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ORIGINAL ARTICLE

Minimal Invasive Transforaminal Lumbar Interbody Fusion in Low Grade Isthmic Spondylolithesis

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ABSTRACT

Background: Symptomatic isthmic spondylolisthesis may cause back and or leg pain that usually needs surgical intervention. The question is what type of surgical treatment option to choose? A good option is the minimal invasive lumbar interbody fusion (MIS-TLIF) with a similar or to somewhat better results than the traditional open-TLIF. Aim: To evaluate the results of MIS-TLIF in management of isthmic spondylolisthesis.

Methods: This is a prospective clinical trial. Between December 2017 to December 2019, 24 patients having a low-grade isthmic spondylolisthesis were subjected to MIS-TLIF surgery in the Spine Unit of the Orthopedic Department, Zagazig University Hospital. Osteotomy of the facet complex, preparation of the disc space and cages insertion was done, with per-cutaneous pedicle screw fixation. Demographic data, radiological imaging, visual analogue scale (VAS) and oswestry disability index (ODI) were collected. Twelve months was the least follow-up period.

Results: The mean slip reduction changed from 23.13% to 6.48%. The mean VAS for back and leg pain improved from 8.42 to 1.79 and from 7.46 to 1 respectively. The mean ODI decreased from 52.21 to 15.71 at the outcome. No implant failure was documented in our patients. Our mean operative time was 110. 20 ± 13.39 minutes, mean radiation exposure was 3.79 ± 0.83 minutes and mean blood loss was 56.45 ± 14.63 ml. The fusion rate was about 95.8%.

Conclusions: MIS-TLIF for low-grade isthmic spondylolisthesis provided a good clinical outcome and good fusion rate. MIS-TLIF can restore and maintain an adequate sagittal vertical access (SVA) and so can provide a good sagittal alignment post-operative.

Keywords: Minimal invasive lumbar interbody fusion (MIS-TLIF); Isthmic spondylolisthesis; Visual analogue scale (VAS); Oswestry disability index (ODI)

INTRODUCTION

Isthmic spondylolisthesis is defined as the slipping of one vertebra in relation to the next one due to abnormal pars interarticularis. When symptomatic, it causes back with/or lower limb pain and variable degree of neurological affection. Fusion is used to treat patients with failed conservative treatment, where successful instrumented fusion is better than non-instrumented fusion. Posterior approach is the standard access for achieving fusion in such cases, where inter-body fusion has better results than postero-lateral one as the interbody space is compressed by about 80% of the pressure, but the postero-lateral area is affected only by 20%. Interbody graft can fill 90% of intervertebral surface area in relation to only 10% in the postero-lateral grafts. Also, the vascularity of the interbody area is more and thus adding more to the fusion rate [1]. Anterior fusion is done with a synthetic (metal or PEEK) cage. Many studies have shown better stiffness of the implant with added anterior fusion to the posterior fixation if compared to posterior alone, with fusion rates of 90% to 100%. Harms and Jeszenszky (1990) described transforaminal lumbar interbody fusion (TLIF) as a method of performing anterior fusion from a posterior only approach in treating degenerative spine conditions. It was performed with bilateral pedicle screw instrumentation to provide rigid fixation [2].

TLIF has many advantages including the reduction of the risk of neural retraction and epi-dural fibrosis if compared to a posterior lumbar interbody fusion (PLIF), avoiding the complications of anterior surgery, that may injury the great vessels or cause retrograde ejaculation if

the pre-sacral sympathetic plexus is affected. TLIF also reduces the probability of adjacent segment disease as it preserves the posterior structures like the laminae and posterior longitudinal ligament complex. The clinical and radiographic outcomes with TLIF in patients with degenerative disease or spondylolisthesis are promising [3].

The tubular retractor systems permitted the advance of minimally invasive techniques that now usually use a para-median incision and radiological guide to get the benefit of minimal invasive surgery (MIS): less trauma to the spinal structures, little bleeding, minimal scar-tissue, with rapid mobilization and recovery, decreased hospital stay, and a fast return to work with the same or better surgical outcome than traditional old surgery [4].

