UW Medicine Eye Institute

Transcleral Laser Induces Aqueous Outflow Pathway Motion and Reorganization

UW Dept of Bioengineering

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Purpose:

To study aqueous outflow system responses to a transcleral µP laser (Iridex™) in an *ex vivo* system using visually guided positioning & real time observation of tissue responses.

Background:

Physical tissue responses are highly relevant because outflow system tissue configuration determines aqueous flow and IOP, parameters that become abnormal in glaucoma.

Materials and Methods:

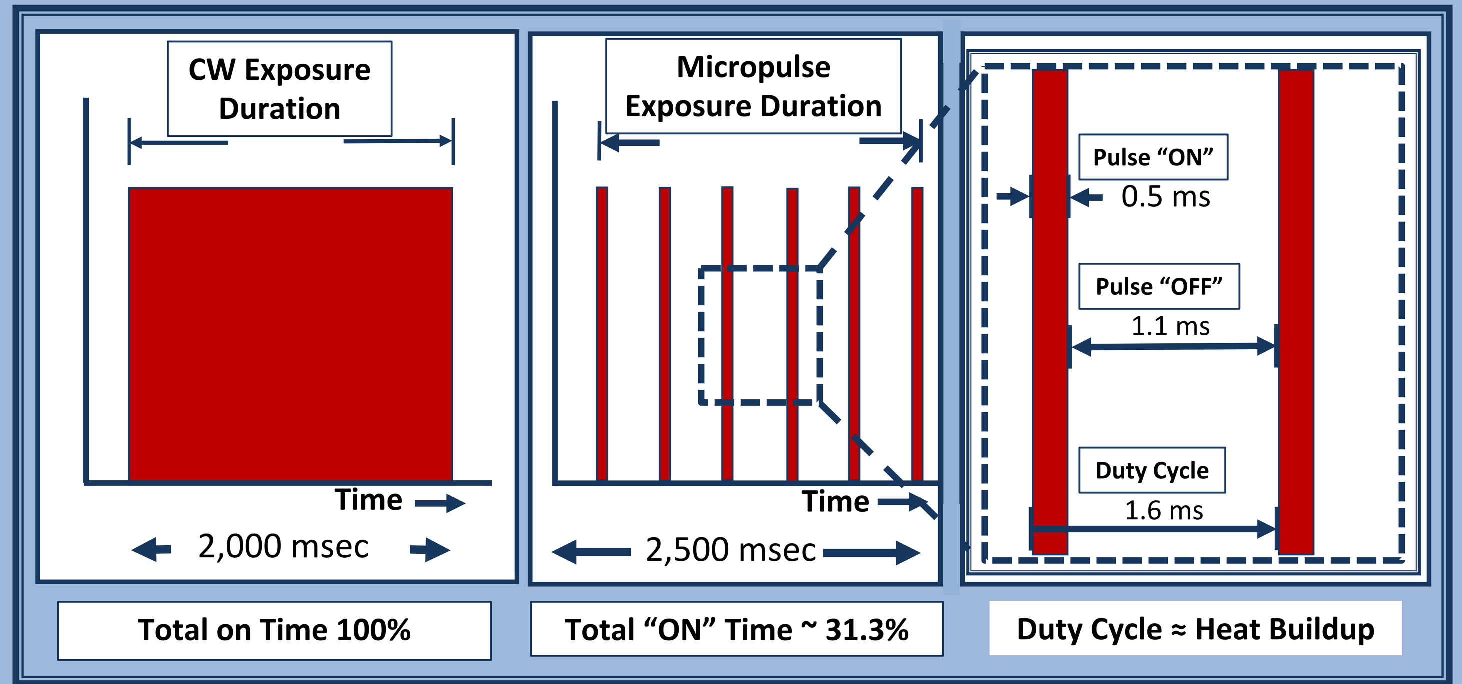
Microscope, video system, micrometer, 1 mm thick radial limbal segments from 4 quadrants (Q) of primate (*M. fasc.*), cornea, sclera, ciliary body pinned to paraffin base in Petrie dish, micromanipulator, Single pulse of 810 nm µP laser, Duty Cycle 31.3%. Paired parameters of stepwise power; range: 500-3000 mW and stepwise duration; range: 125-3,000 msec. Resultant energy level range: 0.08-2.35 joules. (Clinically ~ 1.59 joules are applied per single location). Video capture during pulse. Motion quantitated from still frames with ImageJ.

