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Clinical Study

The concave *versus* convex approach for minimally invasive lateral lumbar interbody fusion for thoracolumbar degenerative scoliosis

Justin K. Scheer [a], Ryan Khanna [a], Alejandro J. Lopez [a], Richard G. Fessler [b], Tyler R. Koski [a], Zachary A. Smith [a], Nader S. Dahdaleh [a,*]

[a] Department of Neurological Surgery, Northwestern University, Feinberg School of Medicine, Suite 2210, 676 North St. Clair Street, Chicago, IL 60611, USA
[b] Department of Neurosurgery, Rush University Medical Center, Chicago IL, USA

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ABSTRACT

We retrospectively reviewed patient charts to compare the approach-related (convex *versus* concave) neurological complications and magnitude of correction in patients undergoing lateral lumbar interbody fusion (LLIF). It is yet to be quantitatively determined if correction of adult degenerative scoliosis from either side of the curve apex using a LLIF results in a reduction in complications and/or improved corrective ability. The inclusion criteria for this study were patients who underwent a LLIF for adult degenerative thoracolumbar scoliosis and had the LLIF prior to any other supplemental procedures. Patients were grouped based on the approach toward the curve apex concavity (CAVE) or the convexity (VEX). Standard coronal and sagittal radiographic measurements were made. Neurological complications and reoperation indications were also recorded. We included 32 patients for review (CAVE: 17; VEX: 15) with a mean age of 65.5 years ± a standard deviation of 10.2, and mean follow-up of 17.0 months ± 15.7. There were eight postoperative neurological complications in eight patients (25.0%), and seven reoperations for six patients (18.8%; CAVE: 4/17 [23.5%]; VEX: 2/15 [13.3%]). The CAVE group had 6/17 neurological complications (35.3%; four ipsilateral and two contralateral to approach side) and VEX had 2/15 (13.3%; one ipsilateral and one bilateral to approach side; $p > 0.05$). All patients significantly improved in the mean regional and segmental Cobb angles ($p < 0.05$), except for T11–T12 ($p > 0.05$). There were no significant differences between the groups for any of the radiographic parameters measured ($p > 0.05$). Approaching the curve apex from either the concave or convex side resulted in significant improvements. The concave approach was associated with more postoperative neurological complications.

1. Introduction

The minimally invasive lateral transpsoas approach to the lumbar spine has been largely accepted as a safe and effective means of achieving lateral lumbar interbody fusion (LLIF) in a wide array of lumbar spinal pathologies [1]. The advantages of this approach include less blood loss, decreased operative times, shorter hospital stays, and less postoperative pain compared to open procedures [1]. Recently, the use of this approach in treating adult thoracolumbar degenerative scoliosis has been gaining popularity as an option for certain patients with adult degenerative scoliosis.

Adult patients with thoracolumbar degenerative scoliosis generally present with chronic back pain, neurological compromise, and spinal deformity in multiple planes [2]. Open techniques have traditionally been associated with high morbidity and complication rates, despite being effective in achieving sufficient deformity correction [3,4]. Therefore, the LLIF has become a viable option for deformity correction and arthrodesis in this patient population. It allows for anterior column reconstruction while simultaneously providing indirect decompression of neural elements and correction of spinal alignment, with the added benefit of a smaller complication profile [5–8]. Recent studies have shown considerable benefits from this technique, resulting in sufficient radiographic correction, improved clinical outcomes, and a minimal complication profile [6,8–11].

However, these studies either omitted the side of approach with respect to the curve apex, or approached the curve from either side of the apex. An approach from the convex side requires a primarily downward force to correct the curve, whereas an approach from the concave side requires a primarily distractive force. Since the concave approach requires a significant distractive force, we

* Corresponding author. Tel.: +1 312 695 6200; fax: +1 312 695 0225.
E-mail address: nader.dahdaleh@northwestern.edu (N.S. Dahdaleh).

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hypothesize that a higher incidence of neurological deficits, possibly due to disruption or stretch injury of the lumbar plexus, may occur. It is yet to be quantitatively determined if the correction of adult degenerative scoliosis from either side of the curve results in a reduction in complications and/or offers improved corrective ability. Therefore, the purpose of the present study was to compare the neurological complications and magnitude of correction in patients undergoing LLIF for degenerative thoracolumbar scoliosis, specifically between those in whom the approach was either from the concave or convex side of the curve apex.

2. Methods

2.1. Patient population

This study is a retrospective analysis of patients who underwent a LLIF between the years 2006 and 2014 at a single institution by multiple surgeons. Approval from the Institutional Review Board was obtained prior to conducting this study. Patients were identified by querying the departmental billing records for current procedural terminology codes for LLIF. The inclusion criteria were patients who were $\geqslant$18 years of age, had a diagnosis of thoracolumbar scoliosis based on the operative note, underwent a LLIF $\geqslant$1 level, and had the LLIF prior to posterior screw and rod instrumentation and/or any other supplemental procedures. The last inclusion criterion was included in order to help isolate the corrective effects of the LLIF by minimizing any potential confounding of alignment correction done prior to the LLIF. Patients were excluded if they underwent the LLIF for significant sagittal malalignment alone, severe degenerative disc disease without coronal malalignment, had the LLIF after posterior instrumentation was placed or another procedure. Based on the LLIF approach, patients were placed into two groups. Those who underwent an approach opposite the curve apex side were defined as concave (CAVE; Fig. 1), and those in whom the approach was toward the curve apex side were defined as convex (VEX; Fig. 2). The decision for the approach side was at the discretion of the treating surgeon, based on their clinical experience and how they felt it was best to manage the patient in the context of the entire clinical picture and patient goals.

