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Evaluation of Limited Screw Density Pedicle Screw Constructs in Posterior Fusions for Adolescent Idiopathic Scoliosis

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Abstract

Study design: Retrospective case series.
Objectives: To compare radiographic and clinical outcomes in posterior spine fusions with pedicle screw instrumentation of varying screw densities in the treatment of adolescent idiopathic scoliosis (AIS).
Summary of background data: Posterior spinal fusion with pedicle screw instrumentation is the mainstay of surgical treatment for AIS. The most commonly used construct consists of screws placed at every level on the concave side of the deformity and nearly every level on the convex side. However, some surgeons have begun using constructs with fewer pedicle screws. The literature comparing outcomes of these differing pedicle screw constructs is limited.
Methods: Fifty-two consecutive cases of posterior spinal fusions for AIS performed by four surgeons were reviewed. High screw density constructs were used in 26 cases and limited screw density constructs in 26 cases. Construct characteristics and radiographic measurements were compared preoperatively and at last follow-up. Operative time and estimated costs were also evaluated. Student *t* tests were used to compare the groups with $p < .05$ considered significant.
Results: There was no significant difference in magnitude of correction for the high versus limited screw density group initially (38.5° vs. 34.9°, $p = .093$) or at final follow-up (36.9° vs. 32.2°, $p = .054$). Sagittal alignment, coronal balance, and translation of the major apical vertebra were comparable and stable in both groups. The high versus limited screw density group utilized significantly more pedicle screws (16.8 vs. 11.6 screws, $p < .0001$), had longer operative times (309 vs. 267 minutes, $p = .007$), and had additional estimated direct costs of $5,800.
Conclusions: Excellent curve correction, stability, and balance can be achieved using fewer screws than commonly used in posterior pedicle screw fusions for AIS. Operative time is reduced, and risk and cost are decreased with the use of limited screw density constructs.
Level of Evidence: III.

Keywords: Adolescent idiopathic scoliosis (AIS); Posterior spinal fusion; Pedicle screws; Screw-density; Instrumentation constructs

Introduction

Since the advent of Harrington instrumentation, spinal fusion with instrumentation has become standard of care in the treatment of adolescent idiopathic scoliosis (AIS) [1,2]. Advancement in the technology of spinal instrumentation has progressed from the use of wires and hooks to pedicle screws. Multiple studies have shown the benefits of pedicle screw constructs over wires, hooks, and hybrid constructs, including increased absolute curve correction and decreased loss of correction over time [3-7]. Accordingly,

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pedicle screw constructs are widely accepted as standard of care in the surgical treatment of AIS.

Despite issues of increased costs [8] and technical complexity [9,10], pedicle screw constructs are accepted as standard of care in the surgical treatment of AIS. Early pedicle screw constructs consisted of screws placed at levels comparable to traditional hook constructs, which did not secure to the spine at every level. As surgical experience and techniques improved, surgeons began placing pedicle screws in an increasing number of vertebrae, eventually instrumenting every level of the spine bilaterally. The rationale for this transition to high implant density constructs—to obtain more rigid fixation and to limit potential stress concentration at any one screw [4]—has been adopted without substantial clinical literature documenting necessity. Given that the placement of an individual pedicle screw requires operative time with associated risk and cost, it would be of benefit to determine the ideal implant density required to maximize correction while minimizing operative risk and cost.

The lack of literature to prove the benefit of higher implant density, knowledge that pedicle screws have a higher pull-out strength than hooks, and the increased operative time, risk, and cost of inserting more screws have driven the consideration of using constructs with lower implant densities. However, few studies have been published evaluating low screw-density constructs in patients with AIS [11-14].

The purpose of this retrospective review is to examine surgical and radiographic outcomes of AIS cases treated with pedicle screw constructs of high versus limited densities. We hypothesize that there will be no significant difference in deformity correction or complications between high and limited screw density constructs. Furthermore, we predict that operative time, blood loss, and cost will be decreased in patients with limited screw density constructs.

Materials and Methods

This retrospective study was approved by the institutional review board of the participating hospital system. The need for informed consent was waived by the institutional review board. A computerized search of medical records was used to identify all children at a single institution undergoing posterior spinal fusion between October 2007 and December 2011. Inclusion criteria included diagnosis of AIS, age 10 or greater at the time of fusion, fusion construct consisting of all pedicle screws except for bilateral down-going hooks at the uppermost instrumented vertebra, and a major curve magnitude between 45 and 75 degrees. Exclusion criteria included any diagnosis other than AIS, previous spine surgery, the use of additional procedures such as Ponte osteotomies, a Lenke 5 classification curve, patients with less than 2 years' follow-up, or the use of hooks or wires below the uppermost instrumented level. Fifty-two patients (43 female, 9 male) met inclusion and exclusion criteria.

All spinal constructs included in the study had the following common features: bilateral pedicle screws at the two lowest instrumented vertebrae, bilateral down-going hooks at the uppermost instrumented vertebrae, a pedicle screw at the apical vertebral segment on the concave side of the deformity, dual 5.5-mm stainless steel rods, and locally obtained autograft fusion supplemented with hydroxyapatite/betatricalcium phosphate bone graft extender granules. The groups differed based on the subsequent number and location of pedicle screw placement. In the limited group, screws were placed at every other level of the concavity of the deformity based on the apical concave screw and every other level on the convex side alternate to the concave side. The high-density group consisted of any other all-pedicle-screw fusions during the study period—which consisted of screws placed at every level on the concave side of the deformity and every level or nearly every level on the convex side of the deformity. Pedicle screw instrumentation was performed by the free hand technique with biplanar fluoroscopic and direct screw EMG impedance testing for confirmation of placement; CT or image guidance is not utilized at our center. With the exception of the upper instrumented level in which bilateral down-going hooks were routinely placed, all preoperatively planned pedicles were instrumented. In rare cases, pedicle anatomy did not permit cannulation, and an unplanned, adjacent pedicle was instrumented. These subtle discrepancies are accounted for by presenting construct density within the Results section.

The limited construct was first used at our institution in February 2009. Prior to that time, only high-density pedicle screw constructs were used. Of the 52 cases included in the study, limited-density constructs were used in 26 cases and high-density constructs in 26 cases. All surgeries were performed by four fellowship-trained pediatric spine surgeons, and there was no statistically significant relationship between surgeon and type of construct utilized ($p = .198$).

Radiographic parameters were measured and compared preoperatively, 2 weeks postoperatively, 2 years postoperatively, and at final follow-up using digital image archiving software. These included coronal Cobb angles, coronal best bend flexibility (%), sagittal Cobb angles, global coronal balance, and coronal translation of the apical vertebral segment. Risser sign, status of the triradiate cartilage, and Lenke classification were noted for each patient preoperatively. Preoperative Nash-Moe [15] apical vertebral rotation of the major curve and postoperative Upasani grade [16] apical vertebral rotation were documented for each patient. The implant density of each construct was calculated as number of pedicle screws used per pedicle available for fixation [number of screws used plus bilateral UIV down-going hooks/(levels fused $\times$ 2)]. Medical records were reviewed to obtain demographic information, operative time, estimated blood loss, and complications. Because institutional policy restricts direct