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HIGH-SPEED PHOTOGRAPHIC EVALUATION OF RETROPULSION MOMENTUM INDUCED BY A LASER CALCULI LITHOTRIPTOR

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INTRODUCTION

Since the mid-1980's, many reports have demonstrated the clinical feasibility of fragmenting urinary and biliary calculi with high power lasers [1,2]. Several lasers such as pulsed dye, alexandrite and holmium:YAG have been successfully used as intracorporeal lithotriptors[3-5]. Calculus fragmentation is produced by the combination of direct thermal energy absorption and laser induced shock waves[5-7]. During this powerful laser-tissue interaction, the calculus is subject to a strong retropulsive momentum caused by particle ejection or laser induced shock waves[8]. If the stone cannot resist this kinetic momentum, it will recoil away from the laser delivery fiber. Then physicians must reorient the fiber to the stone for additional laser irradiation. This cumbersome process makes the procedure inconvenient and difficult and eventually prolongs the operation time. This study is designed to quantify the retropulsive momentum during pulsed laser lithotripsy.

MATERIAL AND METHOD

Calculus phantoms are made from plaster of Paris (calcium phosphate), whose chemical composition is similar to the most common type of urinary calculi (calcium oxalate monohydrate). Calculus phantoms were placed in a clear glass tube that served as an *in vitro* model of the ureter. Each sample was irradiated by a clinical Ho:YAG laser (Coherent, VersaPulse PowerSuite) through a delivery fiber. Movement of the calculus was monitored by a high-speed camera (Photron FastCam 10K) that provided pictures every 300μsecond. We examined the displacement and acceleration of the samples from captured pictures. The kinetic energy consumed by the friction and drag force were extracted from the acceleration. This value should be identical to the retropulsive momentum energy produced by the laser due to the conservation of momentum.

RESULTS

A series of experiments was carried out under various conditions. Variables included laser energy, fiber diameter (200, 365, 550 and 1000μm) and the dimensions of the calculus phantoms. It was found that 1) recoil momentum proportionally increased with increasing laser energy and 2) larger fiber diameter resulted in higher momentum. It was revealed that rebounding of ejected particles from the fiber back to the sample was a significant contributor to the laser-induced recoil momentum during laser lithotripsy.

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