European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 09, 2020

TRANSFORAMINAL LUMBAR INTERBODY FUSION in the MANAGEMENT of LYTIC SPONDYLOLITHESIS: MINIMALLY INVASIVE VERSUS CONVENTIONAL OPEN TECHNIQUES

Ashraf Yassin Amer[1], Ahmed Gamil Ahmed[#1], Ahmed Samir Rady[1] & Mohamed Ahmed Raaft[2] & Mahmoud Mohamed Elbakry[3]

[#1]Department of Orthopedics, Saudi German Hospital, Cairo, Egypt
[2]Department of Orthopedics, Yanbu National Hospital, Yanbu, Kingdom of Saudi Arabia
[3]Department of Orthopedics, New Mowasat Hospital, Salmiya, Kuwait
[#1]dr.ahmedgamil@hotmail.com

***Abstract**:*
This study assesses the difference between Minimally Invasive Transforaminal Lumbar Interbody Fusion (MI-TLIF) surgery and conventional open TLIF surgery incases of lytic spondylolisthesis regarding pain, disability, hospital stay and complications. Lytic Spondylolisthesis patients may require fusion of one or more spinal segments. The chances of achieving a successful lumbar spinal fusion have increased. TLIF technique is gradually being accepted in these cases and widely used by most spinesurgeons. Minimally invasive TLIF is a recent trend for spinal fusion. This is a prospective randomized comparative study conducted from March 2016 to December 2018 that included 40 patients with low grade lytic spondylolisthesis who underwent TLIF. 20 patients underwent MI-TLIF through percutaneous posterior lumbar pedicular screw fixation, microscopic minimally invasive transform aminal discectomy and interbody cage fusion (patients group A) and another 20 patients underwent conventional open posterior lumbar pedicular screw fixation and TLIF (control group B). In our results, bothsurgical techniques showed improvement in pain and function within 12 months (follow up period), but group A showed statistically significant improvement in pain and function in the first 3 months. Regarding blood loss, need for transfusion and hospital stay, group A showed statistically significant better results. As a conclusion, MI-TLIF is a better option in surgical management of spondylolisthesis especially in the early postoperative period.

Keywords: Spondylolisthesis, Minimally Invasive Spine Surgery, Transforaminal Lumbar Interbody Fusion

INTRODUCTION

Spinal fusion in a properly selected patient has demonstrated to be effective in improving pain, function, and quality of life, however, many patients resist having a surgical fusion due to concerns over the morbidity of theprocedure **[Wang et al 2016]**. Some patients require fusion of one or more spinal segments to adequately treat their condition. The chances of successful lumbar spinal fusion increase significantly by addition of a rigid fixation device **[Powers et al 2006]**.In 1982, Harms and Rolinger described transforaminal lumbar interbody

fusion (TLIF) technique to create a 360-degree fusion via a single posterolateral approach **[Harms et al 1982]**. In the TLIF procedure, bone graft and an interbody spacer are placed via a posterolateral transforaminal route into a distracted disc space in conjunction with a supplemental pedicle screw construct **[Mummaneni et al 2005]**. Numerous minimally invasive approaches to the lumbar spine have been developed to minimize approach-related morbidity. Recently, systems for percutaneous pedicle screw and rod insertion under fluoroscopic control or image guidance have become available **[Foley et al]**. Concurrently, surgical instruments, tools for disc space preparation, segmental distraction, and reposition, as well as modified interbody cage systems, have been engineered specifically for use in percutaneous fusion procedures**[Scheufler et al 2007]**. Over the past decade, minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) has become exceedingly popular for treating a variety of lumbar spinal disorders. The use of tubular dilators for decompression in concert with specialized interbody cages and percutaneous screws has led to viable minimally invasive alternatives to open fusion surgery**[Wang et al 2016]**. Minimally invasive TLIF (MI-TLIF) was introduced to minimize iatrogenic soft tissue and muscle injury associated with conventional open TLIF while maintaining comparable clinical, radiological, and economic outcomes.

PATIENTS AND METHODS

This study is a prospective randomized comparative study which includes 40 patients who underwent surgeries from March 2016 to December 2018. 20 patients underwent MI-TLIF through percutaneous posterior lumbar pedicular screw fixation, microscopic minimally invasive transforaminal discectomy and interbody cage fusion (as patients group, Group A) and another 20 patients who underwent conventional open posterior lumbar pedicular screw fixation and TLIF (as control group, Group B). These two groups were compared as regards low back pain and limb pain (Visual Analogue Score “VAS”), disability according to “Oswestry Disability Index – ODI”, hospital stay and peri-operative complications.

Inclusion criteria:
a) Lytic spondylolisthesis: grade I and II (low grade).
b) Single level.
) Age between 20 to 45 years.
d) Complaint of low back pain and orunilateral sciatica.
e) Failed conservative treatment for 3 months.

Exclusion criteria:
a) Grade III and IV spondylolisthesis (high grade).
b) Multiple levels.
c) Previous back surgery.
d) Complaint of bilateral sciatica.
e) Morbid obesity.
f) L5/S1 lytic spondylolisthesis with high iliac crest.
g) Major medical illness (e.g., patients incurrent major psychiatric illness, osteoporosis).
h) General contraindications for anesthesia.

OPERATIVE PROCEDURES

Minimally Invasive TLIF Approach (MI-TLIF):
(Group A)

Pre-operative Planning and Set Up
Preoperative planning was useful in determining the proper starting point and screw trajectory. The starting point was rarely directly over the pedicle. CT axial view or X-ray AP view demonstrated the distance lateral to the pedicle initially taken through the skin.

Patient Positioning
The patient was positioned prone supported on rubber foam blocks. A radiolucent frame with bedrail was used.

We made sure that adequate fluoroscopic images of the pedicles were obtained in both AP and lateral views before proceeding. The patient was then prepared and draped in the usual fashion. A longer prepared area was necessary as the rod inserter mighthave an entry point relatively far away from the levels being instrumented. Fluoroscopy in the anterior-posterior and lateral views was used to locate the affected level.

