Transforaminal lumbar interbody fusion versus posterolateral fusion for the treatment of low-grade isthmic spondylolisthesis in adults

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Background
Isthmic spondylolisthesis means slippage of one vertebra relative to the next caudal vertebra as a result of an abnormality in the pars interarticularis. Isthmic spondylolisthesis has three subtypes: subtype A in which there is stress fracture of the pars (spondylolysis), subtype B in which the pars is elongated, and subtype C in which there is acute fracture of the pars. Isthmic spondylolisthesis is the most common cause of low back pain in adolescents. Spinal fusion is the mainstay of the surgical treatment of low-grade isthmic spondylolisthesis. Spinal fusion can be achieved by posterolateral fusion (PLF) or circumferential fusion. The three basic techniques for circumferential fusion include anterior lumbar interbody fusion, posterior lumbar interbody fusion, and transforaminal lumbar interbody fusion (TLIF).

Patients and methods
Fifty patients with low-grade isthmic spondylolisthesis managed with spinal fusion at the Zagazig University Hospital. Patients were divided into two groups: group I included patients managed by TLIF and group II included patients managed by PLF. The mean age of patients was 34.6 years (range: 26–43 years) in group I and 36.8 years (range: 28–46) in group II. Sex distribution was nine males and 16 females in group I and seven males and 18 females in group II. Exclusion criteria included patients with high-grade spondylolisthesis, traumatic spondylolisthesis, degenerative spondylolisthesis, neoplastic spondylolisthesis, patients with acute or chronic infection, and congenital malformation.

Results
No patients were dropped in the follow-up. In both groups, the mean visual analog scale (VAS) for back pain and leg pain and the Oswestry disability index (ODI) showed statistically significant difference between the values obtained preoperatively and the values obtained at the 1-year follow-up visit. In comparison between both groups for the change in the VAS for back and leg pain and ODI score, group I gave a significant difference regarding the change in the VAS for back pain compared to group II. However, the change in the VAS for leg pain and ODI was not statistically significant.

Conclusion
Both TLIF and PLF are effective options for the treatment of low-grade isthmic spondylolisthesis in adults. However, TLIF gives better clinical outcome, so it is considered a better option.

Keywords:
adults, isthmic spondylolisthesis, low grade, Oswestry disability index, posterolateral fusion, spinal fusion, transforaminal lumbar interbody fusion

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Introduction

Spondylolisthesis is generally defined as an anterior or posterior slipping of one vertebra relative to the next caudal vertebra. The word spondylolisthesis comes from the Greek words spondylos, that means 'spine' 'vertebra,' and listhesis that means slippage [1].

Due to the complex underlying pathologies that may cause spondylolisthesis, numerous classification systems have been described over the years. One of the most commonly used systems is that described by Wiltse and Rothman in which spondylolisthesis is classified into dysplastic, isthmic, degenerative, traumatic, and pathological [2].

A simple and easily applicable grading of the spondylolisthesis is the grading system according to Meyerding. The original grading included four grades according to the percentage of displacement of the

vertebra relative to the adjacent vertebra in which grade I is a slip up to 25%, grade II is a slip between 26 and 50%, grade III is a slip between 51 and 75%, and grade IV is a slip between 76 and 100%. However, it has become international convention that completely displaced vertebrae (spondyloptosis) are defined as grade V. Grade I and II spondylolisthesis is described as low-grade spondylolisthesis [3].

Isthmic spondylolisthesis results from an abnormality in the pars interarticularis, lytic failure (spondylolysis), elongated but intact pars, or acute fracture [2]. It is absent in newborns but present in children and reaches the adult prevalence of 5–8% by age 18 years affecting the lumbosacral region in 89% of patients, L4–5 region in 11%, and L3–4 in 3% of patients [4]. Adult patients with isthmic spondylolisthesis have a higher pelvic incidence, sacral slope, pelvic tilt, and lumbar lordosis compared to those without isthmic spondylolisthesis [5].

