Minimally invasive mini open split-muscular percutaneous pedicle screw fixation of the thoracolumbar spine

Murat Ulutaş,[1] Mehmet Seçer,[2] Suat Erol Çelik[3]

[1]Department of Neurosurgery, Sanko University Hospital, Gaziantep; [2]Department of Neurosurgery, Şehitkamil State Hospital, Gaziantep; [3]Department of Neurosurgery, Okmeydanı Training and Research Hospital, Istanbul, Turkey

Abstract

We prospectively assessed the feasibility and safety of a new percutaneous pedicle screw (PPS) fixation technique for instrumentation of the thoracic and lumbar spine in this study. All patients were operated in the prone position under general anesthesia. A 6 to 8 cm midline skin incision was made and wide subcutaneous dissection was performed. The paravertebral muscles were first dissected subperiosteally into the midline incision of the fascia for lumbar microdiscectomy with transforaminal lumbar interbody fusion cage implantation. After the secondary paramedian incisions on the fascia, the PPSs were inserted via cleavage of the multifidus muscles directly into the pedicles under fluoroscopy visualization. A total of 35 patients underwent surgery with this new surgical technique. The control group for operative time, blood loss and analgesic usage consisted of 35 randomly selected cases from our department. The control group underwent surgery via conventional pedicle screw instrumentation with paramedian fusion. All patients in the minimal invasive surgery series were ambulatory with minimal pain on the first postoperative day. The operation time and blood loss and the postoperative analgesic consumption were significantly less with this new technique. In conclusion, the minimal invasive mini open split-muscular percutaneous pedicle screw fixation technique is safe and feasible. It can be performed via a short midline skin incision and can also be combined with interbody fusion, causing minimal pain without severe muscle damage.

Introduction

Minimal invasive approaches are gradually becoming more popular for spinal surgery. Minimizing the skin incision and the muscle and bone damage are key factors of these procedures. Endoscopic discectomy, thoracoscopic discectomy and percutaneous pedicle screw (PPS) insertion are the leading minimal invasive strategies at present. The standard open approaches of pedicle instrumentation cause severe muscular tissue damage due to extreme cauterization. This extensive muscle damage may increase blood loss and decortication of paramedian bony elements, and result in a severely painful postoperative state.

Magerl initially reported the first use of PPS instrumentation in 1977 and later re-emphasized it in 1984.[1,2] He first used external fixation devices for temporary stabilization. The idea evolved over time and was supported with technological improvements such as intraoperative 3D computer tomography, navigation systems and screw improvements.

We evaluated another minimal invasive approach in the present study. This simplified approach can be used easily for midline surgery, enabling easy treatment of midline pathologies such as disc herniation. Lumbar interbody fusion with a cage system (PLIF or TLIF) can also be easily added to this approach. Pedicle screws can also be inserted using a minimal invasive procedure. Primary wide subcutaneous dissection provides the advantage of removing skin paramedially, muscle injury is minimized by blunt dissection of the multifidus muscle groups inside of their cleavage. This new technique can be used in a vide variety of spinal disorders such as disc pathologies, listhesis and trauma. It can also be combined with other surgical procedures such as kyphoplasty or extradural/intradural tumor removal.

Materials and Methods

A total of 35 cases with various diagnoses treated with minimally invasive PPS between September 2011 and October 2012 were included in this study. There were 22 female and 13 male patients with a mean age of 51.75 years (range 18 to 59 years). The demographic data of the cases are presented in Table 1. The most common diagnoses were spinal stenosis, isthmic spondylolisthesis and degenerative disc disease. A control group was also created to compare with incision length, operative time, blood loss, analgesic requirements and length of stay. The control group had undergone surgery via conventional pedicle screw instrumentation with paramedian bony decortication and fusion by the same surgeons in a similar time period (35 cases).

