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Correcting Degenerative Lumbar Spine Deformity by Stand–Alone Anterior Oblique Lumbar Interbody Fusion

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ABSTRACT

Background Data: Adult degenerative scoliosis has at its starting point the same broader definition of adult scoliosis, which is defined as a Cobb angle of greater than 10 degrees measured in the coronal plane. However, it is exclusive for adults who previously had normal spinal alignment. Such pathology with no specific etiology results from a combination of degenerative lumbar diseases. Oblique lumbar interbody fusion (OLIF) is one of the fusion techniques used. It was introduced to overcome the disadvantages of the commonly used interbody fusions like anterior (ALIF), lateral (LLIF), or posterior (PLIF) interbody fusions. OLIF can achieve spinal stability, correct alignment in coronal and sagittal balance anteriorly, and indirectly decompress neural structures with fewer complications related to traditional transpsoas or retropsoas approaches.

Study Design: Prospective clinical case study.

Objective: To assess the degree of coronal and sagittal deformity correction in patients suffering from degenerative lumbar spine deformities after stand-alone (SA) OLIF.

Patients and Methods: Patients with ADS following specific inclusion criteria underwent SA OLIF. Pre- and postoperative clinical data (back and leg pain VAS and ODI), radiological data (spinopelvic parameters, segmental Cobb's angle, and anterior disc height), and intraoperative data (operative time, amount of blood loss, "intraoperative or postoperative" complications, and hospital stay) were all analyzed and compared statistically.

Results: A total of 28 patients and 30 levels underwent operation by SA OLIF, with a mean age of 50.54 ± 6.05 years, including 14 males and 14 females. The mean operative time/min, blood loss/ml, and hospital stay/day was 91.29 ± 14.23, 195.54 ± 42.299, and 2.78 ± 0.875, respectively. The mean of back pain VAS, the mean of leg pain VAS, and ODI changed from preoperatively 7.36 ± 0.98, 6.36 ± 0.911, and 68.615 ± 8.72 to 4.07 ± 1.01, 2.07 ± 0.9, and 20.23 ± 4.7 in 1 year, respectively. The average SVA, PT, and Cobb angle decreased from 12.93, 19.21, and 10.39 to 8.93, 18.42, and 7.04 in 1 year, respectively.

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The average SS and LL are increased from 37.64 and 28.57 to 38.48 and 31.46 in 1 year, respectively. The average anterior disc height increased from 6.78 to 9.154 in 1 year, respectively. Postoperative complications were 1 cage dislodgement immediately postoperatively and 2 cases of cage subsidence after 1-year.

Conclusion: Stand-alone OLIF has been proved to be effective in selective cases with degenerative lumbar scoliosis, especially in restoring disc height, indirectly decompressing neural structures, correction of spinopelvic parameters, and Cobb's angle restoration. (2021ESJ243)

Keywords: OLIF, scoliosis, degenerative lumbar diseases, spinopelvic, Cobb angle, deformity

INTRODUCTION

Degenerative spine disease is an aging process. In 1983, Kirkandly Willis[34] proposed the theory of the three-joint complex as the mainstay factor commonly affected during the advancement of age and responsible for the spine degenerative changes. Also, Kirkandly divided the degeneration process into three stages, starting from the dysfunction process including disk degeneration and facet laxity to the destabilization process that results in segment instability until restabilization that is formed mainly by osteophytes formation and canal stenosis.[34]

Adult degenerative scoliosis has at its starting point the same broader definition of adult scoliosis, which is defined as a Cobb angle of greater than 10 degrees measured in the coronal plane. However, it is exclusive for adults who previously had normal spine alignment.[12,13] Its mechanism is very similar to the mechanism of degenerative disc diseases (DDD). Along with this mechanism, there is a crucial concept of progression of the imbalance in the axial loading, leading to adult degenerative scoliosis (ADS).[5] Such pathology with no specific etiology results from a combination of degenerative lumbar diseases, e.g., lumbar canal stenosis, asymmetrical lumbar disc degeneration, facets arthropathies, laxity of ligaments, and muscles weaknesses.[3]

Ralph Cloward was the first to introduce the basics of interbody fusion in the 1940s.[7] Since then, improvements in spine fusion techniques have widened. The procedure of interbody fusion aims to stabilize the spine and decompress the neural structures by regaining the disk height. Lumbar interbody fusion can certainly manage a group of spine diseases, like DDD, deformities, and tumors.[18] Oblique lumbar interbody fusion (OLIF) is one of the fusion techniques used. It was introduced to overcome the disadvantages of the commonly used interbody fusions like anterior (ALIF), lateral (LLIF), or posterior (PLIF) interbody fusions.[20,25] OLIF can achieve spinal stability, correct alignment in coronal and sagittal balance anteriorly, and indirectly decompress neural structures with fewer complications related to traditional transpsoas or retropsoas approaches. OLIF technique gives access to work from L1 to S1. Complications reported in the literature were technique-related and self-limited, ranging between slight thigh numbness and frank neurological deficit, but they were less than those found during ALIF or LLIF.[11,27,28,31,33]

This series aims to assess the safety and efficacy of the SA OLIF in the correction of the adult lumbar degenerative deformity.

PATIENTS AND METHODS

This is a prospective study in collaboration between Neurosurgery Department, Suez Canal University Hospitals, and Centre for Spinal Studies and Surgery at Nottingham University Hospitals from January 2019 to January 2021. Inclusion criteria were as follows: degenerative lumbar spine diseases associated with deformity in either sagittal or coronal plans, including fresh or recurrent pathology; age between 30 and 70 years of any sex; failure of adequate conservative therapy. Exclusion criteria were as follows:

osteoporosis "T-score <-2.5"; other pathologies such as trauma, tumor, and metabolic diseases.

Preoperative Evaluation:

Clinical assessment of back and leg pain's visual analogue scale (VAS) score, full neurological examination, and Oswestry Disability Index (ODI) was conducted. Radiological evaluation included full spine X-ray AP, lateral and dynamic views "flexion and extension" to measure lumbar Cobb's angle, sagittal vertical axis (SVA), pelvic tilt (PT), pelvic incidence (PI), sacral slope (SS), and pelvic incidence/lumbar lordosis mismatch using Surgimap®, MRI lumbosacral spine, and DXA.

