APPLICATION OF SCREW DISPLACEMENT AXES TO DESCRIBE ULNOHUMERAL JOINT INSTABILITY AFTER RADIAL HEAD EXCISION AND REPAIR

INTRODUCTION: The ulnohumeral joint is generally considered to be hinge-like, with the medial collateral ligament (MCL) and radial head acting as important valgus constraints to elbow instability. To our knowledge, no study has been performed evaluating the stabilizing influence of these structures using screw displacement axes (SDA's). Thus, the purpose of this study was to quantify the relative contribution to elbow joint stability of the MCL, the native radial head and prosthetic radial head, using screw displacement axis analysis.

METHODS: Seven fresh frozen upper extremities (mean age: 69.7 ± 8.4 yrs) were mounted in a custom testing apparatus. With the humerus in the vertical orientation and forearm maintained in supination, elbow flexion was generated passively and simulated actively using computer controlled pneumatic actuators. A medial epicondyle osteotomy (MEO) was performed to mimic an MCL deficient elbow. A lateral epicondyle osteotomy (LEO) and repair was performed to allow for access to, and excision of, the radial head. Surgical repair of the MCL was performed by reattaching the MEO. Prosthetic replacement of the radial head with a metallic implant, was subsequently conducted. Testing was conducted on each elbow for the following states: (1) intact; (2) LEO repair; (3) MEO; (4) MEO repair (5) radial head excision (6) combined MEO and radial head excision; (7) MEO repair and radial head implantation. Kinematic data from the intact state was recorded using an electromagnetic tracking device (Ascension Technology) and analyzed using SDA's calculated from smoothed source data. Angular excursion was defined as the standard deviation in SDA orientation throughout a range of elbow flexion from 20 to 120°, quantified in the transverse and frontal planes. Each specimen was used as its own control, and thus differences in measurements from the intact state are reported. Measurements were analyzed using one-way repeated measures ANOVA and Student-Newman-Keuls post-hoc tests with significance defined at p<0.05.

RESULTS: Figure 1 illustrates angular excursion calculated in the frontal plane for passive and active flexion, at each level of excursion and/or repair relative to the intact state. For both passive and active motion, the LEO and MEO repair did not alter elbow joint kinematics as compared to the intact state in both the frontal and transverse planes (p>0.05). Isolated radial head excision also showed no alteration in SDA angular excursion from the intact state (p>0.05). However, in passive motion, isolated MEO significantly increased SDA angular excursion in the frontal and transverse planes (p<0.001). A further increase in angular excursion resulted during passive flexion after combined radial head excision and MEO (p<0.001), and was similar to the intact state after MEO repair and radial head implantation (p>0.05) (Figure 1). During active motion, no statistical significance resulted between all levels of excursion and/or repair compared to the intact state (p>0.05).

DISCUSSION: Results from passive motion trials of the present study agree with previous studies, which have shown the MCL and radial head to be primary and secondary valgus stabilizers of the ulnohumeral joint. These reports have shown marked increases in internal-external rotation and varus-valgus laxity following MCL and radial head excision, reflected in this study by an increase in SDA orientational excursion determined throughout elbow flexion. To allow for isolated excision of the radial head in this study, an LEO repair was conducted. The LEO repair was statistically similar to the intact state, thereby validating our model. One recent study has shown radial head excision, even with intact ligaments, causes increased varus-valgus laxity in the elbow and altered kinematics. However, kinematics were measured in the varus and valgus gravity loaded position, compared to the present study that only evaluated the elbow in the dependent (vertical) position. In accordance with previous studies, subsequent implantation of the metallic radial head with repair of the MEO, restored stability of the elbow similar to that of the native radial head. Previous studies have also shown muscular activity to significantly increase the rotational stability in the MCL-deficient elbow compared with passive flexion. During active motion trials with the arm in a dependent orientation, the present study showed no change in instability after combined MEO and radial head excision compared to the intact state, suggesting muscle activity restores stability to the injured elbow by reducing out-of-plane motions.

In the current study, implementation of SDA’s was demonstrated to be an effective method for evaluating elbow instability after radial head excision and replacement. The complex SDA patterns provide greater information than traditional varus-valgus and rotational laxity measurements by combining these measures in a single three-dimensional description of joint kinematics. SDA angular excursion confirmed that the MCL and radial head are important constraints to resist out-of-plane motions. In case of injury to both of these stabilizers, the elbow is highly unstable during passive flexion, as illustrated by increasing SDA excursion in Figure 1. In active motion, this instability appears to be reduced by muscle activity. SDA’s should be considered as a useful additional method to Euler descriptions of elbow kinematics.