

Risk Factors for Rod Fracture in Degenerative Adult Spinal Deformity: Emphasis on Postoperative Spinopelvic Parameters

Aidan Lindgren¹, Mirbahador Athari¹, Daniel Rusu¹, Kevin Mathew¹, Henry Avetisian¹, William J. Karakash¹, Marc A. Abdou¹, Jeffrey C. Wang¹, Ram K. Alluri¹, Raymond J. Hah¹
 Department of Orthopaedic Surgery, Keck School of Medicine of the University of Southern California, Los Angeles, California.
 arlindgr@usc.edu

Disclosures: Aidan Lindgren (N), Mirbahador Athari (N), Daniel Rusu (N), Kevin Mathew (N), William J Karakash (N), Henry Avetisian (N), Jeffrey C. Wang (Biomet, Novapproach, Seaspine, Synthes, GS Medical, DepuySynthes, Bioretec, Bone Biologics, Electrocore, PearlDiver, Surgitech, Illuminant), Ram K. Alluri (Orthofix, eCential Robotics, Globus, Medtronic, HIA technologies, NeoOnc, ATEC, Max BioPharma), Raymond J. Hah (ATEC, NuVasive, Medtronic, Globus, Orthofix, SI-Bone, Cerapedics, Evolution Spine).

INTRODUCTION: Adult spinal deformity (ASD) is associated with pain, disability, and impaired quality of life, for which corrective surgery is often necessary. Although advances in surgical techniques and instrumentation have improved outcomes, implant-related complications such as rod fracture remain a major concern. Rod fracture can result in loss of correction, pain, and need for revision surgery. Prior studies have reported rod fracture rates ranging from 5% to 11% and identified risk factors including higher body mass index (BMI), osteotomy, use of iliac screws, smaller rod diameter, and greater sagittal malalignment. However, limited data exist on how postoperative radiographic alignment influences fracture risk.

METHODS: We performed a retrospective cohort study of ASD patients treated with posterior spinal fusion involving ≥ 5 instrumented levels at a single university-affiliated academic medical center between 2013 and 2023. Patients undergoing surgery for tumor, infection, trauma, or pathologic fractures were excluded. Demographic, clinical, operative, and radiographic variables were collected from a prospectively maintained database. Radiographs were reviewed at baseline, early postoperative, and 1-year follow-up. Rod fracture was defined as radiographic evidence of rod discontinuity. Spinopelvic parameters measured on radiographs included lumbar lordosis (LL), pelvic tilt, pelvic incidence (PI), and modified pelvic femoral angle (mPFA). Patient-reported outcomes were assessed using the Oswestry Disability Index (ODI). Logistic regression analyses were used to identify predictors of rod fracture, with model calibration and discrimination evaluated using the Hosmer–Lemeshow test and area under the receiver operating characteristic curve (AUC). This study was approved by an institutional review board (HS-23-00758).

RESULTS: A total of 138 patients met inclusion criteria, of whom 41 (29.7%) developed rod fracture during follow-up. Demographic characteristics, including age, sex, BMI, ASA class, and smoking status, were not independently associated with fracture. Preoperative radiographic parameters demonstrated no significant associations. In contrast, postoperative radiographic variables were predictive: greater lumbar lordosis (OR 1.12, $p = 0.034$), increased pelvic tilt (OR 1.17, $p = 0.028$), and higher PI–LL mismatch (OR 1.09, $p = 0.050$) significantly increased fracture risk, whereas larger rod diameter was protective (OR 0.0093, $p = 0.014$). Reduction in mPFA showed a trend toward decreased fracture risk ($p = 0.069$). The postoperative model demonstrated good calibration (Hosmer–Lemeshow $p = 0.64$) and acceptable discrimination (AUC = 0.77).

DISCUSSION: Rod fracture occurred in nearly one-third of ASD patients, a higher incidence than previously reported (5–11%), likely due to analyzing an older cohort of ASD patients. While prior studies emphasized BMI, osteotomy, and iliac fixation as risk factors, our findings highlight the importance of postoperative sagittal alignment—specifically increased lumbar lordosis, pelvic tilt, and PI–LL mismatch—in influencing rod durability. These results suggest that rod fracture is strongly mediated by biomechanical loading across fused segments and may be mitigated by optimizing sagittal correction and using strategies such as larger-diameter or multi-rod constructs.

SIGNIFICANCE/CLINICAL RELEVANCE: Rod fracture is a common and challenging complication following adult spinal deformity surgery, occurring in nearly one-third of patients in this study. Our findings emphasize the critical role of optimizing postoperative sagittal alignment to reduce rod stress and improve implant durability, providing actionable insights for surgical planning and construct selection.

CHARACTERISTIC	OVERALL (N = 138)	ROD FRACTURE (N = 41)	NO ROD FRACTURE (N = 97)	P-VALUE
AGE AT SURGERY (YEARS)	63.3 ± 10.7	64.0 ± 6.8	63.0 ± 12.0	0.510
BMI (KG/M ²)	27.6 ± 5.8	28.8 ± 5.3	27.1 ± 5.9	0.112
NO. INSTRUMENTED LEVELS	12.7 ± 3.5	13.8 ± 3.6	12.1 ± 3.4	0.014
FOLLOW-UP (MONTHS)	47.3 ± 7.2	48.2 ± 0.8	46.9 ± 8.5	0.127
GENDER				0.706
- MALE	99 (71.7%)	28 (68.3%)	71 (73.2%)	
- FEMALE	39 (28.3%)	13 (31.7%)	26 (26.8%)	
TOBACCO USE				
- No	84 (65.6%)	24 (63.2%)	60 (66.7%)	
- YES	9 (7.0%)	4 (10.5%)	5 (5.6%)	
- FORMER	35 (27.3%)	10 (26.3%)	25 (27.8%)	
OSTEOTOMY PERFORMED	124 (89.9%)	36 (87.8%)	88 (90.7%)	0.834
INTERBODY FUSION	63 (46.0%)	15 (36.6%)	48 (50.0%)	0.209

Table 1. Baseline demographic and clinical characteristics of patients undergoing adult spinal deformity surgery, stratified by rod fracture status. Values are presented as mean ± standard deviation for continuous variables and number (percentage) for categorical variables. P-values represent comparisons between patients with and without rod fracture.