Operative Technique:

All patients underwent the OLIF procedures in the left lateral decubitus position with ipsilateral hip flexion under general anesthesia on a radiolucent operating table. Stabilizing the patient by the operating table belt and additional tapping is done. The table jack-knifed to distract the intracoastal space for widening the surgical field. Fluoroscopy-guided leveling is obtained and marked on the skin over the centre of the disc space in AP and Lat. Views. Then, surgical sterilization and draping are performed, followed by oblique skin incision anterior to the disc space mark. Incision is 4–10 cm according to the number of levels intended to be operated on followed by blunt dissection of the oblique abdominal muscles. After reaching the retroperitoneal space marked by the fat appearance below the internal oblique muscle, blunt dissection by Kelly Clamps is made until reaching the quadratus lumborum and the psoas muscles. SynFrame blades are inserted in a 4-blade fashion, 2 in lateral position and 2 in craniocaudal position. The operating field is between the psoas muscle and the abdominal aorta. Standard annulotomy and discectomy are initiated. A wide intervertebral space is important to acquire; consequently, discectomy is done in a wide space. The contralateral annulus is carefully opened by a Cobb dissector and confirmed by fluoroscopy. Trials are inserted until reaching the desired intervertebral cage size, followed by insertion of the Spineway Kili cages®. Hemostasis is done in case of any bleeding, followed by removing the SynFrame blades and inserting a suction drain. Fascial and skin closure in layers is the final step (Figure1).

Postoperative Evaluation:

Clinical assessment included back and leg pain

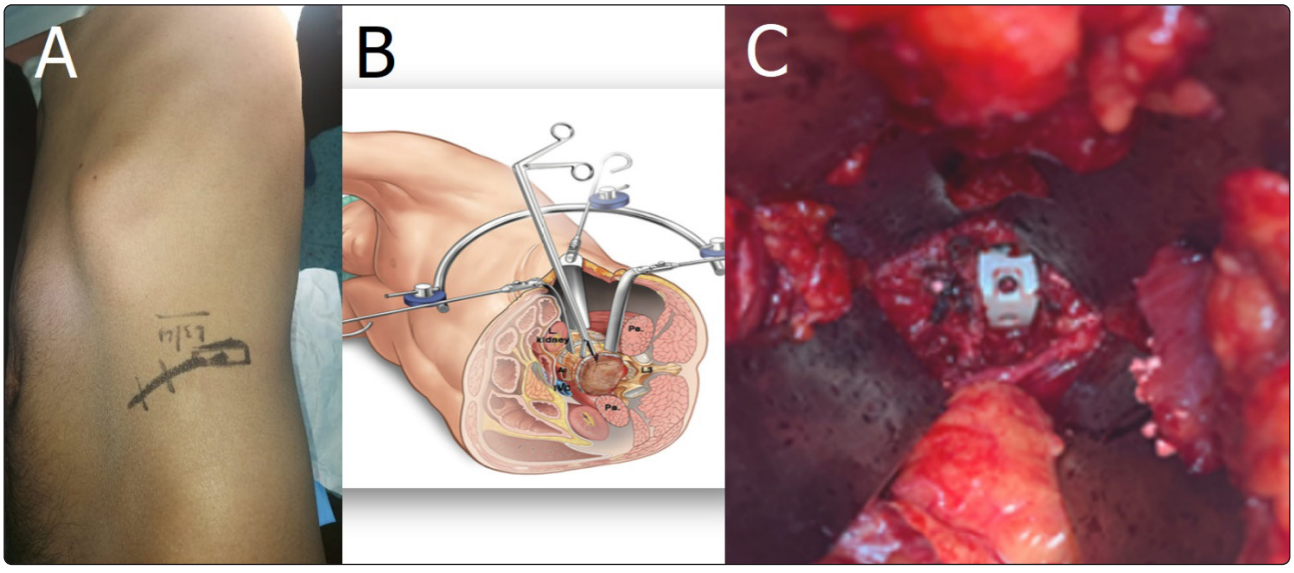

Figure 1. (A) Skin incision marked from anterior axillary line to the left lateral side of the rectus muscles, and as shown, cage mark is the disc space intended. (B) OLIF approach "anterior to psoas."[25] (C). A close-up view of the cage inside the intervertebral disc space.

VAS, ODI, and full neurological examination after 6 months and 12 months. Radiological evaluation included spine X-ray erect in AP and lateral view and MSCT of the lumbosacral spine. The following outcome parameters were recorded at each visit: segmental coronal Cobb's angle, LL, coronal Cobb's angle, SVA, PT, PI, SS, LL, PI/LL mismatch, and fusion grade. II. According to CT scan, fusion grading was as follows: grade 1, bridging trabecular bone; grade 2, continuous bony density; grade 3, marginal radiolucency; grade 4, secondary signs of motion; grade 5, hardware loosening and fatigue; grade 6, subsidence.[6]

Statistical Analysis:

The SPSS (Statistical Package for the Social Sciences) 18.0 software package was used for the statistical analysis of the data. Chi-squared statistics were employed to compare the categorical measurements between groups, and independent *t*-tests were used to compare the numerical measurements between groups. The statistical significance level was taken as 0.05 in all tests.

RESULTS

Twenty-eight patients (14 males and 14 females) were recruited for this study after excluding those lost during the follow-up. All patients suffered from single-level disc disease except two patients with two-level pathology (Figures 2, 3, and 4). Demographic data, preoperative clinical data (back and leg pain VAS, ODI), and comorbidities are shown in Tables 1 and 2.

The mean operative time was 91.29 ± 14.23 min and the mean blood loss was 195.54 ± 42.499 ml. The mean back pain VAS decreased from 7.36 ± 0.99 preoperatively to 5.64 ± 0.87 at 6-month and 4.07 ± 1.02 at 1-year follow-up. The mean leg pain VAS decreased from 7.36 ± 0.99 preoperatively to 5.9 ± 0.54 immediately postoperatively, to 4.01 ± 0.9 at 6-month, and to 2.07 ± 0.9 in 1-year follow-up. The mean ODI also decreased from 68.615 ± 8.72 preoperatively to 28.38 ± 8.5 at 6-month and 20.23 ± 4.7 in 1-year follow-up (Tables 2 and 3).

