A study effecting of the Power settings for Holmium - YAG laser on lithotripsy time Intra corporeale

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Abstract: Among the many devices for lithotripsy inside the body, the lithotripsy device using the Holmium-YAG laser has evolved into the widely used tool for treating urinary tract stones. Purpose: The aim of this research is to show the effect of parameters for Ho-YAG laser (2100 nm) on fragmentation time Intra Corporeal and stone composition for stone disease through is to investigating of stone composition and setting pulsed holmium laser energy with calculating time period for crushing stone. Patients & Methods: from the period of March 2020 to august. 2020 a 63 patient were selected to include in this study (outcome of surgery for lithotripsy ureteral stone below 17 mm by laser) has been 10-85 years for male and female collected from the Hussein Teaching hospital department of urology. using Ho- YAG laser irradiation wave length 2.12 µw interaction absorption coefficient (30 cm⁻¹) at maximum output power 0.5-1.2J for width of the laser pulse is 350 microseconds in an optical fiber with a diameter of 272-550 microns with an energy of 0.8 - 1.2 joules at 6-10 hertz .The samples obtained were selection collections of fragments retrieved following lithotripsy. The aim of this study was to determine the chemical compositions of urinary stones that had been removed, Use infrared spectroscopy Within the range (400-4000) cm⁻¹ using a (Bruker FTIR - Spectrometer) device. Results: This study show mean stone size below 14 mm was (2.758±0.919) mm for First g roup of 21 stones of the same composition ( oxalate calcium ) with pulse energies of o.8 , 1.2 and 1.2 J with repetition rate was 6, 8 and 10 HZ respectively for ureteric stone which included 12 male 57.14 % with 9 female 42.85 %. second groups of 21 stones of the same composition (Uric acid) with pulse energies of o.8 , 1.2 and 1.2 J with repetition rate was 6, 8 and 10 Hz respectively for ureteric stone below 17 mm which comprised 13 male 61.9 % with 8 female 38.09 %. Third group of 21 stones of the same composition (Struvite Stones) with pulse energies of 0.8 , 1.2 and 1.2 J with repetition rate was 6, 8 and 10 HZ respectively for ureteric stone below 16 mm which included 11 male 52.3 % with 10 female 47.61 % Conclusion: That Ho-YAG Laser lithotripsy of ureteral stones is an excellent treatment method, which is related to the period of time required for fragmentation with the type of stones and the different laser settings used.

Keywords: Ho-YAG laser, pulse energy ,laser lithotripsy, , frequency setting.

1. Introduction
Urinary stones are one of the most common and inconvenient urinary system problems In the treatment of urinary lithotripsy, four new technologies have advanced Electrohydraulic lithotripsy, ultrasonic lithotripsy, extracorporeal shock wave lithotripsy, and laser lithotripsy are some of the lithotripsy techniques available [1]. If the stone is too big to move on its own or becomes lodged in a difficult location, it will obstruct the flow of urine, resulting in a persistent urinary tract infection that destroys kidney tissue or continuous bleeding Management methods for therapies include:-Open Surgery (lithotomy):- Percutaneous NephroLithotomy, Ureteral double-J stents, Ureteroscopic Stone Removal [2] . Because of advancements in endoscopic technology and lithotripsy, urinary tract stone treatment has achieved widespread acceptance. [3]. Because of the advancement of small equipment
and the entry of laser science into medicine, using laser for urolithiasis management is now a viable option\textsuperscript{1} ureteroscopic surgery Ho: YAG laser lithotripsy is a preferred method for treating urinary stone disease \textsuperscript{4}. As compared to open surgery, the invention of ureteroscopy appliances and other smaller endoscopy instruments resulted in better calculi fragmentation, more effective calculi evacuation, a larger number of free calculi, and lower morbidity rates.\textsuperscript{5, 7} This laser is the source of electricity. Endoscopes can deliver laser power to both flexible and rigid optical fibers\textsuperscript{6}. It has become the lithotripsy system of choice due to its high performance and small diameter availability\textsuperscript{8}. Optical fibers transmit energy to fragment stones, and their safety profile has previously been demonstrated to be superior to that of other lithotrities, particularly in terms of ureteral perforation risk.\textsuperscript{9} When it comes to technicality and laser settings, stone location is a variable that must be taken into account When handling stones in the ureter, retropulsion is more of a problem\textsuperscript{11}. The structure of kidney stones is responsible for their formation, which contributes to the stone’s formation environment. The crystalline structure of stones must be determined not only to determine the etiology, but also to manage recurrent stone disease.\textsuperscript{12} Owing to biological incompatibility, minerals accumulate and agglomerate on the inner surfaces of the kidneys, forming stones that are hard masses like small rocks.\textsuperscript{13}. Many researchers have identified seven distinct forms and twenty-one subtypes of kidney stones, which include monohydrate and dihydrate calcium oxalates, phosphates, uric acid, urates, protein, and cystine calculi. Urinary stone analysis can be performed in a number of different ways. Optical crystallography X-ray, diffraction, infrared spectroscopy, X-ray spectroscopy and thermogravimetry are some of the physical methods used in stone research. These methods necessitate complex equipment, are only semi-quantitative in nature, and do not detect minor constituents of mixed calculi\textsuperscript{14}.

