Comparison between Minimally Invasive and Open Transforaminal Lumbar Interbody Fusion

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Objective: *To compare the clinical and radiographic outcomes between minimally invasive and open transforaminal lumbar interbody fusion (TLIF) for treatment of lumbar spondylolisthesis*
Material and Method: *A retrospective clinical study of 24 consecutive cases of lumbar spondylolisthesis treated by minimally invasive TLIF (n = 12) or open TLIF (n = 12) was done at Ramathibodi Hospital between June 2008 and December 2009. The following parameters were compared between the two groups, clinical and radiographic outcomes, blood loss, operative time, length of hospital stay, and complications.*
Results: *The average duration of follow-up was 28 months (range, 24 months to 38 months). There was significantly less intra-operative blood loss in minimally invasive TLIF group comparing to open TLIF group (317 cc vs. 645.83 cc: p-value = 0.04). No significant difference was observed in clinical outcomes (VAS or ODI at 2 years), radiographic outcome (91.67% fusion rate in both groups), operative time (340 minutes vs. 324 minutes: p-value = 0.96) length of hospital stay (8.42 days vs. 8.33 days: p-value = 0.09) and major complication (8.33% in both groups) between the two groups.*
Conclusion: Minimally invasive TLIF has similar clinical outcomes and fusion rate compared to open TLIF with additional benefit of less intra-operative blood loss. However, the operative field of this technique is limited so thorough knowledge of anatomy in this region is required.

Keywords: *Lumbar spondylolisthesis, Minimally invasive, TLIF, Transforaminal lumbar interbody fusion*

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Options of spinal fusion for lumbar spondylolisthesis include posterolateral fusion (PLF), posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF)[1-3], anterior lumbar interbody fusion (ALIF) and direct lateral lumbar interbody fusion (DLIF).

TLIF technique requires less mobilization of the thecal sac and traversing nerve root and less risk of retraction injury to the nerve roots comparing to PLIF[4-7].

Minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) has recently been introduced with the aims of smaller wounds, less tissue trauma, less postoperative pain and decreased length of hospital stay[8-13].

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The purpose of the present study was to compare the clinical and radiographic outcomes between minimally invasive and open TLIF.

Material and Method

After approval from the Ethical Committee, charts of the patients who underwent TLIF between June 2008 and December 2009 were reviewed retrospectively. The indication of surgery in all patients was grade 1 or 2 spondylolisthesis presenting with mechanical low back pain, radiculopathy, and/or neurogenic claudication.

All patients underwent pre-operative evaluation with static (anteroposterior and lateral) and dynamic (flexion-extension) plain lumbo-sacral (L-S) spine radiography and magnetic resonance imaging (MRI). All patients had failed conservative management (minimum 6 months) before surgery.

The clinical outcomes in terms of Visual Analogue Scores (VAS) for back pain and leg pain and Oswestry Disability Index (ODI) were evaluated before

surgery and at 3 months, 6 months, 1 year, and 2 years after surgery. The radiographic outcome was assessed by fusion rate at 2 years after surgery using plain film and computerized tomography (CT) of the L-S spine. Definitions of spinal fusion are 1) presence of bone bridging between endplates, 2) absence of spinal motion at fusion segment in dynamic film, 3) absence of pedicle screws and rods breakdown, and 4) absence of radiographic loosening of screws. All data was collected prospectively and this is a retrospective review of that data.

The patient demographic data and other parameters including blood loss, operative time, length of hospital stay, and complications were retrospectively reviewed from the patients' charts as well. Major complications are defined as complications that require re-operation or cause permanent neurological deficits.

Statistical analysis was performed with the use of SPSS version 10.0 and Stata version 11.0 (StataCorp Inc., College Station, TX, US). Student's t-test and/or Mann-Whitney U-test, Chi-square test or Fisher's exact test depending on data distribution were used to assess levels of statistical significance. Significance was defined as p-value <0.05.

