Mini-open Transforaminal Lumbar Interbody Fusion

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Objective: *To demonstrate the surgical technique and advantages of the mini-open transforaminal approach for lumbar interbody fusion (TLIF) combined with transpedicular screw fixation. Clinical and radiographic results were assessed to determine the clinical outcomes in twelve consecutive patients selected for minimally invasive access (mini-open technique) for TLIF in Prasat Neurological Institute.*

Material and Method: *A retrospective analysis was performed on 12 patients (age range, 38-74 yr; mean, 54.8 yr) who underwent mini-open transforaminal approach for lumbar interbody fusion (TLIF) combined with transpedicular screw fixation between September 2006 and June 2008. The titanium pedicle screws were introduced bilaterally through the 3.5 cm length, skin incisions with Spine Classics MLD- system retractor, autologous bone graft were inserted to perform TLIF in all patients. Eight patients were augmented anterior column support with titanium interbody cage, unilateral cage insertion in four patients and the others were inserted bilaterally interbody cages. Six patients presented with low back pain and associated radiculopathy, and six presented with low back pain only. Transforaminal lumbar interbody fusion was performed at L3-L4 in two patients, L4-L5 in four patients, L5-S1 in five patients, and two levels fusion in one patient.*

Results: *All patients were able to ambulate after spinal fusion. The patients were able to walk within 1.4 days (range 1-2 days). The hospital stay averaged 4.4 days (range 3-7 days). Periodic follow-up took place 1 to 21 months after surgery (mean, 7.4 months). The radiological fusion was archived in all nine patients who were operated on more than two months age. The other three patients who had been follow-up less than two months were probably fusion on the 1-month followed-up radiological examination.*

Conclusions: *The use of mini-open technique for pedicle screw instrumentation with spinal fusion procedure provides excellent clinical results and may be an operation of choice for lumbar spinal fusion in selected patients.*

Keywords: *Pedicle screw, Minimally invasive spinal fusion, Mini-open transpedicular screws fixation, Mini-open transforaminal lumbar interbody fusion*

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Spinal fusion of painful motion segments is widely used to treat patients with degenerative low back pain. Successful arthrodesis may be achieved using either posterolateral fusion with pedicle screw fixation or interbody fusion[1,2], depending on the patient's situation[1]. Adding instrumentation to a fusion increases fusion rate[3], and fusion rate is higher with interbody fusion than with posterolateral fusion[4], some series have reported fusion rates of interbody fusion combined with instrumentation more than 90%[5,6].

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The transforaminal approach for lumbar interbody fusion (TLIF) is a technique to insert bone graft and cage into the disc space via a transforaminal route. This approach provides anterior column support for fusion and offers excellent exposure with minimal risk because of minimal retraction on the nerve roots and dural sac is required[2,7].

Conventional lumbar fusion is associated with significant muscle stripping and retraction that can adversely affect both short- and long-term patient outcomes[8,9]. In contrast, minimally invasive lumbar fusion is performed via a local muscle splitting at the area of facetectomy and entry point of pedicle screws insertion has significantly diminishes the amount of

iatrogenic soft-tissue injury. This approach has also shown the potential to reduce the amount of intra-operative blood loss, the intensity of postoperative pain, and the duration of hospital stays as many reports[10-12].

In the present report, the author describes the surgical technique of minimally invasive access for TLIF, shows the clinical outcome in the perioperative period with this approach.

Patients and Method

Patient population

A retrospective analysis was performed on 12 patients who underwent one-level of mini-open TLIF combined with transpedicular screw fixation from September 2006 to June 2008. The patients' mean age was 54.8 years (range 38-74 years) and there were five women and seven men. Six patients presented with low back pain and associated radiculopathy, and six presented with low back pain only. All patients were diagnosed with spondylolisthesis, eight patients were grading I of the Mayerding system and four patients were grade II. Mini-open TLIF was performed at L3-L4 in two patients, L4-L5 in four patients, L5-S1 in five patients, and two levels fusion of L4-L5 and L5-S1 in one patient.