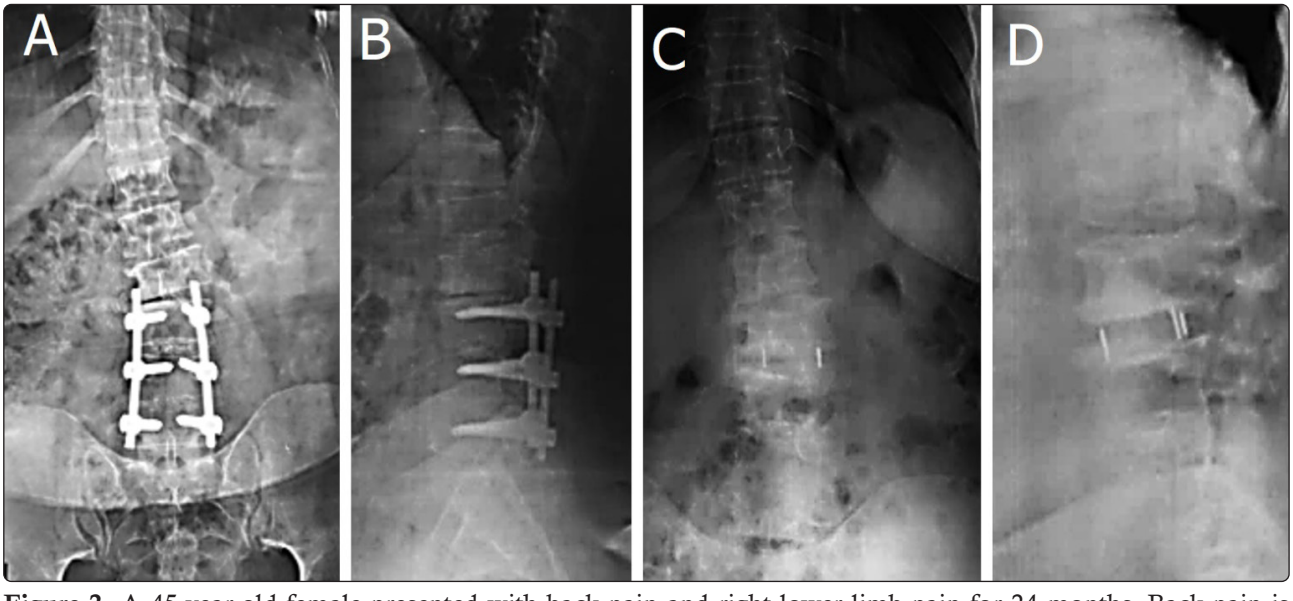

Figure 2. A 45-year-old female presented with back pain and right lower limb pain for 24 months. Back pain is increasing in intensity and aggravated by sitting and standing and relieved by analgesics. Right lower limb pain is found at rest and increased by walking. (A) Preoperative AP L/S X-ray Cobb's angle was 15.5 degrees. (B) Preoperative Lat. L/S X-ray shows SVA: 13 mm, PT: 25 degrees, PI: 53 degrees, SS:28 degrees, LL:16 degrees, PI/LL mismatch: 37, and anterior disc height: 6.2 mm. (C) AP L/S X-ray 1-year follow-up Cobb's angle 6 degrees, Sugrimap software A. Cobb's angle in AP X-ray is 15.5 preoperatively. B. Postoperative follow-up in 1-year period with Cobb's angle being 6. (D) Lat. L/S X-ray 1-year follow-up shows SVA: 8 mm, SS: 29 degrees, PT: 24 degrees, LL 21 degrees, anterior disc height: 8.1 mm, and PI/LL mismatch: 32.

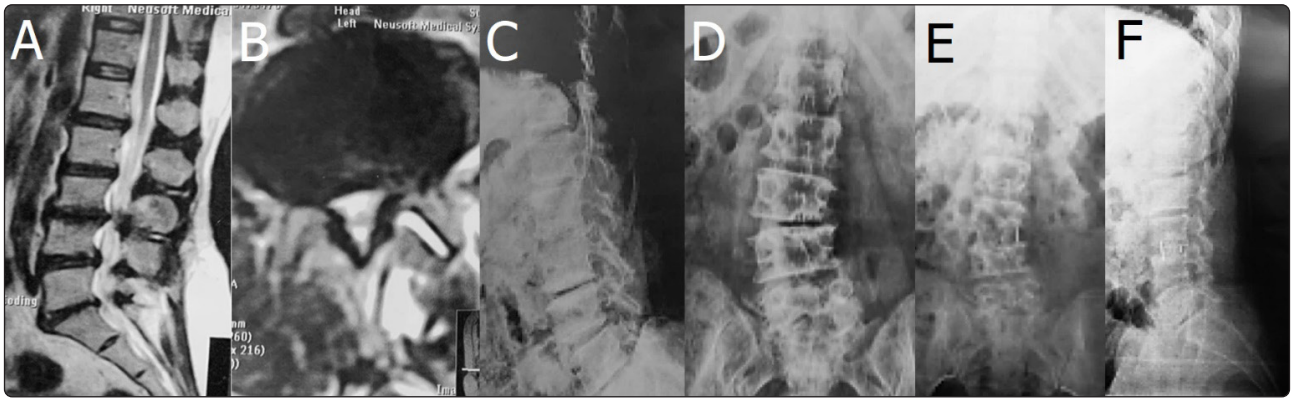

Figure 3. (A) MRI preoperative T2W axial cuts showing facet effusion and disc prolapse and (B) MRI preoperative T2W sagittal cuts showing canal stenosis at L3/L4 and decreased disc height. (C) Preoperative lateral lumbar X-ray showing degenerated intervertebral disc L3/L4, SVA: 10 mm, PT: 27 degrees, SS: 33 degrees, LL: 18 degrees, PI/LL mismatch: 38, and anterior disc height: 5 mm. (D) Preoperative AP lumbar X-ray shows Cobb's angle of 28 degrees, (E) demonstrates AP lumbar X-ray 1-year follow-up with corrected Cobb's angle to 7.3 degrees after stand-alone OLIF L3/L4, and (F) demonstrates lateral lumbar X-ray 1-year follow-up: SVA: 6 mm, SS: 35 degrees, PT: 25 degrees, LL 22 degrees, anterior disc height: 14 mm, and PI/LL mismatch: 35.

