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EFFICACY OF Nd: YAG LASER LITHOTRIPSY OF URIC ACID PHOSPHATE CALCULI IN RELATION TO THE STONE'S COMPOSITION

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ABSTRACT

Urinary stone disease is a major health care problem due to its high prevalence. There are several therapeutic methods used and they depending on stone size, location and anatomical variations of the urogenital tract. Extracorporeal shock wave lithotripsy is a common therapeutic method which was widely used through the past 30 years. The purpose of this study is to evaluate the laser lithotripsy (Stone fragmentation) of urinary calculai with a Q-Switched Nd: YAG laser oscillating at 532nm and 1064nm and to determine the optimum laser energy, Wavelength and frequency for the destruction of kidney stones. Seventy eight of urinary stones of different chemical compositions were included in the current study. Forty two stones were irradiated by Nd: YAG laser of 532 nm, while the other thirty six were subjected to a 1064 nm. Each urinary stone was divided into two parts, one to be prepared for irradiation with two Nd: YAG wavelengths. The weight of each part of the stone and its maximum width were measured. Each stones was immersed in a water bath for (10) mins at 37° to become humidified. The results of the current research showed a significant correlation between the energy of the two used Nd: YAG laser wavelengths and the stone's weight for the uric acid phosphate calculi. It was noticed that for the same stone weight the energy that was needed to break it by 532 nm Nd: YAG laser is lower than the energy required by the doubled wavelength; shorter wavelengths are slightly more efficient for pressure generation. This effect probably resulted from the better laser absorption for the wavelength 532 nm. The Efficacy of Nd: YAG Laser Lithotripsy for the Uric acid phosphate calculi with the wavelength (532nm) is better than the double wavelength in regarding the energy for the same stone's weight.

KEYWORDS: Nd: YAG Laser, Uinary Calculi, Laser Lithotripsy.

INTRODUCTION

Laser lithotripsy was first introduced in the 1980s, where pulsed lasers of 504 nm delivered to the stone by optical fibers through a scope. The Neodymium Yttrium Aluminum Garnet laser (Nd: YAG) is a solid state system used for many years in both the scientific research and medical communities [1]. The fundamental output of the Nd: YAG is at 1064nm. By the addition of the nonlinear crystal (Potassium-titanium-phosphate) (KTP) in the resonant cavity between the YAG crystal and output mirror, the second harmonic is obtained as a bright green line of 532nm.The output is obtained through the front mirror, which is dialectally coated for maximum reflectance at 1064nm and maximum transmittance at 532nm. The Nd: YAG laser can be operated either in a continuous wave or various pulsed modes[2]. The set part from the Nd: YAG in that it is Q- switched and frequency-doubled [1]. The technique of Q switching allows the generation of laser pulses of short duration (from a few nanoseconds to a few tens of nanoseconds) and high peak power (from a few megawatts to a few tens of megawatt) can be obtained by this technique. These pulses can be achieved by introducing time or intensity- dependent losses into the laser cavity. The Q-Switch acts as a extremely high –speed shutter. Since this technique involves switching the cavity Q factor from a low to a high value, it is known as (Q Switching). A short voltage pulse is applied to the Q-Switch which changes its ability to pass polarized light .This change allows a single extremely high energy (35 megawatts) and extremely (10 nanoseconds) pulse of light to exit the cavity. The Q-Switch can be set by the display panel to release the light at pulse rates of 1,2,5, and 10 pulses per second or single Short[3]. Urinary calculi are the third most common affliction of the urinary tract. They are of many types Uric acid**,** Phosphate, Calcium, Oxalate, Sodium, Citrate, and Magnesium When the laser energy hits the surface of the calculus, which is immersed in liquid in the body, laser- induced breakdown (LIB) occurs and plasma is formed. Plasma is defined as a medium consisting of neutral atoms, electrons, ions and quanta emitted from atoms or ions. The plasma is formed due to an avalanche effect[4]. The plasma expands and emits a shock wave which propagates into the stone. This conversion of light energy into mechanical stress gradually destroys the stone.

