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VALIDATION OF NAVIGATED GLENOID COMPONENT PLACEMENT: AN IN-VITRO PILOT STUDY

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Although conventional surgical instruments for alignment and placement of shoulder prostheses are widely used, there is still room for improvement with regards to placement accuracy. Computer-navigated surgery systems exist for the knee and hip, but at this time none of these cater for the shoulder. We have created a prototype system for the planning and placement of the glenoid component in total shoulder arthroplasty. Our system is based on an existing optical navigation system and several new software components that we have designed. The field of view during surgery is very limited, and therefore the major difficulty in placing the glenoid component is determining the optimal inclination and version. In a previous experimental study [unpublished] we found that an orthopaedic surgeon, experienced in shoulder arthroplasty, can make an error up to 12 degrees in placing a guide wire according to the optimal pose.

The goal of this pilot study is to investigate the accuracy of our system throughout the entire process, from planning a glenoid component to actual placement, represented by drilling a guide-wire.

Five sawbone scapulae (Sawbones Europe AB) were coated with zinc paint and were scanned by CT (0.5x0.5x0.5mm voxels). On the CT-scan for each scapula three guide-wires were planned using our pre-operative planning environment (DeVide, Delft University of Technology). In the OR two fluoroscopy images, oriented approximately 45 degrees with respect to each other, were made of each scapula using a mobile C-arm (Philips Pulsera) and a calibration ring (Brainlab AG). Each fluoroscopic image was registered to the pre-operative CT using in-house developed intra-operative 2D-3D registration software. Once a fluoroscopic image was registered, the pre-operative planning was transferred to the computer navigation system (Brainlab VectorVision) and the planned guide-wire was placed in the scapula using computer navigation. Next, carbon rods (3 mm diameter) were inserted into the drilled holes and each scapula was CT-scanned again. The pre- and post-operative CTs were registered and the intersection of the drilled holes with the glenoid surface and the direction vectors were manually indicated in each CT. The planned and drilled position and orientation of the guide-wires were compared using two measures: the distance between the planned and actual intersection with the glenoid surface and the difference angle between the planned and placed guide-wire direction.

Scapula 1 was excluded because one fluoroscopic image was processed with an incorrect software setting. Scapula 4 was excluded because a human error was made in transferring the planning. For the remaining 3 scapulae (9 holes) the mean distance (absolute value) is 2.04 mm (min 0.21, max 4.6), and the mean difference angle (absolute value) is 1.97 deg (min 0.33, max 4.3).

The numbers presented in this study represent the overall error of the entire process from planning to actual guide-wire placement, which compares favourably to the result obtained by an experienced orthopaedic surgeon using conventional instruments. This study shows that our research on pre-operative planning, intra-operative fluoroscopic registration, and computer navigated placement yields good initial results. We are convinced that this approach will benefit shoulder arthroplasty, therefore we will continue to improve and expand this research.