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Original Article

Midline Lumbar Fusion Using Cortical Bone Trajectory Screws for Elderly Patients

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SUMMARY

Background: Midline lumbar fusion (MIDLF) using cortical bone trajectory (CBT) is an alternative method of lumbar spinal fusion. It is useful for reduction not only for approach-related morbidity but also for osteoporosis. This study aimed to present our experience with MIDLF, and focused on survey of postoperative wound pain intensity and outcome assessment.
Methods: We retrospectively collected patients who met criteria of elderly (age more than 65 years old), spondylolisthesis, disc herniation, or spinal stenosis, and those who received MIDLF operation. By reviewing medical records, we analysed pain scores, complication rates, and screws loosening.
Results: Between January 2016 and June 2017, 23 patients were enrolled. One patient had screw malposition who needed reoperation. The rest patients showed significant improvement of the leading symptom. The visual analogue scale (VAS) scores for wound pain on the first postoperative day, second postoperative day, and before discharge were 3.4, 2.3, and 1.4, respectively. Early ambulation was achieved owing to the mild postoperative pain. The mean VAS scores for lower back and leg pain improvement were 4.7 and 4.5 respectively in the 3-month follow-up. At the most recent follow-up, all the patients reported maintenance of the satisfactory result. No screw-loosening or other complications were noted.
Conclusions: In our experience, MIDLF using CBT route seemed to reduce post-op wound pain significantly, so that elderly patients could ambulate earlier. It also had less screws loosening, especially for elderly or osteoporotic patients.

1. Introduction

Lumbar degeneration diseases such as spondylolisthesis, spinal stenosis, and herniated disk are common in elderly patients. When a patient needs surgery, old age and osteoporosis make the operation challenging. Traditional posterior lumbar fixation and fusion procedures have been widely accepted methods for the management of various spinal conditions that require spinal stabilization. The standard open technique for posterior lumbar interbody fusion and pedicle screw (PS) placement, however, requires extensive tissue dissection during exposures. Blood loss can be significant, and transfusion is frequently needed during the procedure. It also requires a longer period of bed rest, lengthened hospital stay, more complications, higher screws loosening rate, and increasing medical costs. Recently, minimally invasive spine surgery (MISS) was developed. It is associated with reduced blood loss, less soft tissue trauma, and less postoperative pain than the traditional open techniques. However, screw loosening remains a problem in traditional pedicle screw insertion, regardless of open surgery or MISS, especially in osteoporotic patients. Midline lumbar fusion (MIDLF) using cortical bone trajectory (CBT) is a new method, first described by Santoni in 2009. The advantage of using the CBT technique include increased screw purchase within the cortical bone and reduced surgical dissection as compared with the traditional transpedicular spinal fusion. The shorter and thinner MIDLF screws starting from entry points, located at the pars interarticularis, directed from the inferomedial to superolateral, anchoring to a denser cortical layer of bone. This "reverse" screw trajectory and much more medial entry points decrease the length of surgical incision and reduce approach-related morbidities such as soft tissue injury, blood loss, or nerve roots injury. Many biomechanical studies disclosed that CBT screws are of equivalent or even higher strength regarding pullout forces than the conventional transpedicular trajectory screws. This is specifically beneficial to elderly and to osteoporotic patients. Since every kind of minimal invasive spinal surgery claimed that less soft tissue injury, less post-operative wound pain, so that patient could regain ambulation earlier. However, evidence is lacking regarding the clinical effectiveness of the technique on immediate post-operative wound pain. By using visual analogue scale (VAS) scores on postoperative days 1 and 2, the objective of our study is to provide information that MIDLF can significantly diminish immediate postoperative wound pain in 2 days in elderly patients. The outcome survey for back pain

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and radicular pain relief, postoperative screws loosening and other complications were also evaluated.