MATERIALS & METHODS

Seventy eight of human urinary stones of different chemical compositions were included in the current study. Forty two stones were irradiated by Nd: YAG laser of 532 nm, while the other thirty six were subjected to a 1064 nm of Nd:YAG.

Stones' measurements and preparation

Each urinary stone was divided into two parts, one to be prepared for irradiation with Nd: YAG laser of a wavelength (532) nm and the second to be irradiated with a laser of wavelength (1064) nm. The weight of each part of the urinary stone was measured by using the Adventurer pro balance, Av212. The maximum width of each stone was measured by a ruler. Each stones was immersed in a water bath for (10) mins at 37° to become humidified**.**

Stones' fragmentation with Nd: YAG laser

LUCAS Q-switching Nd: YAG laser device model, class 4, (Korean made) was used for the irradiation and fragmentation of the urinary stones. It was set to provide Nd:YAG laser with a 532 nm, with energy range of (10 – 400) mj, and 1064 nm with energy range of (100–1200) mj, a focal spot of 2mm, voltage of 220 V and 10 amperes. Each stone was contained in a kidney dish to avoid the heating effect. The laser was directed from the laser arm device to touch the surface of stone through numbers of pulses' shoots. Accordingly, the stone was subjected to different laser's energy values starting from the minimum to the value

Analysis and Chemical Qualitative Method of urinary stones:

Each urinary stone was subjected to a chemical analysis in order to know the individual chemical element (Calcium, Oxalate, Phosphate, Uric acid, Sodium, Citrate, and Magnesium) that contribute in the composition of these stones. This process was done in collaboration with the Clinical laboratory of Al-Yarmouk teaching hospital, where the type of each element was reported. The chemical analysis procedure was done depending on the BIOLABO SAS. Company procedure (WWW. biolabo.fr)

RESULTS

The effect of Nd: YAG laser Energy on Calculi lithotripsyfor 532 nm and 1064nm

The lithotripsy of urinary stones, those which are composed mainly of uric acid phosphate, by irradiating them with 532 nm Nd: YAG laser showed that the fragmentation of each calculi requires a certain value of energy according to its weigh. The increment of the stone's weight was directly and significantly correlated with energy ($P<0.001$).

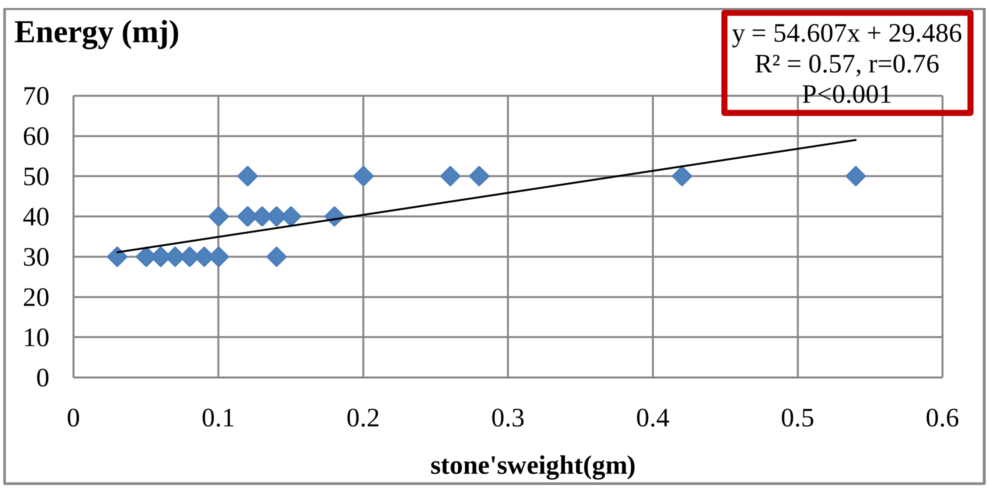

FIGURE 1: The correlation between the stone's weight and the energy of 532nm Nd: YAG laser

