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Research Article

# Early experience with oblique lateral interbody fusion (OLIF) with posterior percutaneous screw placement (OLIFwPPS): Case series with clinical and radiographic outcomes

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ABSTRACT

*Background:* Oblique Lateral Interbody Fusion (OLIF) is a relatively new approach which allows for access to the intervertebral disk space anterior to the psoas muscles, while remaining posterior to the more anterior vascular structures. Compared to posterior only fusion, OLIF results in reduced muscle dissection and preserved spinal anatomy, all while maximizing fusion surface area and providing indirect decompression.
*Methods:* Thirteen patients treated by OLIF with percutaneous posterior screw placement since 2016 were retrospectively analyzed. Post-operative outcomes evaluated included fusion, adjacent segment degeneration, and pain scores. Spinopelvic parameters were analyzed pre and postoperatively.
*Results:* The average number of vertebral levels treated was 2 (1–3), all between L2 and L5. Fusion was confirmed in all patients with an available CAT scan (7 of 7 patients). Adjacent segment degeneration was seen in 0 of the 13 patients. VAS showed an average improvement of 3.8 (2–8), with 11 out of 13 patients experiencing an improvement in pain. All 11 patients with multilevel fusions showed an improvement in pain. 8 of the 13 patients had mild degenerative scoliosis defined as a cobb angle >10°. All five of these patients showed improvement in postoperative pain scores.
*Conclusion:* OLIF with percutaneous posterior screws can be considered a safe and effective treatment option for lumbar disk degeneration, with complication rates and improvement comparable to those seen with alternative approaches. Further studies are warranted to evaluate outcomes in larger samples with longer follow up data.

## 1. Introduction

Low back pain is a leading cause of disability world-wide and is a significant economic burden on the healthcare system [1,2]. Lumbar fusions are occasionally the surgery of choice for degenerative lumbar spine disease. The posterior lumbar interbody fusion (PLIF) has historically been the standard approach to lumbar fusion but carries the morbidity of paraspinal muscle dissection and the removal of posterior bony structures for arthrodesis. In revision surgery there is the added higher risk of cerebrospinal fluid leak and even nerve injury. From these pitfalls to PLIF surgery emerged lateral approaches that protect the integrity of the posterior spinal column and allow for minimal muscle dissection. In recent decades, these lateral approaches have shown to have excellent exposure of the disc space for placement of an interbody graft, shorter operative times, and decreased blood loss [2,3]. Anterior and lateral approaches for lumbar interbody fusion surgery may generally be categorized into three approaches: anterior (ALIF), lateral (XLIF and LLIF), and oblique (OLIF). Each of these techniques have been shown to have > 90% rates of interbody fusion on follow-up imaging studies [3,4]. ALIF, X/LLIF, and OLIF have also shown favorable clinical

*Abbreviations:* ALIF, Anterior LumbarInterbody Fusion; ASA, American Society of Anesthesiologists; BMP, Bone Morphogenetic Protein; CC, Coronal Cobb; LL, Lumbar Lordosis; LLIF, Lateral Lumbar Interbody Fusion; ODI, Oswestry Disability Index; OLIF, Oblique Lateral Interbody Fusion; OLIFwPPS, Oblique Lateral Interbody Fusion with Percutaneous Posterior Screws; PLIF, Posterior Lumbar Interbody Fusion; PPS, Posterior Percutaneous Screw; PT, Pelvic Tilt; SCC, Segmental Coronal Cobb; SL, Segmental Lordosis; SS, Sacral Slope; SVA, Sagittal Vertical Alignment; VAS, Visual Analogue Score; XLIF, eXtreme Lateral Interbody Fusion.

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outcomes measured by pain and disability indices [4,5]. Each of these techniques have varying indications and risks. Specifically, ALIF surgeries typically only provide access to the L4-S1 levels and carry the risk of damage to major abdominal vessels. X/LLIF surgery allows for access to the T12-L5 levels with a *trans*-psoas dissection at the lower levels but requires neuromonitoring to avoid injury to the lumbar plexus. OLIF surgery was first described by Mayer in 1997 and became more popular after the larger series by Silvestre et al in 2012 [6,7]. OLIF surgeries allow for access to L1-S1 while remaining anterior to the psoas and therefore reduces the risk of neurologic deficits to the lumbar plexus. A tradeoff for OLIF surgery is the higher risk of subsidence of the interbody graft, therefore often necessitating the use of pedicle screws for long-term stabilization of the spinal fusion [8].

