

# Minimally Invasive Lateral Lumbar Interbody Fusion for the Correction of Adult Degenerative Spinal Deformity: Current Literature Review

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We reviewed literatures relating to minimally invasive lateral lumbar interbody fusion for the treatment of adult degenerative spinal deformity. Most of literatures were retrospective case series with a small numbers of patients. A prospective multicenter study was published in two separate papers. This procedure was effective in treating the coronal deformity. On the other hand, restoring the sagittal plane remains an issue. Pseudarthrosis was problematic, especially in the cases without use of the human recombinant bone morphogenetic protein-2 (rhBMP-2) and bilateral pedicle screw fixation. Temporary sensory deficits and transient leg weakness was the most common complication after lateral lumbar interbody fusion. Careful patient selection is important for the application of lateral minimally invasive techniques for adult degenerative scoliosis.

**Key Words:** Minimally invasive, Lateral transpsoas approach, Adult degenerative scoliosis, Lumbar spine

## Introduction

Adult degenerative spinal scoliosis appears to be one of the increasing surgical indications in the current field of spinal deformity surgery. The curves were usually located in the lumbar spine. It has a less rotational deformity than adult idiopathic scoliosis and more frequently involved rotary subluxation, especially, at the level of L3-4. As the minimally invasive techniques have evolved in recent years, anterior interbody fusion procedure via lateral lumbar approach has been introduced for the correction of adult degenerative scoliosis. This review demonstrated the current results of minimally invasive lateral lumbar interbody fusion procedure for the treatment of adult degenerative spinal deformity. Review was focused on the following issues: 1) clinical outcome, 2) correction of global coronal and sagittal imbalance, 3) radiographic fusion rate, and 4) peri- and postoperative complications. Current publications have shed some light on these issues.

## Clinical Outcome

Anand and colleagues<sup>1)</sup> reported 28 patients treated with 3 or more levels of minimally invasive lateral transpsoas interbody fusion and percutaneous pedicle screw fixation, with a mean age of 67.7 years and mean follow-up time of 22 months. Mean intraoperative blood loss was 500 mL, and the operative times were a mean of 500 minutes. The visual analogue scale (VAS), treatment intensity scale, 36-Item Short Form Health Survey, and Oswestry Disability Index (ODI) scores at 1 year were statistically better than preoperative values.

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Dakwar and colleagues<sup>2)</sup> retrospectively reviewed 25 adult patients with degenerative deformity who underwent anterior reconstruction with lateral interbody fusion for 3 or more levels with a mean follow-up of 11 months. The mean intraoperative blood loss was 53 mL per level, with a mean length of stay of 6.2 days. VAS scores and ODI scores improved significantly postoperatively.

Acosta and colleagues<sup>3)</sup> retrospectively evaluated the changes in the coronal and sagittal plane after lateral interbody fusion for the treatment of degenerative lumbar disease in 36 patients. The postoperative ODI and VAS scores improved significantly.

Phillips and colleagues<sup>4)</sup> underwent a prospective, multi-center, single-arm study to evaluate the clinical and radiographical results of 107 patients undergoing extreme lateral interbody fusion (XLIF), a minimally disruptive lateral transposas retroperitoneal surgical approach for the treatment of degenerative scoliosis. Clinical and radiographic results were evaluated up to 24 months after surgery. A mean of 3.0 (range, 1-6) levels were treated with XLIF per patient. Overall complication rate was low compared with traditional surgical treatment of degenerative scoliosis. Significant improvement was seen in all clinical outcome measures at 24 months: ODI scores, VAS for back pain and leg pain, and 36-Item Short Form Health Survey mental and physical component summaries ( $P < 0.001$ ). Eighty-five percent of patients were satisfied with their outcome and would undergo the procedure again.

## Correction of Global Coronal and Sagittal Imbalance

Anand and colleagues<sup>1)</sup> reported that the mean coronal Cobb angles were 22° preoperatively and 7.5° postoperatively, but the authors did not report results of sagittal correction.

Tormenti and colleagues<sup>2)</sup> demonstrated their retrospective review of 8 cases performed with a combined lateral interbody fusion and open posterior fixation and compared this cohort with 4 cases who underwent posterior-only open surgery. The mean preoperative and postoperative coronal Cobb angles were 39° and 13°, respectively, in the lateral in-

terbody fusion group versus 19° and 11°, respectively, in the posterior-approach-only group. The authors did not report sagittal balance parameters, either.

