Accuracy of an Augmented Reality Spine Surgery Guidance System with Stereoscopic Targeting Head Mounted Display Compared to Standard Computer Navigation, Robotic Systems, and Existing AR Systems

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Fig. 1: OnPoint AIm-AR system.

Introduction

Augmented Reality (AR) offers the benefit of improved hand-eye coordination by accurately superimposing 3D stereoscopic displays for surgical instruments onto anatomic landmarks.

Objectives

To compare the accuracy of a 4k resolution AR system with novel 3D stereoscopic targeting with existing navigation, robotic and AR systems for implanting thoracic and lumbar pedicle screws.

Methods

120 pedicle screws were implanted using a novel AR system (OnPoint AIm-AR, OnPoint Surgical, Bedford, MA) (thoracic 50, lumbosacral 70; pre-op CT 40, O-arm 80) (Fig. 1).

Heary grading was applied by an independent radiologist assessing the degree of pedicle breaches. 3D measurements of positional error (PE) and angular error (AE) were performed by comparing post-operative CT scans of implanted screws with planned trajectories (Fig. 2). Statistical analyses compared PE and AE for OnPoint AR with the data for other systems using an unequal variance t-test method.

	PE (mm)		AE (degrees)		Sample size
	Mean	Standard Deviation	Mean	Standard Deviation	
Intra-op CT / 3D spin	1.07	0.49	1.29	0.51	80
Pre-op CT	1.92	1.19	2.24	1.32	40
All data	1.35	0.88	1.61	0.98	120

Fig. 3: OnPoint AIm-AR system: Means and 1 SD for positional error (PE) and angular error (AE).

Results

113 screws placed demonstrated Heary grade 1 accuracy. 6 screws had a larger diameter than the pedicle and were planned with in-out-in technique with Heary grade 2 accuracy. One screw demonstrated a 1mm lateral breach (grade 2) caused by a loose connection to the screwdriver.

PE and AE (mean ± 1SD) for OnPoint AIm-AR were the following: for intra-operative spin 1.1mm±0.5mm and 1.3°±0.5°; for pre-operative CT 1.9mm±1.2mm and 2.2°±1.3° (Figs. 3&4). Percent increment in PE and AE for Medtronic Stealth Station, Brainlab navigation, Stryker nav3i, Medtronic Mazor X robot, Globus Excelsius robot, Augmedics Xvision, and Novarad VisAR compared to OnPoint AR ranged between 40–80% (Fig. 5), with differences being highly significant for all comparisons (Fig. 5).

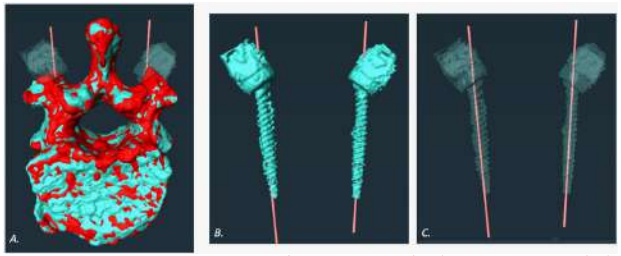

Fig. 2: OnPoint AIm-AR system: A. Registration of intra-operative spin (cyan) with post-operative CT (red). B.&C. Comparison of post-operative screw position (cyan) with intra-operatively planned trajectories (pink); screws are shown with greater transparency in C.

Conclusions

PE and AE for placing pedicle screws are statistically significantly smaller for the novel AIm-AR system compared to existing navigation, robotic, and AR systems. A positional error of 1.1mm and angular error of 1.3° makes this technology particularly suited for small pedicles, challenging anatomy and MIS techniques.

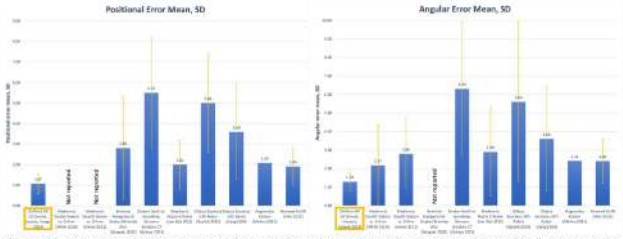

Fig. 4: PE and AE (mean, 1SD) for OnPoint AR, Medtronic Stealth Station, Brainlab navigation, Stryker nav3i, Medtronic Mazor X robot, Globus Excelsius robot, Augmedics Xvision, and Novarad VisAR.

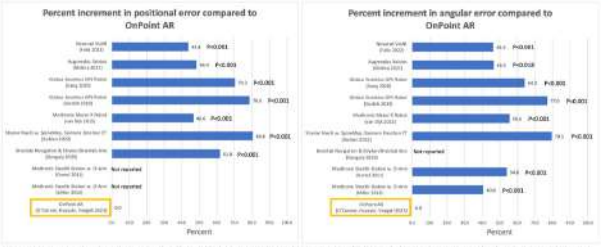

Fig. 5: Percent increment in PE and AE and statistical significance for Medtronic Stealth Station, Brainlab navigation, Stryker nav3i, Medtronic Mazor X robot, Globus Excelsius robot, Augmedics Xvision, and Novarad VisAR compared to OnPoint AR.

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