In patients where their degenerative disease has caused substantial spinal deformity, such as spondylolisthesis and scoliosis, among others, lumbar interbody fusion surgery has shown promising results in restoring normal anatomy [5,9,10]. Success in the correction of these conditions is often measured radiographically by estimating spinopelvic parameters. There have been several studies investigating ALIF, X/LLIF, and posterior approaches to interbody fusion on spinopelvic parameters, but OLIF approaches have received less attention [5,9–12]. This study is a retrospective review of 13 cases of OLIF surgery with percutaneous posterior screws (OLIFwPPS) at a single institution with an emphasis on operative, perioperative, and clinical and radiographic outcomes.

## 2. Methods

We performed a retrospective analysis searching our internal database for all OLIF procedures performed at our primary spine hospital with three spine surgeons (GER, DR, MFG), which was narrowed down to include only OLIF cases with posterior percutaneous screw placement (OLIFwPPS). The study was approved by the local institutional review board (IRB) with a waiver of informed consent given the retrospective analysis of deidentified clinical data. Thirteen patients were identified, and a retrospective review of each patient's chart was performed to obtain information on the following patient demographics: gender, smoking status, history of previous lumbar surgery, American Society of Anesthesiologists (ASA) score, and age at the time of surgery. Details about the operation and hospitalization were collected, including operative levels, estimated blood loss, length of stay, and operation time. Pain and functional outcomes were assessed using Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) results. Immediate postoperative and long-term complications were identified.

All preoperative, immediate postoperative, and final standing radiographs, as well as computed topography (CT) scans, for patients included in the analysis were evaluated. A single spine surgeon (MFG) measured all spinopelvic parameters to reduce the interobserver variability. Parameters measured included coronal Cobb (CC, angle formed between the superior endplate of L1 and the superior endplate of L5), segmental coronal Cobb (SCC, angle between the superior endplates of upper and lower vertebras at the segment of interest), lumbar lordosis (LL, angle between the superior L1 endplate to the superior L5 endplate), segmental lordosis (SL, angle between the superior endplates of upper and lower vertebras at the segment of interest), and sacral slope (SS, angle between the superior sacral end plate and the horizontal reference line). When 36 in. x-rays were available, additional parameters were measured including pelvic tilt (PT, angle between the line through the midpoint of the superior sacral end plate to the center of femoral head and the vertical reference line), pelvic incidence (PI, angle between the line through the midpoint of the superior sacral end plate to the center of femoral head, and the line perpendicular to the midpoint of the superior sacral end plate), and sagittal vertical alignment (SVA, horizontal distance from the posterosuperior aspect of the S1 to the vertical line drawn through the midbody of C7 vertebrae) (Fig. 1). In patients who had received a CT greater than six months postoperatively, scans were evaluated for the presence of interbody fusion. Adjacent segment degeneration was assessed using most recent x-ray (at least 6 mo post-op) and defined as the presence of spondylolisthesis above or below segment of interest. A paired *t*-test was utilized to determine differences between the means of spinopelvic parameters at the immediate post-operative period and on final x-rays in comparison to the preoperative radiographs.

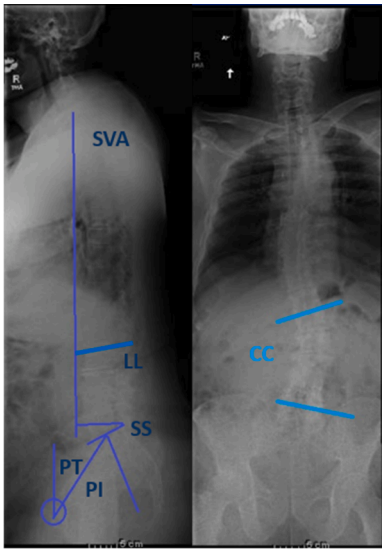


**Fig. 1.** Spinopelvic Measurements. Left: Overlay showing measurements used for sagittal vertical alignment (SVA), global lumbar lordosis (LL, pelvic incidence (PI, pelvic tilt (PT, and sacral slope (SS. Segmental (regional) lordosis and segmental (regional) coronal Cobb not shown above, however were measured from the angle formed between the end plates of upper and lower vertebras at the segment of interest. Right: Overlay showing the measurement used for the global coronal Cobb (CC) angle.

