INTRODUCTION:
The upper cervical spine is a common location for metastatic tumors, which often necessitate surgical intervention to prevent neurological compromise [1]. Removal of the tumor often requires partial or complete resection of cervical vertebrae and therefore causes substantial mechanical instability in the cervical region [2]. Structural integrity is restored by fusion of the base of the skull to C5 using various spinal hardware, including cages and posterior screw-rod constructs. Due to the proximity of the spinal cord and vertebral arteries, these procedures have high associated morbidity and mortality, and the biomechanical necessity of more risky procedures, e.g., additional cages replacing the lateral masses of C2, in order to achieve sufficient rigidity has not been evaluated. Thus, the goal of this study is to determine the optimal fusion configuration following C2 corpectomy that maximized segmental rigidity while minimizing risk to the patient.

METHODS:
Four fresh-frozen human heads were studied (F=2, M=2; 69 ± 10 y.o; skull-C6). The specimens were cleaned of muscles and connective tissue but care was taken not to disrupt ligaments and intervertebral discs. The skull and C6 vertebrae were potted in metal fixtures with quick-set resin (Smooth Cast 300, Smooth-On).

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 Mini-bionix, Eden Prairie, MN) and uniaxial load cell. Relative motion across the fusion site (C1 to C3) was measured (Optotrak 3020, Northern Digital, Waterloo, Ontario, Canada). Specimens were tested up to 1.5Nm with 0.25Nm increments and uniaxial load cell. Relative motion across the fusion site (C1 to C3) was measured (Optotrak 3020, Northern Digital, Waterloo, Ontario, Canada). Specimens were tested up to 1.5Nm with 0.25Nm increments and held at each moment for 45 seconds. Each specimen was tested intact prior to instrumentation.

RESULTS:
Flexion-extension rigidity differed significantly between treatments (p<0.05). Addition of the central cage significantly increased flexion-extension rigidity compared to constructs without the cage, e.g., CF#2 vs. CF#3 (p<0.05). The presence of the central cage had less of an effect in axial rotation and lateral bending, and the addition of the 2 lateral cages did not significantly improve rigidity in any bending direction (p>0.05, CF#6 vs. CF#7). In the case of posterior hardware alone (CF#1 and CF#2), C2 corpectomy reduced flexion-extension bending rigidity (p<0.05) but did not significantly affect rigidity in other directions (p>0.05). Removal of the posterior elements of C2 in the presence of a C3-Clavis cage did not affect ROM in any bending mode (p>0.05, CF#5 vs. CF#6).

DISCUSSION:
Our results indicate that the mechanical stability of cervical fusion constructs following C2 corpectomy is dependent on the hardware configuration. Removal of C2 in the presence of posterior hardware destabilizes the construct, which can be corrected comparably with the addition of a C3-C1 or C3-Clivus cage. Addition of lateral cages to a C3-clivus fusion construct, as proposed by Suchomel P et al [3], does not significantly improve rigidity in any direction, and these results would suggest that this technique is unnecessary considering the increased risk of injury to the vertebral arteries. Results of this study are important clinically as they suggest optimal hardware configurations for maximizing fusion site rigidity while minimizing patient morbidity.

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REFERENCES: