# The Efficacy of a Motocross Neck Brace in Reducing Injury

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**Abstract**

Neck and upper spine fracture account for approximately 10% of all injuries to motocross riders in a crash [Colburn, 2003]. To mitigate such injuries, neck braces have been designed and marketed as a countermeasure for neck injury during an impact. However, there is little biomechanical research that would support claims that cervical spine injuries can be reduced when equipped with a neck brace. <u>The objective of this study was to investigate the efficacy of a motocross neck brace in reducing cervical spine injury following helmeted head impact.</u>

To accomplish this goal, a finite element (FE) model of a production motocross helmet was developed and validated using drop test data with a Hybrid III dummy headform. The helmet and headform FE models were then integrated with the Duke University Neck model (Nightingale et al., 2016), and a Hybrid III thorax model (which provided a simplified effect mass boundary condition at T1). A FE model of a production neck brace was also developed and integrated with the helmeted rider model. The helmeted rider was simulated under a number of 3.2 m/s drop tests (with 7 different neck pre-alignments ranging from -20$^o$ to 20$^o$ extension/flexion), and frontal, rearward, and lateral pendulum impacts to the helmet. Two simulations were performed for each impact condition: one with no brace and one with a standard brace. In each case, injury risk was assessed at the OC2 and C7-T1 joints using the ligamentous neck injury criterion ($N_{ijc}$) (Dibb et al., 2009).

Substantial neck injury ($N_{ijc} > 1$) was predicted for all non-brace extension and flexion cases at C7-T1 within 10ms of impact, as well as instances of OC2 injury in neutral and 10$^o$-flexion cases. Neck pre-alignment greatly influenced the severity of the predicted neck injury, with greater extension/flexion angle correlating with increased peak $N_{ijc}$ at C7-T1. Introducing the standard brace showed negligible brace-to-helmet interaction prior to onset of the predicted neck injury, and resulted in an insignificant reduction in injury risk. The ineffectiveness of the neck brace was attributed to the standoff distance between the brace and the helmet (~50mm) being greater than the amount of neck compression at the time of injury. A modified brace was implemented into the rider model to reduce this standoff and initiate brace-to-helmet interaction prior to substantial neck loading. The modified neck brace showed moderate decreases in injury risk in most impact cases relative to the no brace controls.

The increase in brace-to-helmet interaction help distribute the force of the impact to shoulders of the rider. Since the biomechanics of the shoulder in this loading mechanism is unknown, a parametric study was conducted on the shoulder compliance with the modified brace design. The results indicate that reduced shoulder compliance reduces any benefit of a fully

engaged neck brace. Further investigation on shoulder compliance is necessary before fully concluding on the efficacy of motocross neck-brace designs.

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