Surgical technique

Following the induction of general endotracheal anesthesia, the patient is carefully turned to the prone position on a radiolucent table. Prior to preparing and draping the patient, lateral and AP fluoroscopic images are obtained to make sure that the pedicles and other relevant spinal anatomy can be identified. The location of the skin incision is planned using fluoroscopy to identify and mark the skin overlying the appropriate facet complex. Specifically, on the anteroposterior fluoroscopy view, four 20-gauge spinal needles are inserted into the skin, directly the entry point of pedicle screws insertion. Then mark the intended incisions by connecting the entry points of the two pedicle screws bilaterally. Typically, these incisions are two fingerbreadths off of the midline, 3.5 cm in length and allows for a paraspinal muscle splitting approach to be performed.

After skin and fascial incision, the paraspinal muscles are bluntly dissected by the index on the lateral border of the paraspinal muscles. The appropriate length retractor, Spine Classics MLD-System (Aesculap®, Tuttlingen, Germany; Fig. 1), is positioned cover the lamina-facet junction overlying the disc space and both pedicle screw entry points (Fig. 2). The

Fig. 1 The model of Spine Classics MLD-System, AESCULAP AG & CO KG.®, Tuttlingen, Germany. (reprinted with permission from B. Braun (Thailand) Ltd.)

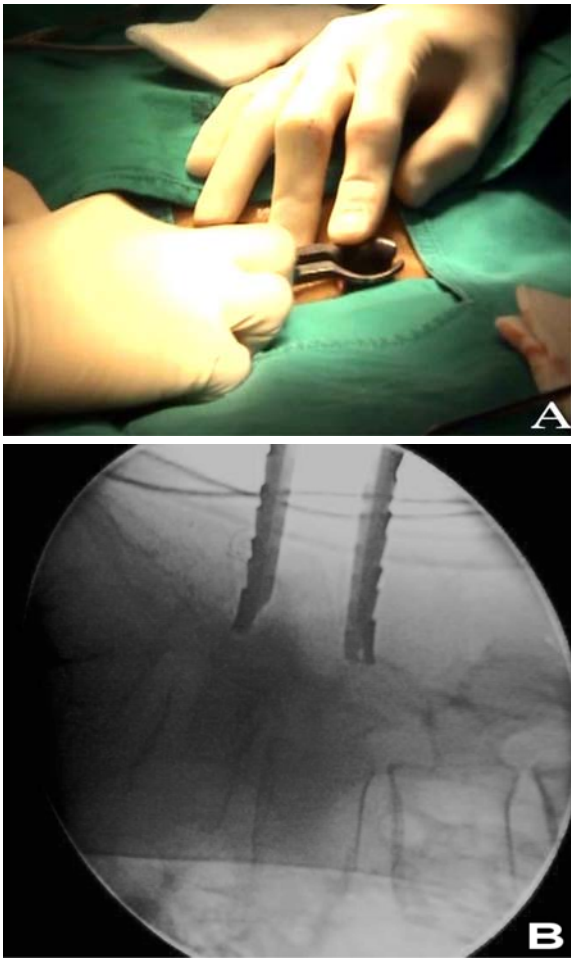

Fig. 2 Intraoperative photograph (A) and fluoroscopic monitoring picture (B) show the retractor was applied in the proper position for mini-open TLIF

pedicles are identified and inserted with the markers for X-ray checking (Fig. 3). The facet is completely resected using osteotomes and Kerrison rongeur under microscopic visualization. The ligamentum flavum is also removed in piecemeal fashion using Kerrison rongeur to expose the exiting and traversing nerve roots (Fig. 4). Then, identify the disc space for aggressive removal of the disc and perform interbody fusion using titanium intervertebral cage (Orthopaesia®, Bangkok, Thailand) which are packed inside with autologous bone derived from the facetectomy placed within the disc space. In most cases, neural retraction is not necessary for insertion of the intervertebral cage. The pedicle screws (S4 system, Aesculap®, Tuttlingen, Germany) are fixed and secure screw head with nut to the rod (Fig. 5). The author always confirms the proper position of screws with C-arm fluoroscope (Fig. 6) before closing suture the paraspinal muscle and skin are made. The other side of spinal fusion and screws fixation are performed with the same technique as the mirror image. In some cases of spondylolisthesis with the quite narrowing disc space, only autologous graft was packed inside the disc space without interbody implant support.

