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ORIGINAL ARTICLE

Do we need Transverse Connectors to maintain Derotation in Scoliosis Constructs?

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ABSTRACT

Introduction: There are numerous biomechanical studies, but no clinical study to support or refute the use of transverse connectors (TCs) in scoliosis constructs. The aim of the study is to critically assess the role of TCs in scoliosis constructs.

Material and methods: All patients of scoliosis that underwent pedicle screw constructs without the use of TCs between July 2007 and July 2011 were evaluated. The immediate postoperative erect radiographs were compared with the erect radiographs at the last follow-up (at least 12 months) by two independent observers (spine fellows). The radiographs were assessed critically for any rotation at the apical vertebra using the Nash–Moe technique. The intraobserver and interobserver reliability were analyzed. The radiographs were additionally evaluated for any loss of correction and implant failure.

Results: There were 28 cases in the study. The total number of levels fused was 277. The average follow-up was 33 months. The average preoperative Cobb angle of the major curve was 72.5° (40–110°) and postoperative angle was 24.75° (5–50°). The mean percentage correction in the preoperative and postoperative Cobb angle of the major curve was 68.88% (46.80–92.3%). The intraobserver reliability was 100%; there was no change in the rotation of the levels evaluated by either observer. The interobserver reliability was 100%. There were no cases of implant failure. There were two cases of distal junctional kyphosis requiring extension of construct distally, not attributable to implant characteristics.

Conclusion: The TCs are not essential to maintain derotation and do not add to stability of long scoliosis constructs. The authors make a strong statement that TCs may not be necessary to maintain derotation in scoliosis constructs.

Clinical significance: The additional complications of implant prominence, metal corrosion, skin breakdown, pseudoarthrosis, and costs can be prevented by excluding TCs from the scoliosis constructs.

Keywords: Derotation, Scoliosis, Transverse connectors.

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INTRODUCTION

Posterior all-pedicle screw-based construct has become the workhorse for scoliosis correction surgery owing to the three-column rigid fixation it provides. Most commonly, scoliosis correction involves a correction and a derotation maneuver, and the instrumentation serves to maintain the correction. Although rod and pedicle screw constructs provide significant sagittal plane stiffness, it was often felt that it may prove inadequate under axial rotation. The concept of using transverse connector (TC) was established to overcome this issue. Since scoliosis is a three-dimensional deformity with a rotational component, the use of TC is desirable owing to the added purported advantage of rotational stability. Their use was originally designed to provide greater correction and stability in scoliosis, particularly in the coronal plane. There is limited literature supporting or refuting the use of TCs to maintain derotation in long posterior constructs. The aim of the study is to critically assess the role of TCs in scoliosis constructs.

MATERIALS AND METHODS

Our series derives from retrospective analysis of prospectively collected date of 28 consecutive patients who underwent posterior all-pedicle screw-based correction for scoliosis at our institute during a study period extending from July 2007 to July 2011. Institutional Review Board approval was obtained. All patients of scoliosis that underwent posterior surgery using pedicle screw constructs without the use of TCs were evaluated. The preoperative X-rays and postoperative erect X-rays were evaluated. The correction achieved was calculated. The immediate postoperative erect radiographs were compared with the erect radiographs at the last follow-up (at least 24 months) by two independent observers (spine fellows not involved in the management of the patients). The radiographs were assessed critically for any rotational instability using the Nash–Moe technique of assessment of vertebral rotation. The apical vertebra was chosen for grading the rotation. The intraobserver and interobserver reliabilities were analyzed. The radiographs

were additionally evaluated for any loss of correction and implant failure.

RESULTS

There were 28 cases in the study. Of these, there were 26 cases of adolescent idiopathic scoliosis and 2 cases of neuromuscular scoliosis. The total number of levels fused was 277. The average follow-up was 33 months. The average preoperative Cobb angle of the major curve was 72.5° (40–110°) and postoperative angle was 24.75° (5–50°). The mean percentage correction in the preoperative and postoperative Cobb angle of the major curve was 68.88% (46.80–92.3%). There was no change in the rotation of the apical vertebra in any of the constructs. The intraobserver reliability was 100%; there was no change in the rotation of the levels evaluated by either observer. The interobserver reliability was 100%. There were no cases of implant failure. There were two cases of distal junctional kyphosis requiring extension of construct distally, not attributable to implant characteristics. Figures 1 to 6 are two case illustrations of two scoliosis corrections where TCS were not used, with maintained correction at 2 years.

