



## Clinical Study

## Poor visualization limits diagnosis of proximal junctional kyphosis in adolescent idiopathic scoliosis

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**Abstract**

**BACKGROUND CONTEXT:** Multiple methods are used to measure proximal junctional angle (PJA) and diagnose proximal junctional kyphosis (PJK) after fusion for adolescent idiopathic scoliosis (AIS); however, there is no gold standard. Previous studies using the three most common measurement methods, upper-instrumented vertebra (UIV)+1, UIV+2, and UIV to T2, have minimized the difficulty in obtaining these measurements, and often exclude patients for which measurements cannot be recorded.

**PURPOSE:** The purpose of this study is to assess the technical feasibility of measuring PJA and PJK in a series of AIS patients who have undergone posterior instrumented fusion and to assess the variability in results depending on the measurement technique used.

**STUDY DESIGN/SETTING:** A retrospective cohort study was carried out.

**PATIENT SAMPLE:** There were 460 radiographs from 98 patients with AIS who underwent posterior spinal fusion at a single institution from 2006 through 2012.

**OUTCOME MEASURES:** The outcomes for this study were the ability to obtain a PJA measurement for each method, the ability to diagnose PJK, and the inter- and intra-rater reliability of these measurements.

**METHODS:** Proximal junctional angle was determined by measuring the sagittal Cobb angle on preoperative and postoperative lateral upright films using the three most common methods (UIV+1, UIV+2, and UIV to T2). The ability to obtain a PJA measurement, the ability to assess PJK, and the total number of patients with a PJK diagnosis were tabulated for each method based on established definitions. Intra- and inter-rater reliability of each measurement method was assessed using intraclass correlation coefficients (ICCs).

**RESULTS:** A total of 460 radiographs from 98 patients were evaluated. The average number of radiographs per patient was 5.3±1.7 (mean±standard deviation), with an average follow-up of 2.1 years (780±562 days). A PJA measurement was only readable on 13%–18% of preoperative films

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and 31%–49% of postoperative films (range based on measurement technique). Only 12%–31% of films were able to be assessed for PJK based on established definitions. The rate of PJK diagnosis ranged from 1% to 29%. Of these diagnoses, 21%–100% disappeared on at least one subsequent film for the given patient. ICC ranges for intra-rater and inter-rater reliability were 0.730–0.799 and 0.794–0.836, respectively.

**CONCLUSIONS:** This study suggests significant limitations of the three most common methods of measuring and diagnosing PJK. The results of studies using these methods can be significantly affected based on the exclusion of patients for whom measurements cannot be made and choice of measurement technique. © 2015 Elsevier Inc. All rights reserved.

**Keywords:** Adolescent idiopathic scoliosis; Measurement; Posterior spinal fusion; Proximal junctional angle; Proximal junctional kyphosis; Radiograph

## Introduction

Proximal junctional kyphosis (PJK) is a form of adjacent segment disease that is characterized by pathologically increased tipping forward cephalad to a fusion that is often discussed in patients undergoing surgery of adolescent idiopathic scoliosis (AIS). It requires identifying the proximal junctional angle (PJA), which is a measure between the upper-instrumented vertebrae (UIV) and the segments above on a lateral radiograph. There have been multiple methods for measuring PJA described in the literature; however, visualization of this angle can be difficult, and there is no consensus on which measurement method to use [1].

The first method for measuring PJK was described by Lee et al. in 1999 [2]. The authors defined PJA as a sagittal Cobb angle measurement from the UIV to T2 (UIV to T2). Pathologic PJK was then defined as more than 5° above the summed normal angular segments as previously reported by Bernhard and Bridwell, a criteria that can be assessed on any postoperative radiograph [3].

Later, Glattes et al. defined the PJA as the sagittal Cobb angle between the UIV to the second cephalad vertebra (UIV+2) in adult scoliosis, and Kim et al. adapted this definition for use in AIS [4,5]. According to the UIV+2 criteria, a patient had pathologic PJK if two criteria were fulfilled: absolute PJA was greater than 10° and this angle was at least 10° greater than the preoperative measurement. This method requires visualization of both the preoperative and postoperative PJAs to be able to diagnose PJK.

More recently, Helgeson et al. defined the PJA as the sagittal Cobb angle between the UIV to the supra-adjacent vertebra (UIV+1) [6]. A postoperative patient had pathologic PJK if there was a 15° increase from preoperative films.

Table 1 summarizes these techniques used for obtaining a PJA measurement and diagnosing pathologic PJK. Despite the number of studies examining PJK in the AIS population, there is still no consensus of which measurement method to use.

Compounding the difficulty in diagnosing PJK is that vertebral end plates are often obscured in preoperative films because of coronal plane deformity at the upper thoracic levels (Fig. 1), making a measurement of PJA technically impossible

Table 1

Definitions of abnormal proximal junctional kyphosis (PJK) based on the proximal junctional angle measure

Measure	Definition of pathologic PJK
UIV+1 (Helgeson et al.)	≥15 degree change from preoperative film
UIV+2 (Kim et al.)	≥10 degrees and ≥10 degree change from preoperative film
UIV to T2 (Lee et al.)	≥5 degrees above summed normal angular segment on any film (no previous films needed)

UIV, upper-instrumented vertebrae.

in many patients. Overlying adjacent structures such as the mediastinal parenchyma, humerus, scapula, and ribs can also confound end plate identification, as these structures commonly course in the same plane (Fig. 2). Although these factors can be partially improved in the postoperative patient, measurements can be challenging for these patients as well.

Previous studies have used varying definitions of PJA and PJK. Further, studies often excluded patients for whom the PJA cannot be assessed, potentially introducing selection bias [2,5,7]. The purpose of the present study is therefore to assess

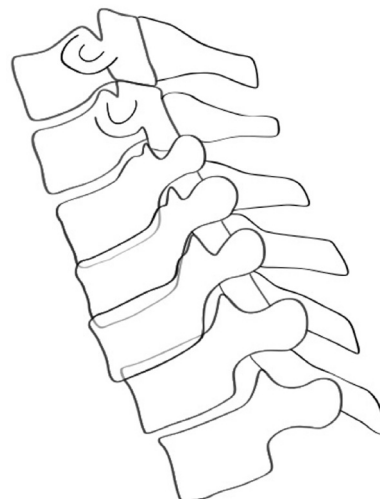


Fig. 1. Depiction of the cervicothoracic junction demonstrating overlap of the vertebral end plates caused by the coronal plane deformity.

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