Results:

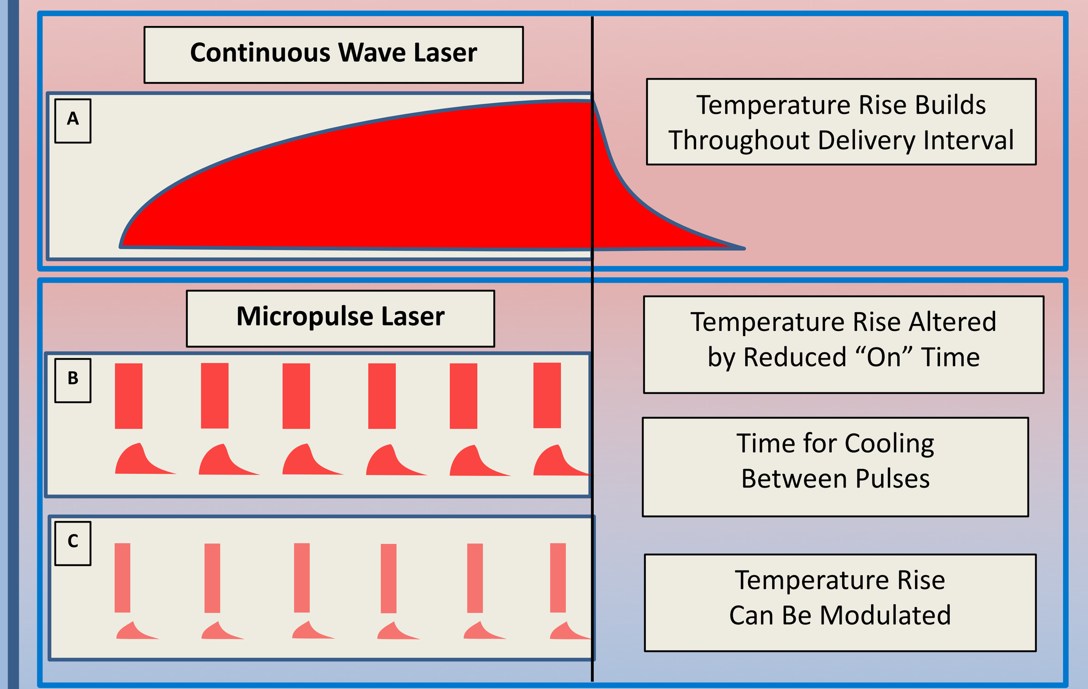
See Videos: www.youtube.com/user/ibmurray

Ciliary muscle (CM) contraction & relaxation was visible at ≥ 0.08 J in the IN & SN Q but at ≥0.16 J in the IT and ST Q. CM contraction caused the CM facing the AC to transiently move inward & posteriorly at ≥0.75 Joules in all Q, Fig. A. The scleral spur (SS), and trabecular meshwork (TM) moved posteriorly with a change (Δ) in Schlemm's canal shape. After contraction, the CM relaxed/recovered to near its pre µP configuration at low energies with a progressive reduction in the recovery response as energy increased, Fig. B. E.g. in the SN Q, CM bundles turned white at 2.35 joules with a lack of recoil/relaxation resulting in a persistent Δ in CB, SS & TM configuration, Fig. C.