**Causes of urinary stones**: Low fluid intake leads to low urine volume, which results in high concentrations of stone-forming solutes in the urine. This is an important environmental player in the development of kidney stones\textsuperscript{15}. The four major chemical forms of renal calculi are mentioned below, each of which is linked to more than 20 underlying causes: Calcium stones, Struvite (magnesium ammonium phosphate) stones, Uric acid stones, Cystine stones Calcium stones: Recent research suggests that in hypercalciuric stone formers, a low-protein, low-salt diet may be preferable to a low-calcium diet for preventing stone recurrences. Struvite (magnesium ammonium phosphate) stones are linked to a chronic urinary tract infection (UTI) caused by gram-negative, urease-positive bacteria that break down urea into ammonia, which then binds to phosphate and magnesium to form a calculus. Stones made up of uric acid: These are linked to a urine pH below 5.5, a high purine diet (e.g., organ meats, legumes, fish, meat extracts, gravies), or cancer (i.e., rapid cell turnover) Stones of Cystine: They appear as a result of an intrinsic metabolic defect that causes cystine, ornithine, lysine, and arginine reabsorption failure in the renal tubules. Urine becomes cystine supersaturated, resulting in crystal deposition.\textsuperscript{16– 18}

**Patients**
From patients with ureteral stones, 54 patient were selected to be included in this study (Outcome of surgery for lithotripsy ureteral stone below 17 mm by laser) has been 10 – 85 years for male and female collected, for the duration from march 2020 to august 2020.

**2. Materials and Methods**

**Laser Source**
Specimens of ureteric calculi used provided by the 63 patients were treated with lithotripsy at Hussein Teaching Hospital’s urology clinic. The aim of this analysis was to see how the wave length of the Ho-YAG laser irradiation affected the results (2.12 nm) In an optical fiber with a diameter of 230-600 microns and an energy of 0.8-1.2 joules at 6-10 hertz, the width of the laser pulse is 350 microseconds at maximum peak power (1.2-0.5 J). In addition to Camera, Monitor and light source (all from Karl Storz TM) with An semi-rigid ureteroscope 40 cm length with 12° Lens and 5 Fr. (PUSEN TM 9 Fr., with 270 deflection in both sides) with use Irrigation with Normal saline.
Holmium laser therapy is indicated for patients with ureteric calculi. It is possible to perform ureteroscopic laser lithotripsy of ureteric calculi. Prior to laser lithotripsy, patients with high-grade obstruction can require the placement of a ureteral stent. Laser energy was launched into a (230m,356m,600m) diameter optical fiber and applied to the stones surface in contact mode from (2100nm HO:YAG laser). The laser pulses were 350 microseconds in length. The initial setting were adjusted from 0.8 to 1.2 Joules at 6 to 10 HZ to fragment most stones. As the stone absorbs laser irradiation, an audible "tic,tic" sound is made. In a fluid environment, determined by using water with calculating the time period for crushing calculi. Analysis of stone fragmentation using (2100 nm Ho: YAG laser) was evaluated. Different sizes, shapes, and composition of human urinary stones were used. Urinary stones of known composition with different sizes, shapes were used for this study. Stones were then hydrated in water for more than one week. The samples obtained were selection collections of fragments retrieved following lithotripsy.

Table (1)\(^{[9]}\): Types and general physical characteristics.

| Element                              | Name of Mineral          | Formula for Chemical                  | A brief Description                                                                 |
|--------------------------------------|--------------------------|---------------------------------------|-------------------------------------------------------------------------------------|
| Oxalate of Calcium Monohydrate (COM) | Whewellite               | CaC2O4.H2O                             | The foundation stone Brown is a color Surface is rough and very stiff, with a laminated structure |
| Calcium Oxalate Dihydrate (COD)      | Weddellite               | CaC2O4.2H2O                            |                                                                                     |
| Hexahydrate of Magnesium Ammonium Phosphate | Struvite Carbonate Apatite | MgNH4PO4.2H2O, Ca10(PO4CO3OH)6(OH)2   | Mixed composition of secondary stone White Smooth, friable white Continuity          |
Calcium phosphate, Hydroxyl form Calcium Hydrogen phosphate, Hydroxy Dihydrate of phosphate Magnesium Tricalcium phosphate Trihydrate with Hydrogen phosphate | Hydroxylapatite Brushite Whitlockite Newberyite | Ca10(PO4)6(OH)2 CaHPO4.2H2O Ca3(PO4)2 MgHPO4.3H2O | The foundation stone The color ranges from off white to brown Hardness that varies