2. Materials and methods

2.1. Patients and symptoms

We retrospectively collected patients who met criteria of elderly (aged more than 65 years old), spondylolisthesis, disc herniation, or spinal stenosis, and those who received MIDLF operation. By reviewing medical records, we analysed pain scores, complications, and screws loosening. This study was approved by the MacKay Memorial Hospital Research Ethics Committee (case number: 17MMHIS135).

Twenty-three patients with at least 3 months' follow-up after a two-or three-level lumbar MIDLF procedure for degenerative disease were enrolled. Six men and 17 women, aged 66–87 years (mean, 74.0 years), were included. All the procedures were performed between January 2016 and June 2017 at a single center. Almost all the patients presented with lower back pain (LBP) initially except three patients. Twenty-one patients had radicular pain on either legs. Thirteen patients had claudication. Six patients had mild to moderate leg weakness. One patient even had incontinence (Patient 5, Fig. 1). The mean symptom duration before operation was 12.5 months (range, 1–60 months). The mean Dual-energy X-ray absorptiometry (DXA) value of patients was −2.4 (ranged from −1.9 to −3.6). The main indication for surgery was spondylolisthesis in 13 patients, disk herniation in seven, and spinal stenosis in three.

The characteristics of the patients are shown in Table 1.

2.2. Procedure

Under general anesthesia and in the prone position, a midline skin incision was made at the level of the affected spinous process, approximately 5–6 cm. Bilateral muscle dissection along the subperiosteal plane was performed up to the lateral edge of the pars interarticularis and intervertebral joints. The anteroposterior view (AP) of fluoroscopy helped to mark four pilot holes at the starting points for CBT, with a high-speed drill at the pars. The starting points, located on the pars interarticularis, just medial to its lateral border and caudal to the transverse process lower edge, reflected the mediocaudal footprint of the pedicle. The spinal canal and intervertebral foramina were opened via complete laminectomy. Further facetectomy from the symptomatic side was performed for disk removal and cage insertion. Microscopic magnification was used during dural sac and nerve root decompressions. A bone margin of at least 3 mm around the starting points was left. After the intervertebral disk removal, the anterior part of the intervertebral space was densely filled with an interbody device. The autologous bone graft was also placed in the central cavity of the device to increase fusion rate. Screw channels were then tapped in the oblique, caudal-to-cephalad, and medial-to-lateral directions under fluoroscopy guidance. Correctness of the channels and lengths of the screws were verified with a probe, and then the cortical screws were placed. The diameter and length of the screws ranged from 4.5 to 5.5 mm and 30–35 mm, respectively (Medtronic Sofamor Danek, USA). Wounds were closed using the standard method, leaving drains if needed.

Table 1
Demographic characteristics in 23 patients with MIDLF.

Characteristics	Value
Sex	
Male	6 (26.1%)
Female	17 (73.9%)
Age, years	
Median (range)	74.0 (66–87)
Symptoms	
LBP	20 (87.0%)
Sciatica	21 (91.3%)
Claudication	13 (56.5%)
Leg paresis	6 (26.1%)
Incontinence	1 (4.3%)
Symptom duration, months	
Median (range)	12.5 (1–60)
DXA	
Median (range)	−2.4 (−1.9~-3.6)
Op indication	
Spondylolisthesis	13 (56.5%)
Disk herniation	7 (30.4%)
Spinal stenosis	3 (13.1%)