Clinical assessment

Intraoperative blood loss was estimated, postoperative pain score on a 10-point visual analog

Fig. 3 Intraoperative anteroposterior radiograph demonstrating placement of X-ray markers in the pedicles using Spine Classic retractor

Fig. 4 Intraoperative microscopic photograph showing the intervertebral disc was removed for preparing placement of interbody cage and bone graft after complete resection of left L4-5 facet. The exiting and traversing nerve root were identified

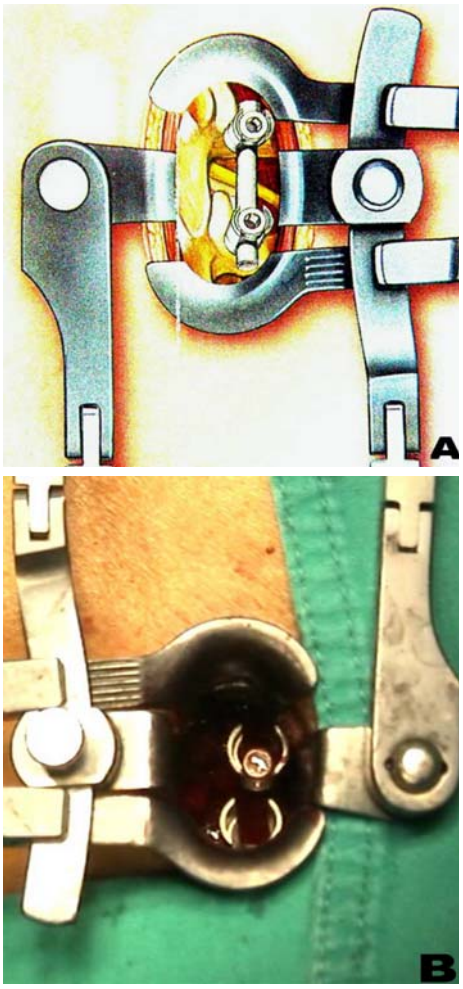

Fig. 5 Intraoperative illustration (A) and photograph (B) showing the pedicle screws were inserted through the minimally invasive access (Reprinted with permission from B. Braun (Thailand) Ltd.)

scale (VAS), post operative date of ambulation and duration of hospital stay for each patient were recorded. Periodic clinical follow-up were visited on 2 weeks, 1, 2, 3 months, then every 3 months. Plain x-ray films (Fig. 7) were obtained before discharge from the hospital and at follow-up visiting date of 1, 2, 3, 6, months, then every 6 months. The additional flexion/extension films and 3-dimension CT scan were taken only on the 6 months for evaluation of bony fusion (Fig. 8). The successful fusion was defined as 1) absence of halo around the screws, 2) presence of bilateral continuous trabecular bone bridge between the fused segments on anteroposterior x-rays, and 3) lack of motion on flexion/extension films (Table 1).

Results

Perioperative results

The mini-open TLIF technique via microscopic visualization and special design of retractor provided excellent exposure as conventional TLIF. The nerve roots can be decompressed with 2-paramedian small incisions, followed by interbody fusion and transpedicular screws fixation. The estimated blood loss was about 130-850 ml (mean 398.3 ml). First day after surgery, the postoperative pain was scored with visual analogue scale as 0-4 of 10 (average 1.5). All patients were able to walk within two days after surgery, seven patients on the first day, and five patients on the second day (table1). The hospital stay averaged 4.4 days (range 3-7 days).

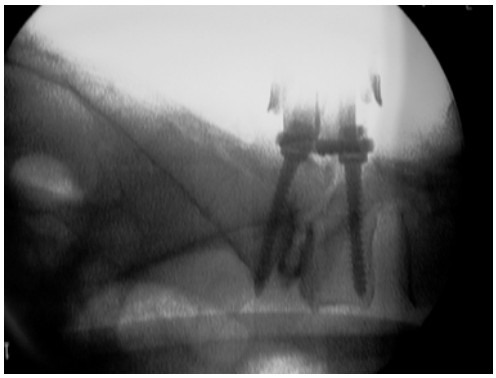

Fig. 6 Intraoperative anteroposterior radiograph demonstrating placement of pedicle screws in the standard fashion through Spine Classic retractor