Minimally Invasive Transforaminal Interbody Cage Application
Incision location and tube trajectory: The location of the incision was approximately 4 cm laterally off the midline; an incision mark was made on the skin at the level of the affected disc space. A K-wire was inserted at this point, aiming for identifiable bony landmarks like the inferior edge of the lamina and facet joints. After fluoroscopic verification, a 2 cm longitudinal incision was made penetrating the fascia to easily accommodate the dilators. Successively increasing dilating tubes were inserted under intermittent fluoroscopy followed by retractor insertion. The retractor was then opened for a customizable exposure by expanding the blades as necessary. Position of the independent blade either medially or laterally and angling of the retractor allowed for preferential instrumentmaneuverability and reached in these directions for thorough disc removal and optimal implant insertion. In performing the TLIF, the approach was just lateral to the laminar edge and then removal of the entire facet on one side was done in order to safely insert the interbody cage without significant nerve root and thecal sac retraction. This operative corridor exposed the thecal sac and exiting nerve root medially and the bony landmarks of the laminectomy cranially and caudally as well as the pedicles. Under direct visualization and with minimal retraction of the nerve root, the interbody disc was identified and removed, and the end plates prepared for the interbody graft.

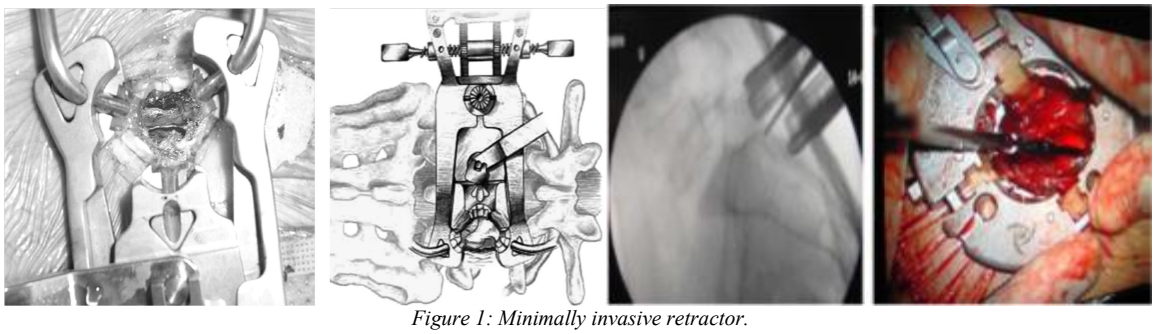


Figure 1: Minimally invasive retractor.

Percutaneous Pedicular Screws Insertion

a) Positioning of Skin Incisions

A 22-gauge spinal needle was used to verify the appropriatelocation of skin incisions. The needle was positioned on the skin directly over the pedicle on AP image. The needle was then moved laterally 1 to 2 cm and inserted through the skin to the intersection of the facet and transverse process.

b) Accessing the Pedicle

A pedicle access needle was used to gain access to the pedicle. After placing the pedicle access needle at the intersection of the facet and the transverse process, the needle was advanced partially through the pedicle.

c) Guide Wire and Dilators Insertion

The inner stylet of the needle was removed to allow the guide wire to be inserted into the pedicle carefully as unintentional advancement may be potentially dangerous. Once the guide wire was inserted, the needle was removed. The fascia and muscle were dilated to allow for screw placement. Three dilators were used to gently make a path of the appropriate dimensions. The first two dilators were removed, leaving the third dilator to serve as a tissue protection sleeve during the taping step.

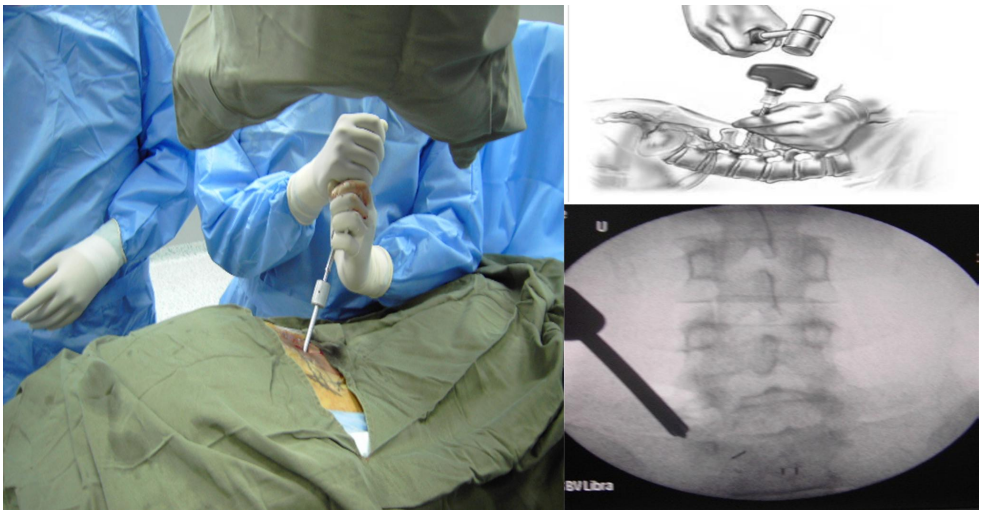


Figure 2: Needle Insertion. AP image shows the needle tip at the lateral margin of the pedicle initially. As the needle advances towards the base of the pedicle, on the lateral image, it approach the pedicle center on the AP image.

d) Pedicle Preparation and Screw Placement

The pedicle was prepared by placing the tap over the guide wire and through the third dilatation sleeve. Fluoroscopy was used to verify the position of the guide wire and the tap during this step. The screw assembly was inserted over the guide wire and into the pedicle. After driving the screw assembly into the pedicle the guide wire was removed. The process was then repeated for the second screw on the same side.

e) Connection of the Extenders

Rotation of the extenders was done so that the two flat sides faced each other. The male and female parts were then mated together and rotated so that there was no gap between the two extenders. Once the extenders were connected and the flat surfaces were completely flush; the rod inserter was attached.

f) Rod Insertion
The rod inserter was attached to the two screw assemblies by lining up the pegs of the inserter and the grooves of the assemblies. A rod was then placed into the tip of the rod inserter. After the rod wasin place. A small skin incision was required, and then the rod was advanced through the screw saddles as confirmed on lateral fluoroscopy.

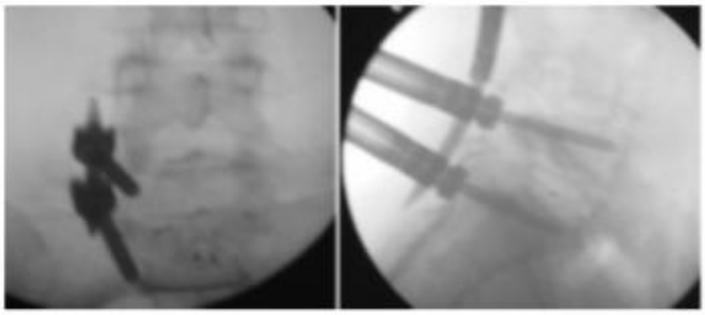


Figure 3: Fluoroscopic rod insertion

h) Final Tightening & Assembly Removal
After verifying with A-P, lateral and oblique views that the rod was seated in the heads of both screws, the set screws were tightened. The rod inserter was then detached from the rod by reversing the steps of attachment followed by removal of the screw assembly. The final construct was then viewed with A-P and lateral fluoroscopy.

