Shock waves accompanying laser medical procedures in human eyes

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Nowadays, about 250 million people worldwide (more than the current population of Brazil) are moderately or severely visually impaired. About 43 % of those who suffer from vision loss that interferes with daily activities have refractive errors and 33 % suffer from cataracts. Some 80 % of cases are preventable or treatable, often using lasers. Refraction-correcting eye laser procedures as well as photoionization-based therapeutic laser eye surgery such as iridotomy, capsulotomy and vitreolysis have become standard methods of treatment. Although it is commonly believed that such laser medical procedure have negligible side effects, our research puts the conviction of minimal invasiveness under question. We have strong evidence implying that shock waves accompanying laser-based ablation or photoionization of water-rich eye tissues reach sufficient negative peak pressure values that can cause permanent damage to delicate parts of the human eye. Such large negative peak amplitudes cause tearing or delamination of the tissue and induce secondary acoustic cavitation in the refocusing volume which is located at a different position relatively far away from the original light-tissue interaction site. We shall reevaluate the measurements of pressure waveforms ex-vivo using a numerical acoustic eye model (AEM) and show how laser-induced compressional shock waves propagate within the eye, reflect from various boundaries and form focal volumes (caustics) with distinctively large negative peak pressures capable of causing unwanted side effects.