Design and development of a multi-axis spine testing machine with some preliminary test data

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ABSTRACT

According to a recent NASS database search, spinal injuries accounted for about 5% to 7% of all AIS 3+ injuries sustained in frontal impacts despite the low occurrence of spinal injuries as a whole. These severe forms of injuries included fracture and dislocation of the vertebrae due to multi-axis (combined) loading. Because spinal responses under combined loading have not been investigated fully, the aim of this study was to design and fabricate a multi-axis machine to depict spine biomechanics due to combined loading.

The machine consists of a loading platen driven by three independently controlled actuators: two in the vertical direction for controlling flexion/extension and tension/compression and one in the horizontal direction to control anterior/posterior shear. A custom designed 8-bit micro-controller programmed in MP Lab (Microchip Technology Inc, Arizona) was used to interface with Windows HyperTerminal 5.1 (Microsoft Corporation, CA) to control the platen motions. A rotary potentiometer was attached to each motor to provide feedback control and to determine the displacement and angle of the platen. A six-axis load cell (Denton ATD, Michigan) was used to measure the forces and moments in three mutually perpendicular directions.

Three series of test setups, nondestructive single mode (tension, compression, anterior shear, posterior shear, flexion, and extension), nondestructive anterior shear with flexion and posterior shear with extension, and failure tests in combined anterior shear with flexion, were conducted using a total of six human spines. Results were well within the corridors reported in the literature for single mode testing, confirming the design accuracy of the testing machine. For the combined anterior shear with flexion failure tests, the average failure force was 1.83 (± 0.41) kN and the failure moment was 210.7 (± 29.9) N-m.