Introduction and Purpose

- Deviations from the preoperative plan, specifically in the initial placement of the K wire, can directly affect the performance and reliability of the implant and the postoperative quality of life for the patient.
- “The durability of implants in total shoulder arthroplasty depends largely on the stability of the glenoid component” (Theopold et al., 2021).
- Digital navigation within the glenoid seeks to improve upon the freehand approach by allowing for a more accurate and reliable method of K wire insertion.
- Other studies using the same navigation system for the humeral component have shown registration error of 2.5±1.2 mm (Cavanagh, Athwal, Johnson and Langohr, 2021) for a single known point on the humeral head.
- The purpose of this work was to validate a navigation tool for the glenoid component. To do this an accurate workflow is required. Inaccuracies between the tool and patient will directly manifest in the placement of the implant.

Methods

- To evaluate the relative accuracy of the three proposed workflows, each workflow was conducted on the same intraoperative registration data set, repeated for all seven specimens.

Workflow 1:
- Performs a landmark registration of the 6 and 12 clock points to initialize ICP registration of the glenoid rim, which in turn initializes ICP of the STL vertices for the entire model.

Workflow 2:
- Performs a landmark registration using SIAP points of the glenoid rim to initialize ICP registration of the glenoid rim, which in turn initializes ICP of the STL vertices for the entire model.

Workflow 3:
- Performs a landmark registration of the first and last points of a coracoid trace, including the lateral most point of the coracoid to initialize ICP registration of the coracoid trace, which in turn initializes ICP of the STL vertices for the entire model.

Results

- During registration, the Superior, Inferior, Anterior and Posterior (SIAP) screw points were digitized as the concave nature of the screw heads provides a repeatable probing point for the tip of the K wire insertion tool.
- The intraoperative data points had the resulting T matrix from each workflow applied to convert them back into the preoperative space.
- The navigational error is the difference between the known and converted coordinates of the SIAP screw head locations.
- Due to the orientation of the model in the preoperative space, navigation need only be accurate in the XY plane, as the Z axis is irrelevant to the tip placement and the angle of an inserted K wire.
- Workflow 1 had large inaccuracies across the SIAP screw locations. The maximum deviation in the X axis was 80.6 mm and the maximum deviation in the Y axis was 41.2 mm. The standard deviation for the XY error vector for each of the SIAP screw locations was 15.3 mm, 15.9 mm, 20.2 mm, and 27.3 mm respectively.
- Workflow 2 had relatively small inaccuracies across the SIAP screw locations. The maximum deviation in the X axis was 2.2 mm and the maximum deviation in the Y axis was 3.1 mm. The standard deviation for the XY error vector for each of the SIAP screw locations was 0.9 mm, 0.8 mm, 0.8 mm, and 1.4 mm respectively.
- Workflow 3 had large inaccuracies across the SIAP screw locations. The maximum deviation in the X axis was 65.5 mm and the maximum deviation in the Y axis was 61.1 mm. The standard deviation for the XY error vector for each of the SIAP screw locations was 22.3 mm, 28.3 mm, 5.9 mm, and 24.2 mm respectively.

Overall workflow two proved to be the most accurate with a registration error of 1.7±1.0 mm. This result is consistent with the degree of error found in [2] for the humeral component of the shoulder and proves that digital navigation can be used as a means of limiting error in the placement of shoulder implants.

References