Comparison of Robotic, CT-Navigated, and Freehand Approaches of Screw Fixation in Correction of Deformity: How Have Outcomes Improved?

Samuel K Ezeonu¹, Nicholas Scott Vollano¹, Juan Rodriguez-Rivera, Alyssa Capasso, Constance Maglaras, Tina Raman², Themistocles Stavros Protopsaltis³

¹NYU Langone Health, ²NYU Langone Orthopedic Hospital, ³NYU Hospital For Joint Disorders

INTRODUCTION: While various studies have demonstrated the efficacy of robotically assisted and navigated screw placement for improved accuracy and outcomes, there still lacks a consensus of whether such systems are still applicable in more complex cases involving deformity. The purpose of the present study was to compare robotic-guided (RG), CT-navigated (NAV), and freehand (FH) placement of pedicle screws in spine deformity and assess trends in clinical outcomes.

METHODS: Patients \geq 18 years of age undergoing deformity correction surgery defined as 5 \geq levels fused were reviewed for surgical characteristics including procedural complexity (number of instrumented levels, use of PSO, interbody placement, and pelvic fixation), complications, 2-year revisions, and screw accuracy. Pedicle screw placement was assessed from postoperative CT-scans. Screw accuracy was measured using the Gertzbein-Robbins classification from grades A-E scale based on the extent by which the screw breached the cortex of the pedicle. Screws were categorized as malpositioned if graded C-E. Post hoc analyses were conducted when significance was found in initial ANOVA and chi-square tests.

RESULTS: 237 patients were included (29 RG, 50 NAV, 158 FH) with a total of 2372 screws reviewed. Comparison of patient characteristics demonstrated that NAV had older patients than FH, RG and NAV had more patients undergoing revision surgery than FH, RG had a higher BMI than FH, and NAV had a higher CCI than RG and FH (all p<0.05). No differences were observed in surgical complexity between each approach. Patients within the FH group were found to experience significantly more EBL than RG (p< 0.05) with a higher incidence of mass blood loss defined as greater than 2L. Further analysis of surgical outcomes showed that NAV exhibited longer operative times compared to FH (p<0.001). In the radiographic screw analysis, multinomial regression revealed that RG and NAV exhibited a significantly lower rate of Grade C-E breaches compared to FH (5.5% vs. 6.6% vs. 13.8% respectively; p< 0.05). FH was also found to have a significantly higher percentage of patients with acute onset of radiculopathy due to screw breach (p< 0.05), along with an increased rate of return to OR for screw revision compared to the other groups.

DISCUSSION AND CONCLUSION: The advent of robotic and navigational technology in the setting of ASD represents a significant shift in the innovation of spine surgery. As we found in the current report, both robotic and CT-navigated pedicle screw placement were both able to offer significant improvements in accuracy and result in a reduction of screw-related symptoms and revisions compared to freehand. These findings demonstrate that for experienced surgeons, adoption of robotic-guided and CT-assisted systems are effective options towards improving the safety and quality of deformity

	Table 1: Patient and Surgical Outcomes Between Robot-Guided, CT-Navigated, and																
	Freehanded Approaches of Screw Placement in Deformity						Table 2: Perioperative and 2-Year Outcomes					Table 2: Padicla Scraw Outcome Appluris					
		Robot-Guided	CT-Navigated	Freehand		Le	angth of Stay (days)	8.38±4.15	8.72±3.80	7.52±4.43	0.180			Table 5: Pedicle 5	uew Outcon	ie Analysis	
~		(N= 29)	(N=50)	(N=158)	p-value	To	otal Intraoperative Complications	8(27.6%)	20(40.0%)	76(48.1%)	0.101			Robot-Guided	Navigated	Freehand	I I
	Are (years)	63.00±10.04	67.94±8.61	57.73±17.73	<0.001		Incidental Durotomy	2(6.9%)	8(16.0%)	13(8.2%)	0.233			(N=29)	(N=50)	(N=158)	p-value
	Geoder (%E)	65.50%	68.00%	68.40%	0.956	-	Neuromonitoring Change	D(0%)	1(2.0%)	0(0%)	0.147			. ,	. ,	. ,	P
	RAI	81 21+7 04	28 16+5 84	27.49+6.99	0.024	To	otal Postoperative Complications	13(44.8%)	18(36.0%)	38(27.0%)	0.121		10 10 10 10 10 10 10 10 10 10 10 10 10 1				I I
\sim	101	216.016	2.00.0.40	0.46-0.60	0.405	_ L	Cardiao	4(13.8%)	30(20%)	7(4.4%)	0.002		Available				
	ASA	Z.00±0.55	2.00±0.49	2.40±0.08	0.185		Pulmonary	5(17.2%)	6[12.0%]	11[7.0%]	0.163		Postoperative CT	16 (55.2%)	30 (60.0%)	83 (52,5%)	0.650
	ca	Z.66±1.70	4.06±1.58	2.46±0.68	<0.001		Neurological Deficit	0(0%)	1(2.0%)	11(7.0%)	0.157		Come Desidence of	252	C24	4407	
	Diabetes Mellitus	6.90%	14.00%	13.30%	0.604		DVT	2(6.9%)	1(2.0%)	4(2.5%)	0.401		screws Reviewed	253	0.94	1965	
	Current Smoker	0.00%	4.00%	5.10%	0.458		lleus	5(17.2%)	4(8.0%)	11(7.0%)	0.185		Grade A-B	23(94.5%)	598(93.4%)	1280(85.2%)	<0.001
2009 2020 2021 2022	Revision Surgery	17(60.7%)	27(54.0%)	53(33.5%)	0.003		Urinary	4(13.8%)	5(10.0%)	5(3.2%)	0.052		Grade C-E	14(5.5%)	41(6.6%)	205(13.8%)	<0.001
Mulpositioned -Fobot (T-Navigated	Instrumented Levels	9.55±3.69	10.50±3.15	10.76±3.26	0.192	Re	eoperation Within 2 Years	9(32.1%)	15(30.6%)	55(35.3%)	0.818		Der Kommer und der				
NUMBER OF A DATE OF A DATE OF A DATE OF A	PSD performed?	6.90%	12.00%	15.20%	0.457		Hardware Complication	2(6.9%)	6(12.0%)	30(19.0%)	0.180		Patients with				I I
of Pedicle Screws by Navigated Approach and Rates of Screw Malposition in	Pelvic Fixation	75.90%	78.00%	70.90%	0.573		Strew Revision	0(0%)	0(0%)	20(6.3%)	0.074		Symptomatic				
ingle institution from 2018 to 2022. The black and gray lines depict rates of	Interbody Placed	16(55,2%)	34(68.0%)	53,20%	0.180		DeepInfection	3(\$0.3%)	2(2.0%)	4(2.5%)	0.084		Screw Breach	1(6.3%)	3(10.0%)	26(32.1%)	0.011
erall rate of mal-positioned screws by year. Within the time period, the	Estimated Blood Loss (mi	1301.72±963.39	1628.76±1477.4	2106.28±1766.54	0.023		Fracture	0(0%)	2(4.0%)	5(3.25)	0.577						
obetic and CT-navigation in deformity surgery contributed to a drop in screw	Operative Time (min)	490.34±138.92	572.54±144.12	446.37±147.34	<0.001												