Technique for open TLIF

The TLIF procedure is performed on the more symptomatic side. If both legs are symptomatic, the approach is from the side of more severe pathology. A midline skin incision is used. Laminotomy, unilateral total facetectomy and contralateral medial facetectomy is performed. This is followed by discectomy and placement of local autogenous bone graft and interbody cage. Bilateral pedicle screw-rod constructs are inserted. Position of the constructs and interbody cage is checked with intra-operative fluoroscopy. The wound is irrigated and closed.

Technique for MIS TLIF

Bilateral paramedian incisions are made approximately 3 to 4 cm lateral to the midline, extending between the rostral and caudal pedicle at the disc level of interest, which is approximately 3 cm long. Tubular sequential dilators and expandable pipeline retractor are sequentially placed down to the facet joint. A total facetectomy is then performed. Discectomy and disc space preparation is performed. The autograft is then placed into the interbody space followed by an interbody cage. All percutaneous pedicle screws-rods are placed. Fluoroscopy is used to ensure satisfactory position of the cage, screws and rods (Fig. 1, 2). Fig. 3 shows postoperative wounds following MIS TLIF.

Results

From June 2008 to December 2009, 12 patients underwent MIS TLIF and 12 patients underwent open TLIF at Ramathibodi Hospital. The mean follow-up period was 28.1 months with a range of 24 to 38 months.

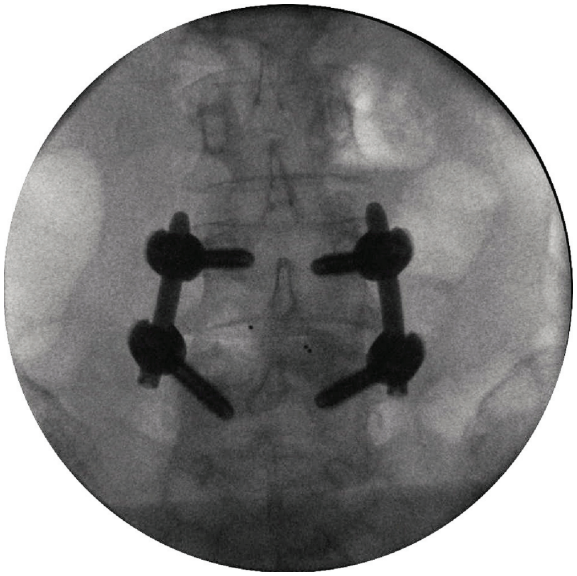

Fig. 1 Intraoperative radiograph: A-P view.

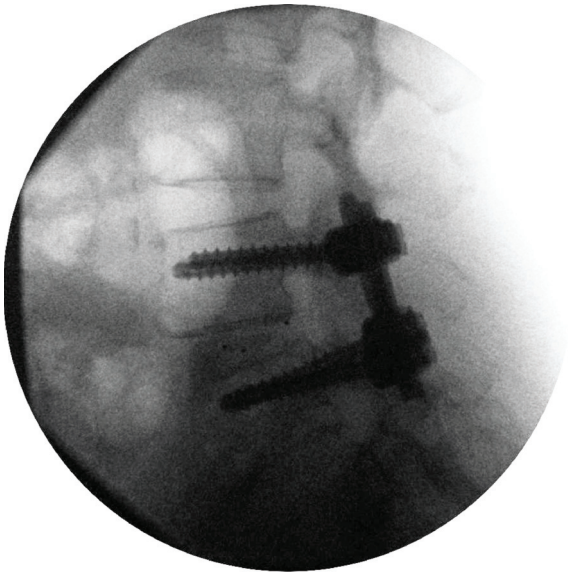

Fig. 2 Intraoperative radiograph: lateral view.

Fig. 3 Small paramedian skin incisions resulting from MIS TLIF.

The mean age and body mass index (BMI) were not significantly different between the MIS TLIF and open TLIF groups. The mean age of MIS TLIF and open TLIF group were 63.1 years (54-73 years) and 67.4 years (50-77 years) respectively. The mean body mass index of the MIS TLIF and open TLIF group were 25.14 (17.58-30.70) and 26.39 (22.15-28.89) respectively.

