LITHOTRIPSY PERFORMANCE OF TRADITIONAL AND SPECIAL DESIGNED LASER FIBERS

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Introduction and Objectives: Novel universal laser lithotripsy fibers claim to have lithotripsy performance enhancing features, including different laser-fiber-tip configurations. The authors decided to evaluate and compare two such fibers with a standard laser lithotripsy fiber.

Methods: Three different fibers were tested: a standard 272-μm core laser fiber (Mk22ST - RecaTec™), a special polished tip fiber (AcuMax 220 - Boston Scientific™), and a ball-shaped tip fiber (AcuTrac - Boston Scientific™). Special polished tip and ball-shaped tip fibers were used and reused without preparation, while the standard fiber was stripped and cleaned according to the manufacturer’s instructions after each experiment. Contrary to single pulse or manual experiments of previous laser lithotripsy studies, an automated fiber fragmentation testing system performed multiple 30-second-long experiments using soft and hard stone material, and high-frequency with low-pulse energy (HFir-LoP) and low-frequency with high-pulse energy (HFir-HiP) settings to cover most typical lithotripsy conditions (Figure 1). Ablation volumes and laser-fiber-tip photos before and after lithotripsy were compared.

Results: The traditional and the ball-shaped fibers were both statistically different from the special polished fiber, which they outperformed by 174% and 186% respectively (p<0.0001), regardless of stone material or lithotripter settings (Figure 2). No significant ablation volume differences were found between the traditional fiber and the ball-shaped fiber (p>0.72).

Microscopic fiber tip analysis showed fiber tip degradation to be surprisingly intense after short-term LoPh-HiP settings in the ball-shaped fiber, with a complete change of the fiber tip appearance (Figure 3). Considering this extreme fiber tip degradation, additional volume analyses revealed that ablation volume of HiP-LoP settings declined on average by 23% (sometimes up to 40%) for special polished and ball-shaped fibers (p<0.01), if high-pulse energy settings were used beforehand (Figure 4).

Conclusions:
- The traditional laser fiber seems to be as good as, sometimes even better than, novel special designed fibers.
- Rapid degradation and performance reduction of special designed laser fibers tip make their usefulness questionable.

Figure 1 - (A), (B) and (C) The three laser fibers tested, the Mk22ST from RecaTec™, the AcuMax 220 and the AcuTrac, both from Boston Scientific™. (D) and (E) Artisan stones made of plasters of Paris and bioplastic. (F) An automated laser fragmentation testing system made up of lifts’ slots, capable of storing test tubes and reproducible experiments.

Figure 2 – Ablation volumes of the three laser fibers tested. Although no statistically significant difference was found between the standard fiber and ball-shaped fiber, both outperformed the special polished fiber by a factor of 1.8. Plotted fiber tips are included as a reference of fiber tips present in column, with an average 24% and 22% increase in ablation volume for LoP-HiP and HiP-LoP settings, respectively. High-pulse energy settings (marked columns) comprise highest high-energy settings for several times more ablation, with an average 236% higher ablation volume, regardless of fiber type or stone material.

Figure 3 – Microscopic analysis of fiber tip changes over time. Minor tip changes occurred using low-pulse energy (HiP-LoP) settings with slight fluctuation of fiber diameter. However, there was intense fiber tip degradation after additional 80 seconds of high-pulse energy (LoP-HiP) laser emission, while the polished fiber tip showed only some subtle degradation and fiber tip specificity, the ball-shaped fiber tip suffered a complete morphological change, losing its ball-shaped appearance and surviving a rotating block, and gradually becoming unidentifiable from the other fibers as the experiment went on.

Figure 4 – Ablation volume decline of low-pulse energy settings for special polished and ball-shaped fibers. If high-pulse energy was used between low-pulse energy settings, there was a drop in ablation volume occurs for any subsequent low-pulse energy settings (p<0.05). Likewise, using high-pulse energy makes these fibers less efficient if low-pulse energy settings are to be used afterwards. The opposite, i.e. using low-pulse energy before high-pulse energy settings, does not affect the performance of the latter significantly (p>0.05).