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Toward endoscopic ultrafast laser microsurgery of vocal folds

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Vocal fold scarring can arise from disease or post-surgical wound healing and is one of the predominant causes of voice disorders. Focused ultrafast laser pulses have been previously demonstrated to create tightly confined sub-surface ablation in a variety of tissue, including vocal folds. Here, we demonstrate how we can take advantage of this unique ability of ultrafast laser ablation to create sub-surface vocal fold microsurgeries with a goal for eventually creating a plane in tough sub-epithelial scar tissue into which biomaterials can be injected. Specifically, we create sub-epithelial ablations in vocal fold tissue in under 1 minute using sub- μ J pulses from a compact, commercially available amplified ultrafast laser system from Raydiance Inc., operating at a 500kHz repetition rate. The use of relatively high repetition rates, with a small number of overlapping pulses, is critical to achieving ablation in reasonable amounts of time while still avoiding significant heat deposition. Additionally, we use multiphoton fluorescence of the ablation region and SHG imaging of collagen fibers to obtain visual feedback of tissue structure and confirm successful ablation. Lastly, we demonstrate microsurgery using amplified ultrafast laser pulses delivered through over 1 meter of air-core photonic crystal fiber to a laser scanning microsurgery probe, illustrating the feasibility of developing an ultrafast laser surgical laryngoscope. We aim to further develop this clinical tool through demonstration of laryngeal microsurgery using a compact laser system in conjunction with a larynx-specific fiber-based surgery probe.

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