Preoperative plain x-ray films including supine lateral and AP views, computerized tomography (CT) scans with reconstruction of 3-D images, and magnetic resonance imaging (MRI) of the spine were obtained. Preoperative MRI showed canal dimensions, degenerative changes, and extradural bony and soft tissue compression if any. MRI images were thoroughly evaluated for severe canal compromise or neural compression that could necessitate an open procedure. CT images were evaluated for bone details and quality and any degenerative changes prior to surgery.

Surgical procedure

After carefully positioning the patient on the Jackson frame at the neutral prone position, the chest and pelvis were supported by silicone pads. Under fluoroscopy control, a 6 to 8 cm skin incision was made at the midline of the surgical level (Figure 1A). A wide subcutaneous dissection was then performed. Initially we performed lumbar microdiscectomy after a midline fascia incision with subperiostal dissection of the paravertebral musculature. A slight superior facetectomy and endplate removal were used for the interbody fusion process. The bone-filled TLIF cage was inserted into the disc level under biplanar fluoroscopic control. A second paravertebral incision was made on the lumbar fascia 4 cm away from the midline and just inside the multifidus cleavage. The multifidus muscles were bilaterally bluntly dissected via finger maneuvers (Figure 1B). Jamshidi needles were inserted into the pedicles and K-wires were placed under fluoroscopic control. PPSs were inserted over the K-wires (Osimplant Company, Istanbul, Turkey) (Figure 1C). Two rods of appropriate length were bent to achieve sagittal balance. After the implantation of rods, the

Correspondence: Suat Erol Çelik, Department of Neurosurgery, Okmeydanı Training and Research Hospital, Istanbul, Turkey.
Tel.: + 90.5323.639455 - Fax: +90.2122.217763.
E-mail: suaterolcelik@yahoo.com

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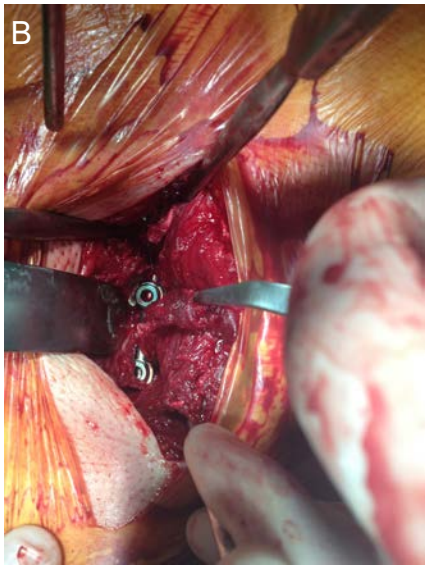

Figure 1. A) Photo shows the length of the skin incision just after the completing of the three-level (L3, L4, L5) surgery with PPS and L3-4/L4-5 TLIF cage insertion. B) Fluoroscopic image of the same patient shows proper pedicle penetrating of the screws with a good alignment of lumbar lordosis after TLIF cages insertion. C) Intraoperative picture of another patient shows the PPSs after implantation. Please note, there is no bleeding on the surface of the back muscles.

fascia incisions were closed with continuous sutures. Final AP and lateral fluoroscopy images were verified in the operation theatre. Three-D reconstructed CT images were obtained immediately after surgery to check the screw and TLIF cage placement accuracy, restoration of sagittal balance, and canal diameter.

Statistical analysis

Statistical analyses were performed using the t test. P values 0.05 were considered statistically significant. The results are presented as mean ± standard error.

Results

All patients had uneventful post-operative recovery. Radiological examinations confirmed satisfactory pedicle engagement of all screws, and good reconstruction of sagittal balance with restoration of canal/foraminal diameters. No complication related to the surgical technique was reported. The average surgery duration was 95 minutes (range 80 to 135 min). It is significantly lower than the control group (153 min) The median intraoperative blood loss was 50 ml (range 25 to 110 mL). The average hospital stay was 1.5 days (range 1 to 3 days). Both two parameters also less than the control group. Postoperative narcotic usage was initiated by patient controlled analgesic pump system. The median consumed dose (pethidine) was 143 mg. It is significantly lower than control group (381 mg). All patients showed good skin healing with vertebral reconstruction and without neural compromise. All patients were easily ambulated with an external brace on the first postoperative day. It was possible to discharge the patients on the 1st or 2nd day after the surgery. All cases were followed up by x-ray and 3D CT at regular intervals regarding postoperative vertebral fusion of the surgical level. The median post-operative follow-up period was 10 months.