Isthmic spondylolisthesis is the most common cause of low back pain in adolescents; however, many adolescents with spondylolisthesis do not actually experience any symptoms or pain. In adult patients with symptomatic isthmic spondylolisthesis, low back pain occurs as a result of disc degeneration (caused by spinal instability), facet arthritis, pars fracture, and spasm of the paravertebral muscles. Other symptoms include tightness of the hamstrings and decreased range of motion of the lower back. Radicular symptoms may occur as a result of irritation of the existing nerve root secondary to foraminal or lateral recess stenosis [6]. Neurogenic claudication caused by central spinal stenosis is uncommon in patients with isthmic spondylolisthesis due to the relative decompression of the spinal canal by the pars fracture [4].

The treatment of isthmic spondylolisthesis relies on the severity of symptoms. Many patients with predominant low back pain without radiculopathy or claudication can be managed successfully by nonoperative modalities, including pain management (medication), functional restoration (physical exercises), cognitive–behavioral therapy, and modification of the activities that induce pain [7].

The surgical treatment is indicated in patients with low-grade isthmic spondylolisthesis after failure of conservative treatment for 3–6 months in order to relieve continuous disruptive back pain or radicular pain [8]. Surgical options include decompression, posterolateral lumbar fusion, and circumferential fusion. As decompression is associated with accelerated disc degeneration and higher rate of slip progression, it is rarely indicated and limited only to older patients with radicular pain [9].

Posterolateral fusion (PLF) using pedicle-screw fixation is considered one of the most popular techniques used in the treatment of isthmic spondylolisthesis. The pedicle screws increase the initial stability and fusion rate when compared with conventional techniques as noninstrumentation or hook systems [10]. However, a number of clinical trials showed a considerable rate of instrumentation failure, loss of segmental lordosis, and pseudoarthrosis in PLF [11].

Circumferential fusion is preferred to PLF as it increases the fusion rate (about 80% of the stress goes through the disc space, so supporting the anterior column with fusion greatly increases the stiffness of the fusion construct), decreases the discogenic pain by removing the disc material, restores disc space height and lumbar lordosis, and improves correction of the deformity [9].

The three basic techniques for circumferential fusion include anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), and transforaminal lumbar interbody fusion (TLIF). The advantage of the posterior approach (PLIF and TLIF) over the anterior approach (ALIF) is the avoidance of vascular and reproductive system complications that can occur with the anterior approach [12]. TLIF has several advantages over PLIF. First of all, it decreases the possibility of damaging the nerve root or dural sac by about 50%; second, one-facet joint is excised while the other is preserved [13].

The aim of this study was to assess and compare the clinical and radiological results of TLIF versus PLF in the treatment of low-grade isthmic spondylolisthesis in adults.

Patients and methods

From February 2013 to June 2016, we had 50 patients with low-grade isthmic spondylolisthesis managed with spinal fusion at the Zagazig University Hospital. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, El Zagazig University, Egypt. Patients were divided into two groups: group I included patients managed by TLIF and group II included patients managed by PLF. The mean age of patients was 34.6 years (range: 26–43 years) in group I and 36.8 years (range 28–46) in group

II. Sex distribution was nine males and 16 females in group I and seven males and 18 females in group II. The level of affection was lumbosacral region in 15 patients in group I and 18 patients in group II, L4–5 region in nine patients in group I and seven patients in group II, and L3–4 region in one patient in group I. Spondylolisthesis was grade I in 22 patients in group I and 23 patients in group II and grade II in three patients in group I and two patients in group II. Low back pain was the main complaint in all patients. Leg pain was present in 11 patients (44%) in group I and in 10 patients (40%) in group II. The mean duration of low back pain was 3.8 years in group I and 3.4 in group II, while the mean duration of leg pain was 9.6 weeks in group I and 9.2 weeks in group II. The mean preoperative visual analog scale (VAS) for back pain was 76.66±6.5 in group I and 74.48±7.75 in group II. The mean preoperative VAS for leg pain was 36.31±11.7 in group I and 33.81±12.4 in group II. The mean preoperative Oswestry disability index (ODI) was 64.4±6.7% in group I and 59.75±7.8% in group II. Exclusion criteria included patients with high-grade spondylolisthesis, traumatic spondylolisthesis, degenerative spondylolisthesis, neoplastic spondylolisthesis, patients with acute or chronic infection, and congenital malformation.

