Mixed-Reality Improves Execution of Templated Glenoid Component Positioning in Shoulder Arthroplasty: A CT Imaging Analysis

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INTRODUCTION: Successful outcomes in total shoulder arthroplasty (TSA) are reliant on glenoid placement. Preoperative templating with three-dimensional (3D) imaging has improved implant positioning, but deviations from the planned inclination and version are still possible. Mixed-Reality (MR) is a novel technology that allows surgeons intra-operative access to 3D imaging and templates, capable of overlaying the surgical field to help guide component positioning, possibly contributing to improved surgical outcomes. The purpose of this study was to compare the execution of preoperative templates using MR versus standard instruments (SI).

METHODS: Following ethical approval, retrospective review of 97 TSAs (18 anatomic, 79 reverse) from a single high-volume shoulder surgeon between January 2021 and February 2023 was performed for patients with primary diagnoses of osteoarthritis, rotator cuff arthropathy, or a massive irreparable rotator cuff tear. To be included, the patients had to have a preoperative plan templated using planning software and had to have a postoperative computed tomography scan available. Postoperative inclination and version were measured by two independent, blinded physicians and compared to the preoperative template. From these measurements, we calculated the mean difference, standard deviation (SD), and variance to compare MR and SI.

RESULTS SECTION: Comparing 25 MR to 72 SI cases, MR significantly improved both inclination ($p<0.001$) and version ($p=0.009$). Specifically, MR improved the mean difference from preoperative templates by over 2º in both planes, narrowed the SD (by 2º inclination, 1.1º version), and decreased the variance (13.4 to 1.7 inclination, 21.8 to 12.9 version). The scatterplot demonstrated most of the MR executed cases were within 5º of the plan, while many more of the SI executed cases with within 10º of the plan.

DISCUSSION: MR improved the accuracy and precision of glenoid positioning. Although it is unlikely that 2º makes a detectable clinical difference, our results demonstrate the potential ability for technology like MR to narrow the bell curve and decrease the outliers in glenoid placement. This will be particularly relevant as MR and other similar technologies continue to evolve into more effective methods in guiding surgical execution.

SIGNIFICANCE/CLINICAL RELEVANCE: MR is a novel tool in the field of shoulder arthroplasty that can act as an alternative to other preoperative templating software that utilizes 3D imaging. This study serves as a foundation for future development of MR and other similar technologies as effective tools in shoulder arthroplasty.

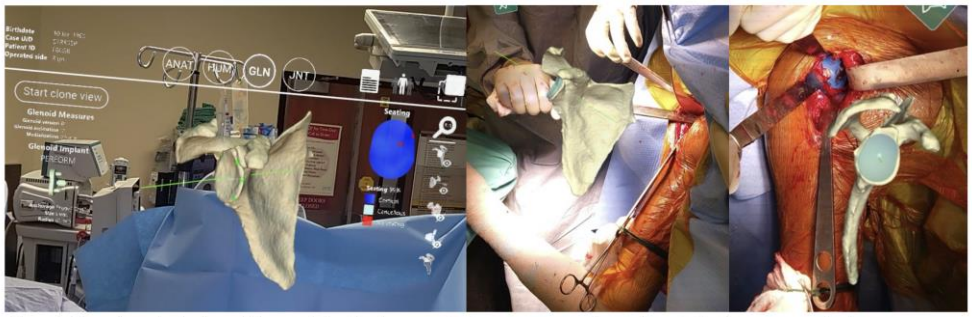

Figure 2: Views from the headset. Using touch-free hand commands, the surgeon may place and manipulate images to overlay the exact anatomy, be near the field, or remain in the periphery.

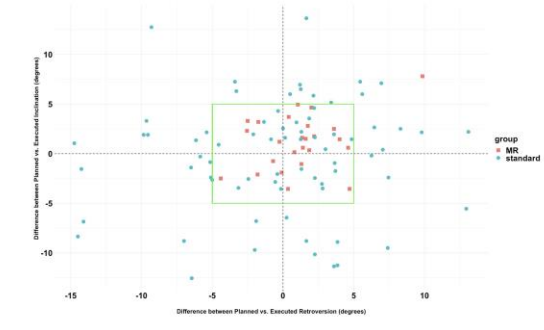

Figure 6: Scatter plots of postoperative deviation from plan for patients with standard instrumentation and those with mixed reality. Note the relative preponderance of values with a deviation of 5 degrees or less in retroversion or inclination (green box) in the MR group.

Table 2. All cases

		Mean difference	SD	Variance	*p-value*
	MR	2.4	1.7	3	
Inclination	*Standard*	4.3	3.4	11.7	***<0.001***
	MR	2.3	2.1	4.3	
Version	*Standard*	4.7	3.9	14.9	***<0.001***