### 2.1. Surgical technique

After intubation, patients were turned in the lateral decubitus position with the right side up (Fig. 2. Lateral fluoroscopy was then used to mark out the disc spaces and to plan an oblique incision approximately two finger breadths anterior to the disc space markings. Incision was made and a retroperitoneal dissection was performed to expose the psoas muscle and corresponding disc space(s). Staying lateral to the sympathetic plexus, the psoas muscle was retracted posteriorly with a Cobb. An annulotomy was made and the discectomy was performed in a routine fashion with shavers, ring curettes, pituitary rongeurs and rasps to rough up the endplates. Trials were inserted under AP and lateral fluoroscopy and the corresponding cage was inserted with 6–8 mg of bone morphogenetic protein per level. The patient was then turned prone onto a Jackson table. An iliac crest fiducial was inserted and O-arm was brought in for intraoperative CAT scan which was uploaded into a Stealth station for navigation. Awl-tipped taps were used to cannulate the pedicle and the corresponding percutaneous screws were inserted along with the rods.

## 3. Results

Preoperative patient characteristics are listed in Table 1. The average age of patients included was 62, with a range of 43–75. Seven of the thirteen (54%) were female. All patients were ASA class 2 or 3, and seven of the thirteen (54%) patients had undergone previous lumbar back surgery. All patients were either non-smokers or quit at least 8 weeks prior to surgery, however two resumed in the postoperative period.

Perioperative outcomes are listed in Table 2. The average number of vertebral levels treated was 2 (range 1–3), all between L2-L5 (Fig. 3).

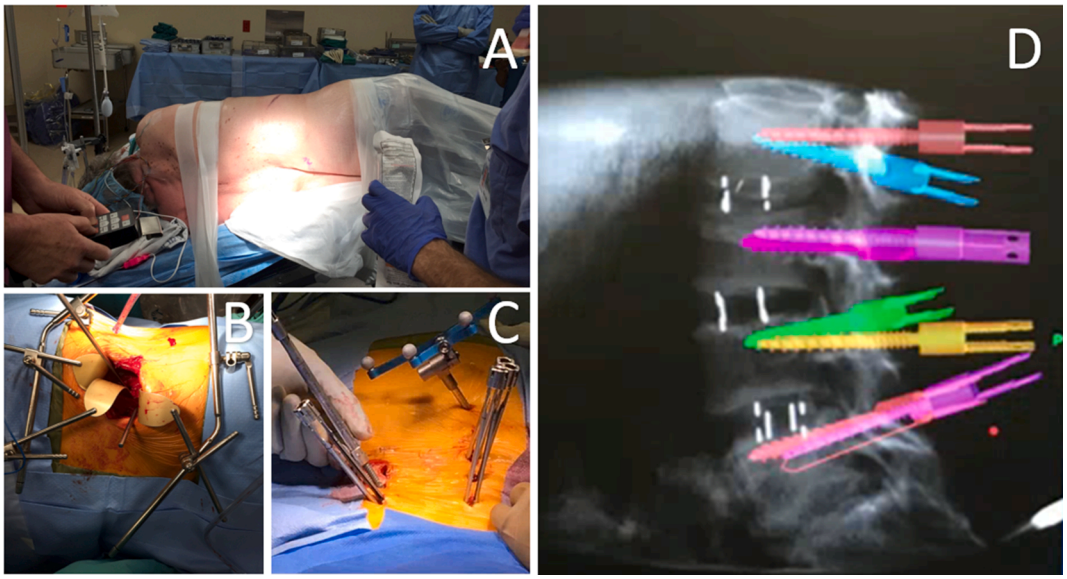


**Fig. 2.** Surgical Technique: (A) Patient placed in the left lateral decubitus position with the right side up, and prepped for oblique incision two finger breadths anterior to the disc space markings. (B) The psoas muscle is retracted posteriorly with a Cobb and the midpoint of the disc space confirmed with a Penfield and lateral fluoroscopy prior to annulotomy, discectomy, and placement of the cage with BMP. (C) Patient is rotated prone and a stab incision is made over the left posterior superior iliac spine and an iliac crest fiducial was inserted. O-arm is used for intraoperative CAT scan and uploaded into a Stealth station for navigation. (D) Optimal screw placement is confirmed using stealth navigation and the O-arm.