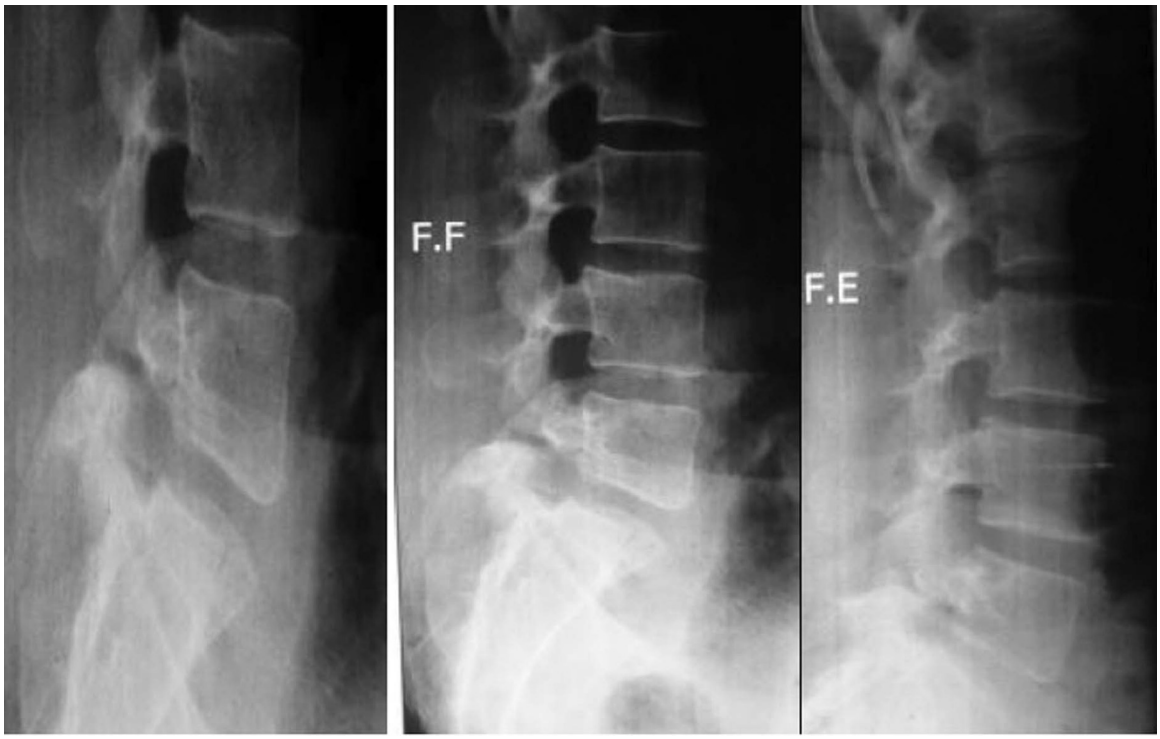
Preoperative evaluation

A detailed history was taken and thorough examination was performed in all patients to evaluate back pain and detect the neurological state of the patients. Plain radiographs (static and dynamic) (Fig. 1) and MRI of the lumbar spine were done in all patients.

Operative technique

All patients were operated under general anesthesia. The patients were positioned in prone position with hips and knees slightly flexed to relieve tension on nerve roots and preserve lumbar lordosis. After sterilization and drapping, a midline posterior approach was performed exposing the posterior spinal elements, including the facet joints. Polyaxial pedicle screws were applied bilaterally in the vertebrae forming the affected segment. In group I, the intervertebral disc was exposed by excision of the facet joint on the side consistent with the patient symptoms. Then, after retraction of the thecal sac and nerve roots, discectomy was done and a rod was applied to the pedicle screws on the contralateral side (Fig. 2). Special dilators were used to distract the disc space (Fig. 3). After distraction, the pedicle screws on the contralateral side were tightened. After that, the endplate cartilage was debrided to provide a host bed of subchondral bone for placement of the cage. Autograft either from the posterior elements after decompression or from the posterior iliac crest was packed into the anterior portion of the disc space. Then, a trial cage was applied to detect the adequate size of the definite cage that was inserted after being filled with autograft.

