Corneal Damage from Mid-Infrared Laser Radiation

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**Institution Receiving Award:** JOHNS HOPKINS UNIVERSITY, APPLIED PHYSICS LABORATORY  
**Program:** PRMRP  
**Proposal Number:** PR012251  
**Funding Mechanism:** Investigator-Initiated Research Award  
**Partnering Awards:**  
**Award Amount:** $549,638.00

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**TECHNICAL ABSTRACT**

**Background:** Most laser biological threshold studies have centered on understanding the biological thresholds and thermal injury mechanisms at the ubiquitous carbon-dioxide laser wavelength of 10.6 micrometers, and only limited studies have been performed at laser wavelengths in the middle-infrared spectrum where the radiation is more penetrating. In our previous investigations of threshold damage from exposure to CO2 and Tm:YAG laser radiation, we found that thresholds could be correlated either by a critical temperature or a modified critical temperature damage model and that multiple-pulse exposures could be correlated by an empirical power law relating the threshold irradiance to the number of pulses.

**Objective/Hypothesis:** Three main hypotheses are considered: (1) damage from 1.55 micrometers radiation is thermal; (2) damage from sequences of pulses is cumulative and is correlated by a power law relating the threshold irradiance to the number of pulses in the sequence; and (3) exposures only slightly above the damage threshold for the corneal epithelium will result in damage to the corneal endothelium for these penetrating wavelengths.

**Specific Aims:** (1) Determine corneal epithelial damage thresholds for single- and multiple-pulse exposures as functions of irradiance, exposure duration, and beam size for wavelengths near 1.55 micrometers; (2) develop and validate damage models for these wavelengths. The effects of convection that may occur in the anterior chamber for this penetrating wavelength will be investigated by including them in the thermal model; and (3) investigate the healing response for exposures above the epithelial damage threshold and determine thresholds for endothelial damage for single-pulse exposures as functions of irradiance, exposure duration, beam size, and position on the cornea.

**Study Design:** Our general methodology combines experimental physical and biological measurements with theoretical analyses to understand corneal damage. Corneal damage thresholds are determined under carefully controlled exposure conditions, and mathematical damage models are developed to correlate and predict damage conditions for other exposures.

**Relevance:** This research directly supports the USAMRMC mission to assess the health effects and hazards of nonionizing electromagnetic radiation from laser systems. It responds to the data requested in the fiscal year 2001 Peer-Reviewed Medical Research Program (Laser Eye Injury) and in the USAMRMC Broad Agency Announcement 99-1. Military laser applications have been shifting into the mid-infrared spectrum, therefore there is an increased need for a better understanding of the biological thresholds, damage mechanisms, and recovery from corneal injuries that can be produced by these types of lasers. The normal repair cycle has not been examined for this spectral region, and must be done before potential treatments can be devised or readily evaluated.

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