Uric Acid is a form of uric acid that sodium Hydroxide irritable Ammonium Hydroxide irritable | N/A | C5H4N4O3 NaHC5H2O3N4.H2O NH4H.C5H2O3N4.H2O | The foundation stone Brown lamination that is smooth, hard, and concentric

Cysteine | N/A | (SCH2CH(NH2)COOH)2 | Yellowish – brown primary stone Extremely firm

We were sent to a biochemistry lab for qualitative chemical analysis for various potential chemical compositions in order to determine the chemical compositions of the extracted urinary stones. The stones were ground into a fine powder before being examined using normal chemical techniques. Calcium (Ca), Oxalate (OX), Phosphate (PO4), Urate (UA), and Magnesium (Mg), Carbonate (Co3), and Amino acids (AA) Use infrared spectroscopy Within the range (400-4000) cm⁻¹ using a (Bruker FTIR - Spectrometer) device and using a potassium bromide tablet at Thi-Qar University-Faculty of Science - Department of Chemistry.

3. Results and Discussion
The efficiency of the Ho: YAG laser for fragmentation of these stones at different energy settings was studied. Holmium laser lithotripsy has shown excellent results in the treatment of urinary stones. The effect of stone installation on fragmentation time depends on the changes in the settings of the pulse energies and frequency. First group of 21 stones of the same composition (oxalate calcium) with pulse energies of 0.8, 1.2 and 1.2 J with repetition rate was 6, 8 and 10 HZ respectively for a power output of 20 W for ureteric stone below 14 mm, this cross sectional study included 12 male (57.14%) with 9 female (42.85%) the mean patient age was (13.38±4.461) year range (10-52) for mean stone size was (2.758±0.919) mm range (6-14) mm. mean the break up time 8.120±2.706 sec. range (63-87) sec, the study show significant relation between the break up time and stone size as shown in table(2). The following are the findings of an FT-IR study of a variety of materials of calcium oxalate samples as follows: Diagnostic band identified for a pure oxalate of calcium monohydrate absorbance at 1621.16 cm⁻¹ an 1318.52 cm⁻¹. Once belonged to C=O and C-O stretching, respectively. The frequency range was set to 780.27 cm⁻¹ in agreement with C-H bending the absorption band at a certain angle 3494.92-3065.48 cm⁻¹. Due to symmetric and asymmetric O-H bending, this occurred. This occurred as a result of symmetric and asymmetric O-H bending. The band of absorption at 1318.52 cm⁻¹ was as a result of C-C, C-O extending .882.67 cm⁻¹ because of C-C extending [19] as presented in Figure1-A.
The absorption bending, The absorption bands at 1305.19-1347.59 were because of N-H stretching, 1117.99 cm\(^{-1}\) because of C-O stretching, 872.68 cm\(^{-1}\) because of C-N bending, The absorption band at 2853.95-2925.06 related to N-H As seen, stretching vibration suggested amino acid ion\(^{20}\). 

**Figure (1. A).** FTIR spectrum of pure COM
Second group of 21 stones of the same composition (Uric acid) with pulse energies of 0.8, 1.2 and 1.2 J with repetition rate was 6, 8 and 10 HZ respectively for a power output of 20 W. A total of 21 patients for ureteric stone below 17 mm, this cross sectional The were 13 men in the study (61.9%) with 8 female (38.09%) the mean patient age was (13.220±4.406) year range (11-55) for mean stone size was (4.013±1.337) mm range (5-17) mm mean the break up time (7.529±2.509) sec. range (54-77) sec, the study show significant relation between the break up time and stone size as shown in Table (2). The formation of uric acid stones can be largely explained in terms of the biochemical conditions that favor uric acid precipitation, according to the FT-IR spectrum of a sample known as uric acid. The concentration of uric acid and the PH of urine are the most significant factors. Patient are found to have uric acid saturation levels that are higher than average, indicating that they are above the point of spontaneous uric acid precipitation. As a result, dehydration may be a major contributing factor in this disease. The (400-600) cm⁻¹ band contains a large number of deep absorption lines, making uric acid stones friable and easily disintegrated. Uric acid at showed N-H a change in frequency 1641.11 cm⁻¹ and frequency 1584.01 cm⁻¹ related to C-N stretching vibration. 1548.46 cm⁻¹ was due to N-O stretching. The absorbance band at 1422.31 cm⁻¹ was due to O-H bending. The absorbance band at 1390.87 cm⁻¹ was due to C-N stretching, 1335.86 cm⁻¹ was due to N-H stretching, 1131.03 cm⁻¹ was due to C-O stretching. C-N stretching and

