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Ligament fibre recruitment of the elbow joint during gravity-loaded passive motion: An experimental study

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Abstract

Background. Knowledge of elbow collateral ligament length during passive motion is essential in understanding ligament physiology and pathology, such as tightness and instability.

Methods. Five anatomical unembalmed specimens were passively placed in six flexion positions together with three forearm rotations, using equipment with gravity as motion force. These 18 positions were recorded using CT-scan. Three-dimensional data of ligament insertions were obtained through anatomical millimetre sections. Ligament length was measured in each position.

Findings. In neutral rotation, the lateral collateral ligament was long between 0° and 30° as well as at 90°, and short between about 60° and 120° of flexion. In pronation, it was long at about 0° and between 60° and 120°, short at about 30° of flexion. In supination, it was long at about 30° and 90° and short between 120° and 150° of flexion. In any forearm rotation, the highest length of the anterior bundle of the ulnar collateral ligament was measured at about 90°, its smallest length between 120° and 150° of flexion, position at which the posterior bundle length was greatest.

Interpretation. At 60° of flexion, the collateral ligaments were slackened in any forearm rotations. Forearm rotation plays an indirect role in the posterolateral stability of elbow as it changes length of the lateral collateral ligament. This ligament can be tested passively at 90° of flexion in supination, the anterior bundle of the ulnar collateral ligament between 0° and 30° in neutral rotation and the posterior bundle between 120° and 150° in neutral rotation.

Keywords: Elbow joint; Ligament length; Flexion; Extension; Pronation; Supination; Ligament fibre recruitment

1. Introduction

Knowledge of ligament fibre recruitment at the elbow articular complex is essential for analysis of relevant mobility and stability. This study carried out in gravity-loaded passive elbow motion seems to us a necessary preliminary prerequisite for analyzing the ligaments in dynamic conditions.

Previous in vitro cadaver studies (Pomianowski et al., 2001; Safran et al., 2005) have shown that forearm rotation influences laxity and stability of the elbow. However these experimental results are conflicting. Pomianowski et al. concluded that forearm pronation increases valgus/varus laxity, particularly in medial collateral ligament deficient elbows (Pomianowski et al., 2001). Safran et al. demonstrated that laxity was always greatest in neutral forearm rotation throughout the ranges of elbow flexion and the various surgical procedures (Safran et al., 2005). Forearm supination has been shown to stabilize the elbows with

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ulnar collateral ligament deficiency (Armstrong et al., 2000; Beingessner et al., 2007). Forearm supination would likely aggravate lateral instability of elbows with lateral collateral ligament deficiency (Dunning et al., 2001). The balance between the two effects should be precise to adapt the post-operatively positioning.

Only the lengths of the limits of collateral ligaments were studied.

The first aim of the current study was to identify the pattern of fibre recruitment of collateral ligaments during gravity-loaded passive elbow motion: the limits of each collateral ligament were measured and the evolution of their length during mobilization analysed. The second aim was to determine the effect of forearm rotation position on the ligament length.

First osseous markers were inserted into the elbow bones of each anatomic specimen to create individual coordinate system. Then passive motion was recorded by CT-scan; ligament insertion shaping was obtained by millimetric anatomical sections. At last, limits of collateral ligament were calculated in each position of passive motion.

We hypothesized that forearm rotation should be considered during the clinical examination of elbow instability since forearm rotation changes the length of the lateral collateral ligament but not that of the medial collateral ligament.

2. Material

2.1. Anatomical specimens

Five fresh anatomical specimens were used: three left upper limbs and two right upper limbs from four cadavers (two men and two women). The average age was 79.5 years (standard deviation (SD 4.5). The anatomical specimen weight measured on a Precia® universal balance (Privas, France) (precision of 100 g) averaged 3300 g (SD 900). None of the upper limbs had post-traumatic or major osteoarthritic lesions on macroscopic examination.

3. Methods

3.1. Ligaments definition

The lateral collateral ligament (LCL) is divided in radial collateral ligament, lateral ulnar collateral liga-

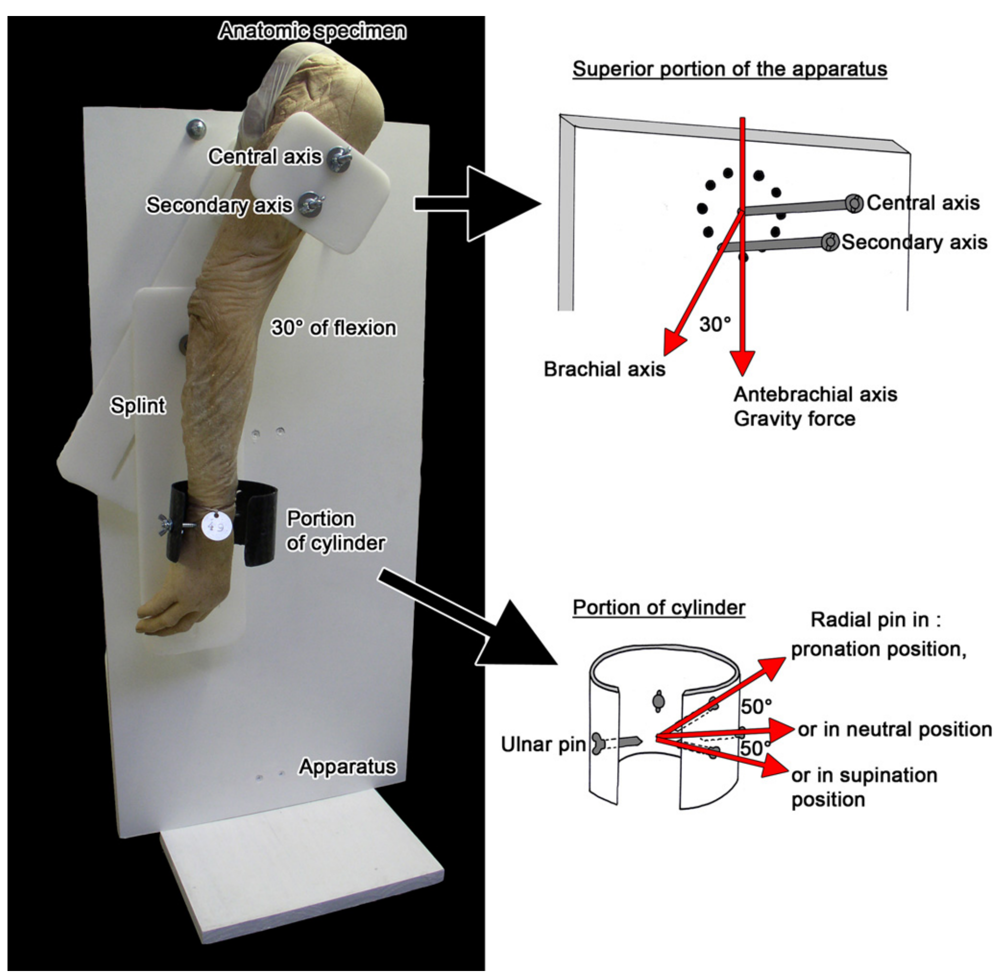

Fig. 1. Photography and schematic drawings of the apparatus and splint with an anatomic specimen in 30° of flexion, with pronation.