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The Effect of Time and Fusion Length on Motion of the Unfused Lumbar Segments in Adolescent Idiopathic Scoliosis

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Abstract

Objective: The purpose of this study was to assess L4−S1 inter-vertebral coronal motion of the unfused distal segments of the spine in patients with adolescent idiopathic scoliosis (AIS) after instrumented fusion with regards to postoperative time and fusion length, independently.

Methods: Coronal motion was assessed by standardized radiographs acquired in maximum right and left bending positions. The inter-vertebral angles were measured via digital radiographic measuring software and the motion from the levels of L4−S1 was summed. The entire cohort was included to evaluate the effect of follow-up time on residual motion. Patients were grouped into early (<5 years), midterm (5−10 years), and long-term (>10 years) follow-up groups. A subset of patients (n = 35) with a primary thoracic curve and a nonstructural modifier type "C" lumbar curve were grouped as either selective fusion (lowest instrumented vertebra [LIV] of L1 and above) or longer fusion (LIV of L2 and below) and effect on motion was evaluated.

Results: The data for 259 patients are included. The distal residual unfused motion (from L4 to S1) remained unchanged across early, midterm, to long-term follow-up. In the selective fusion subset of patients, a significant increase in motion from L4 to S1 was seen in the patients who were fused long versus the selectively fused patients, irrespective of length of follow-up time.

Conclusion: Motion in the unfused distal lumbar segments did not vary within the >10-year follow-up period. However, in patients with a primary thoracic curve and a nonstructural lumbar curve, the choice to fuse longer versus shorter may have significant consequences. The summed motion from L4 to S1 is 50% greater in patients fused longer compared with those patients with a selective fusion, in which postoperative motion is shared by more unfused segments. The implications of this focal increased motion are unknown, and further research is warranted but can be surmised.

Keywords: Adolescent Idiopathic Scoliosis; Post-operative; Spinal flexibility; Long-term follow-up

Introduction

The well-established goal of the surgical management of adolescent idiopathic scoliosis (AIS) is to maximize deformity correction, achieve coronal and sagittal balance, and retain spinal flexibility [1,2]. If the deformity correction can be achieved with minimal levels of fusion, the retention of spinal flexibility is maximized. However, notwithstanding the unfused status of the distal segments of the spine, the mobility/flexibility is altered from the proximal fusion that has occurred. As the spine functions as a unit [3], alterations to segments above or below can disturb the delicate balance that exists in the mobility of the spinal column. These motion alterations are poorly understood, and the short- and long-term effects of disrupted mechanics are also poorly understood.

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Previous research has demonstrated that extending fusion levels distally have an impact on spinal mobility [4,5]. In particular, coronal bending is significantly more concentrated and increased below the fusion, with more distal lowest instrumented vertebra (LIV) at an average of 3 years' follow-up [5]. Yet two very common clinical questions remain unanswered with regards to motion in the unfused lumbar segments before fusion for AIS: What will happen in the long term and what effect will the fusion length have? The purpose of this study was to assess the L4–S1 intervertebral coronal motion of the unfused distal segments of the spine in patients with AIS after instrumented fusion with regards to postoperative time and fusion length, as both independent and interactive factors.

Materials and Methods

Patients with AIS who had undergone spinal fusion for correction of their deformity were prospectively offered inclusion into this IRB approved cross-sectional study at their routine 2–16-year postoperative visits at one of five participating centers. All curve types (Lenke classification types) were included, and fusion with either posterior or anterior instrumentation was accepted. Motion was assessed by standardized radiographs acquired in maximum right and left bending positions (Fig. 1A and B). Radiographic acquisition was standardized at all sites with the following instructions: the right and left bend film were performed in the standing position, with the patient laterally bending to each side with maximum effort and allowing the neck to also bend in the same direction, and rotation in the transverse plane minimized. The intervertebral angles were measured via digital radiographic measuring software (SpineView 2.4, Surgiview, Paris, France) at each level from T12 to S1. All measurements were made by one individual. The intrarater reliability of the individual measurer was tested (on the first 57 patients) and confirmed to be "very good," with an intraclass correlation coefficient of 0.86 and standard error of measurement of 2 degrees. Static angles in the coronal plane at each intervertebral angle between T12 and S1 were measured with the following conventions: (+) intervertebral angle opens to the right and (−) intervertebral angle opens to the left. The range of motion in the coronal plane was measured by the summation of the static angle on the left bend with the static angle on the right bend to equal the total motion at the respective segment (eg, at the L1–L2 disc space: angle measured on left bend of +6 and angle measured on the right bend of −4 summed to equal a total motion of 10 degrees of motion) (Fig. 2). This method of angular measurement has been previously reported and as stated by these authors, "although the radiographic measurements were made in static positions, the term 'dynamic' motion is a calculated quantity and refers to

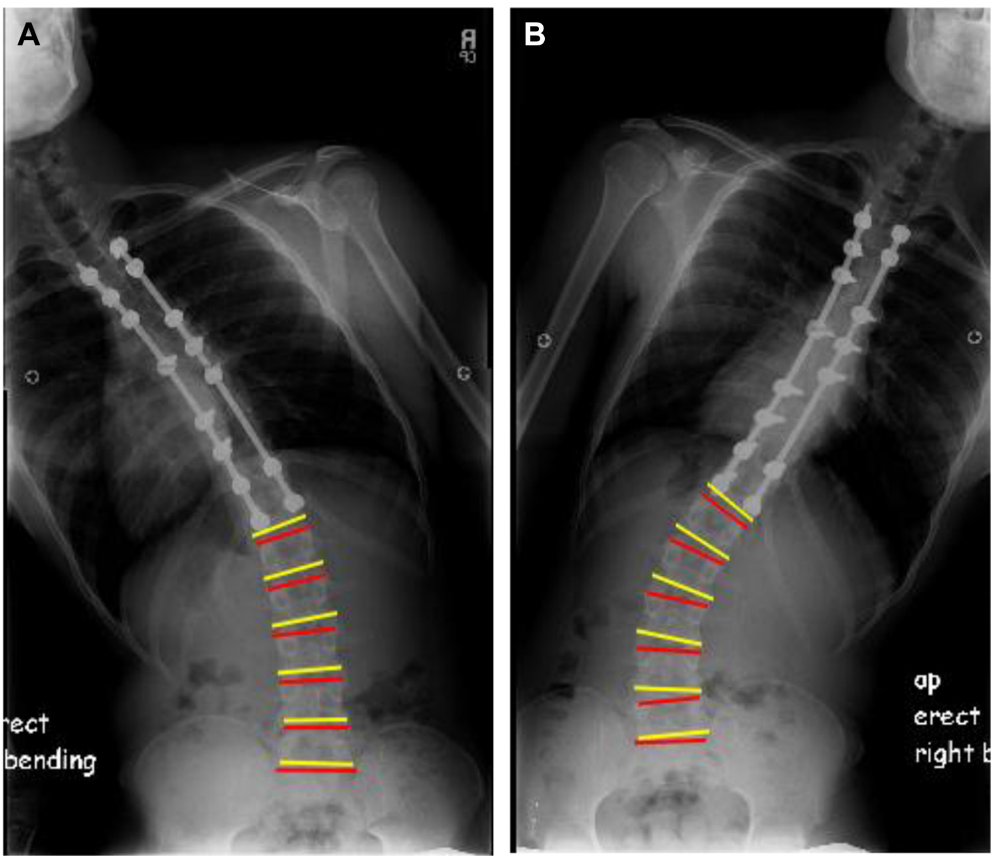

Fig. 1. (A) Left and (B) right coronal bend films.