RUPTURE PRESSURES FOR HUMAN AND PORCINE EYES UNDER STATIC AND DYNAMIC LOADING

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INTRODUCTION

More than 30,000 people lose sight in at least one eye every year in the United States alone [1]. Among the severe injuries that can result in the loss of an eye is globe rupture. Previous studies have attempted to determine the rupture pressure of both human and porcine eyes; however, no studies have been conducted at a dynamic rate. Porcine eyes are frequently used as human eye surrogates in ocular research due to their anatomical similarities. Since biological tissue typically displays viscoelastic behavior, it is hypothesized that the rupture pressure of the eye will be directly affected by the pressurization rate of the eye. Therefore, the purpose of this study is to determine the static and dynamic rupture pressure of human and porcine eyes.

METHODS

A pressure system was developed to internally pressurize the eye with physiological fluid via a needle inserted through the optic nerve. Static testing was accomplished by increasing the internal pressure of the eye by approximately 0.02 MPa/second, using 10 human and 10 porcine eyes until the eyes ruptured at their maximum static pressure. The dynamic testing of 10 human and 10 porcine eyes was accomplished by setting the initial pressure to release at 2.8 MPa, resulting in a loading rate of approximately 2.77 MPa/second, and measuring the pressure at which the eyes ruptured.

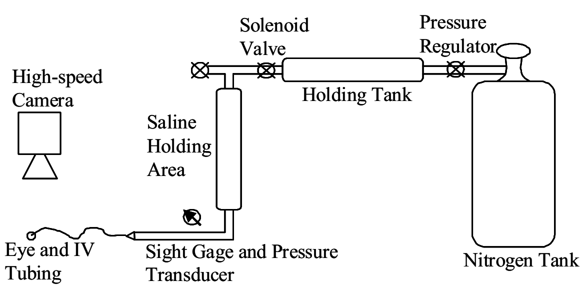

Figure 1: Schematic of eye pressurization system used for both static and dynamic tests.

RESULTS AND DISCUSSION

Globe rupture occurred primarily at the equator for both static and dynamic tests. The average loading rate under static loading was 0.02 ± 0.01 MPa/second while the average loading rate for dynamic tests was 2.77 ± 0.58 MPa/second. Static test results displayed an average rupture pressure for porcine eyes of 1.00 ± 0.18 MPa while the average rupture pressure for human eyes was 0.36 ± 0.20 MPa. Porcine eyes under static loading were found to be significantly stronger than human eyes ($p = 0.01$). For dynamic loading, the average porcine rupture pressure was 1.64 ± 0.32 MPa, and the average rupture pressure for human eyes was 0.91 ± 0.29 MPa. Again, the porcine eyes were found to be significantly stronger than the human eyes ($p = 0.01$). Additionally, the dynamic rupture pressures for both porcine and human eyes were significantly higher ($p = 0.01$) than their respective static rupture pressures.

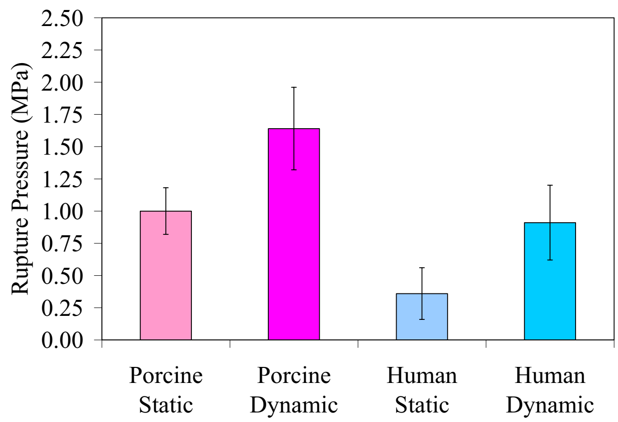

Figure 2: Averages of results of rupture pressure testing with standard deviations. Porcine eyes ruptured at a higher pressure than human eyes ($p = 0.01$). For both human and porcine eyes, dynamic rupture pressures were higher than static rupture pressures ($p = 0.01$).

CONCLUSIONS

Both human and porcine eyes exhibit large viscoelastic effects when loaded dynamically. The viscoelastic behavior of the eye under dynamic loading is consistent with that seen in other biological tissue [2]. Under dynamic loading the human eye can withstand approximately 150% more pressure before rupture than under static loading, while under the same circumstances the porcine eye can withstand approximately 64% more pressure before rupture. This behavior proves that previously determined material characteristics of the eye from static tests will lead to inaccurate predictions of the rupture pressure of the eye, both human and porcine. Finally, due to differences in their response versus human eyes, separate criteria must be utilized to interpret results of porcine eye tests versus human eye tests.

REFERENCES

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