RECRUITMENT OF WRIST JOINT LIGAMENTS

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INTRODUCTION

The wrist is a compact and complex human joint. The ligaments play an important role in the stability of the joint. Better understanding of wrist joint biomechanics may lead to more effective clinical diagnosis and treatment of wrist instability, especially in case of ligament injuries after trauma. Only few studies were aimed at evaluating the function of the wrist joint ligaments, but did not estimate the actual recruitment patterns [1, 2]. A ligament is recruited if its length exceeds the zero-load length. The ligament zero-load length is difficult to determine. However, on the basis of ligament length patterns, an estimate can be determined by assuming that a maximum strain is associated with the maximally observed length [3]. The aim of the present study is to estimate the ligament recruitment pattern of the wrist joint from kinematic measurements combined with geometric reconstructions.

METHODS

13 extrinsic and intrinsic ligaments of the cadaver wrist were considered. Translations and rotations of the carpal bones during dorsal-palmar flexion and ulnar-radial deviation were obtained from 4D rotational x-ray imaging experiments, where a 3D rotational x-ray system is synchronized with cyclic motion of the wrist [4]. The bony attachment points of the ligaments were detected from anatomical images of the joint and reconstructed three-dimensionally [5]. Each ligament was described by at least three lines (Fig. 1).

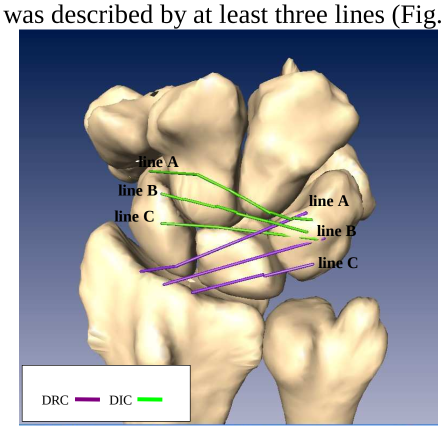

Figure 1*: Dorsal radiocarpal (DRC) and dorsal intercarpal (DIC) ligaments.*

The lengths of the ligament lines L_j in each wrist position j were calculated as shortest distance between the ligament attachments. Within the full range of the wrist joint motion maximum of the ligament length L_{max} was estimated. Using the assumption that the maximum length is associated with a maximum strain value ε_{max} and ligaments normally function within 5% strain and fail above 10% strain, the zero-load length of the ligament L_{ZF} can be calculated: $L_{ZF} = \frac{L_{max}}{1+\varepsilon_{max}}$. Ligament elongation can subsequently be estimated using the equation: $e_j = \frac{L_j - L_{ZF}}{L_{ZF}} \times 100\%$.

RESULTS

From the ligament length changes it appears that each ligament string is recruited for a specific motion of the wrist joint ($e_j > 0$). The recruitment pattern is ligament specific. For example, the extrinsic dorsal radiacarpal (DRC) ligament is recruited during dorsal flexion and not recruited at palmar flexion, while intrinsic ligament at the same side of the wrist, dorsal intercarpal (DIC), is under loading conditions during the whole flexion motion (Fig. 2). In most cases, extrinsic ligaments function as limiters of the certain wrist motion, specific for each ligament, while the intrinsic ligaments operate as permanent links of the carpal bones during joint movements.

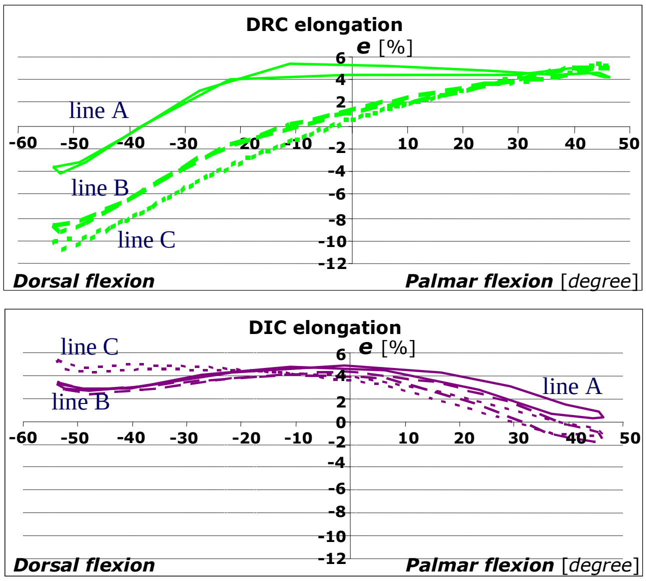

Figure 2*: Ligament elongation DRC (extrinsic) and DIC (intrinsic) ligaments at palmar/dorsal flexion of the wrist joint (assumed ε_{max} is 5%).*

DISCUSSION and CONCLUSION

With carpal kinematical and geometrical data, the zero-load ligament length can be estimated on the basis of an assumed maximum strain. Subsequently, the ligament recruitment patterns can be determined. Knowledge about wrist ligament recruitment patterns gives additional information about ligament function during joint motion.

The study confirms that the extrinsic ligaments of the wrist function as limiters of wrist motion, while the intrinsic ligaments operate as operate as fixators of the carpal bones in carpus during joint movements.

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