Figure 1

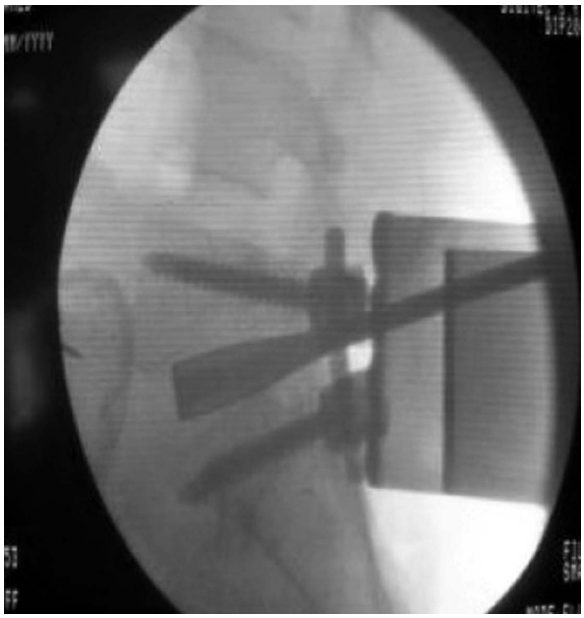


Preoperative lateral view radiograph showing L5–S1 lytic spondylolisthesis.

Figure 2

Intraoperative photograph showing application of pedicle screws and rod on one side to distract disc space.

Figure 3



C-arm view showing distraction of disc space using a special dilator.

Then, distraction of the contralateral screws was released and the rod was applied on the other side, and the screws were tightened on both sides in slight compression. Bone graft was then applied on the contralateral transverse processes after being decorticated. In group II, rods were applied and tightened followed by application of the bone graft (obtained from the posterior elements after decompression or from the posterior iliac crest) between the transverse processes after decortication. A suction drain was applied and the wound was closed in layers. Postoperatively, intravenous antibiotics were given for 3 days followed by oral antibiotics for another 7 days. An orthosis was worn for 6 weeks postoperatively and the patients were allowed to ambulate as early as possible.

Postoperative evaluation

All patients were followed up for a minimum of 1 year (range: 12–30 months, mean: 20 months). The clinical evaluation included the VAS for back and leg pain and ODI. Radiological evaluation was made 1 day postoperatively (Fig. 4) and along with the clinical evaluation at 3, 6, and 12 months postoperatively. Rarely computed tomography was utilized when fusion was questionable.

Statistical analysis

The results were presented as mean±SD. Comparisons between measures (mean±SD) of two groups were done using student *t*-test, while comparisons between measures (mean±SD) between multiple groups were done by one-way analysis of variance test; the difference between each of the two groups was done by least-significant difference post-hoc test. All statistical analyses were performed with SPSS version 24.0 (SPSS Japan Inc., Tokyo, Japan). *P* less than 0.05 was considered statistically significant.

Results

The mean operative time was 158.6±23.4 min in group I, while in group II, the mean operative time was 133.2 ±25.5 min The difference between both groups was significant.

The mean blood loss was 730±235 ml, while in group II, the mean blood loss was 680±304 ml. The average length of hospital stay was 3.6 days in group I and 3.54 days in group II. There was no statistical significant difference regarding these parameters.

In group I, the mean VAS for back pain was significantly improved from 76.66±6.5 preoperatively to 12.25±5.4 at the 1-year follow-up visit. The mean VAS for leg pain was significantly improved from 36.31±11.7 preoperatively to 10.15±3.1 at the 1-year follow-up visit. The mean ODI was significantly decreased from 65.1±6.7% preoperatively to 17.42 ±4.6% at the 1-year follow-up visit (Table 1).

In group II, the mean VAS for back pain was significantly improved from 74.48±7.75 preoperatively