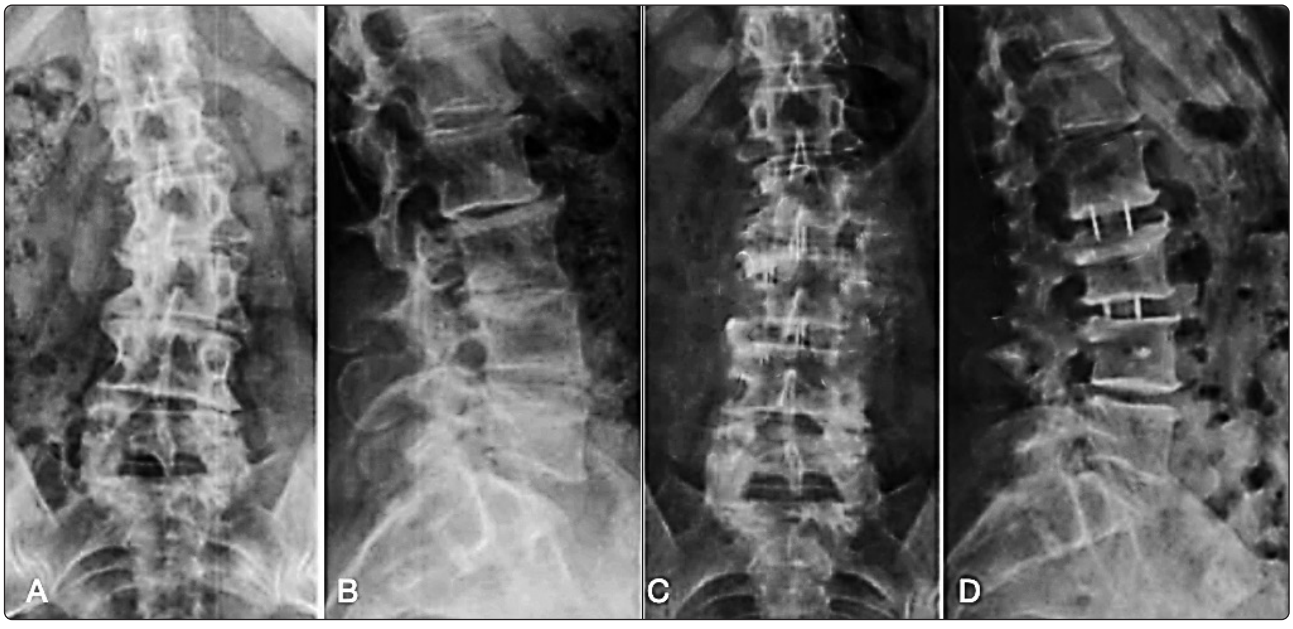

Figure 4. A 31-old-male patient with degenerative scoliosis L2/L3 and L3/L4 complaining of back pain and leg pain for 12 months. (A) AP X-ray L/S spine denoting degenerative scoliosis Cobb's angle of 24 degrees; (B) Lat. X-ray L/S spine with decreased disc spaces and straightening of the lumbar spine, SVA: 10 mm, PT: 16 degrees, SS: 42 degrees, LL: 24 degrees, PI/LL mismatch: 27, and anterior disc height: 7.2 mm for L2/L3 and 8.3 mm for L3/L4; (C) AP L/S spine after OLIF levels L2/L3/L4 1-year follow-up shows improved Cobb's angle to 9 degrees, and (D) lateral X-ray L/S spine 1-year follow-up shows increased anterior disc heights 11.5 mm for L2/L3, 12 mm for L3/L4 on L2/L3 and L3/L4, SVA: 8 mm, SS: 43 degrees, PT: 14 degrees, LL: 35 degrees, and PI/LL: mismatch: 18.

Table 1. Demography, clinical presentation, and comorbidities of reported patients (n = 28).

Parameters		Results
Age/years		50.54 ± 6.05 (38–60)
Sex		Male 50% Female 50%
Symptom's duration/months		34.44 ± 16.68 (12–84)
Presentation	Back pain	67.85% (19 patients)
	Leg pain	57.14% (16 patients)
	Sensory deficit	17.8% (5 patients)
	Reflexes deficit	10.7% (3 patients)
	Motor deficit	3.5% (1 patient)
	Sphincter's deficit	3.5% (1 patient)
Comorbidities	HTN	42.8% (11 patients)
	DM	21.4% (6 patients)
	IHD	32.1% (9 patients)
	Obese	35.7% (10 patients)
	Smoking	28.5(8 patients)

Table 2. Clinical data between preoperatively and 6-month follow-up.

Item	Preoperatively	6-month follow-up	t	*p* value
VAS (Back)	7.36 ± 0.98	5.64 ± 0.870	10.115	<0.05*
VAS (Leg)	6.36 ± 0.911	4 ± 0.903	17.06	<0.05*
ODI%	68.615 ± 8.72	28.38 ± 8.5	12.24	<0.001*

Data are in mean ± SD. *Statistically significant <0.05 at 95 CI.

Table 3. Clinical data between 6-month and 1-year follow-up.

Item	6-month follow-up	1-year follow-up	t	*p* value
VAS (Back)	5.64 ± 0.870	4.07 ± 1.01	12.563	<0.05*
VAS (Leg)	4 ± 0.903	2.07 ± 0.9	11.9	<0.05*
ODI%	28.38 ± 8.5	20.23 ± 4.7	11.9	<0.001*

Data are in mean ± SD. *Statistically significant <0.05 at 95 CI.