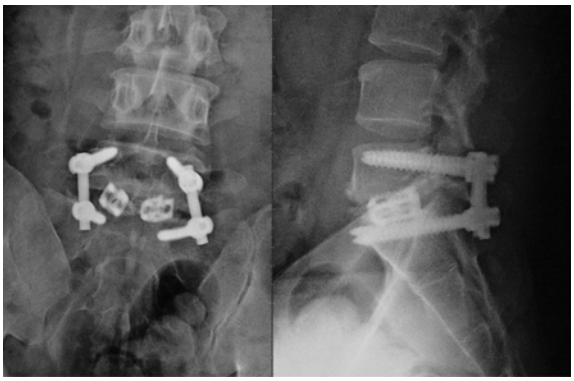

Fig. 7 The 3 months postoperative anteroposterior and lateral radiograph of patient 3 who underwent minimally invasive TLIF for L5-S1 spondylolisthesis

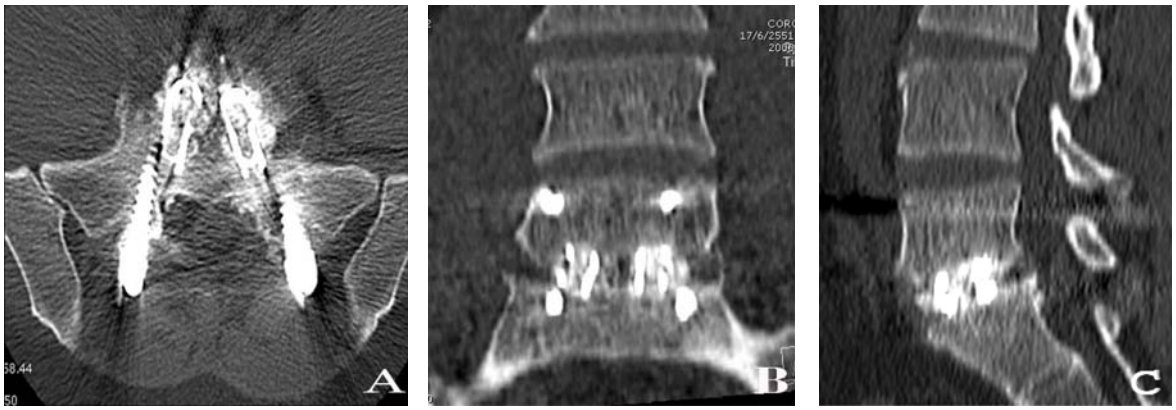

Fig. 8 The 6 month postoperative CT scan of the same patient of Fig. 7. A, the axial view shows the proper position of S1 screws and 2 titanium cages were inserted into the intervertebral space through the facetectomy area. B and C, the coronal and sagittal views are showing the continuous trabecular bone bridge between the end plate of L5 and S1 within the intervertebral cage

Table 1. Summary of patient treated with mini-open transforaminal lumbar interbody fusion combined with transpedicular screws fixation

Patient	Age (yr)/ Sex	Presentation	Diagnosis (Meyerding classification)	Level	Procedure	Estimate blood loss (ml)	Complication	Postop., day 1, pain score (VAS)	Walking (postop. day)	Hospital length of stay (days)	Follow-up (mo)	Fusion
1	56/M	Low back pain	Spondylolisthesis (grade I)	L4-L5	Mini-open TPS/TLIF/ autologous bone graft	200	None	1	2	7	21	Yes
2	57/M	Low back pain with radiculopathy	Spondylolysis with Spondylolisthesis (grade I)	L5-S1	Mini-open TPS/TLIF with 1 interbody spacer	850	None	4	2	7	18	Yes
3	62/F	Low back pain	Spondylolisthesis (grade I)	L5-S1	Mini-open TPS/TLIF with 1 interbody spacer	300	None	1	2	5	15	Yes
4	74/M	Low back pain, radiculopathy	Spondylolisthesis (grade II)	L5-S1	Mini-open TPS/TLIF with 2 interbody spacer	750	None	2	1	5	15	Yes
5	38/M	Low back pain with radiculopathy	Spondylolisthesis (grade I)	L5-S1	Mini-open TPS/TLIF with 2 interbody spacers	200	Drug allergy	1	2	4	6	Yes
6	63/F	Low back pain	Spondylolisthesis (grade I)	L4-L5	Mini-open TPS/TLIF with 2 interbody spacers	300	None	1	1	4	3	Yes
7	44/M	Low back pain with radiculopathy	Spondylolisthesis (grade II)	L4-L5	Mini-open TPS/TLIF with 2 interbody spacers	250	None	0	1	3	3	Yes
8	57/M	Low back pain	Spondylolisthesis (grade I)	L3-L4	Mini-open TPS/TLIF with autologous graft	700	Transient mild weakness of Lt quadriceps m	2	2	4	3	Yes
9	48/M	Low back pain with radiculopathy	Spondylolisthesis (grade II)	L4-L5	Mini-open TPS/TLIF/ autologous bone graft	500	None	2	1	4	2	Yes
10	66/F	Low back pain	Spondylolisthesis (grade I)	L4-L5, L5-S1	Mini-open TPS/TLIF/ autologous bone graft	400	None	1	1	3	1	probable
11	50/F	Low back pain with radiculopathy	Spondylolisthesis (grade II)	L3-L4	Mini-open TPS/TLIF with 1 interbody spacer	200	None	2	1	4	1	probable
12	43/F	Low back pain	Spondylolisthesis (grade I)	L5-S1	Mini-open TPS/TLIF with 1 interbody spacer	130	None	1	1	3	1	probable
Mean	54.8					398.3		1.5	1.4	4.4	7.4	

