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Determining optimal laser settings for the fragmentation of COM stones comparing various lasers and multiple power settings

A. Bhatti[1], C. Bach[2], S. Kachrilas[2], F. Zaman[2], N. Buchholz[2], M.M Knight[1]

[1] *School of Engineering and Materials Science, Queen Mary, University of London, London, United Kingdom*

[2] *Department of Urology, Barts Health NHS Trust, London, United Kingdom*

Introduction and Objectives: In an era of increased use of flexible ureteroscopy, intracorporeal laser lithotripsy has become the primary treatment modality for many urinary tract calculi. This is particularly true for calcium oxalate monohydrate (COM) stones that have been reported to be amongst the hardest stones to fragment. Few studies have reported the effect of holmium laser energy and frequency on stone fragmentation. To our knowledge, no study has reported the optimum conditions for COM stone fragmentation. In this study we attempted to develop an in-vitro model using artificial standardized stones which would allow us to determine the optimal settings for COM stone fragmentation for different lasers.

Material and Methods: Spherical artificial urinary calculi of 10mm diameter mimicking mechanical and fragmentation properties of COM stones were developed from BegoStone® using a powder-water ratio of 15:4. Vickers Hardness tests using 10 s dwell time and a load of 100g, and compression tests using a strain rate of 2mm/min were conducted with dry and immersed samples. An in vitro underwater model was developed simulating laser lithotripsy using a 200 micron laser fiber. The effectiveness of different laser machines (EMS LaserClast®, VersaPulse Holmium® and VersaPulse Select®) were tested using commonly used clinical energy and rate settings (5000 pulses at 0.5 J & 5 Hz = 2.5W; 0.8 J & 8 Hz = 6.4W; 1.2 J & 10 Hz = 12W). Once the most efficient laser had been identified, we used it to continue testing with some more settings.

Results: The ultimate breaking and yield strength was lower in the immersed artificial stones. Vickers Hardness test of BegoStone® phantoms showed a value of 1455±76MPa.

The EMS LaserClast® showed the most efficient stone fragmentation and testing was continued with this laser therefore (Tab 1). A setting of 5Hz and 1.2 J = 6W resulted in the most efficient fragmentation with 11±1.2 (10^{-2}) grams of stone mass (Tab 2).

Table 1. Fragmentation at various clinical settings on EMS LaserClast®, VersaPulse Select® and VersaPulse Holmium®

Energy (J)	Frequency (Hz)	Power (Watts)	Fragments 10^{-2}(g)		
			EMS LaserClast®	VersaPulse Select®	VersaPulse Holmium®
0.5	5	2.5	9±1.2	3±0.06	8±0.01
0.8	8	6.4	8±0.5	2±0.01	8±0.03
1.2	10	12	6±0.2	1±0.02	6±0.02

Values are expressed as mean ± SD (n=4 for each group)

Table 2. Effect of energy and frequency on the Fragmentation at various settings on EMS LaserClast®

Energy (J)	Frequency(Hz)	Power(Watts)	Fragments 10^{-2}(g)
0.5	5	2.5	9±1.2
	8	4	6±1.1
	10	5	5±0.2
0.8	5	4	9±1.6
	8	6.4	8±0.5
	10	8	6±0.6
1.2	5	6	11±1.2
	8	9.6	8±0.9
	10	12	6±0.2

Values are expressed as mean ± SD (n=5 for each group)

Conclusions: Our results show that the EMS LaserClast® was the most efficient laser amongst those tested. A low-frequency high-energy setting within the limits of laser fiber tolerability (i.e. 5 Hz/ 1.2 J) has the best fragmentation rate and fragments are ≤ 2mm which allows their spontaneous passage.

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