Mixed Reality Holographic Assisted Placement of Guidewire in Shoulder Arthroplasty

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INTRODUCTION:

Patient specific 3D printed guides (PSI) and computer navigation are two forms of commercially available options for improved accuracy of glenoid guide pin placement during shoulder arthroplasty. Mixed reality (MR) and virtual reality devices have been utilized in medical education thus far but there has been limited assessment into their intra-operative viability in specific settings such as shoulder arthroplasty. The purpose of this study is to compare the accuracy of MR holographic model assisted glenoid guidewire placement to freehand (FH) and PSI options.

METHODS:

Sixty (60) 3D printed glenoid polyurethane saw bones models with a B2 glenoid defect were created. The 3D model of the B2 glenoid with a guide pin in place was programmed into a Unity based application installed on the Microsoft HoloLens2 mixed reality device. In randomized fashion, five surgeons placed a guide pin into the "sawbones" models using free-hand, PSI or mixed reality with the attempt to replicate the desired preoperative plan. Using fine cut CT, average version, average inclination, and starting point was analyzed amongst all models and surgeons. A priori power analsyis, assuming a Type 1 error of 0.05 and a power of 0.8, determined a sample size of 36 glenoid models would be required.

RESULTS:

Average starting point from the plan for the FH group was 2.21±0.95mm, 2.27±0.80mm for the PSI group and 1.745±0.84mm for the MR group, p=0.12. Average inclination was 10.56±7.37 degrees, 3.02±3.36 degrees, 8.16±5.69 degrees for the FH, PSI and MRI groups, respectively, p=0.0004. Average version was 13.52±9.21 degrees, 7.26±4.64 degrees, 12.36±9.19 degrees for the FH, PSI and MRI groups, respectively, p=0.04. Subgroup analysis of FH to PSI and PSI to MR demonstrated significantly less inclination from plan in the PSI group, p=0.0003 and p=0.02, respectively. There were no differences in version in the subgroup analysis between the FH and MR and PSI and MR groups. Degrees of deviation of inclination from plan was significantly less when comparing all models amongst more experienced surgeons, p=0.026, whereas no statistical differences in deviation of start point or version was noted across all models in the more experienced group. When further analyzing the inclination amongst the FH, PSI and MR groups amongst higher level surgeons, the PSI model demonstrated less deviation from plan compared to the FH model, p=0.02 but there were no differences in inclination when comparing the PSI to MR and MR to FH models.

DISCUSSION AND CONCLUSION: Mixed reality permits accurate glenoid guide pin placement comparable to freehand and instrument assisted placement in a polyurethane B2 glenoid bone substitute model.

Table 1. Comparison of all models (all experience levels)

	Avg Version (degrees)	Avg Inclination (degrees)	Avg Start Point (mm)
Freehand	13.52	10.5625	2.205
PSI	7.255	3.02	2.27
Mixed Reality	12.355	8.155	1.745
p-value	0.0371ᵃ	0.0004ᵃ·ᵇ	0.1218

ᵃ denotes significant difference between PSI and FH
ᵇ denotes significant difference between both PSI and FH, PSI and MR

Figure 4 a-c. Measurements of differences from the preoperative plan for start point (a), inclination (b), and version (c)

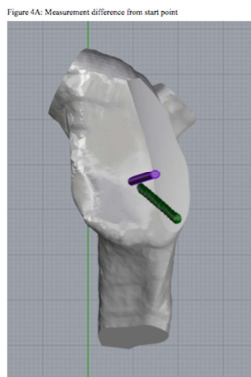Figure 4A: Measurement difference from start point
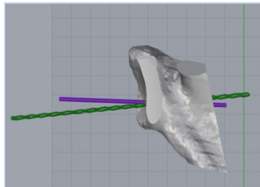
Figure 4B: Measurement difference of inclination

Figure 4C: Measurement difference of version