The mean SVA, PT, and Cobb's angle decreased from 12.93, 19.21, and 10.39 to 11.32, 19.15, and 7.8 immediately postoperatively (Table 4), to 10.64, 19.11, and 8.42 at 6-month, and 8.93, 18.42, and 7.04 at 1-year follow-up (Table 5). The mean SS and LL increased from 37.64 and 28.57 to 37.8 and 29.4 immediately postoperatively (Table 4), to 37.79 and 29.79 at 6-month, and to 38.48 and 31.46 at 1-year follow-up (Table 5). The mean anterior disc height increased from 6.78 to 10.164 immediately postoperatively (Table 4), to 9.27 at 6-month, then to 9.154 at 1-year follow-up (Table5). PI/LL mismatch decreased immediately postoperatively (Table 4) and at 6-month and 1-year follow-up to 28 ± 6.1, 27 ± 6.3, and 25.3, respectively (Table 5). The variances between spinopelvic parameters and anterior disc height between 6 months and 12 months are shown in (Table 6).

Operative complications were reported in four cases. Three cases had vascular injuries to radicular "segmental" arteries during blunt dissection over the vertebral bodies and managed by monopolar electrocautery without clinical sequel. One patient

had one of his two cages anterior dislodgement postoperatively and this cage was removed, and the patient underwent posterior instrumentation in the same setting (Figure 5). Two patients had cage subsidence and refused to have further surgery (Table 7).

Table 4. Radiological data between preoperatively and immediate postoperatively.

Item	Preoperatively	Immediately postoperatively	t	*p* value
SVA/mm	12.93 ± 3.11	11.32 ± 1.73	9.23	0.065
PT/degree	19.21 ± 4.2	19.15 ± 4.13	1.69	0.1
SS/degree	37.64 ± 3.8	37.8 ± 2.9	-2.6	0.3
LL/degree	28.57 ± 5.50	29.4 ± 5.8	-7.9	<0.05*
Anterior disc height/mm	6.7 ± 1.5	10.16 ± 1.34	-13.6	<0.05*
PI/LL mismatch	28.29 ± 6.47	28 ± 6.1	8.1	0.06
Coronal Cobb's angle/degree	10.39 ± 2.4	7.8 ± 1.34	9.23	<0.05*

Data are in mean ± SD. *Statistically significant <0.05 at 95 CI.

Table 5. Radiological data between preoperatively and 6-month follow-up

Item	Preoperatively	6-month follow-up	t	*p* value
SVA/mm	12.93 ± 3.11	10.64 ± 2.75	10.5	<0.005*
PT/degree	19.21 ± 4.2	19.11 ± 4.23	1.8	0.08
SS/degree	37.64 ± 3.8	37.7 ± 3.8	-2.1	0.4
LL/degree	28.57 ± 5.50	29.7 ± 5.3	-7.7	<0.05*
Anterior disc height/mm	6.7 ± 1.5	9.27 ± 1.5	-15.7	<0.05*
PI/LL mismatch	28.29 ± 6.47	27 ± 6.3	7.71	<0.05*
Coronal Cobb's angle/degree	10.39 ± 2.4	8.42 ± 1.8	9.13	<0.05*

Data are in mean ± SD. *Statistically significant <0.05 at 95 CI.

Table 6. Radiological data between 6-month and 1-year follow-up.

Item	6-month follow-up	1-year follow-up	t	*p* value
SVA/mm	10.64 ± 2.75	8.93 ± 2.76	13.74	<0.05*
PT/degree	19.11 ± 4.23	18.4286 ± 3.9	3.8	0.001*
SS/degree	37.7 ± 3.8	38.4 ± 3.71	-3.6	0.001*
LL/degree	29.7 ± 5.3	31.46 ± 5.42	-13.5	<0.05*
Anterior disc height/mm	9.27 ± 1.5	9.17 ± 1.5	-14.9	<0.05*
PI/LL mismatch	27 ± 6.3	25.39 ± 6.420	13.5	<0.05*
Coronal Cobb's angle/degree	8.42 ± 1.8	7.04 ± 1.34	11.32	<0.05*

Data are in mean ± SD. *Statistically significant <0.05 at 95 CI.

Table 7. Fusion grading according to MSCT [6] of the lumbosacral spine (n = 28).

Grade of fusion	6 months postoperatively		1 year postoperatively	
Grade I: bridging trabecular bone	10	35.7%	N=17	60.7%
Grade II: continuous bony density	14	50.0%	N=9	32.2%
Grade III: marginal Radiolucency	1	3.6%	N=0	0%
Grade IV: 2ry signs of motion	0	0%	N=1	3.6%%
Grade V: hardware loosening and fatigue	1	3.6%	N=0	0%
Grade IV: subsidence	2	7.1%	N=2	7.1%