TPS = transpedicular screws fixation, TLIF = transforaminal lumbar interbody fusion, PLF = posterolateral fusion

Postoperative results

After an average follow-up period of 7.4 months, solid fusion was achieved in all nine patients who were operated on more than two months age. The 1-month-follow up radiographs of last three patients (patient 10, 11, 12) show good position of screws fixation and bone graft were visible more dense than early postoperative imaging, the radiologist document them as probably fusion.

There were two complications in the present study, drug allergy to prophylactic antibiotics in patient 5, and transient mild weakness of left quadriceps muscle in patient 8 from electrical injury. Because the bleeding points from epidural venous plexus is very close to the left L3 root during the discectomy procedure, it was partially damaged from bipolar cauterization. However, the patients could walk with a cane on the second postoperative day and nearly complete recovery on the two months follow up. By the way, there was no surgical implant failure and the graft complications in midrange follow up period.

Discussion

Many authors agree that spinal fusion with posterolateral fusion (PLF) may lead to a better clinical outcome for treatment of degenerative spondylolisthesis than surgical decompression alone[13-16]. Spinal instrumentation seems to increase fusion rate and likely prevents progression of spondylolisthesis[1]. Fusion rates with posterolateral fusion and pedicle screw fixation have been reported to range from 50 to 92%[3].

Interbody fusion has higher fusion rate and better clinical result than posterolateral fusion[3,14] with many reasons. Hypertrophy of the bone graft and fusion potential are enhanced if grafts are placed under pressure exerted by the body weight[17]. Interbody fusion places the bone graft in the load-bearing position of the anterior and middle spinal columns (which support 80% of spinal loads and provide 90% of the osseous surface area), thereby enhancing the potential for fusion[3]. In addition, the interbody space has more vascularity than the posterolateral space, also increasing the potential for a solid fusion mass to form.

Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) with instrumentation are more frequently performed than anterior lumbar interbody fusion (ALIF) because it requires only one approach for fusion and instrumentation. The PLIF technique requires significant bilateral retraction on the thecal sac and nerve roots, whereas TLIF provides less extensive neural retraction and injury[2,18] by accessing the spinal canal and disc via a path that runs through the far-lateral portion of the vertebral foramen. Because minimal retraction on the nerve roots and dural sac is required, the surgical risk for neurological deficit is significantly lower. It also offers advantages in revision patients in whom scar tissue makes PLIF techniques difficult[18].

Open instrumented lumbar fusion procedures are related to the significant iatrogenic muscle and soft tissue injury that occurs during routine lumbar fusion exposures for insertion of the screws and preparation of the fusion bed. The procedures may cause soft-tissue injury to muscles, adjacent facet joints, and ligaments. This can result in increased postoperative pain, and lengthened recovery time[13,18].

In 2003, Foley et al[10] first described the minimally invasive PLIF approach combined with percutaneous placement of Sextant pedicle screws, and minimally invasive TLIF procedures using METRx tubular retractors. The hospital stay averaged 1.7 days; all 12 patients were discharged within two days after surgery in the mini-open TLIF group. This procedure has since become an increasingly popular method of lumbar arthrodesis[18-21] with the advantage to minimize tissue trauma without compromising the effectiveness of the conventional fusion.

