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In vitro fragmentation efficiency of holmium: yttrium-aluminum-garnet (YAG) laser lithotripsy - a comprehensive study encompassing different frequencies, pulse energies, total power levels and laser fibre diameters.

Kronenberg P1, Traxer O.

OBJECTIVE:

To assess the fragmentation (ablation) efficiency of laser lithotripsy along a wide range of pulse energies, frequencies, power settings and different laser fibres, in particular to compare high- with low-frequency lithotripsy using a dynamic and innovative testing procedure free from any human interaction bias.

MATERIALS AND METHODS:

An automated laser fragmentation testing system was developed. The unmoving laser fibres fired at the surface of an artificial stone while the stone was moved past at a constant velocity, thus creating a fissure. The lithotripter settings were 0.2-1.2 J pulse energies, 5-40 Hz frequencies, 4-20 W power levels, and 200 and 550 μm core laser fibres. Fissure width, depth, and volume were analysed and comparisons between laser settings, fibres and ablation rates were made.

RESULTS:

Low frequency-high pulse energy (LoFr-HiPE) settings were (up to six times) more efficient than high frequency-low pulse energy (HiFr-LoPE) at the same power levels ($P < 0.001$), as they produced deeper ($P < 0.01$) and wider ($P < 0.001$) fissures. There were linear correlations between pulse energy and fragmentation volume, fissure width, and fissure depth (all $P < 0.001$). Total power did not correlate with fragmentation measurements. Laser fibre diameter did not affect fragmentation volume ($P = 0.81$), except at very low pulse energies (0.2 J), where the large fibre was less efficient ($P = 0.015$).

CONCLUSIONS:

At the same total power level, LoFr-HiPE lithotripsy was most efficient. Pulse energy was the key variable that drove fragmentation efficiency. Attention must be paid to prevent the formation of time-consuming bulky debris and adapt the lithotripter settings to one's needs. As fibre diameter did not affect fragmentation efficiency, small fibres are preferable due to better scope irrigation and manoeuvrability.