Transforaminal Lumbar Interbody Fusion (TLIF):
(Group B)

Patient Positioning
The patient was positioned as mentioned in MI-TLIF method.

Surgical Exposure
Posterior approach landmarks were: spinous processes, posterior superior iliac spine and iliac wings, (however an image intensifier was necessary in every case).

Surgical Dissection
After skin incision in the midline above the spinous processes and the dissection of the subcutaneous layers, the thoracolumbar fascia was incised with a cautery knife. The paraspinal musculature was sub-periostealy detached from the spinous processes and the laminae. Care was taken not to injure upper facet joint capsules.

Lumbar Spine Pedicle Screw Insertion
The pedicle entrance point was at the lateral border of the base of the superior articular process or the mid transverse process point. The screw trajectory was angled 20° to 25° to the midline. In the sagittal plane the screws took a course parallel to the upper vertebral endplates.

Sacral Screw Insertion
Screw placement in the first sacral pedicle was located just below the L5/S1 facet angled medially 20° and cranially towardthe anterior corner of sacral promontory.

Cage Application

Osteotomy of pars interarticularis with excision of the fibrocartilaginous tissue of spondylolysis with excision of ligamentumflavum, cranial retraction of exiting root, discectomy and refreshing of cancellous bone of vertebral body by curetting the bony end plate then insertion of a cage filled with bone graft (autogenous with or without synthetic graft) wasdone.

Wound Closure

The thoracolumbar fascia was closed over suction drains. The fascia was sutured tightly by running sutures. Subcutaneous closure followed by skin closure by subcuticular absorbable sutures was done subsequently.

RESULTS

This is a comparative study including 40 patients. 20 patients that underwent MI-TLIF (group A) and another 20 patients that underwent open conventional TLIF (group B). Early postoperative results data were obtained before hospital discharge, while late postoperative results data were obtained during follow up starting from 1st to 12th month. Follow up duration ranged from 12 to 24 months (average was 18 months).

Baseline characteristics of patients

1-Age: Group A ranged between 21 and 35 years mean 29.1 years. Group B ranged between 22 and 44 years of age mean 30.5years.

Groups	Age		T-test	
	Range	Mean±SD	T	p-value
A	21 - 35	29.1±4.56	-0.74	0.464
B	22 - 44	30.5±7.49		

Table 1: Age distribution.

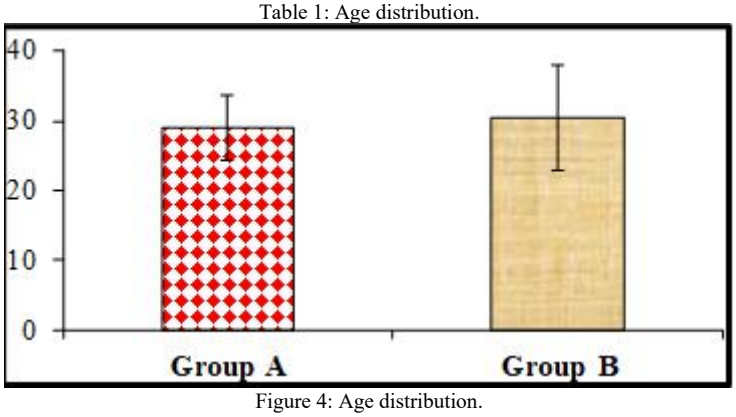


Figure 4: Age distribution.

2-Sex: There were 18 males and 2 females in group A and no females in group B.

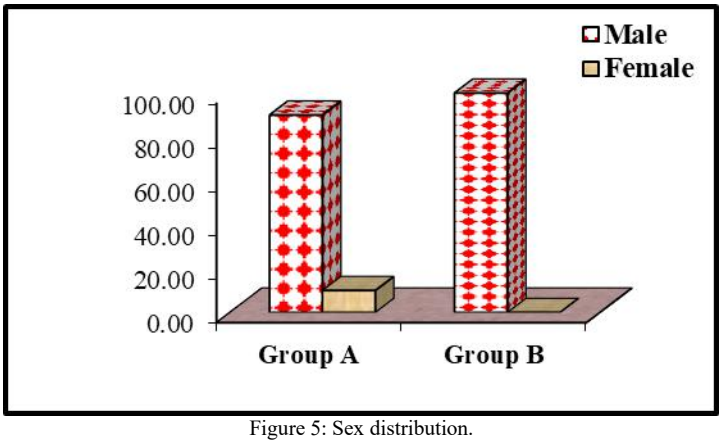


Figure 5: Sex distribution.

3- Level: L5-S1 is the most common level encountered in the study, total of 28 cases 14 in Group A and 14 in Group B. L4-5 level was of 12 cases 6 in group A and 6 in group B. there was no other levels encountered in the study.

Table 2: Levels included in both groups

Level		Groups		
		A	B	Total
L5-S1	N	14	14	28
	%	70	70	70
Level		**Groups**		
		A	**B**	**Total**
L4-5	N	6	6	12
	%	30	30	30
Total	N	20	20	40
	%	100	100	100
Chi-square	X2	1		
	p-value	0		

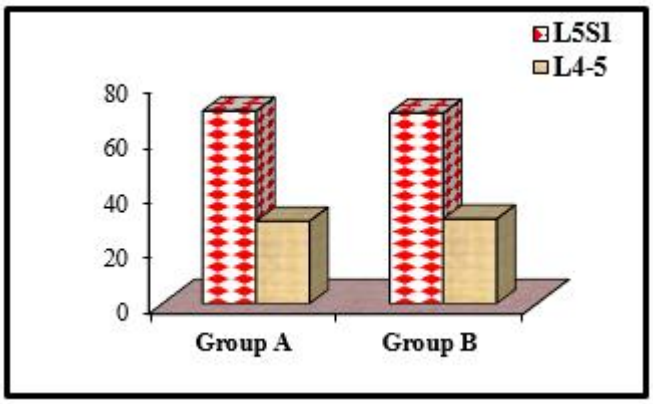


Figure 6: Levels included in both groups.4-

Spondylolisthesis Grades: In group A there were 16 cases grade I and 4 cases grade II. In group B grade I were 12 cases and grade II were 8 cases.