Discussion

Percutaneous pedicle fixation of the traumatic spine is not a new procedure. Magerl first introduced his attempts in 1980 and 1984. He used an external fixation device through the pedicles into the vertebral body for the treatment of unstable spine injuries and spinal osteomyelitis.[1,2] Later, Mathews and Long used a fully percutaneous, endoscope-assisted screw system in 1995 where they employed a plate system instead of longitudinal rods. They also made further improvements in percutaneous systems with their surgical experience.[3] In 2000, Lowery and Kulkarini described a more contemporary system where the insertion of the anterior interbody graft via laparoscopic surgery was used and posterior PPSs with rod connectors were then implanted. The rod connectors were just under the fascia in this system. The results were satisfactory with an almost 61% fusion rate at 8 months.[4] The next year, Foley and Gupta introduced their revolutionary instrument named a sextant. Rod insertion and anchoring was much easier than previous procedures in their initial experience with 12 patients. This device became popular in a short time and is still being used globally.[5] PPS/rod anchoring became more practical with the newer systems. The use of a head tube on pedicle screws enabled faster rod insertion along the tubes and the instrumentation length could be easily increased for more than two segments. Securing the rod into the polyaxial screw head was also effortless with compressing instruments. However, there are two unfavorable perspectives of PPS instrumentation. The first one is the absence of lateral decortication and bony fusion of the

Table 1. Demographic characteristics of patient groups.

	Minimal group (n=35)	Control group (n=35)
Age	1.8±4.6	54.2±7.1
Primary diagnosis		
Spinal stenosis	17	20
Listhesis	16	13
Degenerated disc	2	2
Operation time, min	95±36.3	153.6±42*
Narcotic usage, pethidinc-mg	143±67.2	381.5±81.1*
Incision length, cm	7.4±1.7	24.6±6.3*
Blood loss, mL	51.2±29.3	742±186*
Length of stay, days	1.5±0.8	4.3±1.2*

*P<0.05.

instrumented vertebral segments. This requires an alternative route of interbody fusion with free bone grafts but carries a severe risk of fragments retro-pulsed posteriorly on the neural elements. Posteriorly inserted cage systems are a possible alternative to free interbody fusion. Both TLIF and PLIF cages can be inserted for this purpose but all require a secondary midline incision and disc/endplate removal.[6-9]

The second drawback is the requirement for secondary midline skin incisions at the time of revision or removal of the percutaneous system. These revisions require open surgery with significant muscle dissection.[10-12] Both difficulties can be easily eliminated with the author's surgical approach. The mini midline skin incision is accessible for disc surgery with interbody TLIF cage implantation while revisions do not need a secondary incision. Although the present technique may not be a purely percutaneous approach, it is more minimally invasive as there is little muscle disruption and bleeding, increasing postoperative patient comfort.[13] All patients can be easily mobilized on the first postoperative day and discharged early. Postoperative analgesic consumption is significantly less as there is no bone/muscle removal for posterolateral decortication.

Conventional open surgery is a well-known and widely accepted method for the management of thoracolumbar instability and degenerative scoliosis but it has several surgical risks such as high infection rates, increased blood loss, more paraspinal muscle damage and denervation after cauterization, and prolonged operation time and hospital stay.[14-16] On the other hand, minimally invasive approaches have potential benefits such as smaller scars, diminished local pain, minimal blood loss with reduced postoperative wound pain and shorter hospital stays leading to lower cost and better outcome.[17] The average length of stay was only 1.5 days and no infection was encountered even in obese patients with associated diabetes in our series.

