Urine stone fragmentation by short-pulse thulium fiber laser

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Abstract: Thulium pulse fiber laser with pulse energy up to 200 µJ and 100 nsec pulse width for urine stone fragmentation was examined. Complex fracture process in Urine-Acid stones is indicated by non-proportional dependence of fragmentation rate vs pulse repetition rate.

Keywords – thulium laser, fiber laser, stone fragmentation

I. INTRODUCTION

Pulse mode of operation attracts attention due to combination of high peak power and low thermal load. On the other hand, pulse mode of operation can be characterized with parameters such as pulse energy, pulse duration and pulse repetition rate. It is still unclear what combination of these parameters is suitable for this application.

In this report we present preliminary results of study of urine stone fragmentation with low-average-power thulium pulse laser proposed in [2]. It is shown that provided parameters are acceptable for case of Urine-Acid type stones, although a question about optimal pulse parameters is still open.

II. PULSE LASER SOURCES AND PROCESSING FIBER

In our experiment we investigated two available laser sources:

1) $P_{\text{avg}}=16\,\text{W}, f_{\text{rep}}=100\,\text{kHz}, E_{\text{pulse}}=160\,\mu\text{J}$
2) $P_{\text{avg}}=4.8\,\text{W}, f_{\text{rep}}=25\,\text{kHz}, E_{\text{pulse}}=190\,\mu\text{J}$

Pulse width of both sources was 100 nsec.

During preliminary trials optical fiber tip degradation was observed (see details below). Different processing fiber configurations were tested, with various core and outer diameters. Best performance in terms of stone fragmentation rate and mechanical endurance during the process was demonstrated by fiber with core diameter 100 um, and output diameter 400 um.

III. EXPERIMENT DESCRIPTION AND RESULTS

Urine stone (Urene-Acid type [1]) was sunk into NaCl solution. Stone fragmentation was observed during a contact of fiber tip and a stone. Process is stable in time although fiber tip is also destroyed during the process, tip degradation rate was 0.5 mm per stone.

![Pic.1 sample for source №1](image)

Stone sample №1 (dimensions was 3.5x6x9 mm) was fragmented by 1st source into small parts (2mm or less) in 100 sec.

Stone sample №2 (dimensions was 2.5x7x9 mm) was fragmented by 2nd source into small parts (2mm or less) in 170 sec.

Stone of calcium oxalate monohydrate (COM) was unable to break with any of available sources.

REFERENCES