Table 3:grades of spondylolisthesis in both groups.

Grade		Groups		
		A	B	Total
Grade I	N	16	12	28
	%	80	60	70
Grade II	N	4	8	12
	%	20	400	30
Total	N	20	20	40
	%	100	100	100
Chi-square	X2	1.33		
	p-value	0.248		

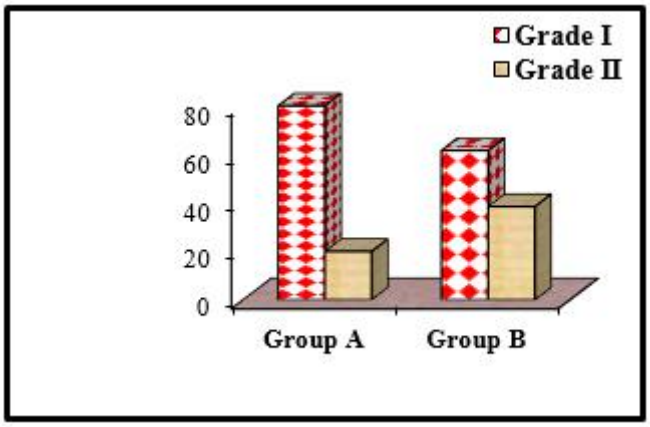


Figure 7: Different grades of spondylolisthesis in both groups.

5- Surgery Time: Group A ranged between 160-240 minutes, mean was 190.5 minutes. Group B ranged between 120-210 minutes and mean was 153.5 minutes. Group A showed statistically significant longer surgery time than group B.

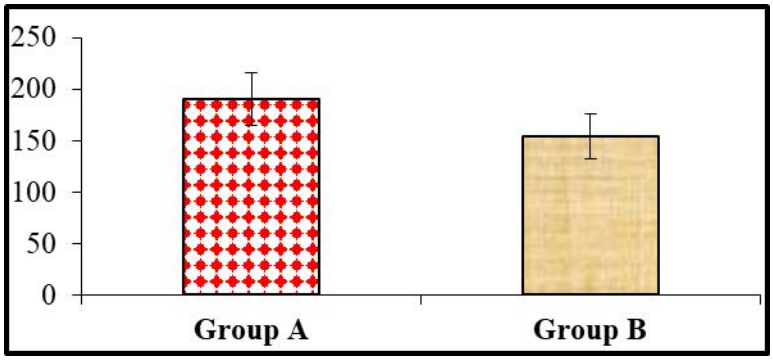


Figure 8:Surgical duration statistics.

6- Blood Loss: In Group A, blood loss was ranged between 110-300cc (mean 168cc) and in Group B, it was ranged between 250-840cc (mean 476.5 cc). Group A showed statistically significant less mean blood loss than group B.

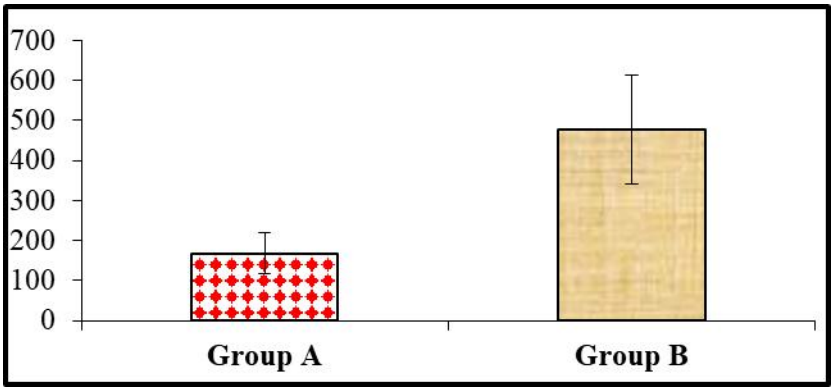


Figure 9: Blood loss statistics.

7- Need for Transfusion: Lower number of cases needed transfusion in Group A (one out of 20) than in Group B (two out of 20) and was statistically non-significant.

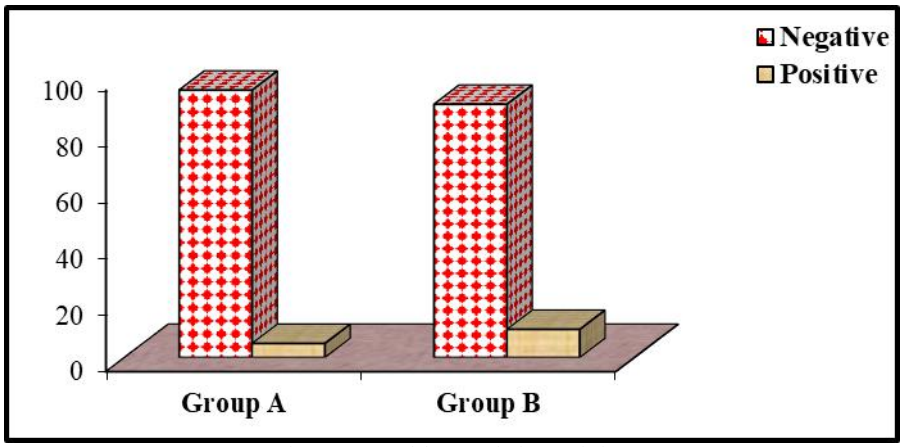


Figure 10: Need for transfusion statistics.

8- Hospital Stay: In Group A, hospital stay ranged between 2 to 5 days with mean of 2.88 days. In Group B, it ranged between 2 to 16 days with mean of 5.12 days. There is statistically significant longer duration of stay in group B than in group A.

