APPLICATION OF SCREW DISPLACEMENT AXES TO QUANTIFY ELBOW INSTABILITY

*Duck, T R; **Dunning, C E; *King, G J W; **Johnson, J A

**Bioengineering Research Laboratory, Lawson Research Institute, University of Western Ontario. Hand and Upper Limb Centre, 268 Grosvenor Street, London, Ontario, Canada, N6A 4L2, (519) 646-6100, Fax: (519) 646-6049, jajohnso@julian.uwo.ca

INTRODUCTION: Traditional kinematic descriptors, such as Euler angles, have often been employed to evaluate kinematics and stability of the elbow. Implementation of instantaneous screw displacement axes (SDA’s) has proven to be a useful tool for describing joint kinematics, however application to quantify elbow instability has not apparently been explored. Recent studies using specialized filtering techniques have shown that this approach is applicable at small angles. The purpose of this study was to determine SDA’s for passive elbow joint motions in-vitro, and to interpret the descriptive value of SDA’s for joint instability with respect to traditional Euler methods. We employed a disrupted lateral collateral ligament complex (LCLC) as a model of elbow instability.

METHODS: Eight fresh frozen upper extremities (mean age: 74±14 years) were mounted in a custom testing apparatus. With the humerus in the dependent orientation, passive elbow flexion was performed with the forearm held in supination. Motion of the ulna relative to the humerus was recorded using an electromagnetic tracking device (Flock of Birds, Ascension Technology, Burlington, VT, USA). Testing was performed on the intact forearm, followed by total excision of the LCLC. Motion pathways were calculated from the kinematic data. Varus-valgus position of the ulna relative to the humerus was calculated using Euler angles at four angles of elbow flexion (30°, 60°, 90°, 120°). SDA’s to describe joint kinematics were calculated at five degree intervals of rotation about the SDA, following the algorithm described by Beggs and Bottlang et al. Data was filtered using a Butterworth double low pass filter with a cutoff frequency of 1.5 Hz prior to SDA calculations. A custom written program calculated the centre of the trochlea, by circle fitting digitization data from the trochlear groove. Average SDA dispersion, defined as the difference between each SDA and the mean SDA, was measured for each motion pathway at a position three centimeters lateral to the trochlear centre. The relative difference between these measures in a single three-dimensional description of joint kinematics. The dispersion of the SDA’s was able to adequately reflect the increase in instability which occurred as a consequence of LCLC transection. SDA’s should be considered as a useful additional method to Euler descriptions of elbow kinematics.

RESULTS: Division of the LCLC resulted in increased varus position of the ulna throughout the arc of elbow flexion (p=0.007) (Figure 1A). An increase in external rotation of the ulna was also evident following LCLC transection (p<0.0001) (Figure 1B). The distribution of the SDA’s for the intact arm were observed to cluster closely together (Figure 2A). A consistent change in the SDA’s was observed following total excision of the LCLC (Figure 2B). This change was quantified by SDA dispersion calculations (p<0.001) (Figure 3).

DISCUSSION: In the current study, the implementation of SDA’s was demonstrated to be an effective method for evaluating elbow instability. Euler descriptions indicate that an increase in varus position and external rotation is present following an aggressive ligamentous disruption, such as injury to the LCLC. The complex SDA patterns provide greater information than traditional varus-valgus and rotational laxity measurements by combining these measures in a single three-dimensional description of joint kinematics. The dispersion of the SDA’s was able to adequately reflect the increase in instability which occurred as a consequence of LCLC transection. SDA’s should be considered as a useful additional method to Euler descriptions of elbow kinematics.

ACKNOWLEDGEMENTS: The authors acknowledge the funding support provided by the Medical Research Council of Canada, and the National Science and Engineering Research Council.

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Figure 1: Division of the LCLC resulted in an increase in: (A) varus position (p=0.0007), (B) external rotation of the ulna (p<0.0001).

Figure 2: A change in SDA pattern (shown for one specimen) resulted following LCLC transection: (A) intact specimen, (B) LCLC transection (units in cm). The circle represents the centre of the trochlea.

Figure 3: SDA Dispersion increased following excision of the LCLC (p=0.001).