**Table 1**
Preoperative patient characteristics. *All patients quit prior to operation, but 2 resumed in the postoperative period.

| Demographics (n=13) | | |
|---|---|---|
| Gender | Male Patients | 6 (46.2%) |
| | Female Patients | 7 (53.8%) |
| Age (years) | | 61.6 ± 9.2 |
| Smoking Status | Yes | 2 (15.4%) |
| | No | 11 (84.6%) |
| Prior Lumbar Surgery | Yes | 7 (53.8%) |
| | No | 6 (46.2%) |

Average follow up post-procedure was 209 days (range 43–398). Post-op fusion was confirmed in all patients with >6 months follow up via CT (7 of 7 patients, 100%). There were no hardware complications found during follow up. Adjacent segment degeneration was seen in 0 of the 13 patients, having been defined as spondylolisthesis above or below level of fusion on most recent XR. All patients experienced <50 mL blood loss, and the mean operative time was 252 min (range 166–327 mins).

Table 3 lists complications. Notably, there were no intraoperative complications recognized, and all complications were transient with the exception of one which required additional surgery (described below). One patient experienced new ipsilateral leg pain which resolved with oral steroids (presumed radiculitis secondary to BMP). A hardware complication was noted in only one patient, who experienced new contralateral leg pain secondary to disk material pushed into the contralateral foramen; pain resolved with epidural injection. No vascular complications were seen. Three out of thirteen patients experienced transient radiculopathy (23%) which resolved within 3 months. This is a common reported event secondary to an OLIF [3] and most likely secondary to retraction of the psoas muscle and associated sensory nerve. Finally, one patient required an additional lumbar operation at 16 months post-op, a subsequent ALIF procedure due to flat back syndrome.

**Table 2**
Operative Results. *All patients experienced < 50 mL blood loss **Fusion was determined in patients with > 6 months FU who had received CT ***Adjacent segment degeneration defined as spondylolisthesis above or below level of fusion on most recent XR.

| Operative Results (n=13) | | |
|---|---|---|
| Number of Levels Fused | 1 | 3 (23.1%) |
| | 2 | 6 (46.2%) |
| | 3 | 4 (30.8%) |
| | Average | 2.1 ± 0.76 |
| Time to follow-up (days) | | 209 ± 128.0 |
| Operation Time (min) | | 252.6 ± 49.6 |
| Blood Loss | | <50 mL* |
| Length of Stay (days) | | 4 ± 2.1 |
| Additional Operations | | 1/13 (7.7%) |
| Fusion** | | 7/7 (100%) |
| Adjacent Segment Degeneration*** | | 0 |

Pain and disability scores were measured at each follow-up visit using VAS and ODI scores, respectively (Table 4). Self-reported VAS pain scores on a 0–10 scale showed an average improvement of 3.8 (range 2 to 8; p-value < 0.0001), with eleven out of thirteen (85%) experiencing an improvement in pain, one experiencing no change, and one with a slight increase. The mean percent improvement in VAS scores was 62% (SD of 42%). Six of thirteen patients (46%) experienced complete resolution of pain. All eleven patients with multilevel fusions showed an improvement in pain. ODI scores were obtained in ten of thirteen patients, with an average follow-up time of 107 days (range 42–368 days). Mean improvement was 7 (range −20 to 50), with the mean percent improvement of 8% (SD of 34.1%). Unlike our results with VAS scores, the improvements in ODI were not significant.

Spinopelvic parameters for all patients are listed in Table 5 and graphed in Fig. 4. As shown, significant improvements were seen in the global coronal Cobb (−4.9° ± 6.0°; p-value = 0.0065), regional coronal Cobb (−6.7° ± 7.7°; p-value = 0.0043), global lumbar lordosis (3.3° ± 5.4°; p-value = 0.0235), regional lumbar lordosis (4.7° ± 7.5°; p-value = 0.0224) and pelvic tilt (3.1° ± 3.0°; p-value = 0.0434). Pelvic Tilt parameters were included only for patients with > 20° on pre-op imaging who received a 36 in. standing XR (n = 5). No significant improvement was observed in sacral slope.

