Biomechanical Study of C2 (Axis) Fracture: Effect of Restraint

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Abstract

Introduction**: In human, the cervical spine region is very susceptible to impact injury. The complex structures of C1 and C2 serve to transmit the weight of the cranium to the greatly similar structural cervical spine from C3 caudally. Application of sudden disruption forces will detach the junction of the cervico-cranium with the pars interarticularis of the neural arch of C2 from the lower cervical spine by fracturing, as in a "hangman's fracture". Severe falls or blows to the head from heavy objects will cause the fracture of the odontoid process of C2. Many biomechanical studies were conducted based on full restraint of the inferior aspects of isolated C2 to produce odontoid fracture. In this study, two different restraining conditions of C2 were adopted experimentally to determine the absolute fracture load and the corresponding fracture patterns that are common to C2. Materials and Methods: Nine C2 vertebrae obtained from cadaver spines, ranging from 51 to 80 years, were used. Two specified restraint conditions were employed: (1) fully constrain the posterior element postero-anteriorly up to one-quarter of the inferior facet; and (2) fixing of C2 by a specially-designed rig whereby the body of C2 embedded in the pivoted cup and its inferior facets positioned on top of two lateral plates. Antero-posterior shear force was applied on the anterior articulating facet of the dens until failure. Results: These specified restraint conditions had resulted in specific fracture of C2. Antero-posterior shear force ranges from 840 to 1220 N was required to cause fracture across the pars interarticularis under restraint condition 1. Failure load of between 900 and 1500 N was found to cause odontoid fracture under restraint condition 2. These values are in agreement with published data. Conclusions: The biomechanical response of C2 was specific to the mode of restraint conditions of C2. In reality, depending on the force vector applied to the head, precise posture at the time of trauma, spinal geometry, and physical properties, different types of C2 fracture patterns may happen. These findings are of potentials for the biomechanical correlation and validation study of C2 vertebra using analytical approaches, and in the surgical anterior screw fixation of odontoid fracture.

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