Introduction: Surgeons risk injury to the central nervous system when excising neoplastic growths from the anterior spinal canal [1]. One method to facilitate access to this region is to combine laminectomy with unilateral facetectomy and pediculectomy. For better exposure, however, surgeons may drill from the origin of the pedicle through the posterior-lateral aspect of the vertebral body [1]. This technique can present challenges when tumors extend beyond a single vertebral level, as the removed lateral masses and pedicles are insertion sites for fixation [1-5]. A novel solution involves the placement of bicortical screws (“artificial pedicle screws - APS”) that extend from the pedicle origin on the vertebral body, through the midline of anterior cortical and protrude 2mm [1, 2]. This technique has been successful in a number of clinical cases, but remains biomechanically uncharacterized [1,2]. We hypothesize that the use of artificial pedicle screws provide stiffness and pullout strength similar to traditional lateral mass screws in the cervical spine.

Materials and Methods: Five fresh-frozen human C2 to C7 cervical specimens were studied (F=1, M=4; 65 ± 5 y.o; occiput-T1). The specimens were cleaned of muscles and connective tissue but care was taken not to disrupt ligaments and intervertebral discs. Specimens with abnormal morphology, e.g., pre-existing cervical fractures and low BMD, were excluded from the study (evaluated via DEXA, Hologic QDR-2000, Hologic, Inc., Bedford, MA). The C2 and C7 vertebrae were potted in a cylindrical metal fixture with polymethylmethacrylate (PMMA).

Non-destructive flexion/extension, lateral bending, and axial rotation tests were conducted using a non-constraining, pure moment loading apparatus [6] (Figure 1, left) in conjunction with a standard servohydraulic test system (MTS 858 MiniBionix, Eden Prairie, MN) and uniaxial load cell. Relative motion across the fusion site (C3 to C6) was measured (Optotrak 3020, Northern Digital, Waterloo, Ontario, Canada). Specimens were preconditioned to 3 cycles of 1.5Nm at 0.1Hz with a 1 min hold prior to testing. Each specimen was tested in the intact and destabilized (laminectomy of C4 and C5 plus unilateral facetectomy and pediculectomy) configurations prior to instrumentation. Lateral mass screws were then placed unilaterally according to the Magerl technique on the C3 to C6 levels (3.5mm x 18mm). Testing was repeated for the following conditions on the contralateral side (Figure 2); 1) lateral mass fixation at C3 and C6 with interconnecting fusion rod, 2) repeat of previous test with the addition of artificial pedicle screws (3.5mm x 40mm) at C4 and C5, 3) repeat of previous test with laminectomy of C6, along with unilateral facetectomy and pediculectomy, insertion of a artificial pedicle screw in place of the lateral mass screw.

A final pull out test at the C4 level was performed to compare the in situ strength of artificial pedicle screw versus lateral mass screw. To perform this procedure, specimens were rigidly mounted in the supine position with a threaded rod inserted into the fixation cap screw thread (Figure 1, right). The rod was then clamped onto the MTS actuator and pulled axially until failure at a rate of 1mm/min. Force data was recorded from a load cell mounted onto the MTS clamp apparatus.

Discussion: We observed no difference between fixation with lateral mass screws and artificial pedicle screws in pullout and multiaxial range of motion tests. In addition, fixation with intervening APS screws did not increase specimen stiffness compared to lateral mass fusion spanning the C3 to C6 segments. This finding may be attributed to the fatigue-less conditions of our testing, and the artificial pedicle screw may indeed impact cervical stiffness under more physiological loading conditions. Nonetheless, improving the biomechanical understanding of the artificial pedicle screw aids clinicians making surgical decisions when access to the anterior spinal canal is necessitated. In particular, if they should strive to maintain the lateral mass screw insertion sites; or alternatively, remove the posterior-lateral elements altogether.

Acknowledgements: Funding by Stryker Spine Incorporated. Michael Tufaga for assisting during biomechanical testing.


Figure 1: (left) Experimental pure moment testing apparatus. (right) Experimental set-up for pullout test

Figure 2: Instrumented testing configurations. Black denotes lateral mass screws, red denotes APS screws, and blue denotes lateral masses.

Figure 3: Primary range of motion in all tested configurations

Poster No. 1372 • 54th Annual Meeting of the Orthopaedic Research Society