In 2000, minimal invasive facetectomy was described, and in 2002, tubular discectomy, anterior fusion and percutaneous pedicle screw fixation were done to provide earliest type of minimally invasive lumbar fusion techniques. The minimally invasive techniques gradually replaced the open-TLIF one. The minimal invasive transforaminal lumbar interbody fusion (MIS-TLIF) approach has perioperative complications like wrong surgical segment, guide wire break or misplacement, pedicle screw malposition, more radiation exposure, and pseudo-arthrosis but still similar or even lower than that of open surgeries [5].The aim of this study was to evaluate the results of MIS-TLIF in management of isthmic spondylolisthesis.

METHODS

Study Design:

This Prospective clinical trial evaluated 24 patients (4 males, 20 females), who underwent MIS-TLIF which was done in the Spine Unit of Orthopedic Department, Zagazig University Hospital, with a mean follow up of 19.42 ± 6.26 months, with a median of 16 (13 – 32); 17 patients were L5-S1 and 7 were L4-L5.

Inclusion Criteria:

The criteria for patients' selection for this study were: Low grade isthmic spondylolisthesis (less than 50% slippage) with axial low back pain and/or leg pain.

Exclusion Criteria:

Our exclusion criteria were: High grade spondylolisthesis, presence of severe osteoporosis (DEXA scan), previous spinal instrumentation, spinal tumor, and spinal infections. A minimum clinical and radiologic follow-up was at least 12 months.

Ethical Approvals:

Written informed consent was obtained from all participants, the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Procedures:

Clinical Evaluation:

Beside the routine physical and neurological exam, assessment of oswestry disability index (ODI) and visual analogue scale scores (VAS) for back and leg pain were evaluated before surgery. Demographic data as: age, sex, occupation, and smoking were collected also from all patients. General and local lumbar spine examination including the motor, sensory and reflexes were performed.

Radiological Evaluation:

Standing anterior-posterior, lateral and dynamic standing (flexion and extension) plain lumbar spine radiographs. Some parameters were included like the C7 sagittal vertical axis (SVA) from the posterior-superior corner of S1 upper end plate to a line vertically from C7, Meyerding slip grades and the lumbar lordosis (LL: angle between the upper endplate of S1 and L1 upper endplate).

MRI pre-operative: sagittal, coronal, and axial view to evaluate the neurological compromise.

X- ray radiology was done pre-operative, 6weeks post-operative, 6 months and one-year post-operative and then every 6 months.

The modified criteria of fusion done by Bridwell (Table 1) for the lumbar spine were used to assess fusion on CT cuts obtained every 6 months till fusion. Both I and II grades were used as a satisfactory fusion rate [6].

Operative Technique:

Start with the non-symptomatic side with insertion of two percutaneous pedicular screws and rod insertion percutaneously then doing distraction. Para-spinal posterior approach is then performed on the side with severe symptoms after radiological guidance.

Two guide wires are placed for per cutaneous pedicular screw. Dilators are used to provide an entry for placing the tubular retractor to expose the facet and the pars interarticularis. TLIF is done with cage placement, two pedicle screws are inserted on the side of the surgical incision over the two wires then we perform compression over the screws (Figure 1). We measured the radiation exposure, blood loss and the operative time.

STATISTICAL ANALYSIS

All data were analyzed SPSS 18.0 for windows (SPSS Inc., Chicago, IL, USA). Continuous variables were presented as the mean ± SD & median (range), and the categorical variables were expressed as a number (percentage). the Shapiro-Wilk test was used to examine the continuous variables. More than two groups of normally distributed variables are compared using ANOVA test, the Friedman's test was used for non-normally

distributed ones. Post-hoc test was done using Paired t-test for two dependent sides of normally distributed variables and for two dependent of non-normally distributed variables we used Wilcoxon singed ranks test. Mann Whitney U test compared two groups of non-normally distributed variables. All tests were two tailed. P value <0.05 is significant.

RESULTS

Demographic data of the studied cases are shown in (Table 2). In the whole study, statistically significant differences (p< 0.05) were found between pre- and post-operative measurements for each parameter.

