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Unintended Change of Physiological Lumbar Lordosis and Pelvic Tilt After Posterior Spinal Instrumentation and Fusion for Adolescent Idiopathic Scoliosis: How Much Is Too Much?

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Abstract

Study Design: Retrospective review of prospective multicenter adolescent idiopathic scoliosis (AIS) database.
Objectives: To investigate the effect of decreased lumbar lordosis (LL) on measured pelvic tilt (PT) after posterior spinal instrumentation and fusion for AIS and to test the hypothesis that lumbar spinal fusion resulting in mismatched LL is associated with increased PT.
Summary of Background Data: Interaction between the spine and pelvis highly influences global sagittal alignment (GSA). In adults, correlation between health-related quality of life measures and LL proportional to a patient-specific pelvic incidence (PI) has been established, although the implications of poor sagittal alignment are less well-defined in AIS. This observation warrants further examination of regional spine contour and its relation to the pelvis in AIS.
Methods: The authors queried a prospective multicenter database for AIS patients who underwent posterior spinal instrumentation and fusion with lowest instrumented vertebra between L2 and L5 and identified 155 patients with minimum 2 years' follow-up. Lumbar lordosis (T12–S1), LL within fusion, LL below fusion, GSA, PT, and PI were measured preoperatively and at 2 years. Change in PT was compared between patients with matched or mismatched LL based on a common clinical definition (LL = PI + 10) and a research-driven model (LL = 0.56 PI + 33.43).

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Results: Thirty-eight percent of patients had decreased LL from before surgery to 2 years after surgery. These patients had significantly higher rates of increased PT (73%) than patients without decreased LL (40%). Multivariate regression demonstrated that change in LL, LL within fusion, and GSA had a significant predictive effect on PT ($p < .001$). Using either definition of LL, patients with LL less than 2 standard deviations from predicted values were more likely to have increased PT.
Conclusions: Iatrogenic loss of LL commonly occurs in spine fusion for AIS and is associated with a reciprocal increase in PT. As such, spinal fusion in AIS can have unintended effects on sagittal alignment with currently uninvestigated potential consequences in the future.

Keywords: Adolescent idiopathic scoliosis; Sagittal balance; Posterior spinal instrumentation and fusion; Pelvic parameters

Introduction

The current standard of care for the surgical treatment of adolescent idiopathic scoliosis (AIS) is posterior spinal instrumentation and fusion (PSIF). Commonly prescribed for moderate to severe AIS, this treatment modality aims to arrest progression of the spinal deformity, achieve optimal 3-dimensional correction, preserve spinal flexibility, and minimize complications [1–3]. Correction of coronal plane deformity has been the primary focus of surgical treatment of AIS because the normal alignment in the coronal plane is relatively easy to define and achieve via PSIF. The effects of PSIF on the sagittal plane, however, have often been neglected. Postoperative sagittal outcomes have gained increased attention in recent years, particularly in the adult population where sagittal plane parameters have demonstrated significant correlation with outcomes measures [4]. However, the goals of sagittal plane alignment are challenging in pediatric patients, whose spinopelvic parameters continue to evolve as they grow [5–8].

In examining the overall effects of spinal fusion, it has been well established that the unfused portions of the spine react to correction of deformity in the coronal plane [9–13], and early studies indicate that there may be a reciprocal effect in the sagittal plane [14]. From these findings, it would appear reasonable that alignment changes in the spine would affect pelvic parameters [15]. Several studies have underscored the strong relationship between lumbar lordosis (LL) and pelvic incidence (PI), and the important effect PI has on LL in maintaining standing balance in healthy subjects of all ages [6,16–22]. In light of this relationship, several authors have proposed the need to restore or preserve sagittal spinopelvic alignment according to the relationship of PI (a constant patient-specific anatomic parameter) and the ideal LL for an individual patient [4,6,23,24]. Two specific associations have been proposed, one commonly used in clinical practice ($LL = PI + 10$) [4,23] and the other a research-driven model describing normal adolescents ($LL = 0.56\ PI + 33.43$) [6]. These studies assert that an individual's PI should be used in preoperative planning to achieve an LL that will maintain a more physiologic spinopelvic alignment and thus decrease the future incidence of pain, functional disability, gait disturbance, or altered forward gaze [4,7,23–25].

There is widespread recognition that loss of LL after spine fusion can result in pain and dysfunction because of flatback syndrome, which may necessitate revision surgery [4,24]. The potential risk for AIS patients to develop such a syndrome, particularly after fusions extending into the lumbar spine, warrants further investigation of post-fusion spinopelvic sagittal alignment in the AIS population.

The purpose of this study was therefore to investigate the effect that lumbar spinal fusion in AIS has on the sagittal alignment of the pelvis by examining the effect of decreased LL after PSIF for AIS on the change in pelvic tilt (PT). Furthermore, this study aimed to examine the patient-specific relationship between LL and PI, testing the hypothesis that spinal fusion resulting in mismatched LL is associated with increased PT.

Materials and Methods

Study design

After the researchers obtained institutional review board approval from the senior author's institution, they queried the prospective multicenter database of the Spinal Deformity Study Group (SDSG) to identify 956 patients who underwent primary PSIF for AIS (aged 10–18 years at diagnosis) that featured any coronal curve type. All patients in the database provided consent. Patients in this study were enrolled from 2002 to 2008 and had their 2-year follow-up visit from 2004 to 2010. Average follow-up was 3.1 years. Of 956 patients, 708 had 2-year follow-up. Only patients with lowest instrumented vertebra (LIV) of L2, L3, L4, or L5 and at least 2 years of complete clinical and radiographic follow-up were included in the study. Exclusion criteria included LIV cephalad to L2 or caudal to L5, anterior or combined surgical approach, juvenile idiopathic scoliosis (aged 8–9 years at diagnosis), or previous spinal surgery. Patients were also excluded if the preoperative or 2-year follow-up radiographs were insufficient for measurement of sagittal spinopelvic parameters. Only 155 patients (24 males and 131 females) had 2-year follow-up with adequate X-rays. Thirteen centers contributed patients to this analysis project.