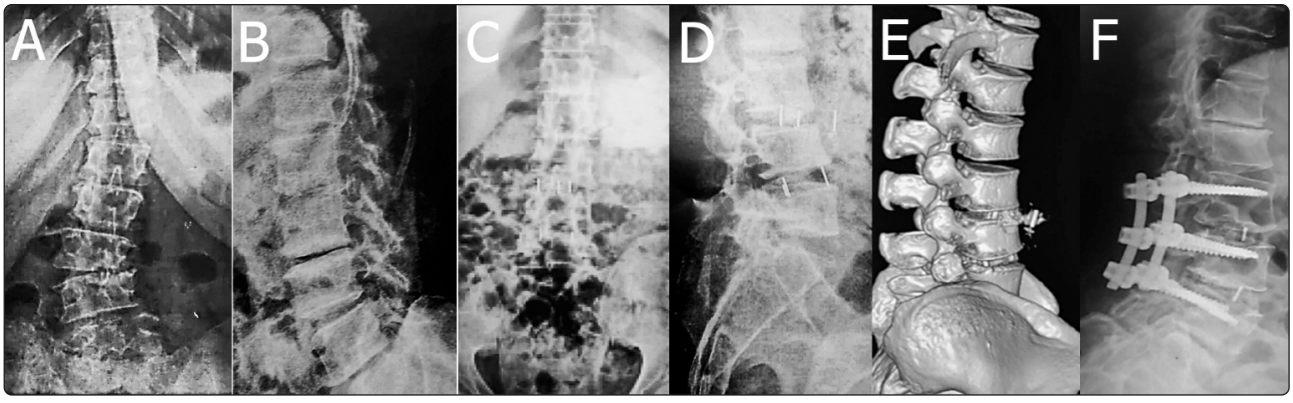

Figure 5. A 31-year-old male patient complaining of back pain and leg pain for 24 months. (A) AP X-ray L/S spine with degenerative scoliosis L3/L4 and L4/L5 and Cobb angle's was 21 degrees. (B) Lat. X-ray L/S spine with lumbar spine decreased lordosis and degenerative pattern in L3/L4 disc and LL was 10.
(C) AP X-ray L/S after the first session shows improved Cobb's angle to 4 degrees. (D) Lat. X-ray L/S spine shows L3/L4 cage dislodgement and stable L4/L5 cage. (E) CT 3D reconstruction. (F) Lat. X-ray L/S spine shows posterior instrumentation and cage reapplication anteriorly.

DISCUSSION

Since its first description in 1977, OLIF has been found effective and safe utilizing a natural corridor between psoas muscle and great vessels retroperitoneally in various studies.[9,24,26] In this series, stand-alone OLIF has proven to effectively manage cases of degenerative lumbar spine diseases. The mean age for the patients was 50.54 ± 6.05 years, 50% were males and 50% were females, and the mean duration of the symptoms was 34.44 ± 16.68 months. Xi et al.[32] in a study comparing ALIF to OLIF on 127 patients with a mean age of 63.73 ± 10.80 and 66 patients who underwent OLIF were 24 males and 42 were females .He et al. [15], in a study of SA OLIF versus combined OLIF with percutaneous fixation, had 32 patients who underwent SA OLIF: males were 31.3% and females were 68.7%. The mean age for the SA OLIF group was 59.8 ± 13.7 years.

In this study, the total number of OLIF was 30 levels: 8, L2/L3; 17, L3/L4;5, L4/L5. Xi et al., in their comparative study between ALIF and OLIF, showed that OLIF was done in 66 patients, where 31 patients underwent operation from L4 to S1, 12 underwent operation from L3 to S1, and 23 underwent operation from L2 to S1. Xi et al.[32] and Liu et al.[23] studied Modic changes with SA OLIF, where 78 patients underwent OLIF with 92 levels as follows: 6, L2/L3; 28, L3/L4; 58, L4/L5.

Preoperative clinical findings statistically improved at 6-month and 1-year follow-ups as follows: back pain VAS changed from 7.36 ± 0.99 preoperatively to 5.64 ± 0.870 at 6 months and 4.07 ± 1.01 at 1 year, leg pain VAS changed from 6.36 ± 0.91 preoperatively to 4 ± 0.903 at 6 months and 2.07 ± 0.9 at 1 year, and ODI changed from 68.615 ± 8.72 preoperatively to 41.38 ± 8.5 at 6 months and to 20.23 ± 4.7 at 1 year. Anand et al., in a prospective study of 111 patients with ASD from January 2015 to January 2019, underwent OLIF L5, S1[4] and showed statistically significant improvement in the clinical findings in their series. He et al., in a retrospective cohort study of patients who underwent OLIF or OLIF and posterior instrumentation between July 2014 and October 2017, showed a significant VAS and ODI improvement after 1 week and 3 months postoperatively in the SA OLIF group.[15] Abbasi et al.[1], in a retrospective study of 37 cases with ADS operated with OLIF in 2017, reported improvement in the pain scale from 8.3 to 3.7 and ODI decreased from 53% to 32%. Zhang et al., in a study between October 2016 to January 2017 of 45 OLIF levels, showed significant improvement

in ODI and VAS as well.[36] Kanno et al.[19], in a case report study in 2014, showed a successful improvement in a series of back pain and leg pain of 2 cases with spinal stenosis at levels L5/S1.

Hospital stay in this study was 2.78 ± 0.875 (2–5) days. In their study, Xi et al.[32] had mean hospital stay for their patients of 7.02 ± 2.65 days; the possible cause is the use of posterior instrumentation along with OLIF. Xi et al. and Zhu et al., in their comparative study between SA OLIF and PLIF, proved that SA OLIF was superior to PLIF in operative time, intraoperative bleeding, postoperative bed rest, and hospital stay as the mean operative time was 52.24 ± 6.24 min for SA OLIF and 134.32 ± 15.84 min for PLIF group, the mean intraoperative bleeding was 34.94 ± 4.05 ml for SA OLIF and 340.68 ± 15.84 ml for PLIF, the mean bed rest 2.47 ± 0.51 days for SA OLIF and 6.95 ± 0.91 days for PLIF, and the mean hospital stay was 6 ± 1.12 days for SA OLIF and 13.10 ± 1.40 days for PLIF.

Regarding spinopelvic parameters assessment postoperatively, as shown in the results, there were a significant decrease in the SVA/mm, PT/degrees, PI/LL, and coronal Cobb's angle mismatch after 1 year from 12.93, 19.21, 28.29, and 10.39 preoperatively to 8.93, 18.42, 25.39, and 7.04, respectively. There was an increase in the SS/degrees and LL/degrees after 1 year from 37.64 and 28.57 preoperatively to 38.4 and 31.46, respectively. Anterior disc height showed a significant increase after 6 months (9.27 ± 1.5) but decreased nonsignificantly after 1 year (9.17 ± 1.5). Abbasi et al.[1] in a study for 37 patients with 100 levels OLIF between March 2012 and October 2016, had a decrease in Cobb angles/degrees from 16 to 9.3 in their series. Anand et al.[4], in a retrospective study of 111 ASD patients between 2015 to 2019, had a significant decrease in PI/LL mismatch, PT/degrees, and SVA/mm (<0.05) and a significant increase in the LL (<0.05). He et al.[15], in a retrospective study between 2014 and 2017, reported a significant increase in anterior disc height after 2 years with 93.8% fusion rates. Wang et al.[30], in a study of 11 patients with DDD operated by OLIF in 2018, proved that OLIF, can restore the lost disc space height and achieve indirect neural compression as LLIF and it can restore sagittal and global spinal alignment by leveling the intervertebral space and fuses it.

