INTRODUCTION:
The long term overhead throwing athlete can develop a painful elbow condition due to impingement of postero medial osteophytes formed on the olecranon. Treatment of this condition can involve arthroscopic removal of the osteophytes and in some cases additional bone in order to prevent the postero medial impingement. Although it has been suggested that excessive resection of the postero medial olecranon may destabilize the elbow, there have been conflicting opinions in the literature. (1) Therefore the objective of this study was to accurately assess the strain field in the anterior bundle of the medial ulnar collateral ligament (AMUCL) using two independent methods and quantify the effects of 4mm and 8mm postero medial olecranon osteotomies and increasing valgus torque.

METHODS:
Seven fresh frozen cadaver elbows were tested. Average specimen age was 76.3 years (range 64-84) with 2 males and 5 females. After capsulo-ligamentous preparation, the bony ends of the humerus and forearm were fixed into PVC pipe using plaster of Paris and K-wires. The forearm was fixed in neutral rotation. A positioning device was used to mount the elbow such that the flexion and extension was oriented in the horizontal plane with the medial ulnar collateral ligament lying in a superior position. A rod was mounted to the end of each forearm to allow for the application of valgus and varus torques by hanging an additional weight at three predetermined points along the rod. The varus load was produced with a freestanding pulley system and a counterbalance weight to create a 3Nm torque. (Figure 1) Small screws(1.4x5mm) were inserted at the anterior and posterior regions of the olecranon, and insertion of the AMUCL. Screw heads served as reference points for the coordinate measuring device. A three-dimensional coordinate measuring device (Microscribe 3DLX; Immersion Corp, San Jose, CA) was used to digitize the screw heads and several points along the mounted forearm to allow the determination of valgus angulation, bone-ligament-bone strain and ulnar rotation. Two trials of measurements were taken and the average was used as the final measurement. As a secondary, non-contact method, a video digitizing system (2) was used to measure changes in the mid-substance ligament strain using six Verhoff elastin stain marker points on the midsubstance of the AMUCL.

Ligament length and forearm position of the intact elbow were measured at flexion angles of 30, 60 and 90 degrees. Measurements were repeated under valgus torques of 1Nm, 2Nm, and 3Nm, followed by a varus torque of 3Nm. Measurements were taken one minute after each condition change to standardize the effect of stress relaxation on the AMUCL. Postero medial olecranon osteotomies of 4mm and 8mm were then performed on each elbow using an osteotome and a burr. (Figure 2) The size of bony resection was measured from the visible articular edge of the posterior and postero medial olecranon. Additional postero medial articular surface was resected to the level of the lowest point of the greater sigmoid notch of the medial olecranon. Elbow measurements were repeated after each interval of olecranon resection. Statistical analysis was performed using univariate repeated measures ANOVA with the Turkey post hoc test.

RESULTS:
Postero medial olecranon osteotomies did not alter the strain in the AMUCL but had a significant influence on the kinematics. Specifically, there was no significant change in the strain pattern of the bone-AMUCL-bone or ligament midsubstance when comparing the strains for 0mm, 4mm and 8mm postero medial olecranon osteotomies. (Figure 3) This was true at all flexion angles. A significant correlation exists between increasing torque and a reciprocal increase in strain within each osteotomy group. With respect to elbow kinematics, corresponding increases were seen in valgus angulation with increasing postero medial olecranon resection. The statistically significant changes were seen after 8mm resections at 60 and 90 degrees. The total varus-valgus laxity of the elbow increased significantly after both the 4 and 8mm postero medial olecranon osteotomies. (Figure 4) This suggests that postero medial olecranon resection may lead to instability and make the joint more susceptible to injury in high demand athletes.

DISCUSSION:
Postero medial olecranon resection did not significantly affect the strain in the AMUCL under valgus loading. However, throwers may be susceptible to AMUCL injury following postero medial olecranon resection due to increased elbow laxity and altered kinematics. The results from this study show that under static valgus loading, there is no significant change in the strain pattern across the AMUCL after postero medial olecranon osteotomy. There is an alteration in elbow kinematics in that overall varus-valgus laxity is significantly increased, especially at 90 degrees of elbow flexion. We believe that this relative destabilization of the elbow can lead to dynamic changes and make the high demand athlete more susceptible to injury. The findings from this study suggest that in the surgical treatment of postero medial olecranon impingement, one should limit resection to osteophytic overgrowth.