DISCUSSION

The idea of TCs for a longitudinal spinal construct like Harrington distraction rod was first proposed by Morscher,[1] with the notion that it might aid in increasing the correction of the curve by closely approximating the concave spinous processes to the rod. With the introduction of the Cotrel–Dubousset[2] system of segmental hooks and rods, the addition of TCs to the construct at both ends was proposed to provide a rectangular construct, which increased the torsional stiffness of the system. This was supported by various biomechanical studies.[3-5] The pedicle screw-rod system, which is the current state-of-the-art in spinal instrumentation, has been proven to be biomechanically superior to the systems utilizing sublaminar wires and hooks by numerous studies.[6,7] The pedicle screws provide a three-column fixation by gaining rigid purchase in the body and the cortical bone of the pedicles. The rigid three-column fixation not only provides for application of strong forces for deformity correction via the derotation maneuver, but

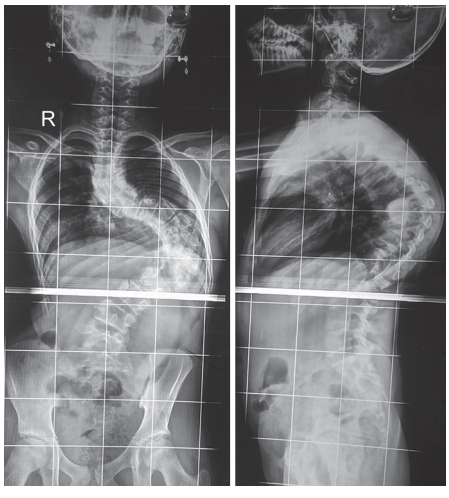

Fig. 1: Preoperative anteroposterior and lateral radiograph

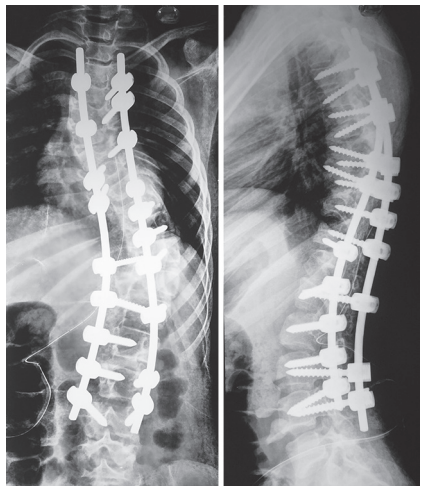

Fig. 2: Immediate postoperative radiograph

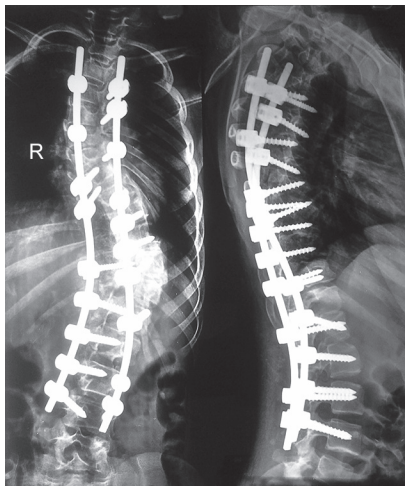

Fig. 3: Two-year follow-up with maintained rotation and correction

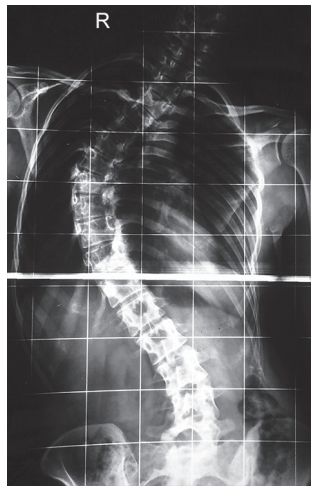

Fig. 4: Preoperative anteroposterior radiograph

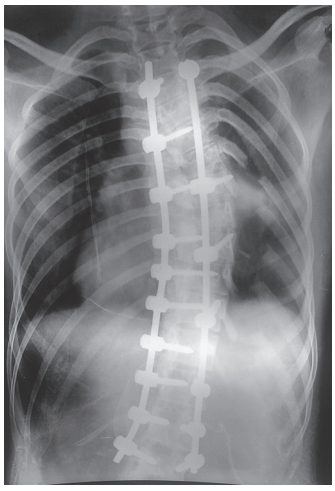

Fig. 5: Immediate postoperative radiograph

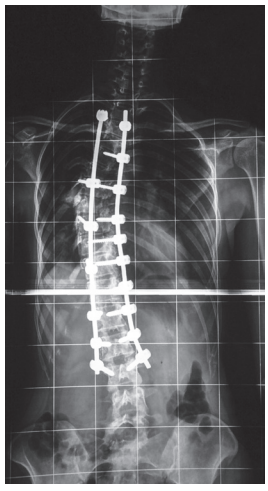

Fig. 6: Two-year follow-up with maintained rotation and correction

also has been found to aid in maintenance of the correction achieved.[8]

Numerous biomechanical studies have explored the use of TCs as adjuvants to posterior constructs. Dick et al[9] analyzed various designs of TCs in sawbones. They concluded that TCs increased the torsional rigidity of constructs incorporating pedicle screws and for use in pedicle screw and hook system. Lynn et al[10] explored the effect of adding TCs to pedicle screw-rod constructs for thoracolumbar fractures in animal cadaveric models. They concluded that the rotational stiffness of constructs with TCs was more rigid than constructs without TCs. Lim et al[11,12] examined