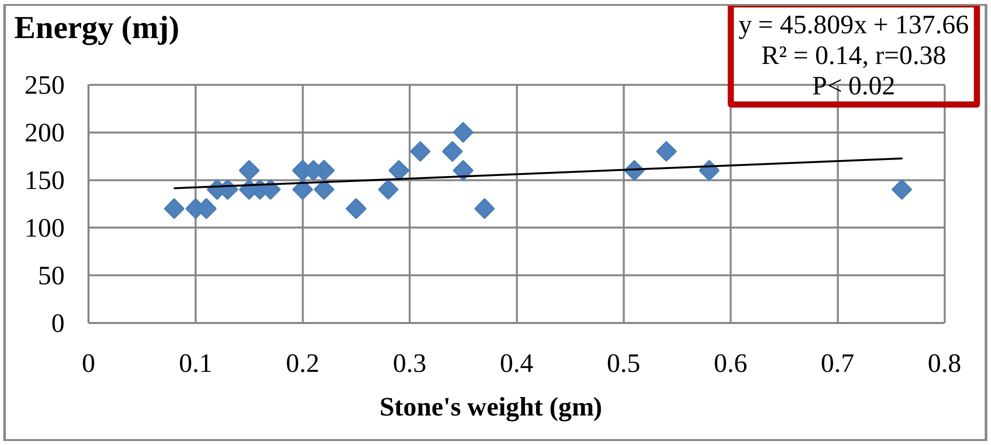

FIGURE 2: The correlation between the stones' weight and energy of 1064nm Nd:YAG laser

In the current study, as the frequency of the Nd: YAG laser was doubled to 1064nm, the results showed a direct and significant correlation between the weight of the uric acid calculi and the laser's energy which were required to break the these stones (P<0.02)

DISCUSSION

Calculus fragmentation begins with the absorption of photon. If absorption does not occur in the calculus, no fragmentation will occur. Therefore, the most important factor is the laser fluence or energy [5]. The results of the current study showed that the energy of both Nd: YAG laser wavelengths (532 and 1064) nm was significantly correlated with the stone's weight. In general, as the stone's weight increase higher amount of energy will be needed to fragment it. It was noticed that for the same stone weight, the energy that was needed to break it by the 532 nm of the Nd: YAG laser is lower than the energy required by the doubled wavelength (1064 nm). It is well known that laser wavelength play an important role in laser-stone interaction processes, shorter wavelengths are slightly more efficient for pressure generation. This effect probably results from better laser absorption [6]. As calculi absorb 532 nm better than 1064 nm, the use of 532 nm lead to initiate a plasma at the calculus surface, the plasma induces a cavitation bubble, which on collapse causes a shock wave[7]. Accordingly, the findings of the current work is supported by C. Palmqvist, 1987 who showed that the destruction threshold for all stone types at 532 nm clearly is much lower than by 1064 nm. If one compares the absorption behaviour of the stone material at 532 nm and 1064 nm, the destruction threshold appears to behave contrary to the absorption coefficient. The large degree of variation of the destruction threshold with the same stone type clearly shows that a series of other factors such as the stone morphology or different constituents have an effect on the fragmentation threshold. On the other hand, The results of the current study showed clearly that the most affected type of calculi by the Nd:YAG laser was the Uric acid phosphate ones, where both of the wavelength can cause stones' fragmentation. Nd: YAG laser data demonstrate the ability to fragment multiple types of urinary stones[8], this supports our experimental study with preference for uric acid and phosphate calculi. Two studies showed that Nd: YAG laser have decreased efficacy with certain stone type including cysteine, and calcium oxalate calculi. This stones' behavior is related to the difference in stones absorption to different wavelength of energy [8]. Measurement of the ability of calculi to absorb energy is provided by materials wavelength-dependent absorption coefficient, which evaluates the amount of heat or acoustic pressure that will be generated by a pulse of laser [5]. Moreover, in the current work, the irradiation of the stones was done in humid environment where the stones immersed in water during the irradiation process; this led to increase the braking rate. This finding was explained by what reported by Mahmood *et al.*, 2013 who reported that stone material weight loss measurement ablated in water shows more effective result than in air. The ablation rate, and therefore the material loss rate were much higher when ablation took place in water because of the higher generated stress.

CONCLUSION

The Efficacy of Nd: YAG Laser Lithotripsy for the Uric acid phosphate calculi with the wavelength (532nm) is better than the double wavelength one regarding the energy for the same stone's weight.

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