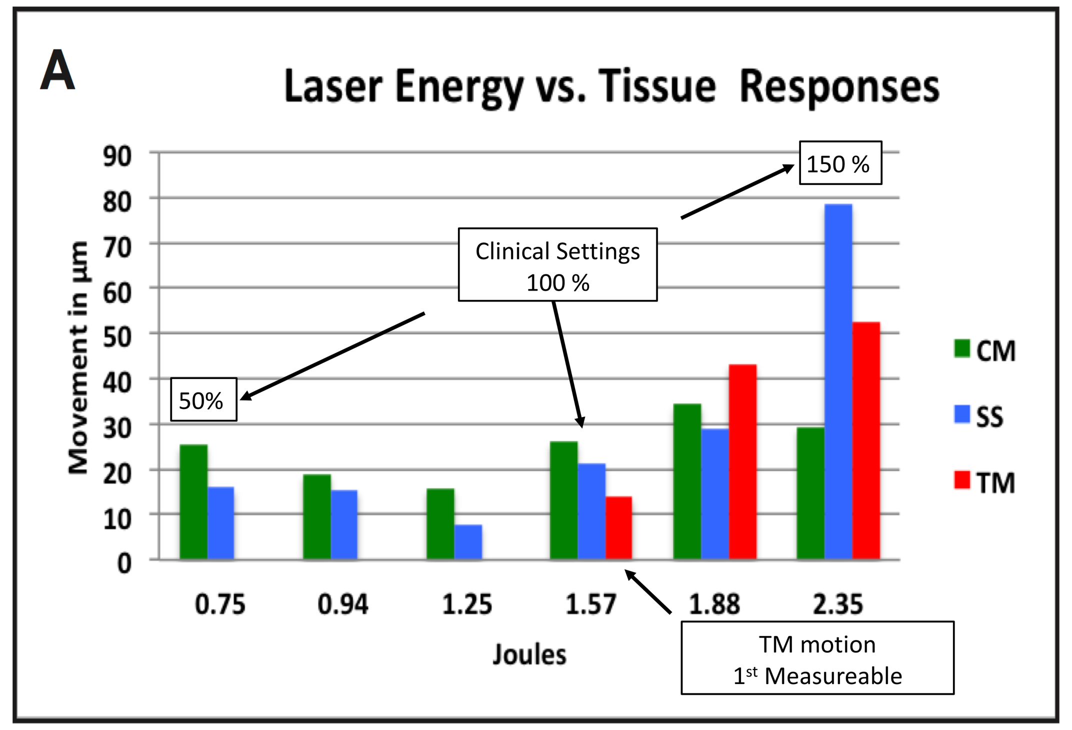
Micropulse to Reduce Heat Damage

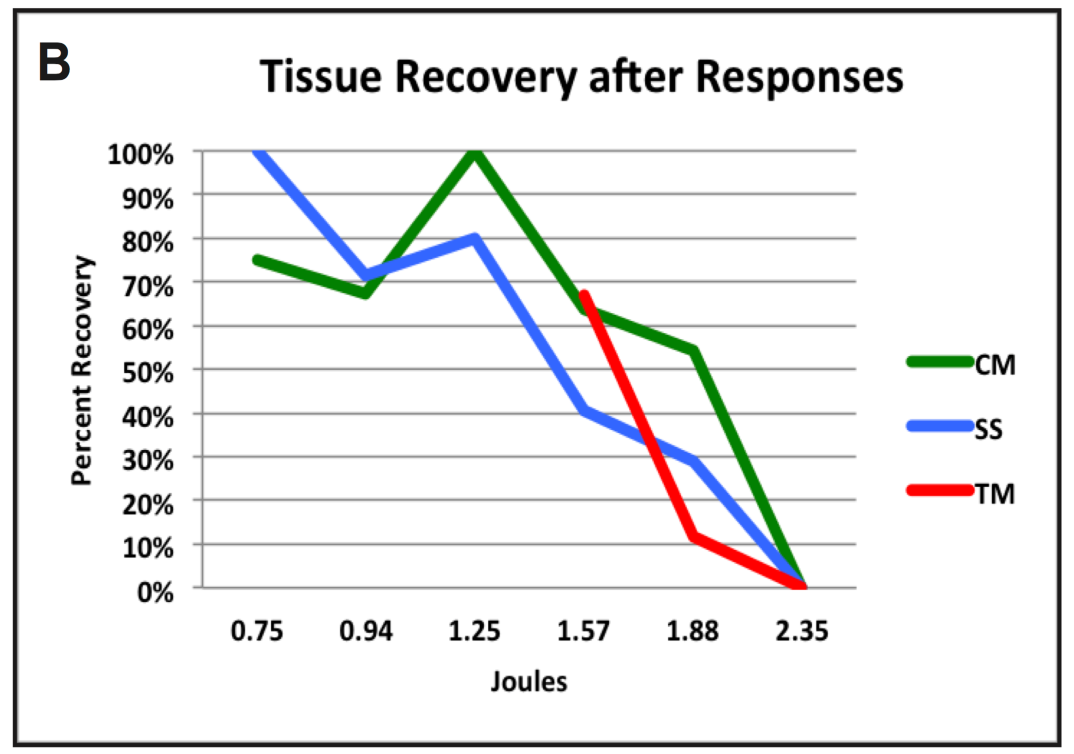


Coagulative Disruption



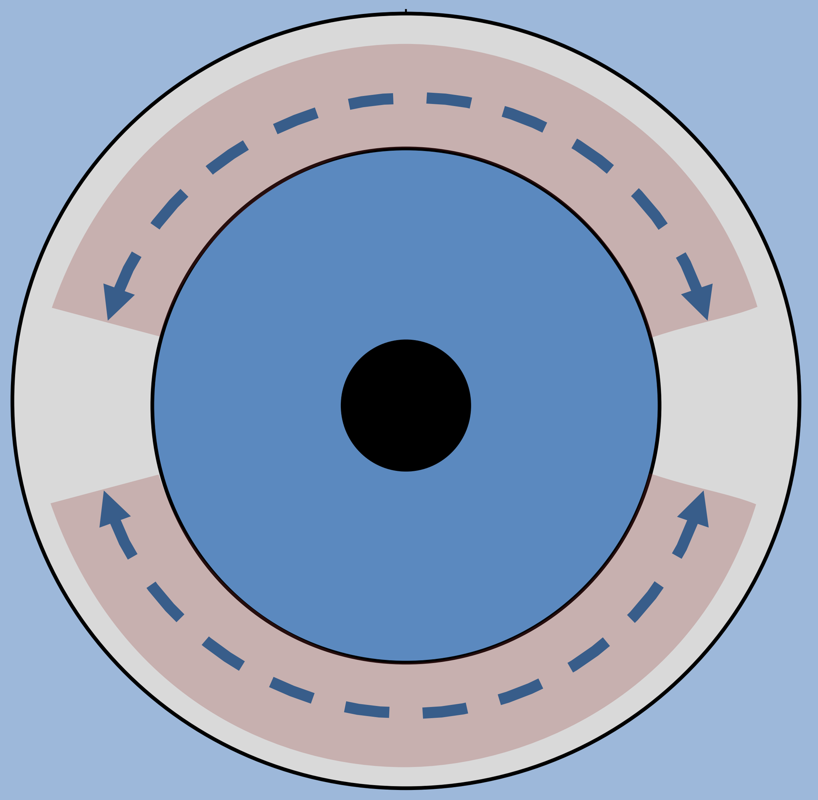
Tissue Shrinkage





Single Probe Site Energy Calculation

Parameter	Iridex Value	Comments
Circumference	52.9 mm	At Location Posterior to Limbus
Clock Hours Treated	10	Spare 3:00 and 9:00 LPC Nerves
Treatment Path Length	44.1 mm	Treatment Path Length
Probe Diameter	700 µm	
Total Probe Locations	63	Assume contiguous probe sites
Duration	160 sec	80 Seconds each hemisphere
Milliwatts	2000	2W = 2000 mW
Joules Calculation	mW x ms = microjoules (10-6)	Calculation without Micropulse
Micropulse	31.3% Total "ON" Time	Multiply Joules by 31.3 %
Joules/Probe Location	1.59 J	
Total Joules	100.16 J	J = W X sec X Duty Cycle (31.3%)



