Accuracy of a mixed-reality intraoperative navigation system with HMD glasses in shoulder arthroplasty for baseplate positioning on cadaveric specimen

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INTRODUCTION:

Intraoperative mixed reality navigation is a new tool developed to improve the precision during shoulder arthroplasty procedures, by reproducing preoperative planing as closely as possible.

The aim of this study was to evaluate the accuracy of an intraoperative mixed reality system (Shoulder+, Pixee Medical, France) in shoulder arthroplasty for glenoid baseplate placement on cadaveric specimens.

METHODS:

Ten fresh frozen shoulders from 5 human cadavers, which were free from fractures or other bony pathologies were used. Computed tomography (CT) scans were obtained for each shoulder, and imported into preoperative planning software (*FX SPS,* Pixee medical, France), and notably to define the target inclination, version and entry point of the glenoid baseplate axis pin. Two senior shoulder-trained surgeons inserted a 1.6mm pin for glenoid baseplate positioning in each shoulder (5 per surgeon) using a mixed-reality navigation software (Shoulder+, Pixee medical, France) with Microsoft Hololens 2 headset, to replicate the planned positioning as accurately as possible. Acquisition times (from the time the coracoid sensor is positioned to the time the glenoid axis pin is inserted) were measured and intraoperative complications recorded. Postoperative CT scans were then obtained for each shoulder and the positioning of the glenoid axis pin was measured (version, inclination and entry point) and compared with the preoperative planning measurements. The deviation between the planned and achieved glenoid axis pin orientation was then measured.

RESULTS:

2 shoulders had to be excluded from the statistical analysis, due to motion of the pin during the CT- scans. The mean deviations between planned and achieved measurements were: for inclination 2.8°±2.0° (range 0.8°–6.5°), for version 2.1°±1.4° (range 0.4°–4.0°) and for entry point 2.3mm ±0.6mm, (range 1.4–3.0mm). The maximum deviation between planned and achieved measurements for all shoulders were: for inclination 6.5°, for version 4.0° and for entry point 3.0mm. The average time taken to complete all acquisitions was 10min 31sec (range 7min 33sec-12min 00sec) No complications were noted, in particular no coracoid fractures.

DISCUSSION AND CONCLUSION:

Few studies have been published on the use of AR for glenoid baseplate positioning. Sanchez-Sotelo et al recently published a cadaveric study with a comparable methodology and similar results to our own: the mean difference between planned and achieved measurements were: for inclination 1.7°±1.5°, for version 1.6°±1.2° and for entry point 1.7mm±0.8mm. The maximum deviation between planned and achieved measurements for all shoulders were: for inclination 5.0°, for version 4.1° and for entry point 3.1mm.

This mixed-reality navigation system made it possible to position the central glenoid pin with an average deviation of 2.8° for the inclination, 2.1° for the version and 2.3mm for the entry point, between preoperative planning and final positioning. The average time taken to complete all acquisitions was 10min 31sec. No coracoid fractures were reported.

Further studies are required to confirm the benefits of this technology in clinical settings.

Specimen number	Shoulder side	Planned data		Surgeon	Time		Post-op data on CT scan			Comment
		Version	Inclinaison		Insertion of Shoulder reference to drill pin insertion	Acquisition	Version	Inclinaison	Distance	
001	Right	0	0	Maxime ANTONI	11:53	03:30	-1	1,97	1,35	
003	Right	0	0	Maxime ANTONI	12:00	03:02	-1,45	1,39	2,83	
005	Right	0	0	Maxime ANTONI	10:00	05:00	0,4	-1,75	2,19	
001	Left	0	0	Maxime ANTONI	12:00	04:30				No post-op measurement due to motion of the pin during the CT- scans
003	Left	0	0	Maxime ANTONI	09:33	04:33	-2,6	5,07	2,45	
002	Right	0	6	Franck DORDAIN	12:00	03:10				No post-op measurement due to motion of the pin during the CT- scans
004	Right	0	8	Franck DORDAIN	07:33	05:10	-4,04	14,5	2,36	
002	Left	0	5	Franck DORDAIN	11:00	02:34	-3,76	5,8	2,31	
004	Left	0	2	Franck DORDAIN	08:20	03:57	0,88	-1,51	1,61	
005	Left	0	0	Franck DORDAIN	11:00	04:44	-3	-1,54	3	