The MIS TLIF group comprised of one male and 11 females while the open group consisted of six males and six females. All patients were diagnosed as unstable grade 1 spondylolisthesis. Patients' demographic data is listed in Table 1.

Blood loss was significantly less in the MIS TLIF group compared to the open TLIF group (p-value = 0.04). In MIS TLIF group, average blood loss was 317 cc (range 150-800 cc). In open TLIF group, average blood loss was 645.83 cc (range 200-1,400 cc).

The operative time and length of hospitalization were not significantly different between the MIS TLIF and open TLIF groups. Average operative time was 340 minutes (240-510 minutes) in the MIS TLIF group and 324 minutes (240-600 minutes) in the open TLIF group (p-value = 0.96). Length of hospitalization was 8.42 days (5-15 days) in the MIS TLIF group and 8.33 days (5-29 days) in the open TLIF group (p-value = 0.09). Perioperative parameters are summarized in Table 2.

The pain score (VAS scores) and disability (ODI scores) were significantly improved at 2-years postoperative follow-up in both MIS TLIF group and open TLIF group. However, there was no significant

Table 1. Patients' demographic data

Variables	MIS TLIF	Open TLIF	p-value
Number of patients	12	12	
Sex			0.02[b]
Male	1	6	
Female	11	6	
Mean age (years)	63.10±6.84 (54-73)	67.40±10.35 (50-77)	0.13[a]
Mean BMI (kg/m^2)	25.14±3.69 (17.58-30.70)	26.39±2.58 (22.15-28.89)	0.34[a]
Level of spondylolisthesis			0.30[b]
L3-4	0	1	
L4-5	11	7	
L5-S1	1	3	
L4-5 and L5-S1	0	1	

Data were presented as mean±SD (range) and number.
[a] Unpaired t-test
[b] Fisher's exact test

Table 2. Perioperative parameters

Variables	MIS TLIF	Open TLIF	p-value
Blood loss (cc)	317.00±195.79 (150-800)	645.83±451.99 (200-1,400)	0.04[a]
Operative time (minutes)	340.00±81.49 (240-510)	324.00±107.45 (240-600)	0.96[a]
Length of hospitalization (days)	8.42±3.34 (5-15)	8.33±6.72 (5-29)	0.09[a]

Data were presented as mean±SD (range).
[a] Unpaired t-test

Table 3. VAS and ODI

	MIS TLIF	Open TLIF	p-value
VAS			
Preoperative	8.75±1.60 (5-10)	7.92±1.62 (5-10)	0.22[a]
Postoperative	2.08±1.41 (0-4)	1.75±1.87 (0-4)	0.74[a]
Difference	6.67±1.76 (5-10)	6.17±2.47 (3-10)	0.54[a]
p-value	<0.001[b]	<0.001[b]	
ODI			
Preoperative	61.80±12.89 (38-82)	58.33±15.96 (46-68)	0.41[a]
Postoperative	12.25±10.52 (4-30)	15.33±17.64 (0-35)	0.52[a]
Difference	49.55±11.24 (30-64)	43.00±16.63 (2-56)	0.14[a]
p-value	<0.001[b]	<0.001[b]	

Data were presented as mean±SD (range)
[a] Unpaired t-test
[b] Paired t-test

Table 4. Fusion rate based on Bridwell classification

	MIS TLIF	Open TLIF	p-value
Fusion rate (Bridwell grade I-II)	11/12 (91.67%)	11/12 (91.67%)	0.99

difference between these two groups. VAS and ODI scores are summarized in Table 3.

Based on Bridwell interbody fusion grading system, there was no difference in fusion rate between the MIS TLIF and open TLIF group (Table 4).

In term of complications, there were two cases of contralateral radiculopathy, one subcutaneous collection, and one screw malposition in the MIS TLIF group. In the open TLIF group, there were one contralateral radiculopathy, one neurological deficit, and one cage migration. One patient in the MIS TLIF group required re-operation due to screw malposition. One patient in open TLIF required re-operation due to cage migration. Major complication rate is 8.33% in both groups.

