School of Medicine
UNIVERSITY OF COLORADO
ANSCHUTZ MEDICAL CAMPUS

DJK and Revision Rates in Multilevel Posterior Cervical Fusions Terminating at the Cervicothoracic Junction: A Retrospective Review

Mentored Scholarly Activity by Dylan Schoo, MS4

Mentor: David Ou-Jang, MD

Disclosure: This study was conducted with no financial relationships that could be construed as a potential conflict of interest.

OBJECTIVES

1) **PRIMARY** - Access differences in revision rates for cPSF ending caudally at C7 vs T1.
2) **SECONDARY** - Access differences in radiographic parameters for cPSF between study groups.

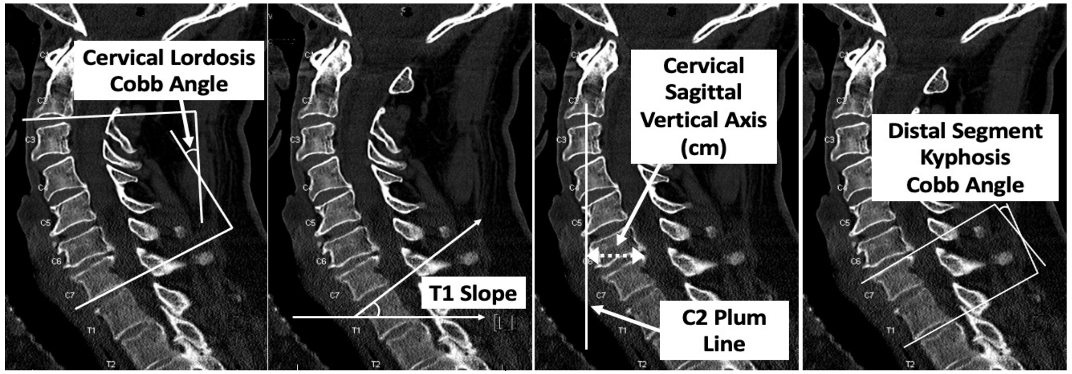
INTRODUCTION

Posterior spinal fusion is commonly used to correct cervical pathologies. Following a historical paucity of literature on outcomes regarding posterior spinal fusion surrounding the cervical thoracic junction (CTJ), several recent studies have begun to look at revision rates of fusions ending at C7, versus those continued to thoracic vertebra, and how each technique may be related to adjacent segment disease. Our current study aimed to compare revision rates as well as distal junctional kyphosis (DJK) between two groups of patients with posterior fusions terminating at C7 versus those terminating at T1, T2, or T3. This study was conducted to evaluate the hypothesis that revision rates and measured radiographic outcomes (including DJK) will have similar outcomes between these two groups.

METHODS

A single center review of medical records was used to identify patients who underwent posterior spinal fusion. Patients were included who had an index procedure within the past 10 years, at least 1 year of follow-up, and at least three segments instrumented. Patients were divided into two groups. Group 1 (G1) included those fusions terminating at C7, and group 2 (G2) included fusions terminating at T1, T2, or T3. Revision rates were assessed, additional procedures were noted, and radiographic measurements were made: CL, T1S, CVA, and DJK (see illustration).

RADIOGRAPHIC PARAMETERS



(CT Images shown for illustration)

RESULTS

Primary Outcome – Revision Rates

Characteristic	Units	Study Groups	Value – N(%)	P-value
Revision after index operation	Yes	C7 (Grp 1)	5(9.4)	0.39
	No		48(90.6)	
	Yes	T1,2,3 (Grp 2)	1(2.6)	
	No		37(97.4)	

A total of 91 patients were identified who met criteria, 53 in group 1, and 38 in group 2.
Primary Outcome - No significant difference in revision rate (G1: 9.4% vs G2: 2.6% P=0.39)
Secondary Outcome - (Radiographic) No statistically significant differences between G1 and G2
Notable findings - Distal segment kyphosis showed a significant increase in G2 when compared to G1 (G1: 0.82°, P=0.31 vs. G2: 2.5°, P=0.0001).

DISCUSSION & LIMITATIONS

The strength of this study in particular is the use of radiographic parameters to measure actual pathological changes in spine geometry as an adjunct to revision rate investigation. Using radiographic parameters allows the potential for higher sensitivity to developing pathology in patients who may not yet have progressed to the point of becoming symptomatic or exhibiting other indications for revision surgery. Of the publications in circulation we are one of the few to use two independent reviewers in taking radiographs and measurements.

The primary limitation of this study is its retrospective nature. Many patients were excluded for poor image quality, a limitation possibly avoided in a purposeful prospective study.