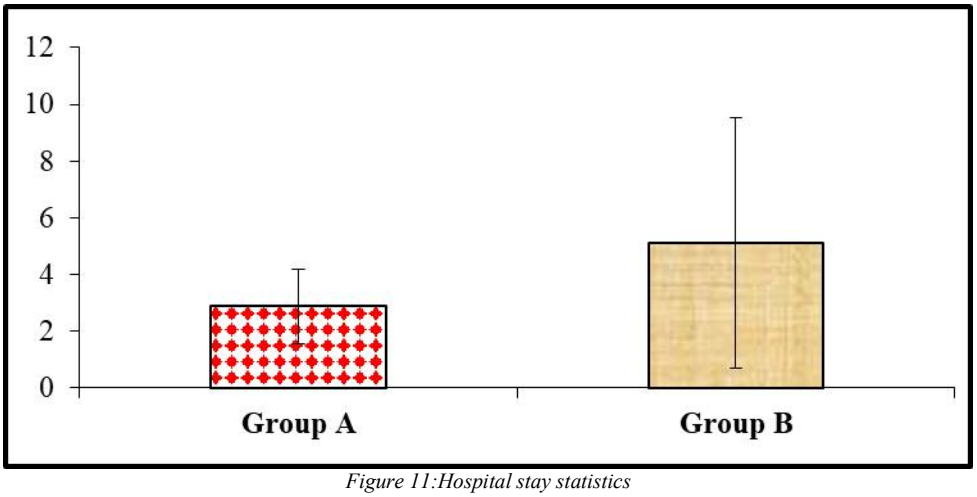


Figure 11:Hospital stay statistics

9- Infection: There was only one case of deep infection (in Group B), representing 5% of the control cases. And 6 cases of superficial infection, 4 in Group B representing 20% of the open TLIF cases and 2 cases were recorded in the minimally invasive group representing 10%. All were treated

conservatively by antibiotic except onepatient in A group had secondary sutures under localanesthesia. It was statistically non-significant.

10- There was no CSF leak, dural tears, screwsmalpositioning, loosening of screws or rapidly progressiveadjacent segment disease in any of the cases of the studyduring surgery or later in the follow-up period (for 1 year).

11- Cage Extrusion and Redo Surgery: There was a case ofposterolateral cage extrusion in Group B, failed conservativetreatment for 6 months (patient initially declined redo) andnecessitated redo surgery for repositioning of cage.There were no other complications in both groups thatmight necessitate redo surgery encountered in both groups infirst year of follow-up and this was statistically insignificant.

12- Oswestry Disability Index:In Group A mean preoperative ODI was 20.3, although it showed mild increase in the 1 month patient evaluation, yet it decreased significantly in further follow-ups starting from 3rd month until reaching 5.0 in 12 months follow-upevaluation. This can be compared to group B mean preoperative ODI which was 20.53 and showed a similarcurve, increasing value in the first month post-operative evaluation, yet also decreasing thereafter in further follow-up until the 12th months evaluation. Statistically significant different results were only obtained in 6th and 12th months evaluations, proving better outcome for group A patients regarding the ODI.

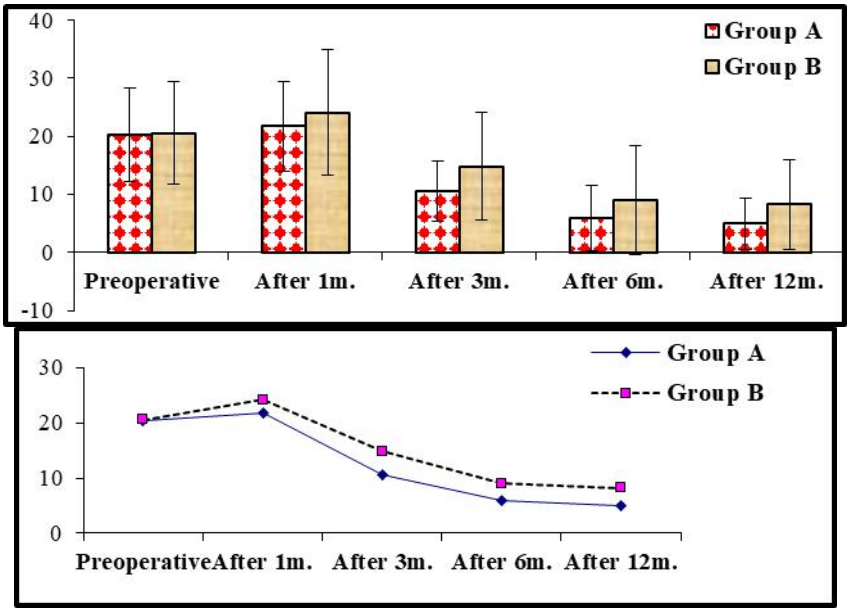


Figure 12: ODI outcome comparing Groups A and B.

13- VAS Back: Preoperative VAS score for low back pain in group A started at a mean of 7.3 and showed statistically significant decrease of values starting of immediate postoperative period reaching a 2.3 value at the 12th month follow-up evaluation. On the contrary to group A, group B curve started to show statistically significant decrease of VAS for low back pain starting from 3rd month follow-up evaluation.

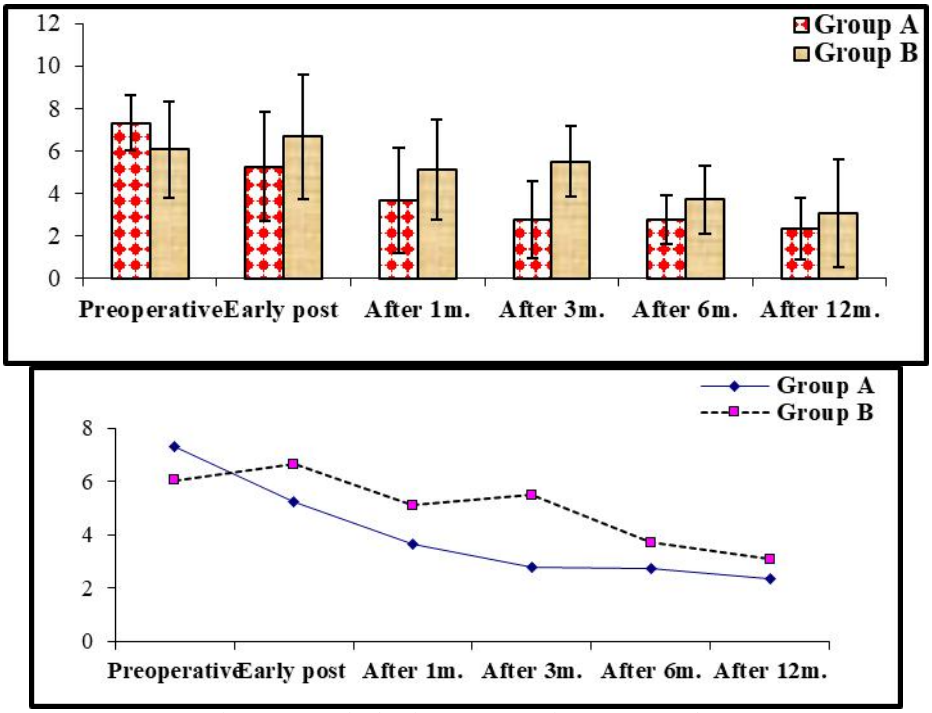
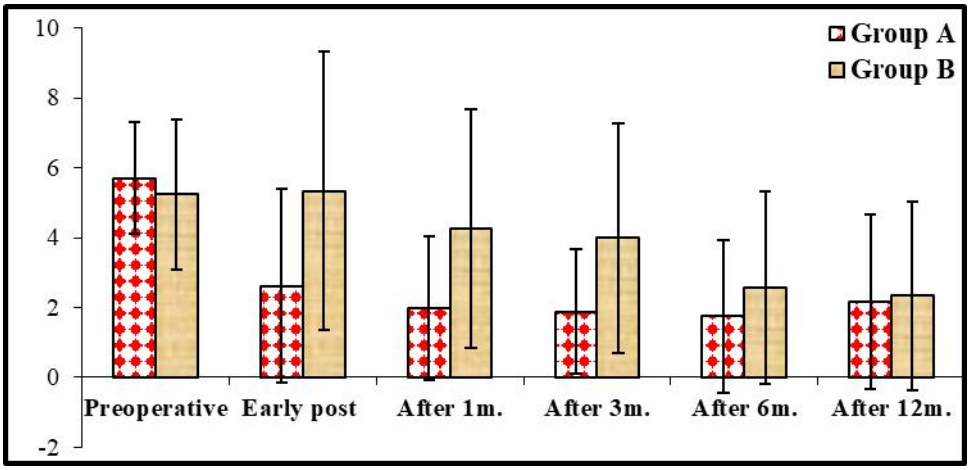