Unilateral and bilateral TLIF involving placement of interbody cages and pedicle screw fixation are effective treatment options in patients with indications for lumbar arthrodesis with high fusion rate and clinical success[2,10,12,14,22].

In the present study, unilateral TLIF with a cage was performed in patients 2, 3, 11, and 12. Because some patients (patients 5, 6, and 7) needed bilateral nerve root decompression, bilateral TLIF with cages insertion was performed through the facetectomy access to disc space. The severe narrowing of the disc space in patients 1, 8, 9, and 10 were packed with autologous bone graft without cage insertion, but the radiological fusion of these patients can be demonstrated on follow up imaging. Although follow-up period of patient 9 was only two month, the author documented the fusion from the imaging was absence of halo around the screws and presence of continuous trabecular bone bridge between the upper and lower body on x-ray films (Fig. 9).

The author believes that the key of the success of this approach is the following;

1. The small skin incisions just lateral to pedicles and facet joints to be fused are guided by fluoroscopy (Fig. 10), the good trajectory of screws

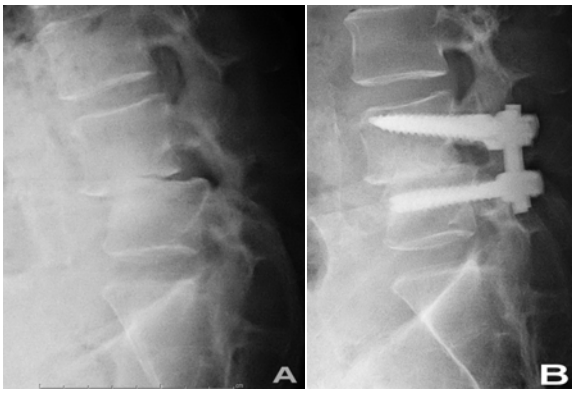

Fig. 9 Preoperative (A) and 2 months postoperative imaging (B) of the patient 9 showing the improvement of alignment of spondylolisthesis. The L4-5 disc space was packed with autologous bone graft, there was radiological fusion of interbody fusion

Fig. 10 Small skin incisions resulting from mini-open TLIF in patient 3

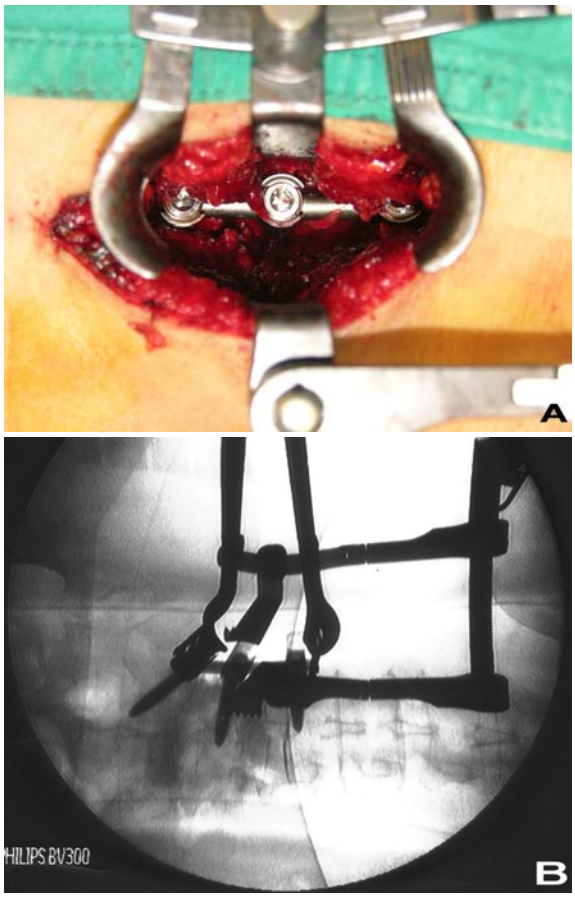

Fig. 11 Intraoperative photograph (A) and radiograph (B) of a patient who were undergoing perform 2 levels fusion using minimally invasive technique for TLIF

insertion were achieved with paramedian incision with less tissue retraction than conventional open fusion.

2. The special design of retractor for minimally invasive spine surgery, tubular retractor, or speculum like retractor as in the present study.