2.2. Data collection

Demographic data including age and sex, and operative data including the number and level(s) of LLIF and any other fusion technique (anterior lumbar interbody fusion [ALIF], transforaminal lumbar interbody fusion [TLIF]), the number, levels, and types of osteotomies performed, the upper-most instrumented vertebra (UIV), the lower-most instrumented vertebra (LIV), and the length of hospital stay (LOS) were collected. The number and type of neurological complications were also recorded, including intra-, peri-, and postoperative complications and reoperations. Neurological complications were defined as any new motor or sensory deficit.

2.3. Radiographic measures

Full length free-standing lateral spine radiographs (36 inch cassette) at baseline and final follow-up were analyzed using validated software [12] (Surgimap; Nemaris, New York, NY, USA). The coronal radiographic measures included global coronal malalignment (C7 plumb line relative to S1), thoracic scoliosis curve (Cobb angle between superior endplate of T2 and inferior endplate of T12), lumbar scoliosis curve (Cobb angle between superior endplate of L1 and superior endplate of S1), and segmental Cobb angles from T10 to S1. The sagittal radiographic measures included thoracic kyphosis (TK; T2–T12, Cobb angle between superior endplate of T2 and inferior endplate of T12), lumbar lordosis (LL; Cobb angle between superior endplate of L1 and superior endplate of S1), sagittal vertical axis (SVA; C7 plumbline relative to S1), pelvic tilt (PT), and the mismatch between pelvic incidence (PI) and lumbar lordosis (PI–LL).

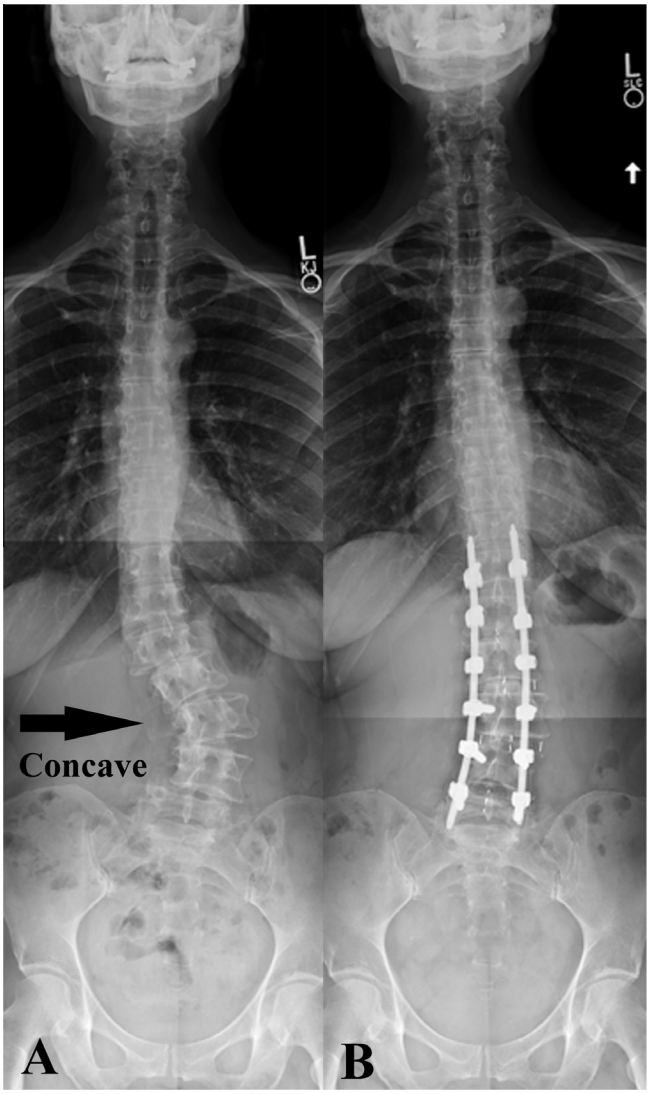

Fig. 1. Antero-posterior radiographs, preoperative (A) and final follow-up at 13.3 months (B). The black arrow denotes the direct lateral interbody fusion approach from the concave side of the scoliosis curve.

2.4. Statistical analyses

Continuous variables are reported as the mean ± standard deviation. Statistical analyses were performed using the Fisher's exact test to compare the complication rates. Pairwise comparisons between preoperative and final follow-up radiographic values were analyzed using repeated measures (pair wise) analysis of variance with Tukey's honest significant difference *post hoc* adjustment for multiple comparisons, to control for type I error. All statistical analyses were conducted using the commercially available JMP software (version 7.0; SAS Institute, Cary, NC, USA) and the level of significance was set at $p < 0.05$ for all tests.