Wang and Mummaneni<sup>5)</sup> retrospectively reviewed 23 patients with thoracolumbar deformity treated with minimally invasive approaches. The mean age was 64.4 years, with a mean follow-up of 13.4 months. The coronal Cobb angles improved from 31.4° preoperatively to 11.5° postoperatively. The lumbar lordosis improved from 37.4° preoperatively to 47.5° postoperatively.

Acosta and colleagues<sup>3)</sup> retrospectively evaluated the changes in the coronal and sagittal plane after lateral interbody fusion for the treatment of degenerative lumbar disease in 36 patients. Of this cohort, only 8 patients had degenerative scoliosis; the mean regional lumbar coronal Cobb angles improved significantly from 21.4° preoperatively to 9.7° postoperatively. The mean global coronal alignment was 19.1 mm preoperatively and 12.5 mm postoperatively ( $P < 0.05$ ). In the sagittal plane, the mean segmental Cobb angle measured -5.3° preoperatively and -8.2° postoperatively ( $P < 0.0001$ ). The mean preoperative and postoperative regional lumbar lordosis was 42.1° and 46.2°, respectively ( $P > 0.05$ ). The mean global sagittal alignment was 41.5 mm preoperatively and 42.4 mm postoperatively ( $P = 0.7$ ).

Phillips and colleagues<sup>4)</sup> also reported that lumbar lordosis was corrected from a mean of 27.7° to 33.6° at 24 months ( $P < 0.001$ ) in patients with hypolordosis. Overall Cobb angle was corrected from 20.9° to 15.2°, with the greatest correction observed in patients supplemented with bilateral pedicle screws.

## Radiographic Fusion Rate

Anand and colleagues<sup>1)</sup> reported all patients had a solid fusion assessed by plain radiographs at 1 year. Tormenti and colleagues<sup>6)</sup> also reported no pseudarthrosis or instrumentation failures. Wang and Mummaneni<sup>5)</sup> stated all of the 16 patients achieved solid fusion at the levels of interbody fusion. Of the 7 cases without use of interbody fusion at every level, 2 patients had pseudarthrosis. The lateral interbody fusion underwent with autobone graft, rhBMP-2, and bone graft substitutes. However, Castro and the colleagues<sup>7)</sup> re-

ported 84% of fusion rate and 29% of high-grade subsidence 2 year after surgery without use of rhBMP-2 and bilateral pedicle screw fixation.

## Peri- and Postoperative Complications

Anand and colleagues<sup>1)</sup> illustrated complications in 23 patients, mostly transient dysesthesia (17/23) related to the lateral transpsoas approach. The authors also reported 2 transient quadriceps weaknesses, 1 retrocapsular renal hematoma, and 1 cerebellar hemorrhage in this cohort.

Tormenti and colleagues<sup>6)</sup> demonstrated 1 case of cecal perforation during the anterior approach in this series. The investigators also reported 6 cases of sensory lower extremity dysesthesia as well as 2 cases of lower extremity motor dysfunction after the lateral transpsoas approach. In most cases, these neurologic issues resolved over several months. The authors also reported 1 case of infection and meningitis, 1 case of ileus, 1 case of pleural effusion, and 1 patient who had a pulmonary embolus after surgery.

Dakwar and colleagues<sup>2)</sup> reported complications included 3 cases of transient postoperative anterior thigh numbness, 1 case of rhabdomyolysis requiring temporary hemodialysis, 1 case of implant failure, and 1 case of asymptomatic subsidence. One-third of their cases failed to restore sagittal balance. Reported perioperative complications included 1 patient with rhabdomyolysis requiring temporary hemodialysis, 1 patient with implant subsidence, and 1 patient with hardware failure. In addition, 3 patients (12%) experienced transient postoperative anterior thigh numbness in the distribution of the anterior femoral cutaneous nerve after the lateral interbody fusion procedure.

Wang and Mummaneni<sup>5)</sup> retrospectively reviewed 23 patients with thoracolumbar deformity treated with minimally invasive lateral interbody fusion procedures. The mean blood loss was 477 mL. They also reported 7 patients developed thigh dysesthesia or numbness on the side of the lateral transpsoas approach. All of these cases recovered except for 1 patient who had thigh numbness and quadriceps weakness that persisted. Other complications included 1 patient with postoperative atrial fibrillation, 1 case of pneumothorax requiring a chest tube, 1 cerebrospinal fluid (CSF)

leak, and 1 patient who needed reoperation for S1 screw pull-out.

