Reducing the Annual Occurrence of Eye Injuries: Determination of Significant Parameters and Eye Injury Risk Functions for Projectile Impacts

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With over 2.4 million eye injuries occurring each year resulting in personal misery and the loss of many billions of dollars in direct and indirect costs, the societal cost of eye trauma is enormous. High speed projectiles or contact with various parts of the car's interior in automobile crashes are responsible for some of the most severe eye injuries (Figure 1). In order to minimize the occurrence of eye injuries further research must be done to investigate the relationship between eye injuries and the mechanical properties of projectiles.

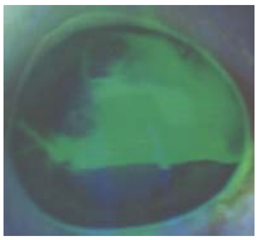
a.  b.  c. 

Figure 1: Examples of eye injuries from impacting objects: a) Corneal abrasion, b) Retinal detachment, and c) Globe rupture.

First, based on a parametric analysis of experimental data, this study will determine the most significant factors in predicting ocular injury. Second, injury risk curves will be developed as a function of the significant parameters causing eye injuries.

Experimental data from all eye injury publications were sorted according to projectile characteristics, such as diameter, mass, and velocity, as well as type of eye injury. Using logistic regression, statistical values were generated to determine significant projectile characteristics for predicting ocular injury. Based on the significant parameters injury risk functions were developed to determine the probability of eye injury for projectile impacts.

A total of nine studies with 104 tests involving projectile impact experiments on eyes were previously published (Table 1). Projectiles used in the experiments included foam particles, metal rods, BBs, baseballs, squash balls, and golf balls. The statistical analysis revealed that a normalized energy value, which is energy per projected area of the projectile, was the most effective injury predictor, yielding a p-value of 0.001 and a Goodman-Kruskal Gamma value of 0.98. As an example, the formulation of normalized energy to predict corneal abrasion, lens dislocation, and retinal damage are presented in Figure 2.

Table 1: Test data summary from ocular experiments with high speed projectiles.

Injury Studied	Cases
Corneal abrasion	24
Hyphema	39
Lens dislocation	44
Retinal damage	26
Globe rupture	71

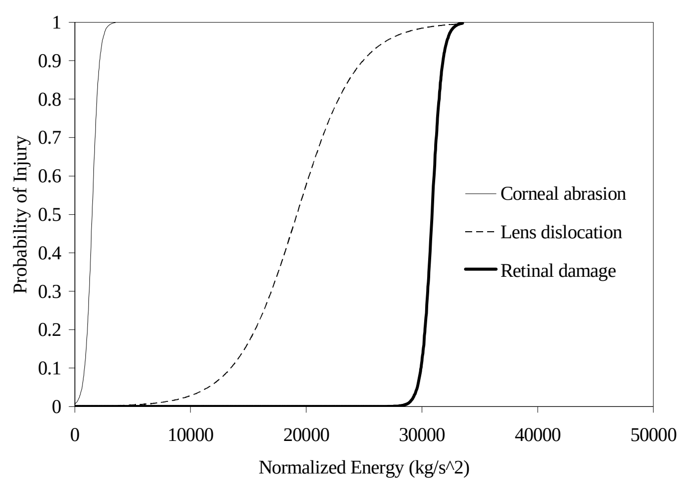


Figure 2: Injury risk curves as a function of normalized energy.

Normalized energy was the most significant predictor of injury type. This finding, together with the injury risk functions in Figure 2, is of great value as a design aid to minimize the risk of ocular injury for consumer products. For example, the deployment of airbags through seamless module covers may release foam particles at high velocities. Based on the injury risk curves generated from this study it is possible to design to reduce the injury risk of these particles.