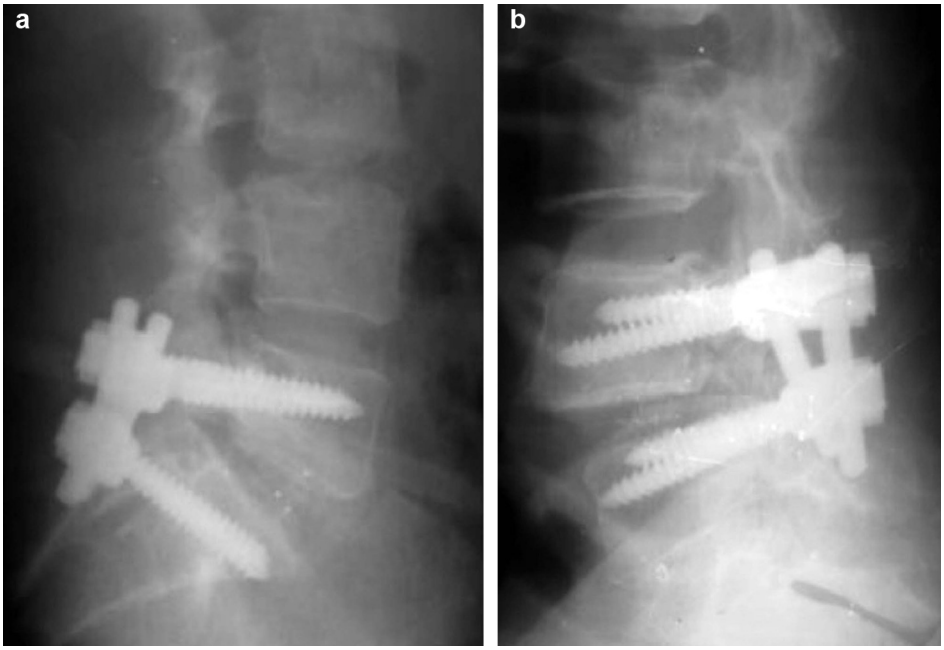
to 16.65±4.5 at the 1-year follow-up visit. The mean VAS for leg pain was significantly improved from 33.81 ±12.4 preoperatively to 10.46±2.9 at the 1-year follow-up visit. The mean ODI was significantly decreased from 59.75±7.8% preoperatively to 17.8±5.7% at the 1-year follow-up visit (Table 2).

In comparison between both groups for the change in the VAS for back and leg pain and ODI score, group I gave a significant difference regarding the change in the VAS for back pain compared to group II. However, the change in the VAS for leg pain and ODI was not statistically significant (Table 3).

Solid fusion occurred in 24 patients (96%) in group I (Figs 5 and 6) and in 21 patients (84%) in group II (Fig. 7). The difference was not significant between both groups.

Complications occurred in five patients (20%) in group I in the form of dural tear in one patient discovered postoperatively by occurrence of postural headache and

Figure 4



(a) Immediate postoperative lateral view radiograph showing fixation L5–S1 level via transforaminal lumbar interbody fusion technique. (b) Immediate postoperative lateral view radiograph showing fixation of L5–S1 level via posterolateral fusion technique.

Table 1 Clinical results in group I before surgery, 3 months, 6 months, and 12 months after surgery

	Preoperative value (mean±SD)	Three-month postoperative. value (mean±SD)	Six-month postoperative value (mean±SD)	One-year postoperative (mean±SD)	*P* value
VAS for back pain	76.66±6.5	32.7±7.8	20.5±6.9	12.25±5.4	<0.001
VAS for leg pain	36.31±11.7	23.45+-8.2	15.88±4.3	10.15±3.1	<0.001
ODI	65.1±6.7	36.6±10.8	23.32±7.3	17.42±4.6	<0.001

ODI, Oswestry diability index; VAS, visual analog scale.

Table 2 Clinical results in group II before surgery, 3 months, 6 months, and 12 months after surgery

	Preoperative (mean±SD)	Three months postoperative (mean±SD)	Six months postoperative (mean±SD)	One-year postoperative (mean±SD)	*P* value
VAS for back pain	74.48±7.75	35.4±8.16	23.25±5.6	16.65±4.5	<0.001
VAS for leg pain	33.81±12.4	22.4±6.2	13.55±3.7	10.46±2.9	<0.001
ODI	59.75±7.8	33.3±10.3	22.6±6.7	17.8±5.7	<0.001