Figure 13: Low back pain VAS, comparing groups A and B.

14- VAS limb: The mean for group A preoperative VAS score of limb pain was 5.7 with statistically significant decrease of values starting from the immediate postoperative period, reaching 2.2 at the 12th month follow-up evaluation. On the contrary group B curve starting to show statistically significant decrease only starting from the 6th month followup (preoperative mean was 5.2 and 12th month postoperative mean was 2.3).



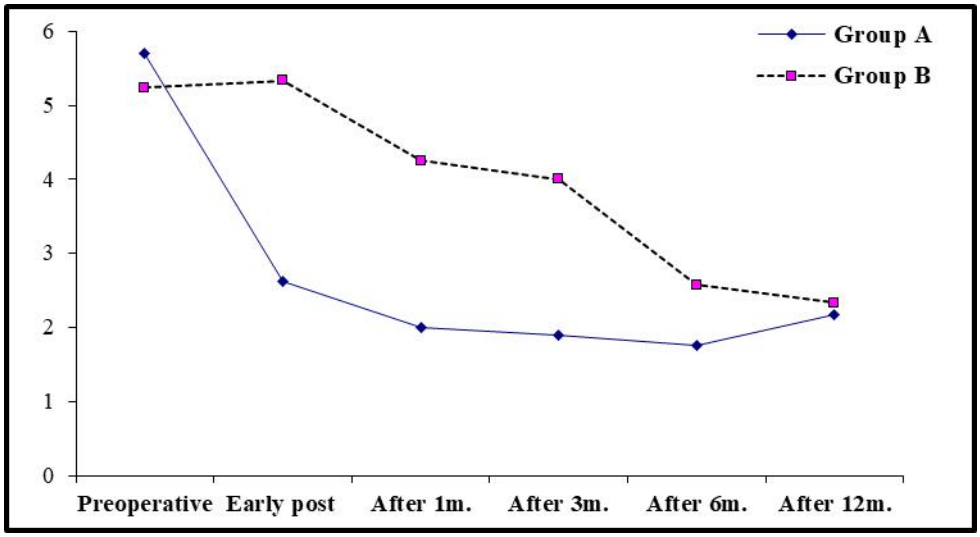


Figure 14:*Limb Pain VAS, comparing groups A and B.*

DISCUSSION

TLIF technique is gradually being accepted and widely used by surgeons. But the conventional open TLIF has beencriticized for iatrogenic damage due to the extensive peelingof soft tissues and muscles**[Schwender et al 2005]**.In recent years, the surgicaltreatment of lumbar degenerative disease has showed minimally invasive trend, and TLIF technique has developedto mini-open incision. Expandable passage tube minimallyinvasive system, such as Quadrant system, establishes thesurgical channel using the step-by-step expansion method,exposing limitedly and minimizing the tissue damage insurgical approach and surgical procedures **[Li et al 2018]**.Since the introduction of MI-TLIF in the early 2000s byFoley et al. as an alternative to conventional TLIF, several studies have compared both techniques for perioperative, postoperative, clinical, and radiological outcomes**[Foley et al2001]**. The parameters that have been compared most often between the two techniques are operative time, blood loss, hospital stay, complication rate, radiation exposure time and various painscores. Other items include fusion rates, clinical and radiological outcomes and the costs involved in both procedures to evaluate the cost-effectiveness of the techniques. On the other hand, other parameters, such as operative timeand complication rate remain highly controversial when comparing MI-TLIF and conventional open TLIF **[Hammad et al 2019]**.Compared with the conventional open surgery, it can notonly complete the operation, but also achieve the goal of smaller incision, better internal stability, less systemic and local responses, faster tissue healing, shorter functional recovery time and better psychological effect. Also, minimally invasive TLIF significantly reduces the risk of bleeding and surgical complications, postoperative serumCPK level is decreased, bedridden time is reduced, postoperative ODI and VAS scores are improved andthe recovery cycle is shortened **[Brodano et al 2015]**.We aimed in this study to include cases with spondylolisthesis due to pars defect only grade one or two. All cases we included had low back pain and unilateralradicular symptoms; this is to do microscopic discectomy through unilateral facetectomy with insertion of TLIFinterbody cage at the same site of radicular symptoms, percutaneous posterior pedicular screws were inserted bilaterally (same incision of microscopic TLIF on one side and two different incisions on opposite side).It was well noticed that the results of the last cases are better than the first cases mainly regarding surgery duration and subsequently other parameters, this is normal ifconsidered the learning curve and the fact that this procedure is completely new.For open procedure, this study operative time (153, 5 min)was better than of Inamdar et al. (240 min) that comparedposterior lumbar interbody fusion versus inter transverse fusion **[Inamdar et al 2006]**.For MI-TLIF procedure; this study operative time results were longer than results

