره الحالب والمضاعفات داخل العملية.

المرضى والأساليب: ادرج في هذه الدراسة 120 مريض تم تقسيمهم الى مجموعتين : (الأولى) تكسير حصاة الحالب باستخدام **تقنيه الطحن** وتم تقسيمها الى مجموعتين الأولى حصاة بين 10-15 ملم والثانية حصاة اصغر من 10 ملم, و(الثانية) باستخدام **تقنيه التكسير** وتم تقسيمها الى مجموعتين الأولى حصاة بين 10-15 ملم والثانية حصاة اصغر من 10 ملم في مستشفى الشهيد غازي الحريري للجراحات التخصصية للفترة من كانون الأول 2019 الى تموز 2022 , تمت المقارنة بين كلتا الطريقتين من حيث وقت العمليه,معدل التخلص من الحصاة، معدل وضع قسطره الحالب, مضاعفات حدثت خلال العملية.

النتائج: وقت العملية في النوع الأول (تقنيه الطحن) أكثر من النوع الثاني (تقنيه التكسير) مع وجود فرق كبير ذو دلاله إحصائية، معدل التخلص من حصاة الحالب في النوع الأول أكثر من النوع الثاني بدون وجود فرق كبير ذو دلاله إحصائية، احتياج وضع قسطره الحالب أكثر في النوع الثاني مقارنه بالنوع الأول مع وجود فرق كبير ذو دلاله إحصائية.

من حيث المضاعفات خلال العملية، أكثر بالنوع الثاني مقارنه بالنوع الأول بدون وجود فرق كبير ذو دلاله إحصائية.

الاستنتاج:ان تفتيت حصاة الحالب باستخدام تقنيه الطحن ذو مضاعفات اقل داخل العملية وذو احتياج اقل لوضع قسطره الحالب، ولكن وقت العملية أطول،تفتيت حصاة الحالب باستخدام تقنية التكسير وقت عمليه أقصر وأكثر مضاعفات داخل العملية وأكثر احتياج لوضع قسطره الحالب.

الكلمات المفتاحية:تكسير ،التفتيت، تفتيت الحصوات بالليزر، حصوات الحالب السفلي