Validating a Device for Whiplash Motion Simulation in a Porcine Model

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Introduction

Whiplash injury, characterized by neck sprains and strains, is the most common injury caused by motor vehicle collisions and can cause chronic pain and other cognitive or psychological symptoms[1,2]. Despite its prevalence, whiplash injury can be challenging to diagnose and treat since tissue damage is often not detectable in patients and the mechanism of injury remains unclear[3]. One proposed mechanism is that the rapid cervical intervertebral motions caused by the impact create pressure transients in the spinal canal that injure nerve cell bodies in the dorsal root ganglia (DRG)[4]. Preliminary research in human cadavers[5] and live pigs[6] has confirmed that such pressure changes occur during simulated whiplash motions and DRG pathology was observed in the latter[6,7]. Though the previous *in vivo* porcine whiplash studies created important foundational knowledge, the method used to generate the whiplash motion was not well controlled and could not be adapted to explore the independent effects of head rotation and retraction. Thus, the objective of this project is to validate a device custom-built to simulate whiplash motions with precise head movement control to enable further study of whiplash injury *in vivo*.

Methods

The proposed whiplash device consists of two servomotors with 20-bit encoders which can precisely actuate the animal's head through a customized biteplate. The anaesthetized animal will be placed prone on the operating table with its head cantilevered off the table and supported by the biteplate. In order to validate the device's function and kinematic patterns, we have conducted preliminary tests with an inert surrogate representing the pig's head and neck. We first reviewed the previous human volunteer[8,9] and human cadaver[10,11] whiplash studies to quantify the input head kinematics and then developed a range of motor motion profiles to generate head kinematics to simulate minor to severe whiplash motions. Next, using the surrogate neck and added weight to represent the head, the motion profiles were programmed and run to confirm the motor capabilities. The surrogate head plate was instrumented with biaxial linear accelerometers (Endevco, 7265A, Irvine, CA) and a uniaxial angular rate sensor (DTS, ARS Pro, Seal Beach, CA) to quantify the accuracy and repeatability of the desired kinematic parameters. Subsequent validation tests will utilize cadaver pigs to demonstrate the feasibility of using this device to simulate and study whiplash injury *in vivo*.

Results

To date, preliminary testing of various motion profiles using a surrogate head/neck has been completed. Motion profiles with defined head retraction and maximum extension angle were tested with head accelerations reaching up to ~30 g with good repeatability and accuracy.

Anticipated Conclusions

This test device will enable us to study the independent and combined effects of head retraction and rotation on spinal pressures and tissue injury through precise control of the head and associated cervical spine motion. Understanding the influence of these parameters on spinal canal pressure and DRG injury will be pivotal in informing the development of safety systems for whiplash injury prevention.