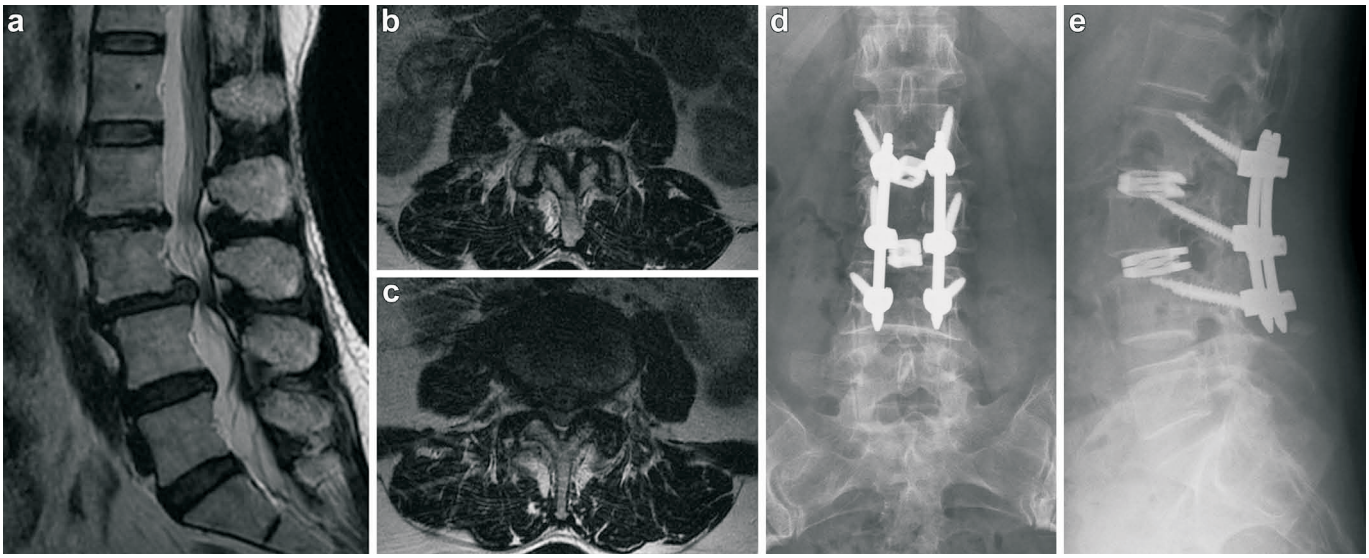

Fig. 1. Preoperative magnetic resonance images (a–c) and follow-up radiographs (d, e) of the patient with L2–L4 central and foraminal stenoses, and spondylolisthesis who presented with claudication, and incontinence.

2.3. Outcome assessment

We focused on postoperative wound pain intensity, evaluated using the VAS score. Procedure related complications and screws loosening were also evaluated. Screw loosening was demonstrated by radiographic lucency surrounding screws. Wound pain was measured three times after the operation, on the first day (in 24 h), second day (24–48 h), and before discharge. Lower back and/or leg pain was evaluated before and 3 months after operation. The length of hospital stay, operative time, and blood loss were also recorded. Control standing radiograph of the lumbar spine was performed for all the patients before hospital discharge and 3 months after surgery. Radiography scans were evaluated and compared for signs of hardware failure, screw loosening, and spinal instability. Procedure related complication such as screws malposition, wound infection, nerve damage, post-op bleeding, cerebral spinal fluid (CSF) leak were collected by chart review.

3. Results

The details of the operations are shown in Table 2. Among the 23 patients, seven underwent three-level fixation and the reset underwent two-level fusion. Seventeen patients received anterior interbody cage fusion, and six patients had posterior-lateral fusion. Patients without interbody fusion presented normal disk heights with listhesis only in imaging studies. The mean operation duration was 235.3 min (range, 120–369 min). Blood loss volume measured 255.2 ml in average (range, 30–800 ml). The mean length of hospital stay was 8.5 days (ranged from 5 to 24 days). And our average follow-up period was 9.4 months (range, 3–18 months).

One case of screw malposition complication (Patient 4, Fig. 2) occurred with this approach. The patient presented with persisted radicular pain postoperatively. The computed tomography performed after the MIDLF procedure revealed adequate decompression of the neural structures. However, the left-side screw malposition at L3 was observed to have compressed the nerve roots inside the lateral recess. The patient underwent screw revision. The symptoms recovered gradually after the revision.