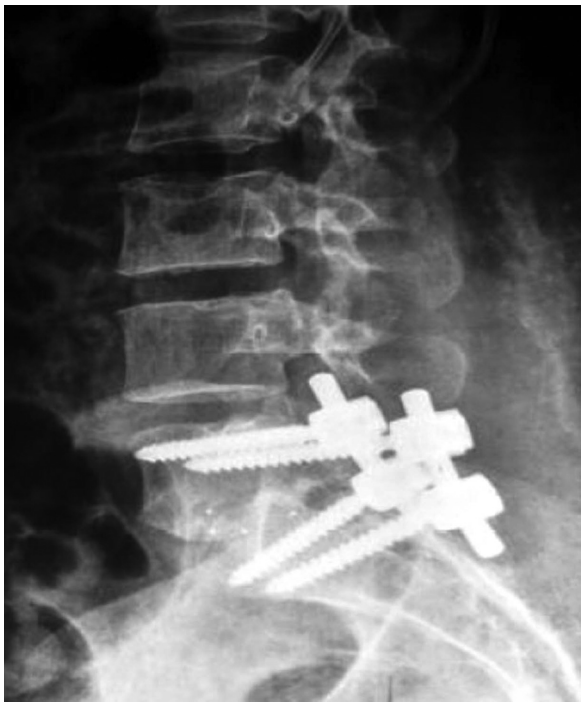
ODI, Oswestry diability index; VAS, visual analog scale.

Table 3 Change in VAS for back pain, VAS for leg pain, and ODI before and 1 year after surgery between both groups

	Changes in 1 year I Mean±SD	Postoperative II Mean±SD	*P* value
Change in VAS of back pain	64.41±5.95	57.83±6.12	0.001
Change in VAS of leg pain	26.16±7.4	23.35±7.45	0.149
Change in ODI	47.68±6.4	41.95±3.7	0.072

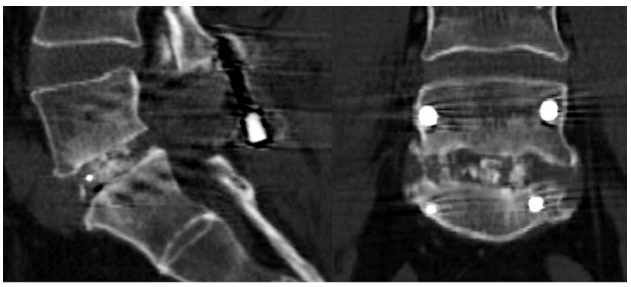
ODI, Oswestry diability index; VAS, visual analog scale.

Figure 5



Twelve-month postoperative lateral view radiograph showing solid fusion after transforaminal lumbar interbody fusion technique.

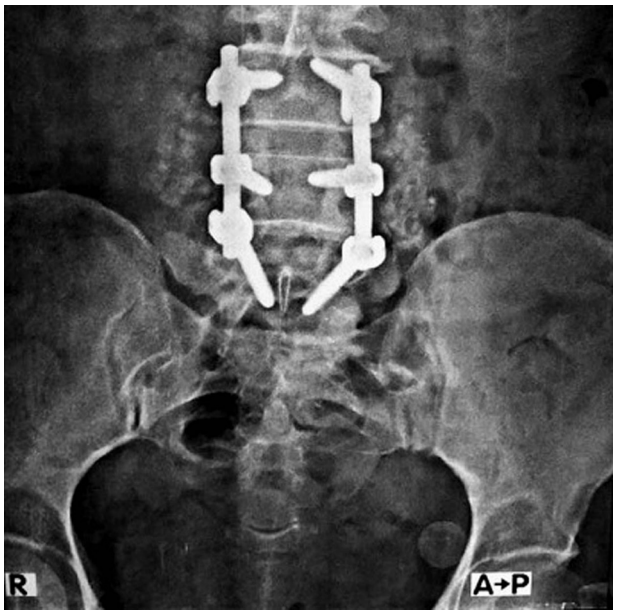
Figure 6



Six-month postoperative computed tomography showing solid fusion after transforaminal lumbar interbody fusion technique.

cerebrospinal fluid leak through the drain and managed conservatively. Superficial infection occurred in one patient treated with proper antibiotics. Transient radicular manifestations in the form of numbness, tingling, and partial motor weakness involving L5 dermatome in two patients improved completely within 3 months. Pseudoarthrosis was present in one

Figure 7



Six-month postoperative anterioposterior view radiograph showing solid fusion after posterolateral fusion technique.

patient presented with mild back pain and treated conservatively. In group II, complications occurred in six patients (24%) in the form of superficial infection in one patient managed with proper antibiotics, dural tear in one patient discovered intraoperatively and repaired. Pseudoarthrosis in four patients managed with second surgery.

