6 INFLUENCE OF FOREARM ORIENTATION AND AXIAL COMPRESSION ON ELBOW INJURIES IN THE EXTENDED ELBOW

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Introduction: The elbow is the second most commonly dislocated joint in the body. Forty-nine percent of these are complex dislocations (ie, associated with a fracture). There are classic patterns for elbow injuries. Previous experiments have attempted to recreate these injury patterns using external forces. There is a common belief that elbow dislocations are caused by an axial force accompanied by flexion and an additional varus, valgus, or rotation force that leads to posterior dislocation with injury to either the medial or lateral structures. The elbow must flex to at least 20 degrees to unlock the olecranon before a dislocation can occur. The hypothesis of this study was that elbow injury patterns are influenced both by forearm orientation and the compressive interaction of joint surfaces in the fully extended elbow. Therefore, the objective of this study was to investigate the joint kinematics and injury pattern of the elbow that resulted from an axial load to failure with the forearm in either pronation or supination. **Methods:** Fourteen upper extremities were resected through the distal 1/3 humerus. Soft tissues were removed, leaving only the joint capsule, ligaments, interosseous membrane, and muscular insertions of the brachialis, supinator, and triceps. The valgus angle of the specimens was determined using markers and digital photos in supination, pronation, and neutral. A custom apparatus was used that allowed free rotation of the ulna, radius, and humerus about a fixed wrist. A compressive load was applied with a material tester (Instron 4411, Canton, MA) at a rate of two millimeters per second until failure occurred. Force and displacement data were collected. An optoelectronic, three-dimensional camera system (Optotrak 3020; Northern Digital Inc, Canada) was used to measure kinematic data for the distal humerus, proximal radius, and proximal ulna. Following failure, the elbow was carefully inspected and photographed to document all fractures and disrupted tissues. **Results:** Of the fourteen specimens, seven elbows failed in pronation and seven elbows failed in supination. In pronation, 6/7 elbows had a terrible triad type elbow injury with fracture of the radial head and coronoid with posterior dislocation. In supination, 6/7 elbows dislocated without coronoid or radial head fractures. Four out of fourteen elbows had damage to the lateral structures and ten out of fourteen had injury to the medial structures. In each case, damage to either the medial or lateral structures correlated with internal or external rotation of the ulna as compared to the humerus. Load to failure of the extended elbow in pronation most commonly led to a terrible triad (fracture of radial head and coronoid with posterior dislocation). In supination, independent rotation of the ulna and humerus enabled the elbow to dislocate without a fracture of the radial head or coronoid. No additional forces were necessary to allow the ulna to rotate out of the olecranon fossa. Post failure dissection revealed injury to the medial or lateral structures. The documented structural injuries correlated with the calculated rotations of the humerus and ulna relative to each other. When the ulna rotated externally relative to the humerus, the lateral structures were damaged. When the ulna rotated internally relative to the humerus, there was damage to the medial structures. The post failure dissection demonstrated rotation laxity at the elbow after reduction. **Conclusions:** During axial compression of the extended elbow, the ulna hinges either medially or laterally and allows the elbow to dislocate. The ligaments on the contralateral side are either torn or attenuated. In our study, the medial structures were more commonly disrupted. The terrible triad injury pattern can be produced with the elbow pronated in full extension.

7 MEDIAL COLLATERAL LIGAMENT RECONSTRUCTION OF THE ELBOW IN THROWING ATHLETES USING THE DOCKING TECHNIQUE

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Introduction: Medial collateral ligament insufficiency of the elbow can be a devastating injury in the throwing athlete. Reconstruction of the MCL was initially described by Jobe and associates; good clinical results have been described following this procedure. Our experience with this technique raised several concerns, and thus the "docking" procedure was developed an as alternative method for elbow MCL reconstruction. The early results of the docking technique were good. We wish to investigate the intermediate term clinical results of this method. **Methods:** Over a five year period, one-hundred consecutive overhead athletes were treated with surgical reconstruction using the docking technique. The inclusion criterion were as follows: (1) a history of medial elbow pain that prevented throwing, (2) a preoperative MRI demonstrating an MCL injury, (3) clinically significant MCL insufficiency, (4) overhead throwing athlete. At the time of surgery, all patients underwent routine arthroscopic assessment. The ulnar nerve was transposed in twenty-two cases. The average follow-up was thirty-six months (range, twenty-four to sixty months). **Results:** Ninety of one-hundred (90%) patients were able to compete at the same or a higher level than before the injury for more than twelve months as noted at the follow-up interval. This outcome meets the Conway classification criteria of an excellent result in 90% of study patients. Seven patients (7%) were able to compete at a lower level for more than twelve months (Conway - good result). One patient (1%) was able to throw only recreationally (Conway - fair result). There were only 2 poor results. Forty-five patients (45%) had associated intra-articular pathology that was treated arthroscopically before ligament reconstruction. There were three complications: two patients had ulnar nerve symptoms postoperatively that required ulnar nerve transposition. Both patients made full recoveries and had excellent results at the time of follow-up. The third patient developed elbow stiffness that required an arthroscopic debridement and had a good result at the time of follow-up. **Conclusion:** The docking technique is a safe and effective procedure that reliably returns throwing athletes to sport. This method allows for excellent graft fixation, the treatment of intraarticular pathology, and minimal ulnar nerve-related complications.

8 DYNAMIC STABILITY OF THE ELBOW: A BIOMECHANICAL STUDY OF MUSCLE CONTRIBUTION TO VALGUS STABILITY

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Background: Limited information is available with regard to the dynamic stability of the elbow joint, ie, the role of muscle function. Biomechanical analysis of common activities, such as overhead throwing, suggests that muscles must play a role in the elbow to aid in counteracting valgus load. We hypothesize that the dynamic action of the flexor pronator mass will decrease the strain on the medial collateral ligament and provide a protective varus correction at the elbow. **Method and Materials:** Eight fresh frozen cadaveric elbows were tested utilizing a custom made testing device. Muscles of the flexor pronator mass (the flexor carpi ulnaris, flexor carpi radialis, flexor digitorum superficialis, and the pronator teres), the extensor supinator mass and the triceps, biceps, and brachialis were isolated and wrapped in a mesh and wire construct. The insertion of each muscle was left undisturbed while eyelets were placed at the origins of each muscle. The wire and mesh construct was passed through each eyelet and to a pulley system attached to the testing apparatus. The elbow was locked in neutral pro/supination, neutral wrist flexion, and 30 degrees of