calf lumbar spines using a corpectomy injury model. Nondestructive flexibility testing on their specimens showed improved stability in axial rotation with cross-links. The same group also studied finite element models, which predicted improvement in both axial rotation and lateral bending when cross-links are used. Brodke et al[13] performed a biomechanical analysis on segmental pedicle screw fixation and cross-links using intact calf lumbar spines. They found increased stiffness in lateral bending and axial rotation when cross-links were added to the constructs.

While the use of TCs has shown advantage in biomechanical studies, the same has not been translated into clinical scenario. The biomechanical studies are performed on polyurethane bone models, animal specimens, human cadaveric specimens, and finite-element models. These do not take into account the natural soft-tissue support to the spine. The muscles acting across a spinal segment exert their own forces adding to the stability of the segment. Scoliosis usually is a thoracic spine deformity. The thoracic spine is inherently stable, so addition of TCs for increased rotational stability need not be necessary. Also, these biomechanical studies do not consider the efficacy of TCs in maintenance of correction achieved over a long period of time.

Numerous biomechanical studies have shown that well-placed bilateral convergent screws can resist rotational shifting of vertebrae even without transverse connection.[9,14,15] A study by Carson et al[16] measured strains when loading transpedicular screws implanted in cadaveric specimens angled 15° inward and found no change when TCs were added. A study by King et al[17] explored the rigidity of scoliosis construct with laminar hooks or pedicle screws as distal anchors, with TCs at the end of the construct. They found that the torsional stiffness was increased by approximately 90% with hooks, but by 215% using pedicle screws as distal anchors. This study made no attempt to determine the relative contribution of the TCs. Wood et al,[8] in their cadaveric study, concluded that adding pedicle screws as distal anchors in scoliosis constructs, cross-linking with one or two devices adds very little additional rotational stiffness and may be unnecessary in many cases.

