Is Cortical Breach at the Upper Instrumented Vertebra Associated with Increased Risk of Proximal Junctional Kyphosis?

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INTRODUCTION: Proximal junctional kyphosis (PJK) is a challenging complication following adult spinal deformity (ASD) surgery. For this reason, several studies have looked to identify preventative measures. While some studies have suggested that characteristics of the upper instrumented vertebra (UIV) have association with PJK, less is known about the impact of screw cortical breach. The aim of the present study was to investigate the relationship between pedicle screw positioning and cortical breach at the UIV with onset of PJK.

METHODS: Patients ≥ 18 years of age undergoing ASD correction surgery with 5 ≥ fused levels were chart reviewed up to their 2-year follow-up and were designated into each group based on PJK progression following surgery. PJK was defined by a Cobb angle ≥10° between the UIV and two vertebrae cephalad and a ≥10° kyphotic change from preoperative measurement. PJF was defined for patients with a change ≥ 20° or who required revision due to severe symptoms. Placement and trajectory of pedicle screws at the UIV were assessed at the first postoperative radiographic and CT-imaging. Medial or lateral breach was categorized if screw breach was ≥ 2 mm on either respective side of the pedicle tract at the UIV. Endplate breach was classified if any part of the screw tip surpassed the superior endplate at the UIV. Pedicle screw trajectory (UIV-PVA) was measured as the mean of the two angles between the UIV superior endplate and both UIV pedicle screws. A positive value for UIV-PVA indicated a cranially-directed screw, and negative value indicated a caudally-directed screw. ROC analysis for UIV-PVA with respect to incidence of PJK performed to determine a cutoff point at 2.58°. T-test, chi-squared analysis, and multivariate regression were performed for comparison of patient and radiographic characteristics between groups to determine significant predictors of PJK.

RESULTS:

86 patients were included in the study. Of these, 31 patients demonstrated evidence of PJK (36%). No significant differences were observed in baseline, surgical, or radiographic alignment parameters. While no statistical differences were found in rates of medial or lateral screw breach at the UIV, incidence of endplate breach was found to be significantly higher in the PJK group (51.6% v. 18.5%; p=0.003). Patients in the PJK group also exhibited significantly more cranially-directed screw trajectory at the UIV compared with non-PJK patients (4.30° vs. 0.43°, p = 0.006). In a further analysis, patients with UIV-PVA > 2.58° demonstrated a higher rate of PJK (57.6% vs. 22.6%, p =0.001) and greater proximal junctional kyphotic angle change (9.49° vs. 5.47°, p = 0.048). Multivariate regression analysis controlling for age and gender revealed endplate breach (OR 4.38, CI 1.54-12.47; p=0.006) and UIV-PVA > 2.58° as (OR 4.02, CI 1.53-10.59; p=0.005) significant predictors of PJK.

DISCUSSION AND CONCLUSION: UIV endplate screw breach and cranial directed screw trajectory greater than 2.58° both contributed to a nearly 4-fold increased risk for occurrence of PJK. As suggested by this study and other biomechanical reports, adverse screw placement and trajectory with respect to the superior endplate can contribute to excessive compensatory stress to the adjacent segments and lead to accelerated rates of degeneration and junctional deformity. All in all, our data highlights the critical importance of safe screw positioning at the UIV in minimizing risk for PJK.

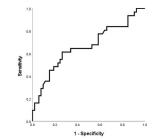

Figure 1. Receiver operating characteristic curve modeling the discriminatory ability of UIV-PVA as prediction of PJK outcome. Area under the curve (AUC) was equal to 0.663 and demonstrated a satisfactory result.

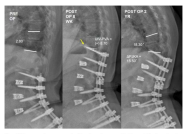

Figure 2. Representative case example of a patient who presented with an endplate breach at the UIV (as indicated by arrow) with bilateral coronal curve regressive postoperatively. At 2 years, the patient had developed significant PJK.