As popular as SA OLIF is getting in recent years, it offers less operative time, less blood loss, small incisions, and less hospitalization time. However, published data on SA OLIF complications have ranged between 3.7% and 66.7%.[19,39] Zeng ZY et al. [35], in a review of 235 patients with OLIF between October 2014 to May 2017, had 22 cases of endplate damage and a higher prevalence of cage subsidence than the posterior instrumented group. The specific pathophysiology of endplate damage is still unknown; therefore, avoiding such complications need more biomechanical studies of SA OLIF. Fang et al.[8], in a finite element study between SA OLIF and posterior instrumentation with OLIF in 2020, found that SA OLIF models had a less limited range of motions than the posterior instrumented group. In addition, they concluded that the posterior instrumented group with OLIF had better outcomes in cage subsidence and SA OLIF has a higher risk for endplate damage and cage subsidence. However, He et al.[14], in a study of the paraspinal muscle atrophy between SA OLIF and posterior instrumentation with OLIF, found that SA OLIF had superior clinical outcomes at 1 week and 3 months over the other group and SA OLIF may not result in paraspinal muscle atrophy at 24 months postoperatively. SA OLIF provided a 30.2% increase in dural sac cross-sectional area and 30% increase in foramen cross-sectional area.[10] However, SA OLIF advantages over the combined method disappeared by the 2-year follow-up period. This may be because SA OLIF does not include muscular manipulation of the spine like the posterior instrumentation, and by the 2-year follow-up, when muscle hematomas disappear and healing is full, both methods had equal results.[25]

In this study, we had 92.9% fusion rates after 1 year; 2 cases had cage subsidence (7.1%) after 1 year, although clinically not troubled much, but

the radiological finding during follow-up detected it. In a prospective study by Huo et al.[16], 154 patients underwent OLIF in 2019, where 2.4% had cage subsidence in their series, and they studied the cases with subsidence and proved that their T-score on DEXA was <-1.0; consequently, they found that patients with T-score <-1.0 are at higher risk of cage subsidence, they performed DEXA as a routine preoperative evaluation for all patients undergoing SA OLIF. Abbasi et al.[1] had a 100% fusion rate in their retrospective series. He et al. [15] had 15.6% cage subsidence in their series of SA OLIF compared with 7.3% in the OLIF combined with posterior instrumentation. Zeng et al.[36] reported 36.3% cage subsidence, and they directed the cause to the endplate damage done during surgery. Lin et al.[21] reported an 81.9% fusion rate in their series at 1-year follow-up. Kim et al. [17] reported 92.9% fusion rates at 1-year follow-up. Xi et al. [32], in a comparative study between ALIF and OLIF, used posterior instrumentation in both groups, with the fusion rates of the OLIF group being 76.3%. Liu et al.[22], in their retrospective study of the correlation between SA OLIF, Modic changes, and risk of subsidence, found that 34.8% of their patients had Modic changes at the 1- year follow-up duration, where only 1 patient had cage subsidence, while for the remaining patients with no Modic changes, 6 had subsidence.

Approach Complications. These are complications related to the surgical technique adopted by this study. In this study, we had 3 cases of segmental arteries injury during tissues dissection at the level of vertebral bodies. These vessels were cauterized in a fashion where the proximal part was cauterized using long forceps and monopolar cauterization, followed by the distal part. None of the injuries were life-threatening or caused massive blood loss or by any means hindered the ability to proceed with the surgery. There were no reported cases with any visceral, neural, or end plate injuries. In a comparative study by Zeng et al.[35], 235 patients underwent SA OLIF and posteriorly instrumented OLIF and found a 13.62% complication rate. They reported 7 cases with vascular injuries, including 4 cases with segmental vessel injury and 3 cases with great vessels injury. In another study by Silvestre et al.[29], 179 patients underwent OLIF, where 2 patients with intraoperative iliac vein lacerations required intraoperative suturing with no major blood loss. Zeng et al. [35] in a comparative study of 235 patients who underwent SA OLIF and posterior instrumentation with OLIF reported damage to the endplates and embedded cage in 22 cases with SA OLIF that required additional posterior instrumentation. Abe et al.[2] in prospective study of 115 patients who underwent OLIF reported 13.5% of the cases with endplate injury with no explanation to the injury cause.

Fusion Complications. In this study, we reported no cases of infections, lower limb paresthesia, sympathetic chain injury, or neurological deficits; however, we had 2 cases of cage subsidence at 1-year follow-up that was diagnosed during routine follow-up imaging and 1 case of cage dislodgement after postoperatively that was also discovered accidentally during a follow-up X-ray (Figure 5). Zeng et al.[35], in their comparative study, reported 7 cases of anterior thigh pain, 3 cases of sympathetic chain injury, and 1 case of contralateral nerve root pain. Improper intervertebral space manipulation, especially by cage trials, could result in dural injury or adjacent neuronal injury. In their prospective study, Abe et al.[2] reported 1 case of cauda equina injury during cage trials insertion, 1 case of ureter injury during dissector installation, and 21 cases of transient thigh pain. Silvestre et al.[29], in their review on the 179 patients who underwent OLIF, reported two patients with permanent neurological deficit: one of them after L3/L5 OLIF in the form of L4 paresthesia and L3/L4 motor weakness.

SA OLIF is an efficient tool in the spine armamentarium for managing adult degenerative lumbar deformities; however, specific items should be fulfilled before proceeding with this procedure. SA OLIF requires stable spine pathologies and normal bone quality and can be perfectly applied from L2 to S1. Proper surgical instruments such as SynFrame and proper sized curettes and reamers

were used. Proper knowledge of the surgical anatomy of retroperitoneal space, including peritoneal spaces, muscular anatomy, neuronal and vascular structures, and spine orientation, is crucial. It is important to avoid endplate injury during clearing the intervertebral space and to insert a properly sized cage. SA OLIF is a simple yet not fully studied technique that reduces the amount of effort and risks exerted in cases of ADS for both the surgical team and the patients.