Discussion

The changes and defects occurring in pars interarticularis of the lumbar vertebrae play a role in the etiology of isthmic spondylolisthesis [14]. Isthmic spondylolisthesis is divided into three subtypes: subtype A in which there is stress fracture of the pars (spondylolysis), subtype B in which there is elongation of the pars, and subtype C in which there is acute fracture of the pars [15].

Isthmic spondylolisthesis is the most common cause of low back pain in adolescents . Other symptoms include radicular symptoms, neurogenic claudication, tightness of hamstrings, and decreased range of motion.

The surgical treatment is indicated in patients with low-grade isthmic spondylolisthesis if the conservative measures are failed to control back pain or neurological symptoms worsen. The surgical options include decompression, PLF, and circumferential fusion. As decompression is associated with accelerated disc degeneration and higher rate of slip progression, it is rarely indicated and limited only to older patients with radicular pain [9].

PLF using pedicle-screw fixation is considered one of the most popular techniques used in the treatment of isthmic spondylolisthesis. The pedicle screws increase the initial stability and fusion rate when compared with conventional techniques as noninstrumentation or hook systems [10]. However, a number of clinical trials showed a considerable rate of instrumentation failure, loss of segmental lordosis, and pseudoarthrosis in PLF [11].

Circumferential fusion is preferred to PLF as it increases the fusion rate (about 80% of the stress goes through the disc space, so supporting the anterior column with fusion greatly increases the stiffness of the fusion construct), decreases the discogenic pain by removing the disc material, restores disc space height and lumbar lordosis, and improves correction of the deformity [9]. The three basic techniques for circumferential fusion include ALIF, PLIF, and TLIF. TLIF causes less violation to the spinal canal when compared to PLIF and avoids the vascular and reproductive system complications that can occur with ALIF.

In our study, we had 50 patients with low-grade isthmic spondylolisthesis managed with spinal fusion . Patients were divided into two groups: group I included patients managed with TLIF and group II included patients managed with PLF. In both groups, the mean VAS for back pain and leg pain and the ODI showed statistically significant difference between the values obtained preoperatively and the values obtained at the 1-year follow-up visit. In comparison between both groups for the change in the VAS for back and leg pain and ODI score, group I gave a significant difference regarding the change in the VAS for back pain compared to group II. This may be attributed to removal of the disc material that may be a cause of back pain and increasing the stability and fusion rate of the affected segment . However, the change in the VAS for leg pain and ODI was not statistically significant.

Comparing to other related studies, in the study of Pooswamy *et al*. [1], there were 40 patients operated for spondylolisthesis by PLF and TLIF, they concluded that PLF and TLIF are equally effective in the management of low-grade spondylolisthesis, except in lytic type. They felt that the lytic spondylolisthesis is better to be managed with interbody or circumferential fusion. In the study of Habib [16], there were 50 patients with isthmic spondylolisthesis managed with PLF and interbody fusion. They concluded that interbody fusion in the form of PLIF gives better clinical results, higher fusion rates, and fewer construct failures when compared to PLF. Danta *et al*. [17] reported that the interbody fusion augmented by pedicle screws leads to better clinical outcomes, prolonged economic and functional scales, and fewer complications when compared with PLF. Ekman *et al*. [18] also reported a significant difference between interbody fusion and PLF in favor of interbody fusion.

On the other hand, several studies reported that there were no significant differences between interbody fusion and PLF as regards the clinical outcomes . In the study of Wu *et al*. [19], both interbody fusion and PLF were comparable in terms of outcome in treating spondylolisthesis. Madan *et al*. [20] reported better clinical outcome in low-grade spondylolisthesis with PLF than interbody fusion. Deuhoux *et al*. [21] reported that the fusion rates are directly related to the degree of displacement and the height of the disc and do not affect the functional outcome. As a result, they prefer using PLF in low-grade spondylolisthesis and prefer using interbody fusion in high-grade spondylolisthesis.

Conclusion

Both TLIF and PLF are effective options for the treatment of low-grade isthmic spondylolisthesis in adults. However, TLIF gives a better clinical outcome, so it is considered a better option.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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