Isaacs and colleagues<sup>8)</sup> performed a prospective multicenter nonrandomized observational study of 107 adult patients with deformity with mean age of 68.4 years who were treated with lateral interbody fusion alone (24.3%) or lateral interbody fusion with either open or percutaneous posterior fixation (75.7%). The mean operative time was 177.9 minutes. A total of 62.5% of patients had a recorded blood loss of less than 100 mL and only 8.4% had greater than 300mL estimated blood loss. The overall complication rate was 24.3%. These authors found that patients undergoing minimally invasive surgery-only procedures (lateral interbody fusion alone or with percutaneous pedicle screws) had significantly lower complications (9% had 1 or more major complications) than those undergoing combined minimally invasive lateral interbody fusion procedures with posterior open pedicle screw fixation procedures (20.7% had 1 or more major complications). The most common major surgical complications were posterior wound infections (3 patients who had open posterior surgery) and postoperative motor deficits (7 cases of persistent motor weakness or having 2 grades decrease in motor strength after procedures).

## Literature Reviews

Mundis and colleagues<sup>9)</sup> performed a literature review on minimally invasive lateral approaches for interbody fusion to treat degenerative spinal deformity. Both patient-centered outcomes and objective radiographic parameters showed significant improvement in most studies. The complication rates varied between studies, but the major complications were low. Thigh dysesthesia was the most commonly reported complication associated with lateral interbody fusion but was transient in most cases. The authors concluded that the minimally invasive lateral approach was an effective surgical strategy for adult degenerative deformity. Acknowledging the details of meticulous surgical technique and local anatomy (e.g., lumbosacral plexus and blood vessels) is the essential key to improving outcomes and reducing the risk of complications. Although a learning curve certainly exists in treating patients with this technique, even preliminary

results, have an overall complication rate that is favorable when comparing to historic controls of open anterior surgery, with the added benefit of good early clinical outcomes.

Berjano and Larmatina<sup>10)</sup> also reviewed the current literature for minimally invasive lateral approaches in the treatment of adult deformity, and they proposed a classification of adult lumbar deformity to guide formulation of a surgical strategy for lateral interbody fusion use. XLIF with posterior percutaneous pedicle screw instrumentation provides 40-75 % correction of coronal curves, with modest increase of lordosis. Only anterior XLIF can provide less correction. They concluded that XLIF is a promising minimally invasive surgery option for adult deformity. Specific surgical strategies are needed to avoid imbalance and define ideal fusion levels and methods. An XLIF-based minimally invasive surgery strategy with a reduced number of levels of lumbar scoliosis can lead to significant advantages.

## Summary

From these published articles, it can be concluded that (1) clinical outcomes can be achieved with minimally invasive lateral transpoas approach for a subset of adult deformity cases; (2) lateral lumbar interbody fusion procedure is effective in treating the coronal deformity. However, restoring the sagittal plane remains an issue; (3) pseudarthrosis is problematic, especially in cases without rhBMP-2 and bilateral pedicle screw fixation; (4) the complication profile of lateral interbody fusion remains to be determined on a large scale, with temporary sensory deficits and transient leg weakness being most common. Because these deficits are approach-related and mostly transient, the question remains whether these temporary neurological changes should be considered as approach related temporary morbidity or as complications. Careful patient selection is important for the application of lateral minimally invasive techniques for adult degenerative scoliosis.

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## 최소침습적 측방 요추체간 골유합술을 이용한 퇴행성 척추 측만증의 교정: 현재까지의 치료결과 문헌고찰

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최근 퇴행성 척추 측만증의 교정을 위한 최소침습적 측방 요추체간 골유합술이 널리 사용되고 있으나, 아직 그 결과에 대한 보고가 잘 알려진 바가 없는 실정이다. 따라서, 여러 문헌들을 분석하여 임상 및 방사선학적 결과와 합병증을 알아 보았다. 문헌 고찰 결과, 최소침습적 측방 도달법을 통한 요추체간 유합술은 시상면보다 관상면 교정에 더 효과적이며, rhBMP-2 또는 양측 척추경 나사못 고정술이 사용되지 않은 경우 골유합술 성공률이 떨어졌다. 또한 가장 흔한 술 후 합병증으로 일시적인 감각 및 운동 마비였다. 성인 퇴행성 척추 변형을 교정 위한 최소침습적 측방 추체간 골유합술의 성공적인 수술결과를 위해선 세심한 환자선택이 중요할 것으로 생각된다.

**색인 단어:** 최소침습적, 측방 추체간 골유합술, 퇴행성 척추 측만증, 요추

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