3. The anatomical structures; lamina-facet joint complex and transverse processes of involved segments should be clearly identified to make the operation easier.

4. A good illumination surgical microscope, C- arm fluoroscope, and radiolucent surgical table.

5. The microsurgical skill of the surgeon to perform the decompression and fusion in the limited operative field.

In addition to fusion rate, the clinical results of the present study also shows the reduction in the amount of intraoperative blood loss, the intensity of postoperative pain, and the duration of hospital stays as in many reports[10-12,14].

The mini-open TLIF can perform two levels fusion as in the present study (Fig. 11), the skin incisions extend to cover the entry points of upper-most and lowermost pedicle screws indicated by fluoroscopic guidance. The lengths of skin incisions are 7 centimeters, the fusion procedure is not different to one segment fusion.

Conclusion

The present study demonstrates mini-open TLIF combined with transpedicular screws fixation can be performed safely and effectively to achieve fusion as conventional open surgery. All patients could walk

independently within two days after surgery because of the minimized soft tissue injury during the operation. Although this technique can be safely applied in patients requiring decompression and fusion, it is challenging and requires a steep learning curve to operate in the limited surgical field with microsurgical technique.

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การผ่าตัดใส่โลหะยึดตรึงกระดูกสันหลังด้วยวิธีเปิดแผลเล็ก

ธีระ ตั้งวิริยะไพบูลย์

วัตถุประสงค์: เพื่อแสดงรายละเอียด ขั้นตอน วิธีการ และข้อดี ของการผ่าตัดใส่โลหะยึดตรึงกระดูกสันหลังด้วยวิธีเปิดแผลเล็ก พร้อมแสดงผลการผ่าตัดด้วยวิธีดังกล่าวในผู้ป่วย 12 ราย ที่ได้การผ่าตัดในสถาบันประสาทวิทยา

วัสดุและวิธีการ: การศึกษาข้อมูลผู้ป่วยย้อนหลัง 12 ราย ที่ได้รับการผ่าตัดใส่โลหะยึดตรึงกระดูกสันหลังด้วยวิธีเปิดแผลเล็ก ตั้งแต่ เดือนกันยายน พ.ศ. 2549 ถึง เดือนมิถุนายน พ.ศ. 2551 อายุผู้ป่วยเฉลี่ย 54.8 ปี ได้รับการผ่าตัดในระดับ L3-4 ในผู้ป่วย 2 ราย ระดับ L4-5 เป็นจำนวน 4 ราย ระดับ L5-S1 จำนวน 5 รายและผ่าตัด 2 ระดับในผู้ป่วย 1 ราย โดยการใส่โลหะ (intervertebral cage) และสกรูไทเทเนียม (pedicle screws) ร่วมกับทำการเชื่อมกระดูกสันหลัง ผ่านแผลผ่าตัดประมาณ 3 เซนติเมตร

ผลการศึกษา: ผู้ป่วยทุกรายสามารถ ลุกเดินได้ ภายหลังการผ่าตัด ไม่เกิน 2 วัน ระยะเวลาในการรักษาตัวเป็นผู้ป่วยในเฉลี่ย 4.4 วัน ติดตามผู้ป่วยเป็นระยะเวลานานตั้งแต่ 1-21 เดือน จากภาพถ่ายทางรังสีวิทยาแสดงผลการเชื่อมกระดูกสันหลังในผู้ป่วยที่ได้รับการผ่าตัดมานานกว่า 2 เดือนทุกราย (9 ราย) เชื่อมติดดีและสกรูอยู่ในตำแหน่งเหมาะสม ส่วนผู้ป่วย 3 รายสุดท้ายยังไม่สามารถชี้ชัดว่ากระดูกเชื่อมกันแล้วหรือไม่ เพราะติดตามผู้ป่วยได้เพียง 1 เดือน

สรุป: การผ่าตัดใส่โลหะยึดตรึงกระดูกสันหลังด้วยวิธีเปิดแผลเล็ก เป็นวิธีที่ได้ผลในการผ่าตัดที่ดี ผู้ป่วยสามารถฟื้นตัวได้เร็ว จึงควรเป็นวิธีที่เหมาะกับผู้ป่วยที่ต้องการผ่าตัดใส่โลหะยึดตรึงกระดูกสันหลังเป็นอย่างมาก