**Figure (1.B).** FTIR spectrum of ion amino acid COM
C-N bending vibration in 997.10 cm$^{-1}$ and 872.83 cm$^{-1}$ respectively. 2857-2922 cm$^{-1}$ related to N-H Amino acid ion was demonstrated by stretching vibration (figure 2) [19, 21, 22].

![FTIR spectrum of uric acid stone](image)

**Figure 2**: FTIR spectrum of uric acid stone

Third group of 21 stones of the same composition (Struvite Stones) with pulse energies of 0.8, 1.2 and 1.2 J with repetition rate was 6, 8 and 10 Hz respectively for a power output of 20 W. A total of 21 patient for ureteric stone below 16 mm, this cross sectional study included 11 male 52.3% with 10 female 47.61% the mean patient age was (14.94±4.98) year range (22-60) for mean stone size was (3.018±1.006) mm range (7-16) mm. Mean the break up time (4.657±1.552) sec, range (41-53) sec, the study show significant relation between the break up time and stone size as shown in Table (2).

Figure 3: Magnesium ammonium phosphate hexahydrate (Struvite) was described by FT-IR, with minor calcium phosphate carbonate (carbonate apatite).
Figure 3: FTIR spectrum of Struvite Stone.

Table (2): Show significant relation between the break up time and stone size.

|                | oxalate calcium stone | Uric acid stone | Struvite stone       |
|----------------|-----------------------|-----------------|----------------------|
| PE (J) | PRR (HZ) | P (W) | Operative time (sec) | Stone size (mm) | Age     | P-value |
| 0.8     | 6       | 4.8   | 13.316 ±7.688    | 3.055±1.763    | 3.605±2.081 | 0.02 (S) |
| 1.2     | 8       | 9.6   | 2.000±1.154     | 1.154±2.000    | 22.501±12.991 | 0.1(NS) |
| 1.2     | 10      | 12    | 3.511±2.027     | 10.016±5.783   | 12.583±7.264 | 0.01(S)  |

|                | oxalate calcium stone | Uric acid stone | Struvite stone       |
|----------------|-----------------------|-----------------|----------------------|
| PE (J) | PRR (HZ) | P (W) | Operative time (sec) | Stone size (mm) | Age     | P-value |
| 0.8     | 6       | 4.8   | 4.041±2.333     | 1.000±0.577    | 16.921±9.769 | 0.003 (S) |
| 1.2     | 8       | 9.6   | 1.154±0.666     | 4.358±2.516    | 8.144±4.702  | 0.07(NS) |
| 1.2     | 10      | 12    | 3.000±1.732     | 6.429±3.711    | 5.131±2.962  | 0.1(NS)  |

|                | oxalate calcium stone | Uric acid stone | Struvite stone       |
|----------------|-----------------------|-----------------|----------------------|
| PE (J) | PRR (HZ) | P (W) | Operative time (sec) | Stone size (mm) | Age     | P-value |
| 0.8     | 6       | 4.8   | 1.154±0.666     | 4.358±2.516    | 6.082±3.511 | 0.04(S)  |
| 1.2     | 8       | 9.6   | 1.000±0.577     | 2.516±1.452    | 13.503±7.796 | 0.01(S)  |
| 1.2     | 10      | 12    | 1.732±1.000     | 2.516±1.452    | 24.986±14.426 | 0.01(S) |
Figure 4: Operative time and stone size for pulse energies (0.8, 1.2) J and repetitions rates (6, 8, 10) Hz sorted according to the intensity of each setting with the error bars as a representation of the break up time (sec) and stone size (mm) for stones types.

4. Conclusion
This study aimed to investigate Fragmentation efficiency was on stone for a wide range of laser application. The difference in the laser settings (pulse energy, pulse duration, and repetition rate) and stone installation resulted in a change in the crushing time required for fragmentation in vivo.

5. Statistical analysis
Both data entry and data processing were done with the statistical kit for Social Version 20 (SPSS20). The mean and standard deviation for continuous variables are shown, while the number for discrete variables is shown (percent). The T test for independence was used to determine the significance of an association for a continuous variable, and the Chi-square test (or fisher exact test when appropriate) was used to determine the significance of an association for a discrete variable with a p-value of less than 0.05 were thought to be important.

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