All the cases in our series underwent posterior corrective maneuvers in the form of compression distraction technique after insertion of segmental pedicle screws. No TCs were used in the constructs. The postoperative correction was satisfactory in all cases. The radiographs were evaluated for derotation using the Nash–Moe criteria.[18] The cases were followed up periodically. At the last follow-up, the Nash–Moe grading was maintained in all cases. There was no loss of correction in any of the cases. All the cases underwent successful fusion. There were two cases that developed a distal junctional kyphosis, but this was related to the natural history or the technique; addition of TCs would not have prevented it. We believe that TCs may be unnecessary for augmenting the long posterior constructs in scoliosis. There are several complications in the use of TCs including prominence of implants in thin individuals,[19] metal corrosion, skin breakdown, and infections.[20] The TCs represent a break in the continuity of

the bed for laying down bone grafts, vital for fusion, thus increasing pseudarthrosis rates.[21-23] An important factor to exclude these implants is the cost factor. Exclusion of TCs will significantly bring down the overall costs when extrapolated to a larger population.[24]

The findings of this clinical study are in agreement with those of Wood et al.[8] Our study is limited by short- to mid-term follow-up and small number of cases. However, our results are similar to recent comparative and multicentric studies that have found that TCs do not improve clinical or radiographic outcomes of posterior spinal fusion with pedicle screws in adolescent idiopathic scoliosis. Dhawale et al[25] studied 75 adolescent idiopathic scoliosis patients who underwent posterior spinal instrumentation with segmental pedicle screws (25 with TC and 50 without TC NCLs) and observed no differences in maintenance of correction, Scoliosis Research Society (SRS) scores, and complications with or without use of TCs over 2-year follow-up. In a multicenter study by Garg et al[26] that included 500 cases of posterior spinal fusion with pedicle screws in adolescent idiopathic scoliosis (377 cross-link and 123 noncross-link), the authors found similar complication rates in both groups with similar SRS-22r scores throughout follow-up.

CONCLUSION

Well-placed, convergent pedicle screws are the main determinants of rigidity and stability of the construct for scoliosis correction. The TCs are not essential to maintain derotation and do not add to the stability of long scoliosis constructs. The additional complications of implant prominence, metal corrosion, skin breakdown, pseudarthrosis, and costs can be prevented by excluding TCs from the scoliosis constructs. The authors strongly suggest that spine surgeons should consider eliminating use of TCs in all pedicle screw constructs. This may add to cost savings also.

