INTRODUCTION

Posterolateral rotatory instability (PLRI) of the elbow occurs secondary to an injury to the lateral ulnar collateral ligament and lateral stabilizing structures [2]. The lateral pivot-shift test (PST) is a clinical examination for diagnosing PLRI. The test involves moving the elbow from full extension to flexion while applying simultaneous supination torque, valgus moment, and axial compression [2]; a positive result is characterized by ulnohumeral subluxation that is seen clinically as posterolateral movement of the radial head and an incongruent radiocapitellar joint [2]. The PST is difficult to reliably reproduce in an office setting [3]. This can be due to patient guarding or inexperience of the examiner. It is likely that the experienced examiner may perform the test differently than the inexperienced examiner. The PST has not previously been characterized biomechanically in the laboratory. Thus, the objective of this study is to fully characterize the biomechanics of the PST for PLRI. We will evaluate the repeatability of the test for multiple surgeons and determine whether the clinician’s level of training influences their method of testing. These results will be useful in developing training guidelines to standardize test application as well as to improve accuracy.

METHODS

Fresh frozen forearms (N=3; 2 right, 1 left) were harvested from normal donors (66 +/- 16 yrs; 2M, 1F). The forearms were cut at mid-humerus and cast in metal cups. Each specimen was mounted to a fixed base that could be adjusted to mimic proper patient positioning during the PST. The proximal specimen cup was fixed to a multi-axial load cell (AMTI MC3A-6-500), which was then attached to a custom hinge joint that simulated physiologic shoulder motion (Figure 1, left). Two clinicians, an established orthopaedic surgeon (experienced) and a resident (inexperienced), were instructed to perform 6-10 PST repetitions for each test session. Test sessions were conducted for each specimen both in its intact state and following sectioning of all stabilizing structures (radial collateral ligament, ulnar collateral ligament, common extensor origin).

Figure 1: (left) An inexperienced surgeon performing the PST on a cadaveric elbow. (right) Identification of anatomical landmarks using x-ray fluoroscopy.

During PST maneuvers, elbow kinematics were measured in real-time using a 3-D motion tracking system (Optotrak 3020, Northern Digital). Marker sets were rigidly attached to the radius, ulna, and humerus via polyaxial cervical screws (Stryker Spine) (Figure 1, right), and a single marker was placed on the load cell to determine its location relative to these marker triads. Anatomical landmarks within the elbow joint were identified under fluoroscopy (BV Pulsera, Philips) using a needle-tipped motion analysis probe (Figure 1, right). Load cell, 3-D motion tracking, and anatomical landmark data were entered into a validated custom-built kinematic analysis program. Time trace and peak values for the following metrics were obtained for every PST maneuver: 1) radial head displacements in the distal (dD), medial (dM), and posterior (dL) directions, 2) valgus moment (MV), 3) axial force (FA), and 4) supination torque (TS).

RESULTS

PST repetitions by the experienced clinician on intact specimens were relatively consistent for all biomechanical outcome measures (3-28% variability, Figure 2 left); however, the inexperienced surgeon showed substantial variability in repeat trials (7-61%). For both clinicians, variability was generally greater for destabilized versus intact specimens. Neither clinician applied uniform forces or moments across all specimens (Figure 2 right).

Figure 2: Variability in outcome metrics for PST repetitions on the same specimen.

The PST kinetics differed notably between clinicians (Figure 3). Specifically, the experienced surgeon demonstrated a moderate correlation ($R^2=0.62$, $p<0.01$) between supination torque and distal radial head displacement across all specimens. This was not the case for the clinician in-training, who instead demonstrated modest correlations between posterior displacement of the radial head and valgus moment ($R=0.58$, $p=0.01$) and axial force ($R^2=0.56$, $p<0.01$).

Figure 3: Supination torque (bold line) and distal radial head displacement (thin line) for two trials of the same specimen by both clinicians.

DISCUSSION

The results suggest that, while both the experienced and the inexperienced surgeons performed the PST consistently on each individual specimen, experienced clinicians are more consistent in repeat trials of the PST on individual specimens. In addition, for each specimen there was a notable difference in the forces and moments applied between the two examiners. Specifically, our data suggest that, when compared to the experienced surgeon, the inexperienced surgeon applies higher amounts of axial force and valgus moment, but lower amounts of supination torque during the PST. This study shows that there is inter-clinician variance in the amount of forces and moments applied during the PST, possibly due to experience level. The results also suggest that the PST is not force-controlled, since neither clinician applied constant forces and moments across all specimens.

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REFERENCES