Emerging research is conflicted as to whether crossing the CTJ impacts revision rates. Several studies concur with our findings that crossing the CTJ makes no difference.[5,9,10,18,19] These however, are still in contrast to those studies which found the opposite and that crossing the CTJ results in lower revision rates, including a meta analysis in 2019.[2,6,7,20,21]

CONCLUSIONS & NEXT STEPS

This study resulted in no statistically significant difference in revision rates, distal junctional kyphosis, or other radiographic parameters detected between patients with posterior cervical fusions terminating at the C7 level compared to those terminating at the first three thoracic levels.

Future studies should continue to examine the stability of posterior spinal fusions, particularly those crossing the cervicothoracic junction. The etiology of breakdown adjacent to the fused segment remains unclear. More directed research with consistent follow-up may provide further insight. A two arm prospective study purposeful follow-up would be ideal.

REFERENCES:

1. Hilibrand AS, Robbins M. Adjacent segment degeneration and adjacent segment disease: the consequences of spinal fusion? Spine J. 2004;4(6 Suppl):190s-4s.
2. Goyal A, Akhras A, Wahood W, Alvi MA, Nassr A, Bydon M. Should Multilevel Posterior Cervical Fusions Involving C7 Cross the Cervicothoracic Junction? A Systematic Review and Meta-Analysis. World Neurosurg. 2019;127:588-95.e5.
3. Protopsaltis TS, Ramchandran S, Hamilton DK, Sciubba D, Passias PG, Lafage V, et al. Analysis of Successful Versus Failed Radiographic Outcomes After Cervical Deformity Surgery. Spine (Phila Pa 1976). 2018;43(13):E773-e81.
4. White AA, Panjabi MM. Clinical Biomechanics of the Spine. 2nd ed. Philidelphia, PA: Lippincot Williams & Wilkins; 1990.
5. Huang KT, Harary M, Abd-El-Barr MM, Chi JH. Crossing the Cervicothoracic Junction in Posterior Cervical Decompression and Fusion: A Cohort Analysis. World Neurosurg. 2019;131:e514-e20.
6. Ibaseta A, Rahman R, Andrade NS, Uzosike AC, Byrapogu VK, Ramji AF, et al. Crossing the Cervicothoracic Junction in Cervical Arthrodesis Results in Lower Rates of Adjacent Segment Disease Without Affecting Operative Risks or Patient-Reported Outcomes. Clinical Spine Surgery. 2019;32(9).
7. Schroeder GD, Kepler CK, Kurd MF, Millhouse PW, Kumar P, Mead L, et al. Is It Necessary to Extend a Multilevel Posterior Cervical Decompression and Fusion to the Upper Thoracic Spine? The Spine Journal. 2016;16(10, Supplement):S115.
8. Hart RA, Tatsumi RL, Hiratzka JR, Yoo JU. Perioperative complications of combined anterior and posterior cervical decompression and fusion crossing the cervico-thoracic junction. Spine (Phila Pa 1976). 2008;33(26):2887-91.
9. Truumees E, Singh D, Lavelle W, Riesenburger R, Geck M, Kurra S, et al. Is it Safe to Stop at C7 During Multi-Level Posterior Cervical Decompression and Fusion? - Multi-Center analysis. The Spine Journal. 2020.
10. Truumees E, Singh D, Geck MJ, Stokes JK. Should long-segment cervical fusions be routinely carried into the thoracic spine? A multicenter analysis. The Spine Journal. 2018;18(5):782-7.
11. Staub BN, Lafage R, Kim HJ, Shaffrey CI, Mundis GM, Hostin R, et al. Cervical mismatch: the normative value of T1 slope minus cervical lordosis and its ability to predict ideal cervical lordosis. J Neurosurg Spine. 2018;30(1):31-7.
12. Rao H, Huang Y, Lan Z, Xu Z, Li G, Xu W. Does Preoperative T1 Slope and Cervical Lordosis Mismatching Affect Surgical Outcomes After Laminoplasty in Patients with Cervical Spondylotic Myelopathy? World Neurosurg. 2019;130:e687-e93.
13. Lan Z, Huang Y, Xu W. Relationship Between T1 Slope Minus C2-7 Lordosis and Cervical Alignment Parameters After Adjacent 2-Level Anterior Cervical Diskectomy and Fusion of Lower Cervical Spine. World Neurosurg. 2019;122:e1195-e201.
14. Hyun SJ, Kim KJ, Jahng TA, Kim HJ. Relationship Between T1 Slope and Cervical Alignment Following Multilevel Posterior Cervical Fusion Surgery: Impact of T1 Slope Minus Cervical Lordosis. Spine (Phila Pa 1976). 2016;41(7):E396-402.
