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# RESISTANCE MECHANISMS OF RETINAL DETACHMENT IN WOODPECKER'S OCULAR

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## SUMMARY

Shaken baby syndrome (SBS) usually occurs in children who are less than 3 years of age when they subjected to high decelerations, which could result in vision loss and so on. Woodpecker has no retinal haemorrhages at a high deceleration of 1000g during pecking. Woodpecker must have special features to attenuate repetative impact force to sustain rapid pecking without ocular injury. In this study, the biomechanical analysis of kinematics parameters and orientation of ocular within the orbit during impact was investigated based on the finite element (FE) method.

## INTRODUCTION

Eye disorders such as retinal hemorrhages were usually associated with shaken baby syndrome (SBS), which could lead to vision loss and blindness [1-2]. Retinal haemorrhages in SBS were thought to be the result of acceleration-deceleration induced shearing forces when the vitreous moves within the globe and the globe moves within the orbit [3]. However, woodpecker has no retinal haemorrhages at a high deceleration of 1000g during pecking [4]. Woodpecker was a naturally occurring model resistant to impact injuries those encountered in SBS. Woodpecker must have special features to attenuate repetative impact force to sustain rapid pecking without ocular injury. It was stated that woodpecker has special kinematics characteristics and its eyes differ from human infants by an inability of the globe to move axially in the oribit, the sclera to deform, and the vitreous to shear the retina in the previous study [4-5]. Therefore, we focused on investigating the kinematics parameters and connections between orbital rim and sclera during impact using the finite element (FE) approach.

## METHODS

A numerical model of eye model with fat tissue and orbit was created according to the anatomy structure (Fig. 1). Retina model was incorporated into the current eye model with breakable bond contact attached to the supporting tissue. When the stress on the contact exceeds a specified threshold, the bond will break to produce retinal detachment. To validate the numerical eye model, six matched simulations were conducted to compare the eye model of Virginia Tech-Wake Forest University (VT-WFU). Pearson correlation test was used to analyze the correlation between the two models. Different FE simulations were done having the whole head moved with an initial velocity and duration of 5 ms based on the kinematic data [4]. Parametric analysis was done by changing the kinematics parameters and orientation of ocular within the orbit to evaluate their biomechanics effects on ocular displacement and strain during impact.

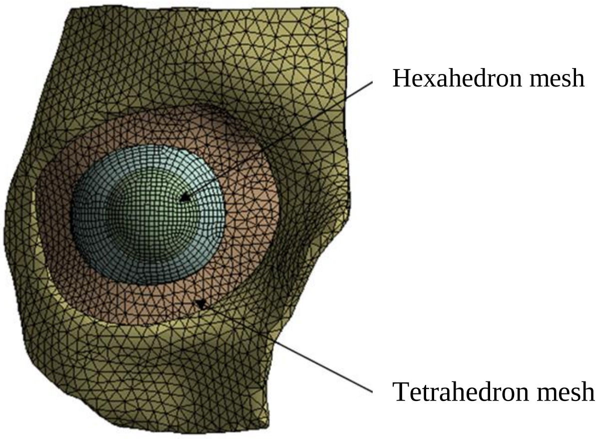

**Fig. 1**: Finite element model of woodpecker's eye including eyeball and extraocular tissues (Two types of meshes were used: hexahedron mesh for axisymmetric structures including cornea, sclera, lens, ciliary body, zonules, retina, aqueous and vitreous humor; tetrahedron mesh for fatty tissue and orbital bone)

## RESULTS AND DISCUSSION

Significant positive correlation was found between the eye model and the VT-WFU eye model (R=0.91 for peak stress, R=0.93 for peak strain and R=0.89 for peak deflection). Stress waves and negative pressure contribute to the detachment [6]. Stress wave propagation in the retina leads to its break. It was stated that the orientation of ocular within the orbit has an obvious influence for woodpecker. By comparing the FE predicted strain of retina, it reduced 15.6% and 28.6% compared to human. It was found that peak strains induced different location of retina for human, on the contrary, no difference for woodpecker when eye subjected to deceleration in different direction during impact.

## CONCLUSIONS

The current eye model provides a detailed understanding of the mechanism of resisting ocular injury of woodpecker eye. For the special birds-woodpecker, the effects of the direction of movement and the connection of orbital rim and sclera on the retina and vitreous strain distribution were obvious. In addition, the orientation of the ocular within the orbit had been minimized the Green Lagrange strain on the retina, which reduced the probability of impact injury

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