found by Logroscino et al. (171 min)**[Logroscino et al 2011]**, Kim M et al. (150.7 min) **[Kim et al 2011]** and Foley et al. (155 minutes) **[Foley et al 2001]**.According to Hammad et al. meta-analysis **[Hammad et al 2019],** 27 studies had sufficient data regarding the operative time. The mean operative time was 214.69 min in the MI-TLIF group vs. 198.03 min in the Open TLIF group. Based on this meta-analysis, the difference was not significant (P = 0.78). This is probably because they used virtual fluoroscopic guidance that eliminate time needed for A-P and lateral images. First few cases of MI-TLIF, screw application was time consuming but last few cases rod application was more time consuming probably due to regression of rod applicator targeting device quality. In our study, blood loss was comparable to the results ofIssacs et al. reporting a mean of 140 cc**[Isaacs et al 2005]**, but was more than Logroscino et al. reporting only 126 cc**[Logroscino et al 2011]** and was lower than the results of Kotani et al. of 181 ml**[Kotani et al 2012]**, taking into consideration that we inserted interbody cage and they did not. In comparison to Hammad et al meta-analysis study, twenty-nine studies had sufficient data regarding the amount of blood loss.The mean blood loss volume was 247.82 ml in the MI-TLIF group vs. 568.18 ml in the Open TLIF group. The difference was highly significant (P < 0.00001) **[Hammad et al 2019]**. In our study, hospital stay was comparable to Foley et al.taking into consideration they used anterior approach for insertion of interbody cage (ALIF)**[Foley et al 2001]**, but were better than Logroscino et al. (5.3 days)**[Logroscino et al 2011]**and Kotani et al. (3.4 days)**[Kotani et al 2012]**.

The immediate post-operative low back pain increased in conventional surgery group rather than in MI-TLIF group, this explained that part of this pain is due to extensive muscle cutting needed in open group in comparison to minimal muscle retraction and no mid line muscle separationin MI-TLIF group. According to Hammad et al., twenty-five studies had sufficient information on length of hospital stay (LOS) **[Hammad et al 2019]**. Themean LOS was 5.05 days in the MI-TLIF group vs. 6.92 daysin the open TLIF group. The difference was highly significant (P <0.00001). Our results of immediate postoperative low back pain VASare inferior to the results of Logroscino et al. (VAS = 2.1),but he did not divide VAS into back and radicular pain, and this may explain their better results **[Logroscino et al 2011]**.

There were statistically significant differences between two groups in immediate, one-month follow-up and threemonths follow-up. So both open and MI-TLIF procedure effectively reduce LBP on long follow up with no statisticaldifference, but MI-TLIF procedure is more effective in themean change of reduction of LBP, this explained by absenceof the muscle cutting factor in MI-TLIF procedure.This is inferior to the result found by Kim et al., theirmean change of VAS scores for back pain was (4.5)**[Kim et al 2011]**, theexplanation for this is that they did not decompress the nerveroot posteriorly, instead they only removed disc fromanterior. As well as inferior to that of Inamdar et al. considering that this study had longer follow-up period and greater number of cases**[Inamdar et al 2006]**.Our results of mean reduction of LBP is lower than what Kotani et al. as they did not use interbody cage**[Kotani et al 2012]**, So wedoubt the efficacy of interbody cage placement for fusion in reduction of low back pain in comparison to posterolateral on lay fusion. Facetectomy and discectomy done in both open group and MI-TLIF group effectively reduce radicular pain, also the distraction obtained by interbody cage greatly increased foraminal height, so nerve root become free of compression.Both procedures had markedly improved radicular pain and MI-TLIF procedure was better in early change of the VAS for radicular pain than open technique. Our results were not comparable to the result found by Kim et al. as the mean change of VAS scores for leg pain was 4.4**[Kim et al 2011]**. On the contrary, they were comparable to those found by Logroscino et al., the MI-TLIF procedure is equally effective as conventional open technique in giving the patients the same advantage of improvement of

functional score and recovery to relevant ordinary life activity in the latefollow-ups and even better in early follow-ups**[Logroscino et al 2011]**. Our functional scores were inferior to Inamdar et al. considering that their preoperative functional score was better than our preoperative score (suspecting the study was biased and included cases with good preoperative functional score and excluded those with poor preoperative functional score), this could explain the difference between two results**[Inamdar et al 2006]**. Our functional scores were comparable Logroscino et al. **[Logroscino et al 2011]** and were better than Kotani et al. **[Kotani et al 2012]**, taking into consideration that his preoperative functional score was lower than ours. This is an important issue about the efficacy of interbody fusion and whether it improves patient functional score, as it improves the fusion rate. Our results regarding ODI Score also was comparable to Hammad et al. **[Hammad et al 2019]**. Twenty studies contained sufficient data on the Oswestry Disability Index (ODI) scores, expressed in percent. The mean preoperative ODI score was 43.08 in the MI-TLIF group vs. 42.95 in the Open TLIF group; the difference was not statistically significant. The mean ODI score at the final follow-up was 19.48 in the MI-TLIF group vs. 20.62 in the Open TLIF group, and the difference was not significant (p=0.25). There was no malpositioned screw in both groups due to the use of intraoperative imaging for confirmation in both open and MI-TLIF and experience in conventional open technique. Safety precaution regarding radiology exposure were applied. Our screws malpositioning results were superior to that of Raley (9.7%)**[Raley et al 2012]**, Smith et al. **[Smith et al 2014]**, Logroscino et al. (1.25%)**[Logroscino et al 2011]**and Kim et al. (11.1%)**[Kim et al 2011]**. The high rate of complications is interpreted in many studies to be due to learning curve, but we noticed that more than one system of percutaneous fixation was used, each with a different technique, and different learning curve. The aim in follow up x-ray was to exclude loosening of screws and cage migration. there were no statistically significant differences between two groups in the complication rate.We had one of the early cases that suffered from postoperative radicular pain at the side of TILF; the postoperativeCT scan showed no misplacement of screws on this side nor cage malposition. We revised our technique in thenext cases and minimized manipulations on the nerve root. This was the only encountered case in MI-TLIF group.Two cases in open group with black lumbar discs in T2 MRI showed no improvement in VAS back pain probablydue to inappropriate patient selection. One case of open group showed malpositioned cage discovered 2 days postoperative as patient continued to complain from limb paresthesia. Patient was informed andadvised to undergo repositioning surgery, but he refused and opted for conservative medical treatment which initially was helpful yet 3 months later he decided to undergo repositioning surgery, performed three months later and the paresthesia improved. (VAS was 8 reduced to 4) but pain did not disappear completely.Infection was encountered in 7 patients all was treated medically except one in MI-TLIF group showed one ofwounds dehiscence and necessitated secondary suturing, done under aseptic conditions under local anesthesia and patient was discharged one day afterwards with no further wound complicationsOverall, our complication rates are superior to that of Logroscino et al. **[Logroscino et al 2011]**; nonunion was observed in threepatients (15%), without hardware mobilization and successful clinical outcome at last follow-up. One superficialwound infection resolved with antibiotic therapy. Also, our results were superior to that of Kim et al. **[Kim et al 2011]**;they encountered two cases of medial penetration of the pedicle border without neurological deficits and one casewith a deep wound infection. However, there were no signs of neurological compromise or fusion failure at the finalfollow up. Our results were comparable to that of Kotani et al. **[Kotani et al 2012]**; he found no major complications. However, two cases in the minimal invasive group demonstrated some surgical difficulty in rod passage during the percutaneous rod placement procedure. In these cases, the rods were placed directly on heads of pedicle screws via extended midline skin incisions involving

lateral intramuscular exposure, but without conversion to a major open procedure. Both cases successfully led to solid bony fusion without implant failure.