Limitations of this study are as follows: the small sample size that likely affected the statistical power, the expensive cage used for the OLIF technique, and the short follow-up duration. Large-sample, prospective, and long-term case-control studies are required to give a broad perspective about the efficacy and validity of OLIF.

CONCLUSION

Stand-alone OLIF has been proved to be effective in selective cases with degenerative lumbar scoliosis, especially in restoring disc height, indirectly decompressing neural structures, correction of spinopelvic parameters, and Cobb's angle restoration. Back pain and functional outcomes showed significant improvement. These advantages are associated with fewer complications and high rates of fusion.

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LIST OF ABBREVIATIONS

ADS: Adult degenerative scoliosis
ALIF: Anterior Lumbar interbody fusion
DDD: Degenerative disc disease
LL: Lumbar lordosis
LLIF: Lateral lumbar interbody fusion
MRI: Magnetic resonance imaging
ODI: Oswestry disability index
OLIF: Oblique lumbar interbody fusion
PI: Pelvic incidence
PLIF: Posterior lumbar interbody fusion
PT: Pelvic tilt
SA: Stand-alone
SS: Sacral Slope
SVA: Sagittal vertical axis
VAS: Visual analogue scale

الملخص العربي

تصحيح تشوه العمود الفقري القطني التنكسي عن طريق الالتحام الامامي القائم بذاته للفقرات القطنية

البيانات الخلفية: تشوهات الفقرات القطنية التنكسي مرض مزمن و معناه حدوث اعوجاج في سن مبكر بدون حدوث اي اعراض في سن صغير و عدم شكوي المريض من اعراض اعوجاج العمود الفقري قبلا و حدوث ما يزيد عن عشرة درجات جنف في الفقرات القطنية. نسبه حدوث هذا المرض ليست محدده و الدراسات اشارت ان نسبته تتراوح من 30 الي 60 من المرضي ذو الاعمار الكبيره فوق 40 عام . و لكن هذا المرض منتشر في المرضي ذو الاعمار الكبيره و اسبابه ليست واضحه و لكن النظريات تشير الي حدوث هذا الاعوجاج ناتج من التنكس الذي يحدث في غضاريف و مفاصل العمود الفقري مما ينتج عنها حدوث ضمور في ارتفاع الفقرات الطبيعي و يحدث عنه جنف في الفقرات القطنية و يحدث اختلاف في المقاسات الطبيعيه التي تربط الحوض بالعمود الفقري والناتج النهائي مجموعه من الاعراض التي يشتكي منها المريض مثل الم الظهر و الانحناء و الم مفصل الحوض والطرفين السفليين و قد يشتكي المريض ايضا من ضعف حركي قد يصل الي عدم القدرة علي التحرك وضعف حسي بالاطراف السفليه و صعوبة بالتبول و التبرز و تفاقم الانحناء أو ازدياد التشوه.كل هذه الاعراض تمثل تدهور في الحاله العامه للمريض و تدهور الحياه اليومية بالنسبة لمرض جنف الفقرات القطنية.

الغرض: تقييم دور الالتحام الامامي القائم بذاته للفقرات القطنية في تصحيح تشوه العمود الفقري القطني التنكسي،

تصميم الدراسة: دراسة بحثية مستقبلية بالاشتراك بين قسم جراحة المخ والاعصاب جامعة قناة السويس، مصر وقسم دراسات العمود الفقري مستشفي كوينز جامعة نوتينجهام إنجلترا.

المرضى والطرق: مجموعه البحث عددها 30 مريض بعد الدراسة الإحصائية وسوف يتم جراحه اصلاح الاعوجاج بالعمود الفقري باستخدام جراحة تثبيت الفقرات من الامام بين اجسام الفقرات القطنية. تشخيص هذا المرض يكون عن طريق الاشعة العادية لتصوير العمود الفقري كاملا من الفقرات العنقيه حتي الحوض من الجانب والامام وقياس زواية الجنف وعمل اشعات مقطعية علي العمود الفقري المصاب بالجنف القطني و العجزي و عمل اشعات رنين مغناطيسي علي منطقه الجنف القطنية و العجزية بعد الفحص الاكلينيكي الكامل و عمل قياسات الجنف و قياسات الحوض مع العمود الفقري و عمل تحضيرات ما قبل الجراحة. نتائج الاوليه لدرجات الاستعدال للعمود الفقري و درجات زوايا التي بين الحوض و الفقرات العجزية سوف تقاس و تقارن بالنتائج قبل الجراحة وتحلل احصائيا و ذلك لعمل نتائج تضع توصيات لافضل طريقة لاستعدال تشوهات الفقرات القطنية التنكسيه.

النتائج: اثبتت النتائج ان هذه الطريقة الجراحية فعالة في تخفيف متوسط حدة الألم في الظهر من 7.36 الي 4.07 و تخفيف متوسط حدة الألم في الطرف السفلي من 6.36 الي 2.07 و تحسن في متوسط مقياس اوزفيرستي من 53.71 الي 45.25 في المئة بعد عام. و اثبتت أيضا تقليل في متوسط الانحناء الامامي من 12.93 مم الي 8.93 مم و تقليل في متوسط درجة انحناء الحوض من 19.21 الي 18.42 درجة و تقليل في متوسط درجة الجنف من 10.39 الي 7.04 و زيادة في متوسط درجة انحناء الفقرات القطنية من 28.57 الي 31.46 درجة. ظهرت مضاعفات اثناء الجراحة في عدد 4 حالات و كانت إصابة شريان فقاري و تم السيطرة عليه بواسطة جهاز الكي. ونسبة الالتحام الفقاري بعد مرور عام وصلت الي 92 ٪ مع ظهور حالتين فشل في الالتحام الفقاري فقط مع عدم ظهور أي اعراض عليهم.

الخلاصة: جراحة تثبيت الفقرات من الامام بين اجسام الفقرات القطنية اثبتت فعاليتها في اصلاح جنف الفقرات القطنية التنكسي مع ظهور مضاعفات اقل من الطرق الاعتيادية الخلفية لاصلاح جنف الفقرات القطنية التنكسي.