In conclusion, the minimally invasive procedure of percutaneous midline mini open split-muscular screw fixation in the treatment of thoracolumbar and lumbar instabilities represents a worthy alternative.[18,19] Detailed knowledge of the surgical anatomy with augmented experience in percutaneous procedures will increase the surgical ability for successful instrumentation of the thoracolumbar spine in routine practice.

References

1. Magerl F. [Injuries of the thoracic and lumbar spine]. Langenbecks Arch Chir 1980;352:428-33. [Article in German].
2. Magerl F. Stabilization of the lower thoracic and lumbar spine with external-skeletal fixation. Clin Orthop 1984;189: 125-41.
3. Mathews HH, Long BH. Endoscopy assisted percutaneous anterior interbody fusion with supracutaneous suprafascial internal fixation: evolution of technique and surgical considerations. Orthop Int Ed 1995;3: 496-500.
4. Lowery GL, Kulkarni SS. Posterior percutaneous spine instrumentation. Eur Spine J 2000;1:126-30.
5. Kevin FT, Gupta SK. Percutaneous pedicle screw-rod fixation of the lumbar spine. Neurosurgery 2001;49:536-7.
6. Thomsen K, Christensen FB, Eiskjaer SP, et al. Volvo Award winner in clinical studies. The effect of pedicle screw instrumentation on functional outcome and fusion rates in posterolateral spinal fusion. A prospective, randomized, clinical study. Spine 1997;22:2813-22.
7. Khoo LT, Palmer S, Laich DT, Fessler R. Minimally invasive percutaneous posterior lumbar interbody fusion. Neurosurgery 2002;51:166-81.
8. Denis F, Armstrong GWD, Searls K. Acute thoracolumbar burst fractures in the absence of neurologic deficit. Clin Orthop 1984;189:142-9.
9. Cheung NK, Ferch RD, Ghahreman A, Bogduk N. Long-term Follow-up minimal access and open posterior lumbar interbody fusion for spondylolisthesis. Neurosurgery 2013;72:443-51.
10. Tian W, Han X, He D, et al. The comparison of computer assisted minimally invasive spine surgery and traditional open treatment for thoracolumbar fractures. Zhonghua Wai Ke Za Zhi 2011;49:1061-6.
11. Wild MH, Glees M, Plieschnegger C, et al. Five-year follow-up examination after purely minimally invasive posterior stabilization of thoracolumbar fractures: a comparison of minimally invasive percutaneously and conventionally open treated patients. Arch Orthop Trauma Surg 2007;127:335-43.
12. Park Y1, Ha JW, Lee YT, Sung NY. Percutaneous placement of pedicle screws in overweight and obese patients. Spine J 2011;11:919-24.
13. Ringel F, Stoffel M, Stuer C, Meyer B. Minimally invasive transmuscular pedicle screw fixation of the thoracic and lumbar spine. Neurosurgery 2006;59:361-7.
14. Siebenga J, Leferink VJM, Segers MJM, et al. Treatment of traumatic thoracolumbar spine fractures: a multicenter prospective randomized study of operative versus nonsurgical treatment. Spine 2006;31:2881-90.
15. Weber BR, Grod D, Dvorak J, et al. Posterior surgical approach to the lumbar spine and its effect on the multifidus muscle. Spine 1997;22:1765-72.
16. Kim DY, Lee SH, Chung SK, et al. Comparison of multifidus muscle atrophy and trunk extension muscle strength: percutaneous versus open pedicle screw fixation. Spine 2004;30:123-9.
17. Tessitore E, Tribolet N. Far-lateral lumbar disc herniation. The microsurgical transmuscular approach. Neurosurgery 2004;54:939-42.
18. Domenicucci M, Preite R, Ramieri A, et al. Thoracolumbar fracture without neurological involvement: surgical or conservative treatment? J Neurosurg Sci 1996;40:1-10.
19. Fuentes S, Blondel B, Metellus P, et al. Percutaneous kyphoplasty and pedicle screw fixation for the management of thoraco-lumbar burst fractures. Eur Spine J 2010;19:1281-7.