Relation between wrist morphology and 3D kinematics

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Introduction

Individual variations of bony morphology and ligament anatomy have been reported and related to some pathological conditions (Burgess, 1990, Viegas et al., 1990 Feipel et al., 1997, 1998, 1999). Carpal kinematics and ligament behaviour have also been shown to vary (de Lange et al., 1990, Feipel et al., 1992, 1998, 1999, Salvia et al. 2000, Savelberg et al., 1992), but no study has yet assessed the relation between morphologic and functional variations. The aim of the present study was to analyse carpal radiographic anatomy, capsular ligament dimensions and 3D kinematics in anatomic specimens in order to investigate the relationships between wrist kinematics and morphology. It is hypothesised that this study may contribute to a better understanding of wrist anatomy, kinematics, pathology and treatment.

Methods

In this study, 11 unembalmed upper extremity specimens were used. Donor age and wrist pathology history were unknown, however pathological specimens (X-ray) were excluded. Carpal kinematics was assessed using a previously developed 3D CT technique (Feipel et al., 1992, 1999, fig. 1). The wrists were scanned in 5 positions (neutral, dorsal and palmar flexion, radial and ulnar deviation). Landmarks of scaphoid, lunate, triquetrum, pisiform, hamate and trapezium were digitised on 3D reconstructions in each position. Using the helical axis concept, kinematics data were computed from the landmarks 3D co-ordinates. For bony morphology, PA radiographs in neutral position were obtained (Feipel et al., 1998, 1999). Using over 40 radiographic landmarks, the frontal dimensions and orientations of the carpal bones and several clinical parameters were computed (fig. 2).

Figure 1: 3D reconstruction of a wrist specimen in neutral position. Palmar (a), ulnar (b), dorsal (c) and radial (d) views.

Figure 2: Radiographic study. Standard PA radiographs with examples of parameters measured: (a) carpal dimensions, (b) carpal angles, (c) ulnar variance and radial inclination, (d) carpal height ratios.
Capsular ligaments were dissected under magnification (fig. 3). The length and width were measured at 3 levels using an electronic calliper (Feipel et al., 1999). Pearson’s correlation coefficients were computed between radiographic, kinematics and ligament dimension parameters.

Figure 3: Capsular ligament dimension study. Palmar aspect (a), dorsal aspect (b). Ligaments for which dimensions were measured are indicated by arrows.

Results & Discussion

Our results agreed with previous reports on quantitative radiographic and ligament anatomy of the wrist. Kinematics data were also in agreement with previous results. Variations concerned central column orientation (fig. 4), bony dimensions, dorsal ligament dimensions and out-of-plane motion ranges. Scaphoid motion components are shown in figure 5. Relevant correlations are presented in figure 6.

Figure 4: Some results of the radiographic study. Average angles (in degrees) within the central carpal column.

Figure 5. Average scaphoid rotation component ranges during sagittal and frontal plane wrist motions.
This study confirmed the variability of numerous wrist morphologic and kinematics aspects (Burgess, 1990, de Lange et al., 1990, Viegas et al., 1990, Savelberg et al., 1992, Feipel et al., 1992, Craighen et al., 1995, Feipel et al., 1997, 1998, 1999, Salvia et al., 2000). However this investigation revealed little correlation between these parameters, so that it remains difficult to predict ligament anatomy or functional aspects from plain radiography. Clinical parameters, such as the carpal height, have been validated by the relationship to other parameters. Our results stress the need for investigations on the precise role of the ulnocarpal ligaments.

References


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