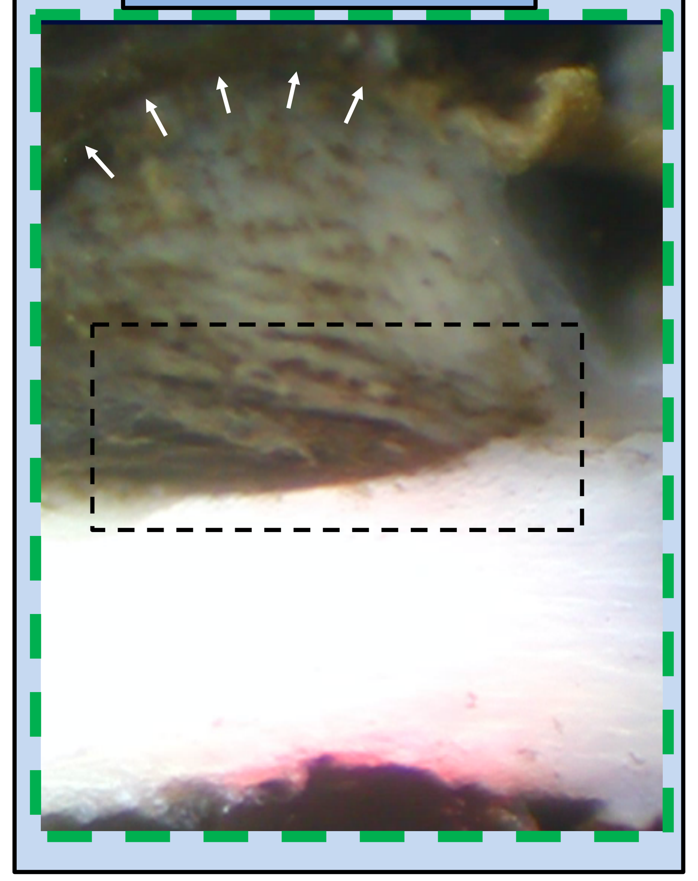
C

Video of Real Time Motion: Access by QR Code →
Or: www.youtube.com/user/ibmurray

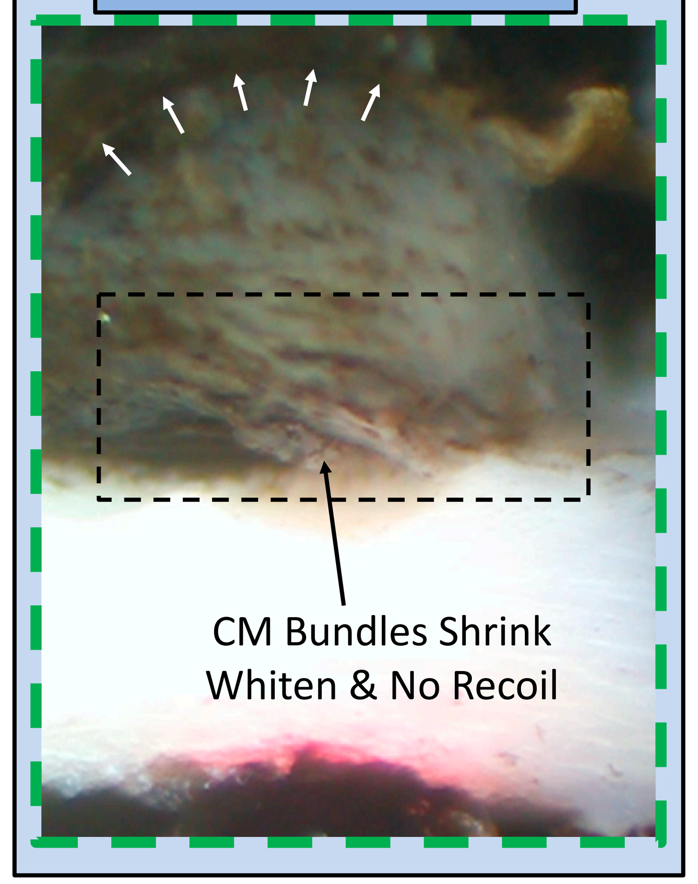
Micropulse Laser Effects on Ciliary Muscle & Scleral Spur

