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Reliability and accuracy of the NextAR Shoulder[®], an augmented reality surgical platform for intraoperative guidance

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1. Introduction

Reverse total shoulder arthroplasty is increasingly performed worldwide. Proper placement of the glenoid baseplate is essential to ensure biomechanical stability, functional outcomes, and avoid complications. Inaccurate retroversion or inclination can compromise implant longevity. Technologies such as navigation systems and augmented reality (AR) platforms have emerged to improve placement accuracy. Navigation-assisted AR, such as the NextAR Shoulder[®] system, provides real-time visual feedback by overlaying the preoperative plan onto the surgical field. While such systems have shown promising results, their impact on performance across different levels of experience is underexplored.

This study evaluated the reliability and accuracy of glenoid baseplate placement using the NextAR Shoulder[®] system compared to the freehand technique. Specifically, we assessed whether it improves reliability and accuracy (deviation from target orientation) using sawbones across three experience levels.

2. Methods

2.1 Procedure

Left scapula sawbones (solid foam) from the same mold were used. Preoperative planning was performed using MyShoulder (Medacta Intl., Switzerland), targeting 0°

of retroversion and -5° of inclination. Each sawbone was mounted in a 3D-printed support. Glenoid component placement was then performed using the Medacta shoulder system, including a 25-mm baseplate, one central peg, and two screws. Placement followed classical steps defined by Boileau et al. (2005). Two techniques were compared: Freehand (T1), where surgeons had access to the plan but no feedback, and NextAR Shoulder[®] (T2), which provided real-time visual feedback to guide alignment. Nine operators (3 per group: G1 = Expert, G2 = Intermediate, G3 = Beginner) each performed 3 trials per technique. After placement, sawbones were scanned by a unique operator (ATOS Q, Zeiss, Germany) to compute through an automatic process baseplate retroversion and inclination.

2.2 Statistical analysis

Normality testing using the Shapiro-Wilk test revealed that retroversion measures were normally distributed ($W = 0.981$, $p = 0.563$), whereas inclination measures deviated significantly from normality ($W = 0.915$, $p < 0.001$). Given this, and considering the limited sample size of the study, all subsequent statistical analyses were performed using non-parametric methods.

To assess the reliability of each technique, inter-operator and intra-operator variabilities were analysed separately within each group. Variance components

were estimated using linear mixed-effects models (lmer, lme4 v1.1-36, R v4.4.2, RStudio 2024.12.0), with the operator parameter defined as a random effect. To statistically compare variances between techniques, two-sample permutation tests were conducted (one-way.test, stats v3.6.2, R v4.4.2, RStudio 2024.12.0; 10,000 resamples). For each comparison, an effect size was calculated as the relative change in standard deviation between techniques.

To assess the accuracy (validity) of each technique, the absolute difference between measured and target angles was analysed. The target angles were 0° of retroversion and -5° of inclination.

3. Results and discussion

Overall, 54 baseplate installations were performed (3 groups x 3 operators x 2 techniques x 3 trials). The resulting measurements were merged per group and technique (Figure 1).

3.1 Reliability

T2 was associated with a reduction in total variance across most groups, both for retroversion and inclination. For retroversion, the total variance significantly decreased in G2 (from 21.4° to 3.1°, $p = 0.024$, effect size = 0.90) and G3 (from 37.5° to 7.4°, $p = 0.004$, effect size = 0.77), indicating improved reliability. For inclination, the total variance decreased in all groups, though significance was reached only in G3 (from 43.3° to 9.8°, $p = 0.002$, effect size = 0.89). The inter-operator variability consistently decreased with T2, particularly in G2 (retroversion: from 12.6° to 0.2°, $p = 0.217$; inclination: from 0.0° to 0.0°, $p = 0.589$) and G3 (retroversion: from 33.5° to 0.0°, $p = 0.655$; inclination: from 33.5° to 0.0°, $p = 0.597$), though these differences were not statistically significant. The intra-operator variability remained stable across techniques and groups, with no significant differences observed (all $p > 0.300$).

3.2 Accuracy

T2 was associated generally with a reduced median bias in both retroversion and inclination across all groups. For G1, bias decreased for both angles (retroversion: 3.4° to 1.9°; inclination: 4.0° to 0.7°). For G2, retroversion bias increased (0.0° to -2.5°), while inclination bias decreased (3.8° to 1.1°). G3 showed the most notable improvements, with a bias reduced for both retroversion (3.6° to -1.4°) and inclination (14.8° to -1.8°).

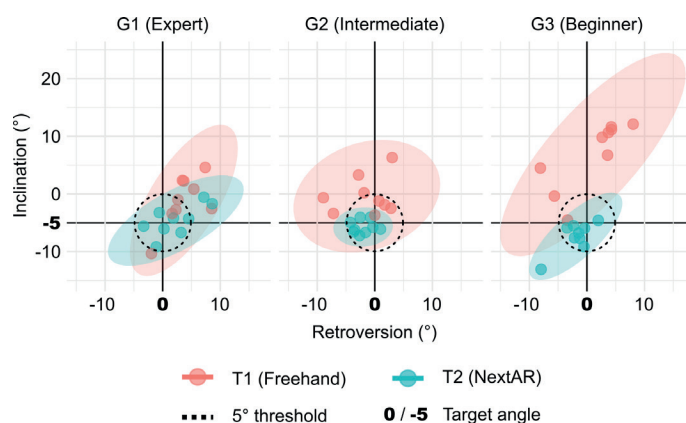


Figure 1.

The proportion of baseplates placed within 5° of the surgical planning (Figure 1) increased with the use of T2: from 33.3% to 77.8% for G1, from 44.4% to 100% for G2, and from 11.1% to 88.9% for G3.

4. Conclusions

This study demonstrated the potential of the surgical platform for intraoperative guidance NextAR Shoulder® to increase reliability and accuracy in terms of baseplate retroversion and inclination. These improvements mainly concern intermediate and beginner users, while having a limited influence on the expert practice. Future studies should involve a wider range of operators to validate these results and explore why the platform's benefits are more pronounced for intermediate and beginner users than for experts.

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Conflict of Interest Statement

Elda Paoli is employed at Medacta International. Chiara Munegato is employed at Medacta International. Nicolas Holzer works as paid consultant for Medacta International.

Contributor Roles

FM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Validation, Visualization, Writing-original draft, Writing-review & editing; CB: Formal analysis, Investigation, Writing-review & editing. EP: Investigation, Methodology, Resources, Writing-review & editing. CM: Resources, Supervision, Writing-review

& editing. RG: Investigation, Writing-review & editing. GC: Investigation, Writing-review & editing. BC: Investigation, Writing-review & editing. NH: Conceptualization, Investigation, Project administration, Resources, Supervision, Validation, Writing-review & editing.

Data, software, code availability

https://github.com/fmoissenet/Reliability_validity_NEXTAR

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