**THE NUCHAL LIGAMENT RESTRAINS CERVICAL SPINE FLEXION**

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INTRODUCTION Progressive kyphosis after laminectomy or laminoplasty for canal stenosis has been linked to the surgical release of posterior cervical ligaments, including the nuchal ligament. Few studies have considered the function of the nuchal ligament. No prior study has quantified the role of the nuchal ligament in the structural mechanics of the cervical spine. The purpose of this study was to test the hypothesis that the nuchal ligament contributes significantly to the restraint of cervical flexion.

METHODS Twelve cervical spines consisting of the occiput to the first thoracic vertebra were excised from human cadavers (mean age 75 years, range 57-94). All ligaments were preserved. Radiographs were taken to eliminate specimens with clear bone abnormalities. Specimens were mechanically tested in a materials test system using custom fixtures (Fig. 1). Flexion moments were applied to the occiput; the first thoracic vertebra was rigidly mounted to the base. Large rotations were accommodated by the system. At the occiput, a polished stainless steel shaft was mounted using a variable angle bracket aligned in the mid-sagittal plane. The shaft extended anteriorly. The slot in the load cell connector shaft was designed to allow for small out-of-plane alignments over the rotation range.

RESULTS The flexion range was 24° ± 7° for the intact spine. After nuchal ligament resection, the range increased to 31° ± 8°, then to 37° ± 10° after all resections (Fig. 3A). Therefore, the mean flexion range increased 29% after removing the nuchal ligament. After cutting the rest of the posterior ligaments, the range increased 54% compared to intact (p<0.01). Tangent stiffness was 0.19 ± 0.03 Nm/deg for the intact spine. After removal of the nuchal ligament, stiffness decreased to 0.13 ± 0.04 Nm/deg (Fig. 3B). Therefore, tangent stiffness decreased 31% after nuchal ligament resection (p<0.01); additional resection caused no further decrease.

DISCUSSION The nuchal ligament significantly limited flexion and contributed to the stiffness in flexion of the cervical spine. Surgical procedures that compromise the nuchal ligament likely increase the risk of progressive kyphosis. The results suggest that preserving the nuchal ligament is particularly important in laminectomy, because it is the only posterior ligament that may be preserved. In laminoplasty, additional attention to preserving the nuchal ligament is warranted, especially in patients with spinal instability and when posterior fusion is not recommended.

The contribution of the nuchal ligament relative to all structures that restrain flexion was not assessed; only ligamentous structures potentially compromised by surgery were considered. The order of cutting the ligaments could not be varied. The nuchal ligament was considered a single discrete structure. A complex loading mode was applied that included compression as well as flexion. The very large rotations precluded cycling to the extension limit, so the origin was set within the neutral zone using the test system. A few assumptions were required to convert from load-displacement to moment-rotation curves. Despite these limitations, this is the first study to determine quantitatively that the nuchal ligament contributes significantly to the restraint of flexion of the cervical spine.


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