Quantitative measurement of proximal interphalangeal joint lateral stability using a three-dimensional motion capture system

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Background
Lateral stability of the proximal interphalangeal (PIP) joint is crucial for various activities of daily living. A full three-dimensional (3D) finger joint kinematics measure method is lacking. Therefore, the aim was to adapt a 3D motion capture system for measuring PIP joint lateral stability, and conduct pilot trials with this system in healthy volunteers as well as in a patient after surface-replacing arthroplasty to establish its reliability.

Materials & Methods
The machine-vision optical tracking system CamBar B2 C4 (Axios 3D GmbH, Oldenburg, Germany) was used for motion analysis measurements. Rigid plates with retroreflective markers were mounted onto the proximal and intermediate phalanx (Fig. 1). The proximal phalanx was fixed and a lateral bending moment in the PIP joint was generated using free hanging weights of 40, 90 and 170 grams (Fig. 2). Measurement reliability was evaluated with a test-retest (intraclass correlation coefficient (ICC)) method in ten healthy volunteers. Lateral stability measurements were also performed in a 68-year-old PIP osteoarthritis patient treated with a CapFlex-PIP implant (KLS Martin Group, Tuttlingen, Germany) five years ago.

Results
Reliability measurements showed an easy system handling with short measurement time of 20 minutes per subject as well as stable and continuous motion data, which allowed the calculation of representative deflection angles. The ICC was high with a value of 0.83. The first patient test confirmed these observations and showed a radial and ulnar deflection angles of less than 1.5 degrees (Fig. 3).

Conclusion
The current system provides a simple, fast and precise measurement of PIP joint lateral stability as well as reliable and repeatable kinematic data. It will be used in a further study to compare PIP joint lateral stability between a surface-replacing implant and silicone arthroplasty (Fig. 4).

Fig.1: Marker fixation using rigid plates, each fitted with four 3mm-diameter markers
Fig.2: Measurement set up for lateral stability with the CamBar B2 C4 and pulley device
Fig.3: Lateral stability of the PIP joint with measured deflections under alternating loads
Fig.4: a) CapFlex-PIP implant, b) Silicone implants

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