

The effect of radial head fracture size on elbow kinematics and stability

Daphne M. Beingessner^a, Cynthia E. Dunning^b, Karen D. Gordon^c,
James A. Johnson^b, Graham J.W. King^{d,*}

^a Division of Orthopedic Surgery, The University of Western Ontario, London, Ont., Canada

^b Department of Mechanical and Materials Engineering, The University of Western Ontario, London, Ont., Canada

^c Department of Biomedical Engineering, The University of Western Ontario, London, Ont., Canada

^d Division of Orthopedic Surgery, The University of Western Ontario, Hand and Upper Limb Centre,
St. Joseph's Health Care London, 268 Grosvenor Street, London, Ont., Canada N6A 4L6

Received 27 May 2004

Abstract

This study determined the effect of radial head fracture size and ligament injury on elbow kinematics. Eight cadaveric upper extremities were studied in an in vitro elbow simulator. Testing was performed with ligaments intact, with the medial collateral (MCL) or lateral collateral (LCL) ligament detached, and with both the MCL and LCL detached. Thirty degree wedges were sequentially removed from the anterolateral radial head up to 120°. Valgus angulation and external rotation of the ulna relative to the humerus were determined for passive motion, active motion, and pivot shift testing with the arm in a vertical (dependent) orientation. Maximum varus–valgus laxity was calculated from measurements of varus and valgus angulation with the arm in horizontal gravity-loaded positions. No effect of increasing radial head fracture size was observed on valgus angulation during passive and active motion in the dependent position. In supination, external rotation increased with increasing fracture size during passive motion with LCL deficiency and both MCL and LCL deficiency. With intact ligaments, maximum varus–valgus laxity increased with increasing radial head fracture size. With ligament disruption, elbows were grossly unstable, and no effect of increasing radial head fracture size occurred. During pivot shift testing, performed with the ligaments intact, subtle instability was noted after resection of one-third of the radial head. In this in vitro biomechanical study, small subtle effects of radial head fracture size on elbow kinematics and stability were seen in both the ligament intact and ligament deficient elbows. These data suggest that fixation of displaced radial head fractures less than or equal to one-third of the articular diameter may have some biomechanical advantages; however, clinical correlation is required.

© 2004 Orthopaedic Research Society. Published by Elsevier Ltd. All rights reserved.

Keywords: Radial head; Fracture; In vitro testing; Biomechanics; Elbow joint; Elbow ligament deficiency

Introduction

Radial head fractures are common injuries [17] and controversy exists as to the optimal management of displaced wedge fractures (Mason Type II [14]). Management options include non-operative treatment, fragment excision, open reduction internal fixation, or radial head excision with or without replacement [5,9,12,16,17,20]. Operative management has been recommended for displaced fragments larger than one-fourth [4,8,14] to

one-third [20] of the radial head; however, these recommendations remain controversial.

The radial head is an important valgus stabilizer of the elbow, especially in the setting of ligamentous injury [18]. Radial head fractures may decrease the intrinsic osseous stability of the radiocapitellar joint and result in radiocapitellar subluxation and posterolateral rotational instability. This instability may lead to painful clicking and secondary osteoarthritis [3]. The effect of excising smaller fragments of the radial head on elbow stability is unknown. In a previous study in a model without soft tissues [2], a progressive decrease in radiocapitellar joint stability was observed with larger fracture sizes. However, the biomechanical effects of radial head fracture

* Corresponding author. Tel.: +1-519-646-6011; fax: +1-519-646-6049.

E-mail address: gking@uwo.ca (G.J.W. King).

size in elbows with intact ligaments and disrupted ligaments have not been reported.

The objectives of the present study were: to determine the effect of radial head fracture size on the kinematics and stability of the elbow with intact ligaments and with disrupted medial, lateral, or both medial and lateral collateral ligaments.

Materials and methods

Eight unpreserved cadaveric upper extremities (mean age 74 years, range 65–78 years) were amputated at mid-humerus and stored at -20°C . The specimens were thawed for 18 h at room temperature ($22 \pm 2^{\circ}\text{C}$) and were prepared for mounting on an elbow testing apparatus (Fig. 1) that was used to simulate both passive and active elbow motions [6,10]. Stainless steel cables (0.8 mm diameter) were attached to the distal tendons of three elbow flexors (biceps, brachialis, and brachioradialis), the primary extensor (triceps), and a forearm pronator (pronator teres). Skin incisions were closed, and the specimen was kept moist using 0.9% normal saline solution throughout testing.

The humerus was attached in neutral position to a custom clamp on a base plate that rigidly held the arm while allowing unconstrained elbow motion. The cables were attached to computer-controlled pneumatic actuators, which allowed for simulated active joint motion. The lines of action for the biceps, brachialis, and triceps cables were controlled using an alignment system. The cables for pronator teres and brachioradialis were placed through the humeral canal via Delrin® sleeves inserted into the medial and lateral supracondylar ridges. A

universal joint on the bottom of the base plate allowed orientation of the arm in the dependent position (i.e., with the arm in a vertical orientation) and in varus and valgus gravity-loaded positions (i.e., with the arm in a horizontal orientation) (Fig. 1).

