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Effect of Lowest Instrumented Vertebra on Trunk Mobility in Patients With Adolescent Idiopathic Scoliosis Undergoing a Posterior Spinal Fusion

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Abstract

Study Design: Prospective.
Objectives: The goal of this study was to evaluate the effect of posterior spinal fusion surgery terminating at different lowest instrumented vertebrae (LIV) on trunk mobility in individuals with adolescent idiopathic scoliosis (AIS).
Summary of Background Data: Posterior spinal fusion with instrumentation is the standard surgical technique employed in AIS for correcting spine deformities with Cobb angles exceeding 50°. Surgical correction of curve deformity reduces trunk mobility and range of motion. However, conflicting findings from previous studies investigating the impact of different LIV levels on the reduction in trunk mobility after surgery have been reported.
Methods: The study was designed as a prospective study with 47 patients (7 males and 40 females) with AIS who underwent posterior spinal fusion. Patients were classified into 5 groups based on their surgical LIV level (ie, T12, L1, L2, L3, and L4). Trunk flexion-extension (sagittal plane), lateral bending (coronal plane), and axial rotation (transverse plane) kinematics were assessed during preoperative, 1 year postoperative, and 2 years postoperative evaluation visits.
Results: There were postoperative reductions of 41%, 51%, and 59% in trunk range of motion in the sagittal, coronal, and transverse planes, respectively ($p < .0001$). A trend toward greater postoperative reductions in peak forward flexion at more distal LIVs was observed ($p = .04$).

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Conclusions: Fusion reduces trunk mobility in the sagittal, coronal, and transverse planes. More distal LIV fusions limit peak forward flexion to a greater extent which is considered clinically significant. After fusion, the reductions seen in axial rotation, lateral bending, and backward extension do not differ significantly at more distal LIVs.

Keywords: Adolescent idiopathic scoliosis; Posterior spinal fusion; Trunk mobility; Range of motion; Lowest instrumented vertebra

Introduction

Posterior spinal fusion with instrumentation (PSFI) is the standard of care for correcting spine deformities in individuals with adolescent idiopathic scoliosis (AIS) and Cobb angles exceeding 50° [1-3]. Long-term results suggest that PSFI can effectively limit curve progression and ensure spine stability for individuals with AIS [4-7].

Although PSFI effectively corrects spine deformity, postoperative limitations in intersegmental mobility among the fused vertebral levels ultimately result in reduction of overall trunk mobility (ie, forward flexion, backward extension, bilateral lateral bending, and bilateral axial rotation) [4-10]. Furthermore, some studies suggest that loss in trunk mobility may cause an increased compensatory mobility at unfused segments adjacent to the fusion, which may eventually lead to spinal degeneration of unfused segments and low back pain [4,6,8-12].

Currently, few studies have attempted to accurately measure reduction in trunk mobility after fusion. Recent studies have commonly employed either inclinometers or motion capture techniques to accurately quantify trunk mobility reduction after surgical fusion [8-10]. However, these studies are not without limitations, which range from being retrospective to using heterogeneous sampling of different fusion techniques (ie, anterior spinal fusion, posterior spinal fusion, or both), and to using unvalidated or nonstandardized models of kinematic computation for determining spine range of motion (ROM) [8-10,13].

Despite the obvious reduction in trunk mobility after fusion, even fewer clinical studies conclusively address how surgical choice of the lowest instrumented vertebra (LIV) influences the amount of reduction. The direct impact of LIV level on postoperative trunk mobility in patients with AIS has not been conclusively demonstrated [8-10,13-16]. Today, many clinicians are still faced with difficult questions posed by families who inquire about changes to expect after fusion, particularly how reductions in trunk mobility vary with LIV over time. The purpose of this study was to quantitatively examine and compare trunk mobility in individuals with AIS undergoing posterior spinal fusion surgery at different LIVs preoperatively and at 1 and 2 years postoperatively. We hypothesized that PSFI terminating at a more distal LIV will result in greater reductions in sagittal, coronal, and transverse plane trunk kinematics during trunk bending tasks while standing. Specifically, we expected that fusion to the distal lumbar segments would result in greater reductions in kinematic peaks and overall trunk ROM than fusion terminating at proximal lumbar and thoracic segments.

Materials and Methods

Study design and participants

This was a prospective study performed on a sample of convenience between October 2007 and August 2012 at a single specialized pediatric orthopedic institution. A consecutive series of 120 patients had a posterior spinal fusion during that time, of which 47 patients (7 male and 40 female) agreed to participate in this institutional review board−approved study as the scoliosis group. Thirty-nine patients made the 1-year follow-up visit (mean, 1.15 years; range, 0.8−1.5 years) and 36 made the 2-year visit (mean, 2.2 years; range, 1.8−3.4 years). All patients and a legal guardian gave signed consent before testing. To be included, patients had a diagnosis of AIS and a Cobb angle $> 50°$ (group mean Cobb angle, $56° \pm 12°$). The average age at the time of the PSFI was 15.3 years (range, 11.9−18.9 years). Patients were classified into 5 groups based on their surgical LIV level (T12, L1, L2, L3, and L4). Five patients were fused to an LIV of T12, 4 to L1, 8 to L2, 15 to L3, and 15 to L4. Of 47 patients, 44 had upper instrumented vertebrae between T2 and T4. Patients were excluded if they had a neuromuscular pathology, were unable to walk or stand independently, were pregnant, or required a fusion outside the LIV groups listed above. All patients were given the same basic postoperative rehabilitation instructions that were to be mobilized out of bed on the first day and to increase activity as tolerated. Table 1 lists demographic data for all patients in this study.

Surgery and radiographic assessment

Posterior spinal fusion with instrumentation surgery was performed on all patients. Radiographic assessment was performed preoperatively and at postoperative years 1 and 2 to determine Cobb angle, Lenke curve type, trunk shift (in centimeters), sagittal balance (in centimeters), and pelvic incidence [17-21]. All radiographic measurements were obtained from a single orthopedic surgeon.

Trunk movement data collection

To prepare for protocol testing, all subjects were instrumented with 20 reflective markers placed in accordance with the Full Body Plug-in-Gait model (Vicon Motion Systems, Oxford, UK) [22-24]. This model consists of a single trunk segment with 6 markers placed over the