A subgroup of patients with mild degenerative scoliosis was analyzed with results listed in Table 6 and graphed in Fig. 5. Mild degenerative scoliosis was defined as a preoperative coronal Cobb > 10°. Eight

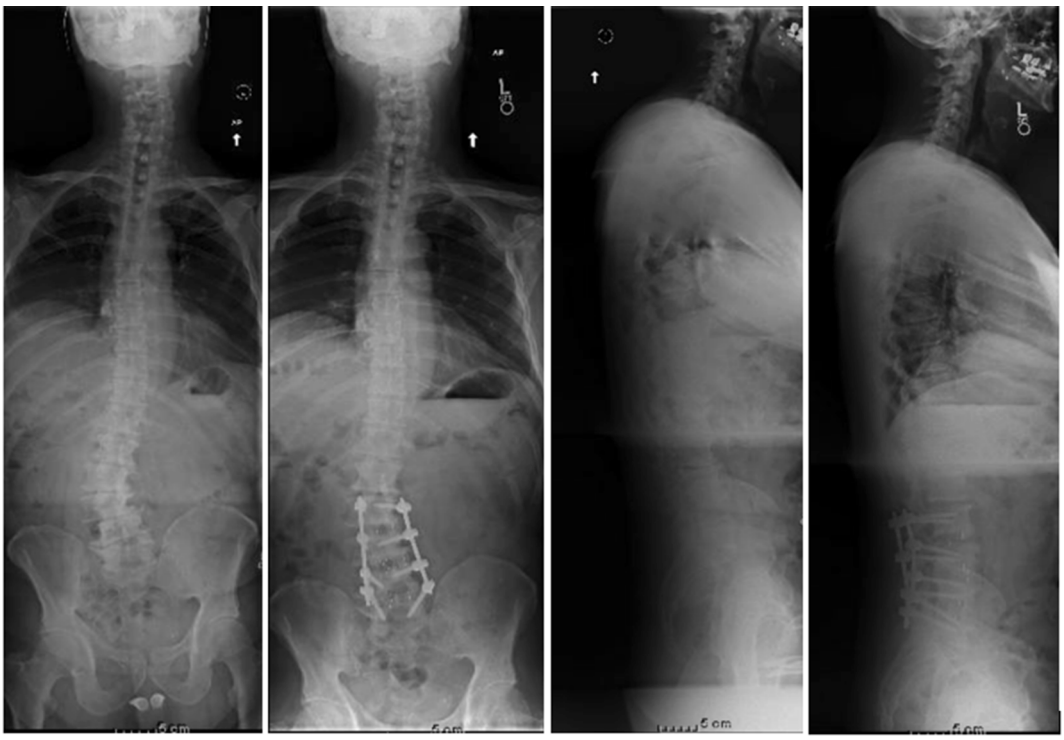

**Fig. 3.** Pre/Post of a patient with preoperatively defined mild degenerative scoliosis.

**Table 3**
Complications. All complications were transient with the exception of patient who developed flat back syndrome requiring an additional operation.

| Complication | N | Percentage |
|---|---|---|
| Re-operation | 1 | 7.7% |
| Adjacent Segment Disease | 0 | 0.0% |
| Retrograde Ejaculation | 0 | 0.0% |
| Transient radiculopathy | 3 | 23.1% |
| Intraoperative Vessel Injury | 0 | 0.0% |
| Hardware Complication | 1 | 7.7% |
| Deep Vein Thrombosis | 1 | 7.7% |
| SIADH | 1 | 7.7% |

**Table 4**
Pain and Functionality Scores. VAS is measured on a 10-point pain scale where higher numbers represent higher levels of pain. ODI is scored on a scale of zero to 100 with higher numbers representing increased disability. VAS: Visual Analogue Scale; ODI: Oswestry Disability Index.

| Parameters | VAS Pain Score | ODI |
|---|---|---|
| n | 13 | 10 |
| Days FU (days) | 209 ± 128.0 | 106.7 ± 110.7 |
| Preoperative | 6.7 ± 1.7 | 51.3 ± 17.6 |
| Postoperative | 2.9 ± 3.5 | 44.3 ± 17.1 |
| Change | −3.8 ± 2.6 | −7 ± 19.3 |
| Percent Improvement | 62.3% ± 41.9 | 8.1% ± 34.1 |
| P-value | **0.0001** | 0.14 |

patients in our series (8/13, 62%) met this criterion and were included in this subset. Similar to the overall population, significant improvements were seen in the global coronal Cobb (−7° ± 6.7°; p-value = 0.0106), regional coronal Cobb (−9.8° ± 8.2°; p-value = 0.0058), global lumbar lordosis (4.2° ± 5.9°; p-value 0.0417), and regional lumbar lordosis (7° ± 8.7°; p-value = 0.0283). No significant improvement was seen in pelvic tilt (p-value = 0.1039) or sacral slope (p-value 0.1882).

