Introduction  Posterior wire fixation and fusion, including the Brooks-Jenkins and Gallie techniques, is a widely accepted procedure for the treatment of pathologic upper cervical spine instability. Recently, the addition of transarticular screws was utilized in clinic in order to enhance the posterior cable fixation and decrease the rate of pseudoarthrosis. Frequently, anatomical constraints preclude the insertion of a transarticular screw unilaterally or bilaterally, however, no testing has been done to determine the efficacy of this practice. If the placement of one screw provides adequate stabilization of C1-C2, this would provide surgeons with multiple options for surgery. The purpose of this study was to compare the biomechanical stability of five posterior cervical fusion techniques in order to assess the relative value of varying the number of screws in different posterior wire constructs.

Method  Ten adult human cadaveric upper cervical spine specimens were sectioned at C3 level. The occiput and C3 vertebrae were potted in PMMA using alignment jigs. The specimens were tested under the following conditions: intact; after a destabilizing procedure including odontoid transection and sectioning of the transverse and capsular ligaments; after stabilization with each of the following techniques: Brooks-Jenkins cable fixation, Brooks-Jenkins with unilateral transarticular screw, Gallie posterior wire construct with unilateral transarticular screw, Brooks-Jenkins with bilateral screws, and Gallie with bilateral screws. The constructs were applied in a balanced, randomized order by experienced spine surgeons.

The methods for testing were similar to those used by Grob, Panjabi, Goel, and Hajek[1-4], where pure moments were applied in flexion/extension, lateral bending, and torsion within physiological limits (<1.5Nm). The three dimensional movements of the vertebrae were recorded using a Fastrak electromagnetic system (Polhemus Inc., Colchester, VT), with sensors attached to each vertebra and the occiput. Three dynamic loading cycles were applied in each motion in order to precondition the specimen and minimize viscoelastic effects.

Results  The relative positional data between vertebrae was analyzed, with special attention paid to the motion at C1-C2. The neutral zone (NZ) and range of motion (ROM) for each condition were measured in the main plane of each motion, as well as in the coupled planes. In flexion-extension and lateral bending, the ROM and NZ increased significantly after the specimens were injured as compared to intact specimens (p<0.0001) (Fig. 1, 2).

In axial torsion, there was no significant difference between the intact and injured spines at C1-C2 level (Fig. 3). When each specimen was sequentially instrumented with the different fixation systems, the ROM and NZ were significantly lower than in injured and intact spines in all motions (p<0.01) except the lateral bending in intact spine (Fig. 2). Among the five instrumented techniques, the NZ and ROM for the Gallie construct with one screw were significantly higher than for the Brooks-Jenkins construct with one or two screws in flexion/extension (p<0.05). In axial torsion, the Gallie construct with one screw displayed a larger NZ and ROM than any of the other four constructs (p<0.05).

Discussion  The injury created at C1-C2 increased the neutral zones and ranges of motion at that level in flexion/extension and lateral bending, but not in axial torsion. In this study, each construct increased the stability over the injured state. However, the Gallie technique with one transarticular screw provided significantly less stability than a Gallie construct with two screws or any of the techniques employing a Brooks-Jenkins construct. Although there was no significant difference between any of the Brooks-Jenkins techniques, a trend was noted that displayed increased stability with the insertion of one or two transarticular screws. The lack of statistical significance can be attributed to the high degree of stability seen with the original Brooks-Jenkins construct, which would, therefore, not allow much improvement with the addition of more transarticular screws.

Many surgeons agree that the most effective surgical construct for atlantoaxial immobilization is the combination of posterior transarticular screws and a posterior bone graft secured with a cable. In approximately 1/3 of the cases, bilateral transarticular screws are very difficult to use due to the anatomical constraints. In such cases, clinical studies suggest that a single screw plus a posterior tension band construct is adequate. Based on our results, if transarticular screws are considered to be necessary to augment the fixation of a C1-C2 fusion, but only a single screw can be inserted, we recommend performing a Brooks-Jenkins technique rather than a Gallie technique.

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References