PP57

Laser drilling weakens kidney stones but does not alter fragmentation efficiency: an *in vitro* study

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Introduction: Whereas percutaneous and retrograde combined endoscopic surgeries can deal with large and even staghorn stones, there is a small group of medical high risk patients that can not undergo even such minimally invasive procedures. They would benefit from a non-touch approach such as extracorporeal lithotripsy (SWL). We therefore hypothesised that drilling holes into a large stone in a well defined fashion – possibly using the all seeing needle under local anaesthesia – would facilitate stone fragmentation in such cases. Consequently, this study used artificial stones (Begum stones) to evaluated the impact of laser drilling on subsequent SWL fragmentation.

Material and Methods: A total of 21 identical artificial stones were created in a custom mould using powder:water ratio optimised to produce spherical stones with a tensile fracture strength similar to that reported for staghorn stones. A single hole was drilled in each stone to a depth of either 6mm or 8mm using a 200µm laser fiber (Flexiva™ 200) at 0.5J and 5Hz with a 20W Versa Pulse® Holmium laser generator. Control stones were left undrilled. The total mass of each stone was then measured. Stones were placed individually in a waterbath onto a Storz Modulith SLX-F2 lithotripter, focused and treated with 1500 shockwaves in a defined energy escalating scheme up to 4J mimicking clinical treatment conditions. After SWL, the stone fragments were sieved through a 3.15mm mesh. The mass of each collected fragment was measured and the fragmentation efficiency for each stone calculated as follows:

$$Fragmentation\ efficiency\ (\%) = \frac{(total\ mass\ of\ stone) - (mass\ of\ fragments > 3.15mm)}{(total\ mass\ of\ stone)} \times 100$$

The procedure was repeated for a sample of 7 stones in each group.
In separate studies, diametric compression tests were performed to measure the tensile strength of the stones with and without holes.

Results: Stones without previous laser drilling had a SWL fragmentation efficiency of 37.4% ± 9.3 (mean ± st_dev). There was no statistical difference between stones with 6 mm or 8 mm deep holes which combined had a fragmentation rate of 33.3% ± 15.1. There was no significant difference in fragmentation efficiency between laser drilled and non drilled stones ($p>0.05$). Similarly laser drilling had no statistically significant effect on the mass of individual fragments produced by SWL. However, the diametric compression test found that laser drilling resulted in a statistically significant reduction in tensile strength.

Conclusions: Laser drilling of artificial staghorn stones is able to weaken the stones but does not increase the fragmenation efficiency under SWL.