## 4. Discussion

This study investigated the operative outcomes, perioperative measures, radiologic spinopelvic parameters, and clinical outcomes of 13 consecutive patients that underwent OLIF surgery with posterior percutaneous screw placement at a single institution. OLIFwPPS surgery showed favorable operative results with estimated blood loss, operation time, length of stay, and radiographically confirmed fusion parameters being similar to other studies of anterolateral approaches for lumbar fusion surgery [2,3,5,10,13,14]. This cohort had a particularly high rate of confirmed spinal fusion at 6-months follow-up of 100% by CT imaging, therefore reinforcing that OLIFwPPS is an effective technique at achieving spinal fusion in the lumbar spine. Other studies have consistently reported confirmed spinal fusion in OLIF procedures with rates > 90% [3,4].

The cases reported here had few post-operative complications. Three patients out of thirteen (23%) reported radiculopathy-type symptoms that were self-resolving. It is likely that their transient pain is due to retraction of the psoas muscle during the OLIF procedure and compression of the associated sensory nerves from associated edema of surrounding structures. A recent review paper by Xu et al. reported a transient weakness after OLIF surgery in 6–22% of patients, suggesting that our data is congruent with the current literature [3].

Clinical outcomes of this study showed favorable improvements in VAS pain scores. Post-operative pain scores reduced to an average of 2.9 ± 3.5, representing an average of 62.3% improvement in pain after OLIFwPPS surgery. Others have seen similar reductions in VAS pain scores after OLIF surgery [2,15,16]. Furthermore, these reductions in pain scores are also comparable to other anterolateral approaches to lumbar fusion [3,17]. Particularly notable was that all 11 patients with multilevel procedures showed improvement in pain scores post-operatively. These results emphasize that OLIF surgery is an effective surgical solution for patients with severe degenerative spine disease and provides considerable pain relief to patients.

This study included an extensive analysis of spinopelvic parameters in patients with OLIFwPPS surgery; to our knowledge, this study is the

**Table 5**
Spinopelvic Parameters (All) *Pelvic Tilt parameters included only for patients with > 20°on pre-op imaging who received a 36 in. standing XR.

| Parameters | n | Preoperative | Postoperative | Change | Percent Improvement | P-value |
|---|---|---|---|---|---|---|
| Global Coronal Cobb | 13 | 12.9 ± 10.1 | 8.0 ± 6.4 | −4.9 ± 6.0 | 29.3% ± 38.7 | **0.0065** |
| Regional Coronal Cobb | 13 | 11.6 ± 10.3 | 4.9 ± 5.2 | −6.7 ± 7.7 | 40% ± 67.2 | **0.0043** |
| Global Lumbar Lordosis | 13 | 39.8 ± 14.0 | 43.2 ± 15.2 | 3.3 ± 5.4 | 9.1% ± 18.9 | **0.0235** |
| Regional Lumbar Lordosis | 13 | 15.0 ± 9.2 | 19.7 ± 9.7 | 4.7 ± 7.5 | 41.5% ± 54.1 | **0.0224** |
| Pelvic Tilt* | 5 | 30.3 ± 4.4 | 27.3 ± 2.9 | 3.1 ± 3.0 | n/a | **0.0434** |
| Sacral Slope | 13 | 31.7 ± 6.33 | 32.6 ± 6.5 | 0.9 ± 4.6 | n/a | 0.7586 |