15. Lawrence BD, Hilibrand AS, Brodt ED, Dettori JR, Brodke DS. Predicting the Risk of Adjacent Segment Pathology in the Cervical Spine: A Systematic Review. Spine (Phila Pa 1976). 2012;37.
16. Steinmetz MP, Miller J, Warbel A, Krishnaney AA, Bingaman W, Benzel EC. Regional instability following cervicothoracic junction surgery. 2006;4(4):278.
17. Chapman JR, Anderson PA, Pepin C, Toomey S, Newell DW, Grady MS. Posterior instrumentation of the unstable cervicothoracic spine. J Neurosurg. 1996;84(4):552-8.
18. Kennamer BT, Arginteanu MS, Moore FM, Steinberger AA, Yao KC, Gologorsky Y. Complications of Poor Cervical Alignment in Patients Undergoing Posterior Cervicothoracic Laminectomy and Fusion. World Neurosurg. 2019;122:e408-e14.
19. Lee D-H, Cho JH, Jung JI, Baik J-M, Jun DS, Hwang CJ, et al. Does stopping at C7 in long posterior cervical fusion accelerate the symptomatic breakdown of cervicothoracic junction? PLoS One. 2019;14(5):e0217792-e.
20. Osterhoff G, Ryang Y-M, von Oelhafen J, Meyer B, Ringel F. Posterior Multilevel Instrumentation of the Lower Cervical Spine: Is Bridging the Cervicothoracic Junction Necessary? World Neurosurg. 2017;103:419-23.
21. Fayed I, Toscano DT, Triano MJ, Makariou E, Lee C, Spitz SM, et al. Crossing the Cervicothoracic Junction During Posterior Cervical Decompression and Fusion: Is It Necessary? Neurosurgery. 2020;86(6):E544-E50.
22. Katsuura A, Hukuda S, Saruhashi Y, Mori K. Kyphotic malalignment after anterior cervical fusion is one of the factors promoting the degenerative process in adjacent intervertebral levels. European spine journal : official publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society. 2001;10(4):320-4.
23. Scheer JK, Tang JA, Smith JS, Acosta FL, Protopsaltis TS, Blondel B, et al. Cervical spine alignment, sagittal deformity, and clinical implications. 2013;19(2):141.
24. Saavedra-Pozo FM, Deusdara RAM, Benzel EC. Adjacent segment disease perspective and review of the literature. Ochsner J. 2014;14(1):78-83.
25. Xu R, McGirt MJ, Sutter EG, Sciubba DM, Wolinsky J-P, Witham TF, et al. Biomechanical comparison between C-7 lateral mass and pedicle screws in subaxial cervical constructs. 2010;13(6):688.
26. Ito Z, Higashino K, Kato S, Kim SS, Wong E, Yoshioka K, et al. Pedicle screws can be 4 times stronger than lateral mass screws for insertion in the midcervical spine: a biomechanical study on strength of fixation. J Spinal Disord Tech. 2014;27(2):80-5.
27. Jones EL, Heller JG, Silcox DH, Hutton WC. Cervical pedicle screws versus lateral mass screws. Anatomic feasibility and biomechanical comparison. Spine (Phila Pa 1976). 1997;22(9):977-82.
28. Johnston TL, Karaikovic EE, Lautenschlager EP, Marcu D. Cervical pedicle screws vs. lateral mass screws: uniplanar fatigue analysis and residual pullout strengths. Spine J. 2006;6(6):667-72.
29. Dunlap BJ, Karaikovic EE, Park HS, Sokolowski MJ, Zhang LQ. Load sharing properties of cervical pedicle screw-rod constructs versus lateral mass screw-rod constructs. Eur Spine J. 2010;19(5):803-8.
30. Abumi K, Shono Y, Ito M, Taneichi H, Kotani Y, Kaneda K. Complications of pedicle screw fixation in reconstructive surgery of the cervical spine. Spine (Phila Pa 1976). 2000;25(8):962-9.
31. Uehara M, Takahashi J, Ikegami S, Mukaiyama K, Kuraishi S, Shimizu M, et al. Screw perforation features in 129 consecutive patients performed computer-guided cervical pedicle screw insertion. Eur Spine J. 2014;23(10):2189-95.
32. Tukkapuram VR, Kuniyoshi A, Ito M. A Review of the Historical Evolution, Biomechanical Advantage, Clinical Applications, and Safe Insertion Techniques of Cervical Pedicle Screw Fixation. Spine Surg Relat Res. 2018;3(2):126-35.
33. Bayoumi AB, Efe IE, Berk S, Kasper EM, Toktas ZO, Konya D. Posterior Rigid Instrumentation of C7: Surgical Considerations and Biomechanics at the Cervicothoracic Junction. A Review of the Literature. World Neurosurg. 2018;111:216-226.

Acknowledgments: Special thanks to Dr. Sabri Shahbaaz , who co-mentored me for much of this project; and Clayton Hoffman who was a second reviewer for data and literary review.