The clinical outcome (Table 3) showed a statistically significant improvement of symptoms at postoperative evaluation. As regards VAS (Figure 2) for back deceased from 8.42 preoperative to 1.79 and VAS for leg pain from 7.46 to 1 at final outcome. The ODI (Figure 2) also decreased from severe disability (52.21) to mild disability (15.71) post-operative and continue like that till our final outcome measures.

The mean radiation exposure was about 3.79 ± 0.83 minutes. Cases showed less amount of blood loss with a mean of 56.45 ± 14.63 cc. On the whole cases, blood transfusion was never required during the perioperative period. Time of operation was about 110.20 ± 13.39 minutes (Table 4).

The mean lumbar lordosis changed also from 57.23 (40-73) to 57.94 (47.4-68.90). The mean slip percentage showed magnificent reduction from 23.13 (5-42) to 6.48(1.8-23) % (Table 5).

The SVA showed change from range of (-65.1 to 110) pre-operative to (-29 to 35) mm post-operative. We had 2 patients with SVA more than 50mm pre-operative. All patients were balanced post-operative.

The fusion rate was about 95.8 % with only one case showed non-union with cage subsidence. Our patient satisfaction was about 95.8% satisfied with surgery.

Complications: We had one case with non-union, but the patient refused any further interference.

Table (1): Modified Bridwell Fusion Criteria.

Grade I	**Fused with remodeling and trabeculae present**
Grade II	Graft intact, not fully remodeled and incorporated, but no lucency present
Grade IIII	Graft intact, potential lucency present at top and bottom of the graft
Grade IV	Fusion absent with collapse/resorption of the graft

Table (2): Patients' Demographics.

Basic characteristics	**The operated patients (N=24)**	
	No.	%
Sex		
• **Male**	4	16.7%
• **Female**	20	83.3%
Age (years)		
• **Mean ± SD**	40.42 ± 4.65	
• **Median (Range)**	42 (32 – 47)	
Comorbidity		
• **HCV**		
• **Absent**	21	87.5%
• **Present (HCV)**	3	12.5%
• **Smoking**		
• **Smoker**	1	4.2%
• **Non-smoker**	23	95.8%
Follow up period (months)		
• **Mean ± SD**	19.42 ± 6.26	
• **Median (Range)**	16 (13 – 32)	
Level of spondylolithesis		
• **L5-S1**	17	70.8%
• **L4-L5**	7	29.2%

Table (3): Functional Outcome.

	Baseline	Post-operative			Test•	p-value
		6 weeks	6 months	final		
	(N=24)	(N=24)	(N=24)	(N=24)		
VAS of back pain						
Mean	8.42	3.58	2.17	1.79	62.074	<0.001 (HS)
Std. Deviation	0.58	0.65	0.38	0.88		
Median	8	3.5	2	1.5		
Minimum	7	3	2	1		
Maximum	9	5	3	3		
VAS of leg pain						
Mean	7.46	3.33	1.25	1.00	66.792	<0.001 (HS)
Std. Deviation	0.98	0.48	0.44	1.59		
Median	7	3	1	1		
Minimum	6	3	1	0		
Maximum	9	4	2	8		
ODI						
Mean	52.21	17.54	14.04	15.71	59.484	<0.001 (HS)
Std. Deviation	6.79	1.25	2.35	9.95		
Median	51	18	14	14.5		
Minimum	42	15	10	10		
Maximum	63	19	19	61		

•Friedman's test, p< 0.05 is significant and Sig.: Significance. Oswestry disability index (ODI). Visual analogue scale scores (VAS).

Table (4): Operative Data.

Operative Data	The operated patients (N=24)
Radiation exposure (min.)	
• **Mean ± SD**	3.79 ± 0.83
• **Median (Range)**	4 (3 – 5)
Blood loss (cc)	
• **Mean ± SD**	56.45 ± 14.63
• **Median (Range)**	52.50 (40 – 90)
Operation duration (min.)	
• **Mean ± SD**	110.20 ± 13.39
• **Median (Range)**	110 (90 – 135)

Table (5): Change in lumbar lordosis and slip percentage pre and post operative after 6 weeks, 6 months, and the final outcome.