REFERENCES

1. Morscher E. Possibilities and limitations of Harrington's method in the surgical treatment of scoliosis. Arch Orthop Unfallchir 1971;70(2):136-151.
2. Cotrel Y, Dubousset J. New segmental posterior instrumentation of the spine. Orthop Trans 1985;9(1):118.
3. Asher M, Carson W, Heinig C, Strippgen W, Arendt M, Lark R, Hartley M. A modular spinal rod linkage system to provide rotational stability. Spine (Phila Pa 1976) 1988 Mar;13(3):272-277.
4. Ashman RB, Birch JG, Bone LB, Corin JD, Herring JA, Johnston CE 2nd, Ritterbush JF, Roach JW. Mechanical testing of spinal instrumentation. Clin Orthop Relat Res 1988 Feb;227:113-125.
5. Johnston CE, Ashman RB, Corin JD. Mechanical effects of cross-linking rods in Cotrel–Dubousset instrumentation. Orthop Trans 1987;11:96-97.
6. Ashman RB, Galpin RD, Corin JD, Johnston CE 2nd. Biomechanical analysis of pedicle screw instrumentation systems in a corpectomy model. Spine (Phila Pa 1976) 1989 Dec;14(12):1398-1405.
7. Barr SJ, Schuette AM, Emans JB. Lumbar pedicle screws versus hooks. Results in double major curves in adolescent idiopathic scoliosis. Spine (Phila Pa 1976) 1997 Jun;22(12): 1369-1379.
8. Wood KB, Wentorf FA, Ogilvie JW, Kim KT. Torsional rigidity of scoliosis constructs. Spine (Phila Pa 1976) 2000 Aug;25(15):1893-1898.
9. Dick JC, Zdeblick TA, Bartel BD, Kunz DN. Mechanical evaluation of cross-link designs in rigid pedicle screw systems. Spine (Phila Pa 1976) 1997 Feb;22(4):370-375.
10. Lynn G, Mukherjee DP, Kruse RN, Sadasivan KK, Albright JA. Mechanical stability of thoracolumbar pedicle screw fixation. The effect of crosslinks. Spine (Phila Pa 1976) 1997 Jul;22(14):1568-1572.
11. Lim TH, Eck JC, An HS, Hong JH, Ahn JY, You JW. Biomechanics of transfixation in pedicle screw instrumentation. Spine (Phila Pa 1976) 1996 Oct;21(19):2224-2229.
12. Lim TH, Kim JG, Fujiwara A, Yoon TT, Lee SC, Ha JW, An HS. Biomechanical evaluation of diagonal fixation in pedicle screw instrumentation. Spine (Phila Pa 1976) 2001 Nov;26(22):2498-2503.
13. Brodke DS, Bachus KN, Mohr RA, Nguyen BK. Segmental pedicle screw fixation or cross-links in multilevel lumbar constructs. A biomechanical analysis. Spine J 2001 Sep-Oct;1(5):373-379.
14. Krag MH. Biomechanics of thoracolumbar spinal fixation. A review. Spine (Phila Pa 1976) 1991 Mar;16(Suppl 3):S84-S98.
15. Margulies, JY.; Caruso, SA.; Gorup, JM.; Haher, TR. Effects of transverse connectors on rotational stiffness in a vertebrectomy model. Scoliosis Research Society 31st annual meeting, Ottawa, Canada, September 25–28, 1996.
16. Carson WL, Duffield RC, Arendt M, Ridgely BJ, Gaines RW Jr. Internal forces and moments in transpedicular spine instrumentation. The effect of pedicle screw angle and transfixation: The 4R-4bar linkage concept. Spine (Phila Pa 1976) 1990 Sep;15(9):893-901.
17. King, AG.; Tahmoush, KM.; Thopmas, KA. Biomechanical testing of pedicle screws versus lamina hooks as distal anchors for scoliosis instrumentation. Scoliosis Research Society 32nd annual meeting, St. Louis, MO, September 25–27, 1997.
18. Nash CL Jr, Moe JH. A study of vertebral rotation. J Bone Joint Surg 1969 Mar;51(2):223-229.
19. Brown, JC. Cotrel–Dubousset instrumentation in the treatment of adolescent idiopathic scoliosis. In: Bridwell, KH.; DeWald, RL., editors. The textbook of spinal surgery. 2nd ed. Philadelphia, PA: Lippincott–Raven Press; 1997. p. 489-534.
20. Cook, S.; Asher, MA. The frequency of re-entry following primary posterior instrumentation and fusion for idiopathic scoliosis: Harrington, CD, and Isola. Paper presented at: Scoliosis Research Society 31st annual meeting, Ottawa, Canada, September 25–28, 1996.
21. Lenke LG. Lenke classification system of adolescent idiopathic scoliosis: treatment recommendations. Instr Course Lect 2005;54:537-542.
22. Richards BR, Emara KM. Delayed infections after posterior TSRH spinal instrumentation for idiopathic scoliosis: revisited. Spine (Phila Pa 1976) 2001 Sep;26(18):1990-1996.

23. Lynn G, Mukherjee DP, Kruse RN, Sadasivan KK, Albright JA. Mechanical stability of thoracolumbar pedicle screw fixation: the effects of crosslinks. Spine (Phila Pa 1976) 1997 Jul;22(14):1568-1572.
24. Kulkarni AG, Dhruv AN, Bassi AJ. Should we cross the cross-links? Spine (Phila Pa 1976) 2013 Aug;38(18):E1128-E1134.
25. Dhawale AA, Shah SA, Yorgova P, Neiss G, Layer DJ Jr, Rogers KJ, Gabos PG, Holmes L Jr. Effectiveness of cross-linking posterior segmental instrumentation in adolescent idiopathic scoliosis: a 2-year follow-up comparative study. Spine J 2013 Nov;13(11):1485-1492.
26. Garg S, Niswander C, Pan Z, Erickson M. Cross-links do not improve clinical or radiographic outcomes of posterior spinal fusion with pedicle screws in adolescent idiopathic scoliosis: a multicenter cohort study. Spine Deform 2015 Jul;3(4): 338-344.