Discussion

Lumbar spinal fusion is a common procedure for spine surgeons. There are many options for this procedure including PLF, PLIF, TLIF, ALIF, and DLIF. The TLIF procedure was pioneered by Harms[1]. The advantage of TLIF over PLIF is to provide a more lateral approach to the disc space, thus reducing the thecal sac and nerve root retraction[4-7]. MIS TLIF was created to reduce tissue trauma. This technique uses intraoperative fluoroscopy to guide the percutaneous screw insertion.

In the present study, both MIS TLIF and open TLIF group showed significant improvement in the clinical outcomes at two-years compared to before the operation. When comparing between the two groups, there was no clinical outcome difference in terms of VAS and ODI score. These satisfactory outcomes of MIS TLIF have been also reported by other investigators[14].

Based on Bridwell grading system[15], the fusion rate was not different between MIS TLIF and open TLIF group (91.67% in both groups). The high fusion rate of MIS TLIF was also reported by Schwender et al[10]. They reported 100% fusion rate based on plain radiographs. However, some studies showed decrease fusion rate in MIS TLIF group[16]. The authors explained that the limitation of exposure in this technique might cause inadequate end plate preparation and decreased fusion rate.

In present study, intraoperative blood loss was significantly less in the MIS TLIF group compared to the open group (317 versus 645.83 cc: p-value = 0.04). This result has also been reported in other MIS TLIF series[17-21]. The patients who undergo MIS TLIF are likely to need less blood transfusion, so risks of blood transfusion might be decreased.

Operative time and length of hospitalization were not significantly different between MIS TLIF and the open TLIF group. The operative time of both techniques were relatively longer than other reports because all operations were performed under microscopic view and each pedicle screw was placed under continuous fluoroscopic guidance. The length of hospitalization was longer than other studies[22]

because the cost of hospital stay in Thailand is not expensive, so most patients want to stay in the hospital until the sutures have been removed.

The complications such as contralateral radiculopathy, subcutaneous collection, screw malposition, neurological deficit, and cage migration occurred in the present study. However, there was no difference in major complication rate between MIS TLIF and the open TLIF group (8.33% in both groups). Schwender et al[10] explained that compression of the screw-rod construct at the end of the case, in conjunction with pre-existing (although asymptomatic) contralateral lateral recess stenosis, is likely to lead to the occurrence of contralateral radiculopathy. This could be minimized by avoiding overcompression of the screw-rod construct. Screw malposition could be minimized by attention to anatomic detail and use of intraoperative electromyography during screw insertion.

The limitations of the present study are relatively small population group and steep learning curve of this new MIS TLIF technique. The understanding of three-dimensional anatomy at the surgical area is critical for a successful operation.

Conclusion

Minimally invasive TLIF has similar clinical outcomes and fusion rate compared to open TLIF with additional benefit of less intra-operative blood loss. However, the operative field of this technique is limited so thorough knowledge of anatomy in this region is required.

Acknowledgement

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Potential conflicts of interest

None.