Table 1: Patient and Surgical Characteristics Between Patients Who Did Not Develop PJK Versus Those Who Did Develop PJK

	NoPJK (N= 55)	PJK (N= 31)	p-value
Age	64.76±10.02	68.29±7.31	0.204
Gender (%F)	31(56.4%)	24(77.4%)	0.063
BMI	28.57±5.42	26.96±5.87	0.759
Smoking	4(7.3%)	0(0.0%)	0.292
Diabetes	4(7.3%)	6(19.4%)	0.158
Osteoporosis	10(12.7%)	11 (35.5%)	0.816
UIV location			
Upper Thoracic (T1-T5)	40.00%	22.60%	0.249
Mid Thoracic (T6-T9)	9.10%	9.70%	
Thoracolumbar (T10-L1)	50.90%	67.70%	
Levels Fused	10.24±3.31	9.42±3.00	0.259
3CO performed?	16.40%	6.50%	0.314
Pelvic Fixation	80.00%	90.30%	0.362

Table 2: Radiographic Analysis Between Patients Who Did Not Develop PJK Versus Those Who Did Develop PJK

		NoPJK (N= 55)	PJK (N= 31)	p-value
Preoperative				
	SVA (cm)	7.38±6.82	5.22±4.02	0.111
	TPA°	27.69±12.80	26.32±8.51	0.605
	PI°	56.37±14.16	55.88±10.24	0.881
	TK°	31.96±21.22	36.02±19.20	0.438
	PI-LL°	23.99±22.76	20.56±16.34	0.514
	PT°	26.88±10.80	28.64±8.45	0.490
Postoperative				
	SVA (cm)	3.48±4.80	4.36±4.20	0.519
	TPA°	19.09±9.39	23.63±9.70	0.100
	PI°	55.59±13.20	56.19±15.85	0.877
	TK°	42.51±10.47	42.86±12.63	0.916
	PI-LL°	7.31±14.49	12.05±11.95	0.214
	PT°	22.51±9.54	26.57±10.24	0.136
UIV Screw Analysis				
	Medial Breach	7 (12.7%)	7 (22.6%)	0.246
	Lateral Breach	10 (18.2%)	1 (3.2%)	0.088
	Endplate Breach	**10 (18.5%)**	**16(51.6%)**	**0.003**
	UIV-PVA°	**0.43±5.88**	**4.30±6.50**	**0.006**

Table 3: Patient and Surgical Characteristics by UIV-PVA

	UIV-PVA > 2.58° (N= 33)	UIV-PVA < 2.58° (N= 53)	p-value
Age	67.82±7.11	64.43±10.40	0.104
Gender (%F)	25(75.8%)	30(56.6%)	0.106
BMI	28.20±5.09	29.03±5.86	0.506
Smoking	0(0.0%)	4(7.5%)	0.293
Diabetes	5(15.2%)	5(9.4%)	0.497
Osteoporosis	13(39.4)	16(30.2%)	0.483
UIV location			
Upper Thoracic (T1-T5)	13(39.4%)	16(30.2%)	0.557
Mid Thoracic (T6-T9)	2(6.1%)	6(11.3%)	
Thoracolumbar (T10-L1)	18(54.5%)	31(58.5%)	
Levels Fused	10.24±3.56	9.75±2.99	0.514
3CO performed?	4(12.1%)	7(13.2%)	1.000
Pelvic Fixation	29(87.9%)	43(81.1%)	0.552

Table 4: Radiographic and PJK Analysis by UIV-PVA

		UIV-PVA > 2.58° (N= 33)	UIV-PVA < 2.58° (N= 53)	p-value
Preoperative				
	SVA (cm)	6.83±6.69	6.41±6.65	0.784
	TPA°	26.90±10.25	26.18±11.89	0.352
	PI°	57.58±11.80	55.38±13.31	0.503
	TK°	36.60±19.02	31.72±21.20	0.354
	PI-LL°	22.34±19.54	22.89±21.26	0.918
	PT°	29.37±8.75	26.51±10.52	0.263
Postoperative				
	SVA (cm)	4.00±4.33	3.69±4.75	0.821
	TPA°	23.67±8.09	19.21±10.14	0.121
	PI°	58.17±11.30	54.57±14.99	0.355
	TK°	44.20±13.26	41.85±10.07	0.484
	PI-LL°	10.32±12.57	8.20±14.45	0.581
	PT°	26.01±9.15	22.79±10.19	0.240
PJK Analysis				
	Preoperative PIKA°	5.28±3.44	4.98±3.11	0.673
	Δ PIKA°	**9.49±8.84**	**5.47±9.12**	**0.048**
	PJK	**19 (57.6%)**	**12(22.6%)**	**0.001**
	PJF	8(24.2%)	6(11.3%)	0.139