A COMPARISON OF REGISTRATION TECHNIQUES FOR COMPUTER- AND IMAGE-ASSISTED ELBOW SURGERY

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BACKGROUND

• Optimal function following elbow replacement, ligament reconstructions and dynamic external fixators is dependant on the accurate replication of the flexion-extension axis, defined by the geometric centers of the capitellum and trochlear sulcus

• Intraoperatively, the position and orientation of the axis are estimated from visual landmarks.

PURPOSE

• A surface-based registration technique, employing a hand-held laser scanner, was evaluated to determine whether it led to improved flexion-extension axis alignment.

• Our hypothesis was that the laser scanner combined with a surface registration would contribute to a more accurate axis alignment.

METHODS

• Computed tomography images of twelve fresh-frozen cadaveric distal humeri were obtained.

• To perform paired-point (PP) registration, key anatomical landmarks (capitellum, trochlear sulcus, distal and proximal humeral shaft) were digitized using a tracked probe (TP) instrumented to a receiver from an electromagnetic tracking system (Flock of Birds, Ascension Tech).

• Geometric centers were calculated using a sphere fitting algorithm and PP registration to the CT data was performed using a landmark registration technique.

• Two surface-based registrations were performed using the iterative closest point (ICP) algorithm.

RESULTS

• Registration error was lowest (p < 0.001) for the HHLS-ICP registration, with a mean of 0.8±0.3 mm in translation compared with a mean error of 1.5±0.5 mm for TP-ICP registration and 1.9 ± 1.0 mm for PP registration (Figure 2).

• Maximum inaccuracy for HHLS-ICP registration was 1.4-mm, compared with 2.4-mm for TP-ICP registration and 4.4-mm for PP registration.

• The flexion-extension axis following registration was computed and compared against the axis of the target landmarks (Figure 3).

• Errors in paired-point registration (Figure 3 (A) and (D)) were most apparent in the coronal plane while the use of the tracked probe for surface registration (Figure 3 (B) and (E)) often resulted in an error along the transverse plane.

• Varus-valgus error was most prominent for the PP registration technique while internal-external error was most prominent for the TP-ICP registration technique.

• A significant concern regarding computer assisted joint replacement surgery is the limited exposure of the joint intraoperatively. However, in most cases clinically, the majority of the articular surface will be available.

• Surface registration using the information of the articular surface was found to be consistent with studies focusing on other joints.

• Overall, the high reliability of the surface-based registration combined with the implementation of the hand-held laser scanner show promise for providing the surgeon with a valuable clinical tool.

• A reliable surface-based registration technique will lead to a more accurate determination of the elbow’s flexion axis, allowing for proper placement of the implant.

• This may well improve clinical outcomes and implant longevity following elbow replacement.

REFERENCES


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