References

1. Harms J, Rolinger H. A one-stager procedure in operative treatment of spondylolistheses: dorsal traction-reposition and anterior fusion (author's transl). Z Orthop Ihre Grenzgeb 1982; 120: 343-7.
2. Moskowitz A. Transforaminal lumbar interbody fusion. Orthop Clin North Am 2002; 33: 359-66.
3. Rosenberg WS, Mummaneni PV. Transforaminal lumbar interbody fusion: technique, complications, and early results. Neurosurgery 2001; 48: 569-75.
4. Kuslich SD, Ulstrom CL, Griffith SL, Ahern JW, Dowdle JD. The Bagby and Kuslich method of lumbar interbody fusion. History, techniques, and 2-year follow-up results of a United States prospective, multicenter trial. Spine (Phila Pa 1976) 1998; 23: 1267-79.
5. McAfee PC, Regan JR, Zdeblick T, Zuckerman J, Picetti GD III, Heim S, et al. The incidence of complications in endoscopic anterior thoracolumbar spinal reconstructive surgery. A prospective multicenter study comprising the first 100 consecutive cases. Spine (Phila Pa 1976) 1995; 20: 1624-32.
6. McDonnell MF, Glassman SD, Dimar JR II, Puno RM, Johnson JR. Perioperative complications of anterior procedures on the spine. J Bone Joint Surg Am 1996; 78: 839-47.
7. Rajaraman V, Vingan R, Roth P, Heary RF, Conklin L, Jacobs GB. Visceral and vascular complications resulting from anterior lumbar interbody fusion. J Neurosurg 1999; 91: 60-4.
8. Peng CW, Yue WM, Poh SY, Yeo W, Tan SB. Clinical and radiological outcomes of minimally invasive versus open transforaminal lumbar interbody fusion. Spine (Phila Pa 1976) 2009; 34: 1385-9.
9. Scheufler KM, Dohmen H, Vougioukas VI. Percutaneous transforaminal lumbar interbody fusion for the treatment of degenerative lumbar instability. Neurosurgery 2007; 60: 203-12.
10. Schwender JD, Holly LT, Rouben DP, Foley KT. Minimally invasive transforaminal lumbar interbody fusion (TLIF): technical feasibility and initial results. J Spinal Disord Tech 2005; 18 Suppl: S1-S6.
11. Morgan FP, King T. Primary instability of lumbar vertebrae as a common cause of low back pain. J Bone Joint Surg Br 1957; 39-B: 6-22.
12. Dupuis PR, Yong-Hing K, Cassidy JD, Kirkaldy-Willis WH. Radiologic diagnosis of degenerative lumbar spinal instability. Spine (Phila Pa 1976) 1985; 10: 262-76.
13. Whitecloud TS III, Davis JM, Olive PM. Operative treatment of the degenerated segment adjacent to a lumbar fusion. Spine (Phila Pa 1976) 1994; 19: 531-6.
14. Park Y, Ha JW, Lee YT, Oh HC, Yoo JH, Kim HB. Surgical outcomes of minimally invasive transforaminal lumbar interbody fusion for the treatment of spondylolisthesis and degenerative

segmental instability. Asian Spine J 2011; 5: 228-36.
15. Bridwell KH, Lenke LG, McEnery KW, Baldus C, Blanke K. Anterior fresh frozen structural allografts in the thoracic and lumbar spine. Do they work if combined with posterior fusion and instrumentation in adult patients with kyphosis or anterior column defects? Spine (Phila Pa 1976) 1995; 20: 1410-8.
16. Kho VK, Chen WC. Posterolateral fusion using laminectomy bone chips in the treatment of lumbar spondylolisthesis. Int Orthop 2008; 32: 115-9.
17. Arai Y, Takahashi M, Kurosawa H, Shitoto K. Comparative study of iliac bone graft and carbon cage with local bone graft in posterior lumbar interbody fusion. J Orthop Surg (Hong Kong) 2002; 10: 1-7.
18. Hee HT, Castro FP Jr, Majd ME, Holt RT, Myers L. Anterior/posterior lumbar fusion versus transforaminal lumbar interbody fusion: analysis of complications and predictive factors. J Spinal Disord 2001; 14: 533-40.
19. Pradhan BB, Nassar JA, Delamarter RB, Wang JC. Single-level lumbar spine fusion: a comparison of anterior and posterior approaches. J Spinal Disord Tech 2002; 15: 355-61.
20. Whitecloud TS 3rd, Roesch WW, Ricciardi JE. Transforaminal interbody fusion versus anterior-posterior interbody fusion of the lumbar spine: a financial analysis. J Spinal Disord 2001; 14: 100-3.
21. Humphreys SC, Hodges SD, Patwardhan AG, Eck JC, Murphy RB, Covington LA. Comparison of posterior and transforaminal approaches to lumbar interbody fusion. Spine (Phila Pa 1976) 2001; 26: 567-71.
22. Dhall SS, Wang MY, Mummaneni PV. Clinical and radiographic comparison of mini-open transforaminal lumbar interbody fusion with open transforaminal lumbar interbody fusion in 42 patients with long-term follow-up. J Neurosurg Spine 2008; 9: 560-5.

