

Navigated and Robotic-Assisted Pedicle Screw Placement are More Cost-Effective than Freehand Technique for Posterior Spinal Fusion in Pediatric Idiopathic Scoliosis: A Payer's Perspective

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INTRODUCTION:

Freehand (FH) pedicle screw placement has been associated with screw malposition rates greater than 5% in pediatric patients with idiopathic scoliosis (IS) undergoing posterior spinal fusion (PSF). More recent technologies such as image-guided intraoperative navigation (NAV) and robotic-assisted navigation (RAN) increase pedicle screw placement accuracy and safety profiles compared to FH. However, the utilization of NAV for PSF in patients remains below 5% in the United States, and the cost-effectiveness of both NAV and RAN remains unstudied in this patient population. The primary aim of this study was to determine the cost-effectiveness of NAV compared to FH from a payer's perspective, and determine any net cost-savings to the payer associated with NAV. The secondary aim was to determine the cost-effectiveness of RAN compared to FH and RAN compared to NAV.

METHODS:

A decision-analysis model for a cost-utility analysis of FH/NAV/RAN for pediatric patients with IS was created in TreeAge Pro (Figure 1). Probabilities of health states (uncomplicated course, post-operative neurological injury, superficial/deep infection, revision), associated reimbursement costs, and quality-adjusted life years (QALYs) were estimated from literature (Table 1). Ten thousand second-order Monte Carlo simulations were used for probabilistic sensitivity analysis. For each technique, incremental cost-utility ratio (ICURs), net costs, incremental net monetary benefit, net monetary benefit, and QALYs were calculated. Statistical analysis was used to compare metrics between techniques. Cost-effectiveness acceptability (CEA) curve analysis was performed by varying WTPT between \$10,000 to \$250,000. Deterministic sensitivity analysis (DSA) was performed by varying probabilities, QALYs, and costs. For cost-effective treatment strategies, cost savings to payers, if present, were calculated over a 10-year horizon with 100% utilization, based on prior data demonstrating that 1768 IS patients undergo PSF per year.

RESULTS:

When compared to FH technique, the ICUR of RAN (\$10,672/QALY) and NAV(-\$108,831/QALY) were below the societal willingness-to-pay threshold (WTPT) of \$50,000. RAN was not more cost-effective than NAV (ICUR: \$255,518/QALY) at a WTPT of \$50,000. However, CEA demonstrated that RAN was the most cost-effective strategy for all WTPTs above \$50,000 (Figure 3). The mean cost of NAV per patient was lower than FH by \$3610 (95% CI: \$3419 - \$3801; $p < 0.001$). Mean cost of RAN per patient was higher than FH by \$527 (95% CI: \$267 - \$786; $p < 0.001$) and NAV by \$4137 (95% CI: \$3953 - 4320; $p < 0.001$). DSA demonstrated sensitivity to $< 25\%$ of variables, indicating a robust analysis. Widespread adoption of NAV over FH could result in \$64 million in cost savings for the payer over the next decade.

DISCUSSION AND CONCLUSION:

Previous studies in adults undergoing spinal fusion suggest that NAV and RAN are more cost-effective than FH. We demonstrate that in pediatric patients with IS undergoing PSF, NAV is more cost-effective compared to FH at WTPT of \$50,000 and widespread adoption of NAV over FH could result in \$64 million in cost savings for the payer over the next decade. RAN is more cost-effective than FH at a WTPT of \$50,000, and is more cost-effective than both NAV and FH at WTPTs above \$50,000. Payers should consider increasing reimbursement coverage for NAV and RAN, and provide additional incentives to both physicians and hospitals utilizing these technologies. Payer support of NAV and RAN for patients with pediatric IS undergoing PSF could offset the capital costs faced by hospitals, which currently hinder the adoption of these technologies.

Table 1. Net probabilities, costs, and QALYs for each health state, stratified by technique.

	*Net Probability (% ± SD, Range)	Net Costs (\$)	Net QALYs
FH			
Uncomplicated Course	94.33±1.91, (91.92-98.13)	60,533.55	22.9
Neurological Injury	0.38±0.23, (0-1.87)	1,952,045.73	19.3
Deep Infection	0.21±0.22, (0-0.50)	126,043.91	11.72
Superficial Infection	0.44±0.24, (0-0.80)	82,428.83	17.41
Revision	2.35±1.44, (0-0.70)	12,1067.1	22.7
NAV			
Uncomplicated Course	96.7 ± 1.76, (94.7-100)	60,846.51	22.9
Neurological Injury	0.22 ± 0.09, (0-0.29)	1,952,338.69	19.3
Deep Infection	0±0	126,356.87	11.72
Superficial Infection	0.44 ± 0.25, (0-0.59)	82,741.79	17.41
Revision	1.35 ± 0.78, (0-5.3)	121,693.02	22.7
RAN			
Uncomplicated Course	96.85±3.58, (88.89-98.56)	60,846.51	22.9
Neurological Injury	0.46±0.48, (0-0.93)	1,952,338.69	19.3
Deep Infection	0±0	126,356.87	11.72
Superficial Infection	0±0	82,741.79	17.41
Revision	0.48±0.64, (0-0.818)	121,693.02	22.7

Level of Evidence: Economic and Decision Analysis Level IV

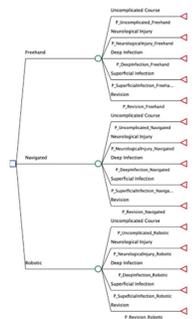


Figure 1. Decision-analysis model depicting health states for each technique. Prefix "P" denotes probability.

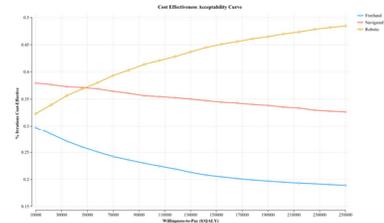


Figure 2. Cost-effectiveness acceptability curve varying willingness-to-pay threshold between \$10,000/QALY to \$250,000/QALY