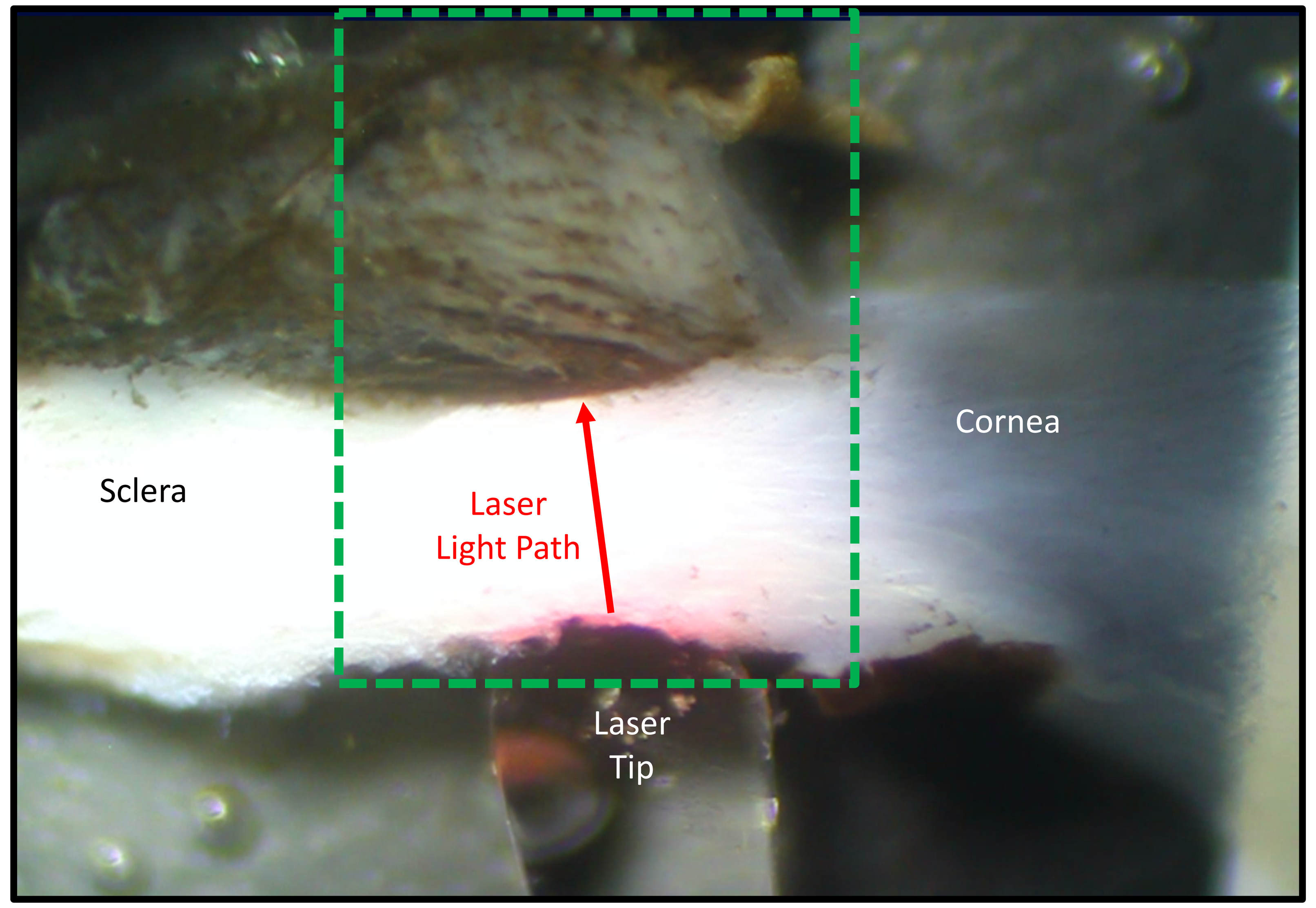
No Evidence of Ciliary Epithelium Motion or Damage (White Arrows) ⇧

Before Laser Pulse



After 2.35 J Laser Pulse





Discussion:

Transcleral µP laser induces contraction of the CM, a well-characterized muscle response to uP lasers.[1, 2] CM shortening causes posterior and inward movement of the SS changing TM and aqueous outflow pathway shape. Currently used clinical parameters are sufficient to induce outflow system pathway Δs generally associated with improved aqueous flow.[3] The above described system permits systematic assessment of probe location posterior to the limbus, power, duration and focal depth, all parameters subject to optimization.

Conclusions:

A transcleral 810 nm µP laser can induce CM shortening, SS rotation, TM movement and SC Δs, types of outflow pathway anatomic changes thought to improve aqueous flow that in turn reduces IOP. This pilot effort suggests that systematic studies can determine optimal parameters necessary for providing a non-incisional glaucoma surgical (NIGS) procedure to alter aqueous flow & IOP.

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