Forward and reverse kinematic modelling of normal finger motion, compared to finger motion in entrapment neuropathy

K. J. VAN ZWIETEN [1], P. L. LIPPENS [1], J. GELAN [1], P. ADRIAENSENS [1], K. P. SCHMIDT [1], G. J. BEX [1, 2], C. THYWISSEN [3] and W. DUYVENDAK [4]

[1] *Department of Anatomy, BioMed, University of Hasselt, Diepenbeek, Belgium*
[2] *Department of Mathematics, University of Hasselt, Diepenbeek, Belgium*
[3] *Department of Radiology, Virga Jesse Hospital, Hasselt, Belgium*
[4] *Department of Neurosurgery, Virga Jesse Hospital, Hasselt, Belgium*

Normal function of the human hand is a prerequisite for most activities of daily living. Power grip and precision handling largely depend upon finely tuned finger motions. The following analysis highlights some of the underlying mechanisms of finger coordination.

Most analyses of finger interphalangeal coordination do not take into account the shifts of the different tendon fibre bundles within the extensor assembly, which occur during interphalangeal motion. This extensor assembly consists of tendon fibers of extrinsic and intrinsic finger extensor muscles. Its respective bundles are often depicted as single lines, although medial bundle and lateral bundles are flattened ribbon-like structures at proximal interphalangeal (P.I.P.) joint level. Beyond the extended joint these bundles maintain dorsal positions. Lateral bundles constitute the terminal extensor tendon of the distal interphalangeal (D.I.P.) joint.

To demonstrate some of the subsequent positions of finger flexion, a mathematical simulation model of finger motion is used (Van Zwieten *et al*., 2002). In this forward kinematic model, tendons and tendon fibre bundles are supposed to be non-elastic and non-contractile, such as ropes for instance.

P.I.P. flexion by the tendon of *m. flexor digitorum superficialis* includes a distal shift of the extensor assembly. The medial bundle thereby follows the curvature of the flexed P.I.P. joint, staying in its pulley over the joint. Compared to the medial bundle, the lateral bundles will follow shorter courses along the flexed P.I.P. joint. Extra length is thus yielded for the terminal tendon for the D.I.P. joint, which is the direct continuation of the lateral bundles. Now this terminal extensor tendon is slack enough to shift more distally. It does no longer act as an antagonist of the tendon of *m. flexor digitorum profundus* in subsequent flexion of the D.I.P. joint, thus allowing distal interphalangeal flexion simultaneous with proximal interphalangeal flexion. The lateral bundles are now located in sagittal plane. The shifts of the lateral bundles are controlled by the spiral fibre apparatus, which suspends them to the medial bundle.

Simultaneous proximal interphalangeal flexion and distal interphalangeal flexion are correlated. Plotting of the successive angles of D.I.P. flexion against corresponding angles of P.I.P. flexion, in normal intrinsic-plus fingers, results in a S-curve. In a pre-operative patient with intrinsic-minus fingers due to ulnar nerve compression neuropathy at his elbow, this S-curve appeared to be more convex to the left. The effect was most pronounced during the early phases of finger flexion.

To analyze the normal S-curves as well as those in neuropathy, forward and reverse kinematic modelling of the extensor assembly of the finger may be applied.

Reference

Van Zwieten, K. J., Lippens, P. L., Geusens, P., Kowalski, M., Sholukha, V. A., Zinkovsky, A. V. (2002) Clinical application of finger mathematical modelling. Acta of Bioengineering and Biomechanics, **4**, 1, 354, ISBN 83-7085-639-X