	Baseline	Postoperative			Test	p-value
		6 weeks	6 months	final		
	(N=24)	(N=24)	(N=24)	(N=24)		
Lumbar Lordosis (LL)						
Mean	57.23	54.87	57.78	57.94	7.213•	0.047 (S)
Std. Deviation	9.23	6.88	7.20	6.83		
Median	56.35	57.15	58	59		
Minimum	40	42	44.90	47.40		
Maximum	73	65.10	68.40	68.90		
Slip (%)						
Mean	23.13	5.13	5.98	6.48	53.27•	<0.001 (HS)
Std. Deviation	8.09	3.97	4.71	5.58		
Median	23.5	4	4.5	4.5		
Minimum	5	1	1.80	1.80		
Maximum	42	16	18	23		

Repeated measures ANOVA test, •Friedman's test, p< 0.05 is significant.

Figure 1: A: Pre-operative x-ray lateral view with spondylolisthesis L4-L5. B: Sagittal view MRI. C&D: Post-operative lateral and AP view of the lumbar spine and pelvis respectively shows slip reduction, TLIF cage anterior in the disc space and pedicular screws fixation and E: Post-operative photo of the wound measuring about 3.8 cm.

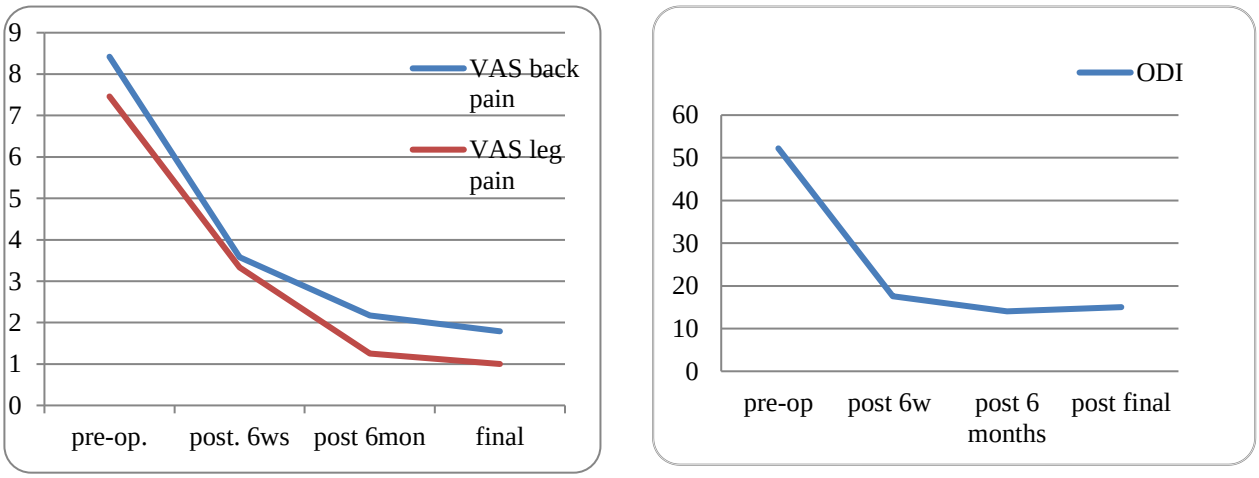

Figure (2): Changes in visual analogue scale scores (VAS) of back and leg pain on the left figure and of Oswestry disability index (ODI) on the right one.