CONCLUSION

MI-TLIF is an effective procedure in surgical managementof low grades lytic spondylolisthesis. In comparison to conventional TLIF, MI-TLIF has less blood loss, hospital stay, postoperative infection and need for transfusion. The MI-TLIF gives better reduction of low backpain, radicular pain in early follow-ups and functional recovery. Surgery duration of MI-TLIF cases is still statistically significantly longer than those of open conventional method but hopefully surgery duration will belesser with growing learning curve. Intraoperative and postoperative complications other than infection showed similar rates. MI-TLIF requires more advances and a better equipped theater; hence, it is an expensive surgery.

REFERENCES

[1] Wang MY, Grossman J. Endoscopic minimally invasive transforaminal interbody fusion without general anesthesia: initial clinical experience with 1-year follow-up. Neurosurg Focus. 2016 Feb; 40 (2): E13.
[2] Powers CJ, Isaacs RE. Minimally invasive fusion and fixation techniques. Neurosurg Clin N Am. 2006 Oct; 17 (4): 477–89.
[3] Harms J, Rolinger H. [A one-stager procedure in operative treatment of spondylolistheses: dorsal traction-reposition and anterior fusion (author's transl)]. Z OrthopIhreGrenzgeb. 1982 Jun; 120 (3): 343–7.
[4] Mummaneni PV, Rodts GE. The mini-open transforaminallumbar interbody fusion. Neurosurgery. 2005 Oct; 57 (4Suppl): 256–61; discussion 256-261.
[5] Foley KT, Gupta SK. Percutaneous pedicle screw fixation ofthe lumbar spine: preliminary clinical results. J Neurosurg.2002 Jul; 97 (1 Suppl): 7–12.
[6] Scheufler K-M, Dohmen H, Vougioukas VI. Percutaneoustransforaminal lumbar interbody fusion for the treatment ofdegenerative lumbar instability.Neurosurgery. 2007 Apr; 60(4 Suppl 2): 203–12; discussion 212-213.
[7] Schwender JD, Holly LT, Rouben DP, Foley KT. Minimallyinvasive transforaminal lumbar interbody fusion (TLIF):technical feasibility and initial results. J Spinal Disord Tech.2005 Feb; 18 Suppl: S1-6.
[8] Li H-J, Ge D-W, Zhang S, Aisikeerbayi A-J, Wang H, He Y-L,et al. Comparative study between mini-open TLIF via Wiltse's approach and conventional open TLIF in lumbar degenerativediseases. Eur Rev Med Pharmacol Sci. 2018; 22 (1 Suppl):53–62.
[9] Hammad A, Wirries A, Ardeshiri A, Nikiforov O, Geiger F.Open versus minimally invasive TLIF: literature review and meta-analysis. J Orthop Surg. 2019 Jul 22; 14 (1): 229.
[10] Brodano GB, Martikos K, Lolli F, Gasbarrini A, Cioni A,Bandiera S, et al. Transforaminal Lumbar Interbody Fusion in Degenerative Disk Disease and Spondylolisthesis Grade I:Minimally Invasive Versus Open Surgery. J Spinal DisordTech. 2015 Dec; 28 (10): E559-564.
[11] Inamdar DN, Alagappan M, Shyam L, Devadoss S, DevadossA. Posterior lumbar interbody fusion versus intertransverse fusion in the treatment of lumbar spondylolisthesis. J OrthopSurg Hong Kong. 2006 Apr; 14 (1): 21–6.
[12] Logroscino CA, Proietti L, Pola E, Scaramuzzo L, TamburrelliFC. A minimally invasive posterior lumbar interbody fusion for degenerative lumbar spine instabilities. Eur Spine J OffPublEur Spine SocEur Spinal Deform SocEur Sect Cerv Spine Res Soc. 2011 May; 20 Suppl 1: S41-45.

[13] Kim M-C, Chung H-T, Cho J-L, Kim D-J, Chung N-S. Factorsaffecting the accurate placement of percutaneous pedicle screws during minimally invasive transforaminal lumbarinterbody fusion. Eur Spine J Off PublEur Spine SocEurSpinal Deform SocEur Sect Cerv Spine Res Soc. 2011 Oct;20 (10): 1635–43.
[14] Foley KT, Gupta SK, Justis JR, Sherman MC. Percutaneouspedicle screw fixation of the lumbar spine. Neurosurg Focus.2001 Apr 15; 10 (4): E10.
[15] Isaacs RE, Podichetty VK, Santiago P, Sandhu FA, Spears J,Kelly K, et al. Minimally invasive microendoscopy-assisted transforaminal lumbar interbody fusion with instrumentation.J Neurosurg Spine. 2005 Aug; 3 (2): 98–105.
[16] Kotani Y, Abumi K, Ito M, Sudo H, Abe Y, Minami A. Midtermclinical results of minimally invasive decompression and posterolateral fusion with percutaneous pedicle screws versusconventional approach for degenerative spondylolisthesis with spinal stenosis. Eur Spine J Off PublEur Spine SocEur SpinalDeform SocEur Sect Cerv Spine Res Soc. 2012 Jun; 21 (6): 1171–7.
[17] Raley DA, Mobbs RJ. Retrospective computed tomographyscan analysis of percutaneously inserted pedicle screws for posteriortranspedicular stabilization of the thoracic andlumbar spine: accuracy and complication rates. Spine. 2012 May 20; 37 (12): 1092–100.
[18] Smith ZA, Sugimoto K, Lawton CD, Fessler RG. Incidence oflumbar spine pedicle breach after percutaneous screw fixation: a radiographic evaluation of 601 screws in 151 patients. JSpinal Disord Tech. 2014 Oct; 27 (7): 358–63.