In the dependent position, both passive motion and simulated active motion with the forearm in pronation and supination were performed. In the gravity-loaded position, passive motion with the forearm in pronation and supination was performed. To simulate passive motion in the dependent position, the tester (DMB) grasped the wrist and placed the forearm into pronation or supination until resistance was felt. Care was taken to ensure that a pure 'lifting' action was performed, such that the arm was not subjected to any inadvertent varus/valgus moments and the flexion motion was guided by the bony and soft tissue constraints of the elbow. To simulate active motion in the dependent position, the pneumatic actuators attached to the cables applied forces to the tendons causing the forearm to be positioned and maintained in pronation or supination. Additional muscle loads were then applied to move the arm through an arc from full extension to full flexion. The muscle loading protocol was based on EMG data and a previously validated in vitro system developed in our laboratory [6,10]. Passive testing was also performed in both the varus and valgus gravity-loaded positions. For each sequence, the forearm was either fully pronated or supinated and brought from full extension to full flexion by the tester grasping the hand and wrist.

Medial and lateral epicondylar osteotomies were performed to simulate MCL and LCL deficiency, respectively. Using an oscillating saw, the medial and lateral epicondyles were detached. Care was taken to ensure the MCL and common flexor origin remained fully attached to the medial epicondyle fragment, and the LCL and common extensor origin remained fully attached to the lateral epicondyle fragment. The osteotomies were securely repaired using 3.5 mm cortical screws (Synthes Canada, Mississauga, Ont.) to reconstitute the collateral

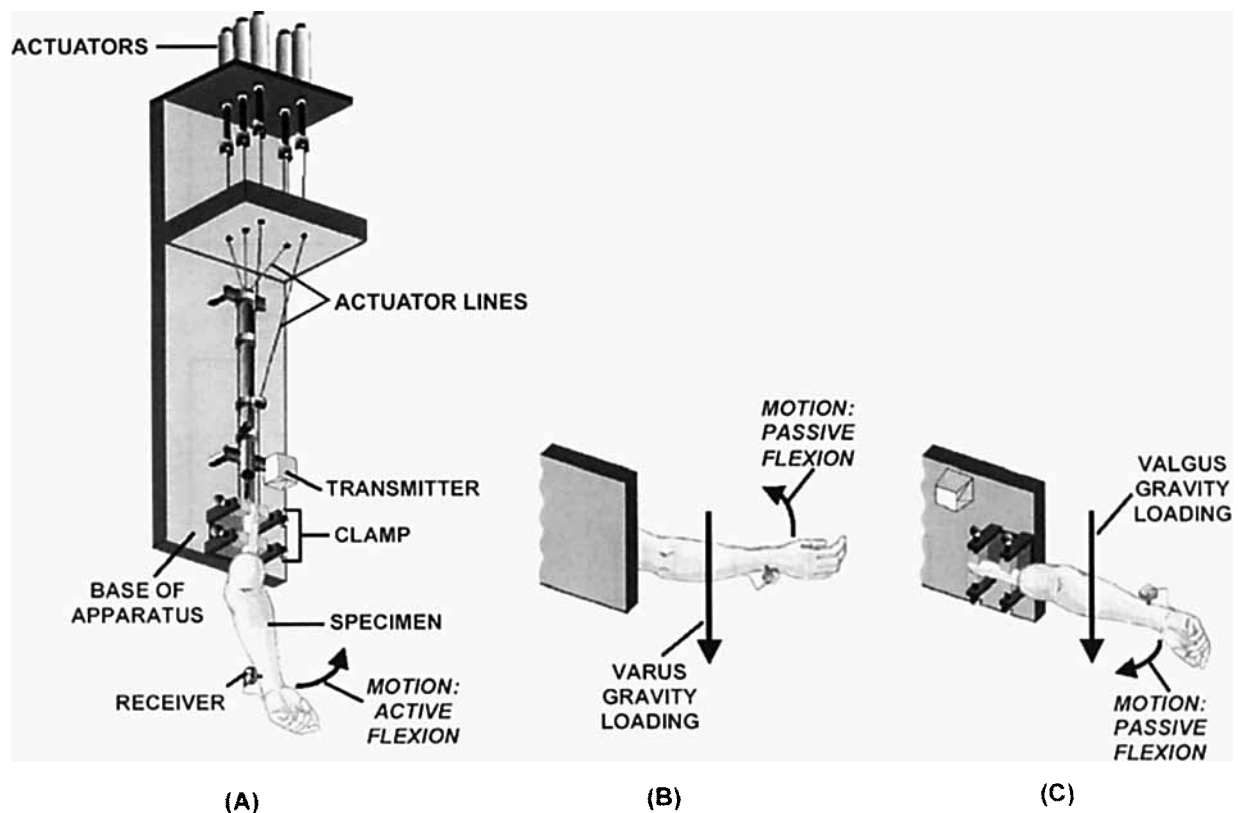


Fig. 1. (A) Specimens were mounted on a specialized elbow testing apparatus. Cables were sutured to tendons of the various muscle groups and were secured to pneumatic actuators that allowed simulated active elbow motion. A computer was used to control the timing and magnitudes of loads applied by the actuators, such that elbow/forearm motion was achieved. A hinge on the base plate allowed positioning of the arm in both (B) varus and (C) valgus gravity-loaded positions.

Download English Version:

<https://daneshyari.com/en/article/9354048>

Download Persian Version:

<https://daneshyari.com/article/9354048>

[Daneshyari.com](https://daneshyari.com)