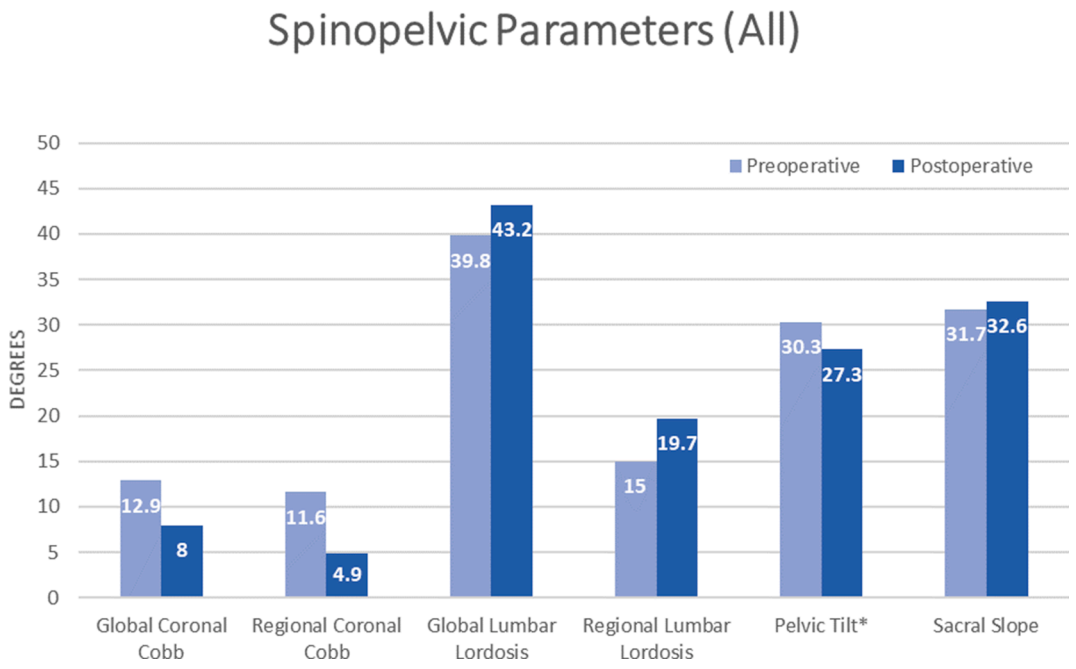


**Fig. 4.** Spinopelvic Parameters (All).

**Table 6**
Spinopelvic Parameters (Scoliosis subgroup; Pre-op coronal Cobb > 10°) *Pelvic Tilt parameters included only for patients with > 20° on pre-op imaging who received a 36-inch standing XR.

| Parameters | n | Preoperative | Postoperative | Change | Percent Improvement | P-value |
|---|---|---|---|---|---|---|
| Global Coronal Cobb | 8 | 17.7 ± 9.7 | 10.75 ± 6.7 | −7 ± 6.7 | 38.1% ± 43 | **0.0106** |
| Regional Coronal Cobb | 8 | 16.8 ± 9.9 | 7 ± 5.6 | −9.8 ± 8.2 | 39.7% ± 74.9 | **0.0058** |
| Global Lumbar Lordosis | 8 | 36.1 ± 12.7 | 40.3 ± 15.1 | 4.2 ± 5.9 | 11% ± 22.6 | **0.0417** |
| Regional Lumbar Lordosis | 8 | 17 ± 9.5 | 24 ± 8.2 | 7 ± 8.7 | 59% ± 59.2 | **0.0283** |
| Pelvic Tilt* | 4 | 30.8 ± 5.0 | 28.1 ± 2.6 | 2.7 ± 3.4 | n/a | 0.1039 |
| Sacral Slope | 8 | 30.4 ± 7.2 | 32.8 ± 6.0 | 2.3 ± 4.5 | n/a | 0.1882 |

first of its kind and hopefully provides a basis of reference for expected correction. The results showed significant improvement in global and regional coronal Cobb angle and global and regional lumbar lordosis angle. The most profound improvements were in the regional coronal Cobb angle and lumbar lordosis angle, with improvements of 40.0% ± 67.2 and 41.5% ± 54.1, respectively. Furthermore, in a subgroup analysis of patients with a preoperative coronal Cobb angle of >10° (CC > 10°), an even larger change of the regional lumbar lordosis angle of 7° ± 8.7, corresponding to change of 59% ± 59.2. There were also more modest improvements in the CC > 10° group in the global coronal angle and global lumbar lordosis angle when compared to the entire 13 patient cohort analysis. Several others have studied the changes in spinopelvic parameters after different anterolateral approaches to lumbar interbody fusion surgery and have achieved similar results in regional and global lumbar lordosis angle as well as global Cobb angle [5,8,9]. For example, Alquist et. al demonstrated significant enhancements in global and regional lumbar lordosis angles of 7.9° and 5.5°, respectively for ALIF surgery and 4.4° and 7.7° for LLIF surgery; all of which are comparable to the results presented in this study (Table 7).

These results have strengthened the argument of non-inferiority of OLIFwPPS surgery compared to other anterolateral approaches for lumbar fusion operations. Specifically, the complication rates were similar to other approaches such as ALIF and LLIF, along with the improvement in both clinical and radiologic outcomes. This study demonstrated the capacity for OLIFwPPS surgery to achieve significant reductions in coronal Cobb angles and increases in lumbar lordosis angles. Due to the reduced risk of neural damage compared to an LLIF approach and reduced risk of vascular injury compared to an ALIF approach, OLIF surgery has shown promising utility in corrective lumbar spine surgery.

