POSTEROLATERAL ROTATORY INSTABILITY IN POST-TRAUMATIC CUBITUS VARUS DEFORMITY: A BIOMECHANICAL ANALYSIS

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Introduction

Recent evidence has suggested that posterolateral rotatory instability (PLRI) can develop in patients with long standing post-traumatic cubitus varus deformity. In one study, the authors found attenuated, stretched (PLRI) can develop in patients with long standing post-traumatic cubitus varus. Several studies have shown that the lateral unlar collateral ligament (LULC) is most responsible for preventing posterolateral rotatory instability, and it is this ligament that is reconstructed in operative repair of PLRI. We have therefore explored the strain generated in this ligament with the elbow under load with varying degrees of varus deformity, in order to determine the biomechanical relationship between post-traumatic cubitus varus deformity and LULC strain.

Methods

Eleven fresh, frozen, cadaveric elbow joints were thawed overnight at room temperature. Each was dissected free of all soft tissues except the elbow joint capsule and surrounding ligamentous structures, the interosseous ligament, and the distal radioulnar joint soft tissues. The LULC was identified in each specimen. A small arthrotomy was made well posterior to the LULC to observe ulnohumeral joint gaping. The humeri were sectioned 25 cm proximal to the elbow joint, and the wrists disarticulated at the radio-carpal joint. The distal radio-ulnar joints were left intact. Each specimen was mounted in an apparatus that allowed active triceps extension to counteract a coupled flexion and supination force applied to the ulna. Supracondylar, 30 degree, medial closing wedge osteotomies were performed on all specimens well proximal to the ligaments. Bone wedges of 5 to 25 degrees in 5 degree increments could then be placed in the osteotomy site to allow for a final cubitus varus deformity of 0 to 30 degrees. Osteotomies were secured with small fragment screws and plates on the medial and lateral columns. All osteotomies were stable once secured. A differential variable reluctance transducer (DVTR-3, Microstrain Inc., Burlington VT) was sutured to the LULC in a standard location. The DVTR had been previously calibrated on a micrometer stage, and linear regression analysis used to determine the calibration coefficients. Error analysis of the DVTR revealed ±0.018 mm maximal error over a 3 mm working range, or ±0.6% error, which is highly linear. This resulted in a maximal strain error of 0.133% strain, or 0.00133 mm/mm.

Cubitus varus osteotomies were performed sequentially, but in random order of degrees of varus from specimen to specimen, so as to not introduce bias. At each given position of varus, following zero strain length determination, the elbow was loaded with a supination moment of 1.2 Nm and a resistive triceps extension force. The triceps force was adjusted such that the elbow rested at 35° flexion. This angle was used because PLRI is maximal at 40° of flexion. The lateral aspect of the ulnohumeral joint was observed to gap open to a variable degree with loading, and a hand held micrometer was used to measure this ulnohumeral gap at its widest point. Three iterations were performed at each position of varus, and the resulting strain and gap values averaged. The size of each specimen was quantified by measuring the transepicondylar width using a hand held micrometer. Statistical analysis was performed using ANOVA and ANCOVA with transepicondylar width as the covariant. Correlation between varus deformity and gap or strain was calculated with Pearson’s correlation coefficient.

Essential Results

Strain in the LULC was found to increase, with a given supination load, as the cubitus varus deformity increased (R= 0.429; p< 0.001). Likewise, the ulnohumeral gap was seen to progressively widen with increasing cubitus varus (R= 0.628; p< 0.001). Using ANOVA, statistical significance was not achieved until 30° of varus for ligament strain, and 25° varus for ulnohumeral gap because of the wide variability in response to a single load used for all specimens. The average strain and ulnohumeral gap for all eleven specimens at a fixed load of 1.2 Nm are presented graphically in figure 1.

Discussion

The elbow is a highly congruent joint, with a significant portion of it’s stability arising from the bony anatomy of alone. The LULC is known to play a primary role in preventing supination and posterolateral rotatory instability. At a normal carrying angle, or cubitus varus of 0°, when the supination load of the apparatus was applied in conjunction with a resistive pull of the triceps, the supination moment was balanced by the articular geometry and triceps pull alone, essentially without producing strain in the LULC. As cubitus varus angles increased, the direction of pull of the triceps tendon in relation to the elbow joint axis was altered, such that the triceps produced a supination moment as well as an extension force. This caused a decline in articular geometric stability and allowed the supination moment of the apparatus to subluxate the joint, producing strain in the LULC, and producing an ulnohumeral gap. Our findings suggest that the degree of cubitus varus and the size of the specimen are both factors in producing LULC strain in response to a standard load. There is no one specific degree of varus at which the LULC becomes abnormally loaded, but rather higher degrees of cubitus varus produce higher LULC strain and more risk for subsequent LULC attenuation and the development of PLRI. Therefore, patients with more severe cubitus varus deformities are at increased risk for LULC strain and the development of PLRI.

References