การศึกษาเปรียบเทียบการผ่าตัดเชื่อมกระดูกสันหลังส่วนบั้นเอวระหว่างการผ่าตัดแบบที่มีความรุนแรงน้อยกับการผ่าตัดแบบดั้งเดิม

เกรียงศักดิ์ แซ่เตีย, อนุชิต พันธ์คงทรัพย์, วีระพันธ์ ควรทรงธรรม, สมโภชน์ ไพบูลย์ศิริจิต

วัตถุประสงค์: *เพื่อศึกษาเปรียบเทียบผลของการผ่าตัดรักษาภาวะกระดูกสันหลังส่วนบั้นเอวเคลื่อนโดยการเชื่อมกระดูกระหว่างการผ่าตัดแบบที่มีความรุนแรงน้อยกับการผ่าตัดแบบดั้งเดิม*

วัสดุและวิธีการ: *ศึกษาแบบย้อนหลังโดยการทบทวนเวชระเบียนผู้ป่วย 24 ราย ที่ได้รับการผ่าตัดรักษาภาวะกระดูกสันหลังส่วนบั้นเอวเคลื่อนในโรงพยาบาลรามาธิบดีระหว่างมิถุนายน พ.ศ. 2551 จนถึง ธันวาคม พ.ศ. 2552 โดยเปรียบเทียบผลการรักษาระหว่างการผ่าตัดเชื่อมกระดูกสันหลังแบบที่มีความรุนแรงน้อย (12 ราย) กับการผ่าตัดแบบดั้งเดิม (12 ราย) โดยเปรียบเทียบในแง่อาการก่อนและหลังผ่าตัด อัตราการเชื่อมของกระดูกระยะเวลาที่ใช้ในการผ่าตัด ปริมาณเลือดที่เสียไประหว่างผ่าตัด ระยะเวลาที่นอนพักรักษาตัวในโรงพยาบาล และภาวะแทรกซ้อนจากการผ่าตัด*

ผลการศึกษา: *ระยะเวลาเฉลี่ยในการติดตามผู้ป่วยเท่ากับ 28 เดือน (24 ถึง 38 เดือน) การผ่าตัดเชื่อมกระดูกสันหลังแบบที่มีความรุนแรงน้อยมีปริมาณเลือดที่เสียไประหว่างผ่าตัดน้อยกว่าการผ่าตัดแบบดั้งเดิมอย่างมีนัยสำคัญทางสถิติ (317 และ 645.83 มิลลิลิตร ตามลำดับ) ในขณะที่ไม่มีความแตกต่างระหว่างการผ่าตัด 2 วิธี ในแง่ของอาการของผู้ป่วยก่อนและหลังผ่าตัด อัตราการเชื่อมของกระดูก (ร้อยละ 91.67 ทั้ง 2 วิธี) ระยะเวลาที่ใช้ในการผ่าตัด (340 และ 324 นาทีตามลำดับ) ระยะเวลาเฉลี่ยที่นอนพักรักษาตัวในโรงพยาบาล (8.42 และ 8.33 วัน ตามลำดับ) และภาวะแทรกซ้อนรุนแรงจากการผ่าตัด (ร้อยละ 8.33 ทั้ง 2 วิธี)*

สรุป: *การผ่าตัดเชื่อมกระดูกสันหลังส่วนบั้นเอวแบบที่มีความรุนแรงน้อยได้ผลดีในแง่ทำให้ผู้ป่วยอาการดีขึ้น และมีการเชื่อมของกระดูกเทียบเท่ากับการผ่าตัดแบบดั้งเดิม ในขณะที่ข้อได้เปรียบของการผ่าตัดแบบมีความรุนแรงน้อยคือ มีการเสียเลือดระหว่างผ่าตัดน้อยกว่า อย่างไรก็ตามเนื่องจากการผ่าตัดวิธีนี้จำเป็นต้องทำผ่านพื้นที่ที่จำกัด ศัลยแพทย์จำเป็นต้องมีความรู้กายวิภาคศาสตร์ของบริเวณนี้เป็นอย่างดี*