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CONSTRUCTION AND GLOBAL VALIDATION OF A BIOFIDELIC 6-MONTH-OLD PEDIATRIC HEAD FINITE ELEMENT MODEL

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ABSTRACT

To date, none of a 6-month-old pediatric head finite element (FE) model in the literature was validated by cadaver test data from similar age group.This study developed an anatomical 6-month-old pediatric head FE model with high quality meshes. The head response under compression and drop impact conditions were quantitatively compared with the published cadaver experiments. Results showed that the pediatric head FE model corresponded well with present cadaver test data, which proved that the head FE model can be further used to predict the head injury under impact conditions.

Keywords: biomechanics, pediatric head, FE modelling, impact conditions.

INTRODUCTION

Head injury is the leading cause of pediatric fatality and disability [Atabaki et al. 2007]. Finite element (FE) modeling is an essential tool for understanding the head injury mechanism, injury criteria and investigation of the dynamic response from blunt impact. However, compared with the built adult head FE models, there are only a few 3D pediatric head FE models, such as the pediatric head FE models developed by Klinich et al [2002]; Coats et al [2006] and Roth et al [2010], etc.

Even the aforementioned pediatric head FE models provided encouraging results for investigating child head injuries, only the newborn child head model from Roth et al. [2010] were quantitatively validated against cadaver experimental data. None of a 6-month-old pediatric head FE model was quantitatively validated against cadaver test from similar age group.

RESULTS AND CONCLUSION

The anatomical geometry of the 6-month-old FE model was extracted from an early version FE model constructed by Klinich et al [2002] who obtained the geometry from CT scan of a 6-month-old child head. The primary anatomical components of the head, including scalp, craniums, sutures and fontanels, face, dura mater, CSF, pia, and components of brain were constructed. The “butterfly and projection” meshing approach were used to obtain the high quality hexahedron solid elements and quadrilateral shell elements. Different components of the head FE model and the corresponding material properties are illustrated in Figure 1 and Table 1 respectively. The head FE model was validated against the cadaver experiment under compression and drop impact conditions. The head FE model response in terms of “force-displacement” histories were well validated as shown in Figure 2. The head response in terms of “Acceleration-time” histories under drop condition were also well matched, but were not reported due to space limitations.

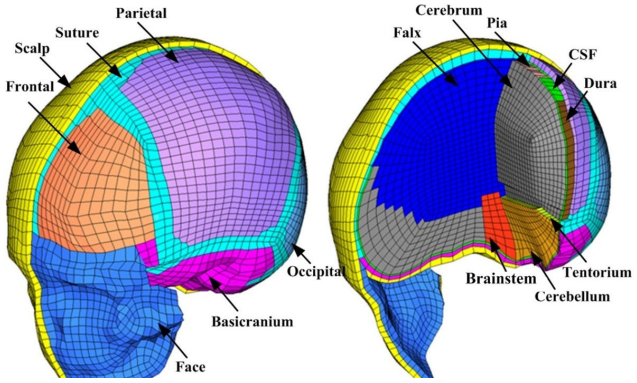
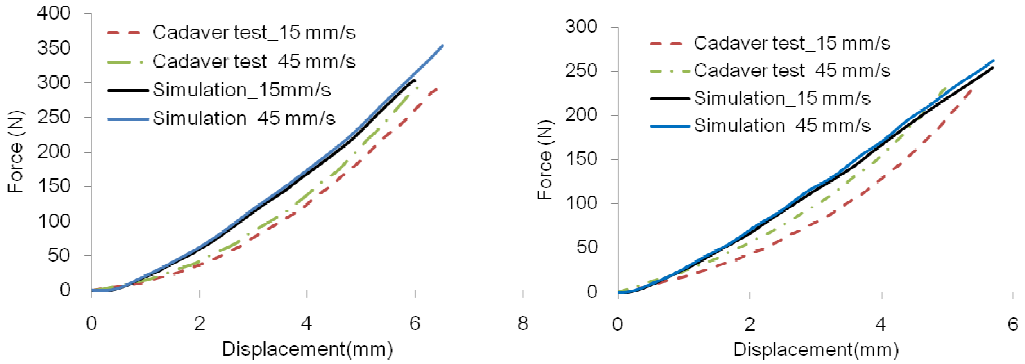


Fig. 1 - Developed 6-month-old head FE model in this study

Table 1- Material properties used in the pediatric head FE model

Components	Elastic (MPa)	Passion ratio	Density(kg/m^3)
Cranial and face bones	421	0.22	2150
Sutures & fontanels	8.3	0.49	1130
Scalp	16.7	0.42	1200
CSF	0.012	0.499	1040
Dura mater, falx, and tentorium	31.5	0.45	1133
Pia mater	11.5	0.45	1133
Brain	$G(t) = G_\infty + (G_0 - G_\infty)e^{-\beta t}$ G_0=0.01; G_∞=0.002 ; β=80 /s; K=2.19GPa		1040



(a) Forward-rearward (FR) direction compression (b) Right-left (RL) direction compression

Fig. 2 - Comparison results between cadaver test and simulation under compression condition

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REFERENCES

[1]-Atabaki, S. M. Pediatric head injury. Pediatr. Rev. 28(6):215-224, 2007.

[2]-Klinich, K. D., Hulbert, G. M., and Schneider, L. W. Estimating infant head injury criteria and impact response using crash reconstruction and finite element modeling. Stapp Car Crash J. 46:165-194, 2002.

[3]-Coats, B., S. Margulies, S., and Ji, S.. Parametric study of head impact in the infant. Stapp Car Crash J. 51:1-15, 2007.

[4]-Roth, S., Raul, J. S. and Willinger, R.. Finite element modelling of paediatric head impact: global validation against experimental data. Comput. Methods Programs Biomed. 99:25-33, 2010.