Articular surfaces of the proximal interphalangeal (PIP) joint of the finger, and its proper collateral ligament (PCL) fiber bundles, presented as a crossed four-bar linkage system

Koos Jaap van Zwieten (1), Klaus P. Schmidt (1), Piet P.M.M. Geusens (1,2), Stephanie De Munter (1), Lauren Kosten (1), An Hotterbeekx (1), Ivo Lambrichts (1), Peter L. Lippens (1), Peter Adriaensens (1,3)

(1) Functional Morphology, Department of Anatomy, Biomedical Research Institute, University of Hasselt, Diepenbeek, Belgium.
(2) Department of Internal Medicine, Maastricht University Medical Center, Maastricht, The Netherlands.
(3) Division Chemistry, Institute for Materials Research (IMO), University of Hasselt, Diepenbeek, Belgium.

Introduction

Combining micro-anatomy with high resolution imaging offers possibilities to perform mechanical analyses at a tissue level and at a cellular level. Starting from analyses, applied to design total knee joint prostheses (Wachowski *et al.*, 2011), we used similar approaches for the proximal interphalangeal (PIP) joint of the finger. Incongruences between the articular curvatures of the proximal phalanx´s caput and the middle phalanx´s basis were taken into account, as well as superficial and deep fiber bundles within the PIP proper collateral ligament (PCL) (van Zwieten *et al.*, 2011).

Results

Intercrossing collagen fibers of PCL are clearly visible in High Resolution MRI frontal and sagittal slices. On cellular level they could be matched to microscopic serial sections. Specific histological staining did not reveal notable differences in elasticity between the PCL bundles. Because these bundles are fully tautened during PIP flexion, and in view of their intercrossing, we could conceive the PIP joint as a crossed 4-bar linkage system. Taut bundles were modeled as solid bars, as were their solid areas of bony attachment on either phalanx.

Introducing into this 4-bar linkage model numerical values, obtained after measurements in sagittal HR-MRI slices, allowed us to construct the curvatures of the only two articulating surfaces which can perform PIP flexion by rolling relative to each other without any gliding.

Conclusion

Although deviating from normal anatomy e.g. by their "inverted ball-and-socket" characteristics, such engineering results may be useful for finely tuned "personalized artificial joints" design.

References

Wachowski MM *et al.* (2011) Construction-conditioned rollback in total knee replacement: fluoroscopic results. Acta of Bioengineering and Biomechanics, 13, 3, 35-42

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