This study presented several limitations. First, we presented a small retrospective cohort of 13 patients at a single institution, which may limit the generalizability of our results to wide populations. Follow-up of patients ranged from 43 to 398 days post-surgery and therefore this

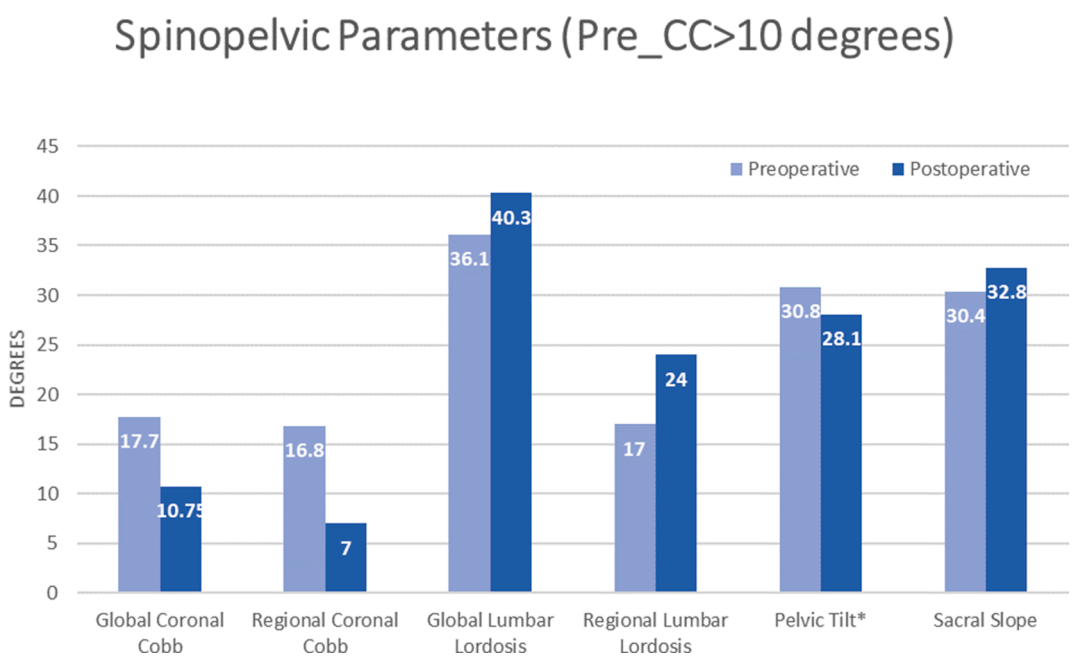


**Fig. 5.** Spinopelvic Parameters (Scoliosis subgroup; Pre-op coronal Cobb > 10).

**Table 7**
Mean improvements in measured spinopelvic parameters by procedure. *Measurements for ALIF, X/LLIF, TLIF, and PLF from Ahlquist et al. 2018 [9].

| Study | Ahlquist* | | | | Gary |
|---|---|---|---|---|---|
| Procedure | ALIF | X/LLIF | TLIF | PLF | OLIF |
| SL | 7.9 | 4.4 | 1.7 | −0.3 | 7 |
| LL | 5.5 | 7.7 | 2.7 | −0.5 | 4.2 |
| SCC | – | – | – | – | −9.8 |
| CC | – | – | – | – | −7 |

study cannot comment on the longevity or durability of the results seen with OLIFwPPS surgery beyond the first year. Finally, this study only presents results from one procedure and cannot offer direct comparisons to other lumbar interbody fusion techniques such as ALIF or LLIF surgery. Our hope is that this presents a relatively homogenous series of patients that future studies can build off and presents clinical and radiographic outcomes to guide decision making.

## 5. Conclusion

OLIF with percutaneous posterior screws can be considered a safe and effective treatment option for lumbar disk degeneration, with complication rates and improvement comparable to those seen with alternative approaches. Early results show potential utility in patients with adult degenerative scoliosis, particularly when associated with other spinal pathology, as significant reductions in coronal Cobb angles and improvements in lumbar lordosis were observed. Surgical technique appears to be an important determinant of postoperative alignment.

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None.

## Disclosures

Dr. Rodts has received royalties from Medtronic and Globus Medical; Dr. Refai has consulted for Stryker and Medtronic and receives royalty from Stryker. No other authors report financial disclosures or conflicts of interests, and all report proper ethical adherence.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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