DISCUSSION

Isthmic spondylolisthesis incidence is 6% of the population and likely affect the L5–S1 level more than L4–L5 level. It occurs with fatigue or stress fracture of pars. It is associated with loss of disc height with instability both rotational and translational in the sagittal alignment. Symptomatic patients usually need intervention; the ideas are to stabilize the spine motion segment, decompress the neural structures, increase the disc height, and proper sagittal plane standing position [7]. TLIF in treating low-grade spondylolisthesis provide a safe type of surgery with high fusion and low complications. In the other side, open-TLIF is related to patient morbidity due to muscle retraction and necrosis during the operation. The effect of prolonged muscle ischemia adversely affects the patient clinical outcome. To avoid the complications of open surgery, MIS-TLIF has developed. The beneficial aspects of MIS are less trauma, little bleeding, and scar-tissue, with more rapid recovery and a rapid return to work with less hospital stay. It is important not to affect the strategy of surgery and to achieve the same outcome as traditional open surgery through a less damaging approach for both the patient and surgical team as well by using these modifications [8].Our aim was to examine the clinical and radiological outcome in patients with low grade isthmic spondylolisthesis, who underwent MIS-TLIF.

Wang et al. [9] showed better results with MIS-TLIF than with Open-TLIF in obese patients with a follow up period of 2 years. There was lower blood loss, operative time, significantly decrease in pain, and significantly better VAS and ODI scores in the MIS group.

These results were comparable to our results in relation to the mean operative time of 110.20 ± 13.39 and the mean blood loss 56.45 ± 14.63with a mean BMI of 28.12 ± 7.82. So, MIS-TLIF can be considered as a safe fusion technique in obese

patients with similar or even higher benefits when compared to the traditional Open-TLIF.

Gu et al. [10] showed smaller operative time with MIS-TLIF than that of open surgery as the last cases in his study between 2006-2008 was past the initial learning curve of the first 100 case in a study between 2002-2004.

The smaller the operative field with failure to visualize the bony landmarks and the learning curve in MIS surgery, the more prolonged operative time and more radiation exposure that is nearly needed for placement of percutaneous pedicular screws with the MIS-TLIF in relation to the open-TLIF that has little radiation exposure [10]. Taking about the clinical outcomes, a significant change in VAS (for back and leg pain) and ODI scores was seen postoperative, patients experienced significantly less post-operative pain with less use of medications. This indicates that MIS-TLIF improve the clinical outcome as evidenced by early recovery from the operation, early discharge from hospital and return to work. This is due to protecting the posterior tension band system and the para-spinal muscles. This is similar to the findings by Glassman et al. [11].

Our study provided a good radiographic outcome with good decompression of the neurological tissue and slip reduction. This was achieved by maintaining intraoperative physiologic lordosis with proper hip extension position, cage insertion anterior as possible with compression of the screws over the lordotic rod. The postoperative lumbar lordosis maintained as the preoperative value and within the normal range. We performed a unilateral facetectomy with a single cage with four per-cutaneous screws MIS-TLIF.

Spondylolisthesis slip reduction establish a correct alignment of the vertebrae by correcting the kyphosis of the slipped level, resulting in less degenerative risk on the adjacent segments. Also, the reduction of the slipped vertebrae promotes the fusion and the healing by placing the vertebrae in a more physiological and anatomical point. Our cases showed significant reduction values with a mean of 23.13% pre-operative to 6.45% post-operative [12].

Increasing the sagittal vertical axis (SVA) that correlate with pain and poor health-related quality of life scores was described by Glassman et al, [11] and found that SVA was related to the pain and a decrease in function as measured using VAS and ODI. In our results, setting the threshold of SVA = 50 mm, we found a good clinical outcome in both the VAS and the ODI [13].

A year was the least the follow-up period for our patients. We used the Bridwell fusion grading system with fusion rates about 95.8 (grade I &II). Villavicencio et al. [14] examined retrospectively 139 patients with open or MIS-TLIF, Patients with the open technique showed improved fusion at 6 months when compared to those with MI-TLIF but with no statistically significant difference. However, at 4 years follow-up, the same fusion in the two groups were done. We have one case (4%) of pseudo-arthrosis, we attributed it for being a heavy smoker.

CONCLUSIONS

MIS-TLIF treatment of low-grade isthmic spondylolisthesis provided us with good clinical outcome and good fusion rate. Restoration of adequate lumbar lordosis is important for sagittal alignment of the patients. MIS-TLIF can restore and maintain an adequate SVA and so can provide us with good sagittal alignment post-operative.

Conflicts of Interest/ Financial Disclosures: Nothing to declare.

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