In the remaining 22 patients, an improvement of the leading symptom in the early postoperative period (lower back pain 18/18, sciatica 19/19, and claudication 12/12) was achieved. All of them regained ambulation on postoperative Day 1 was possible. The early standing radiography revealed satisfactory CBT screw placement in all the patients. No pedicle fractures at the insertion site were observed. On the follow-up radiographs, no signs of screw loosening or other hardware failures such as angulation, fracture, or disconnection were found. During the follow-up visit at 3 months after surgery, all the patients reported maintenance of the satisfactory result.

Table 2
Details of the operations.

Variable	Value
Operation level	
3-level	7 (30.4%)
2-level	16 (69.6%)
Interbody fusion device	
Yes	17 (73.9%)
No	6 (26.1%)
Operation duration, min	
Median (range)	235.3 (120–369)
Blood loss, ml	
Median (range)	255.2 (30–800)
Hospital stay, days	
Median (range)	8.5 (5–24)
Follow-up duration, months	
Median (range)	9.4 (3–18)

As shown in Fig. 3, the VAS score for wound pain was 3.6 (range, 2–6) 24 h after operation, 2.3 (range, 1–3) 48 h after operation, and 1.4 (range, 0–3) before discharge. The medication records indicated a limited postoperative analgesia consumption. For leg pain, the mean VAS scores were as follows: before surgery, 5.2 (2–9) and at 3-month follow-up, 0.9 (0–3). The pain relief score was 4.3 points. The mean VAS score for lower back pain was 5.0 (range, 0–8) before surgery and 0.9 (range, 0–3) at 3-month follow-up. This shows a satisfactory pain relief of 4.1 points in the VAS.

During post-op follow up, at least 3 months, there was no screws loosening was found by X ray confirmation. No case of wound infection, nerve damage, postoperative bleeding, CSF leak were collected in our results.

4. Discussion

Posterior lumbar screw and rod fixation and fusion are accepted treatments for patients in whom conservative treatment has failed to adequately treat degenerative lumbosacral disease because of segmental screw instability. It also has a high morbidity rate due to iatrogenic muscle and soft tissue injuries. The long surgical incision, prolonged wide retraction of soft tissue, and possible injury to the medial branch of the posterior ramus of the spinal nerve can result in ischemic necrosis and denervation of the paraspinal musculature. This may lead to loss of functional muscular support with disturbed segmental mobility and increased biomechanical strain, resulting in persistent back pain.[1]

In 2009, Santoni et al.[2] introduced a new concept for lumbar pedicle screw placement, called “cortical bone trajectory.” Santoni et al. reported that the pullout strength increased by 30% from that with the conventional PS. Matsukawa et al.[3,4] reported that the insertion torque increased 1.7-fold. The toggle test results indicate that the use of the CBT method resulted in a significantly higher stability than the PS fixation method.[5] Recent studies confirmed this finding and showed that this specific unconventional trajectory seemed to be more important for increasing strength than a specially designed screw.[6,7]

CBT is considered to have several advantages. First, the trajectory reduces the amount of paraspinal muscle exposure required. Second, the screw is placed from the inferior and medial border of the pedicle to the cranial and lateral corner of the posterior one-third of the vertebral body in a bicortical manner. Thus, despite the screws being shorter and thinner, CBT provides greater adherence of the screw thread to higher density bone and provide stable fixation even in osteoporotic bone.[8] Third, spinal canal and intervertebral foraminal decompressions and discectomy, interbody fusion, and screw fixation are all possible with one limited midline incision and a familiar approach.[9]

The risk of spinal canal violation by a screw is low because of the mediolateral trajectory direction. However, some complications were reported in the literature, such as pars/pedicle fractures during both intraoperative and postoperative periods. The fracture started at the entry point, through the superior facet, and then exited to the lateral aspect of the pedicle. Screw loosening was demonstrated by the radiographic lucency surrounding pedicle screws.[10] Several studies reported intraoperative and late postoperative complications, as well as fusion rates, in the CBT and PS groups. Result showed that the risk of intraoperative complications was lower by approximately 12% in the CBT group than in the PS group. The risk of late complications

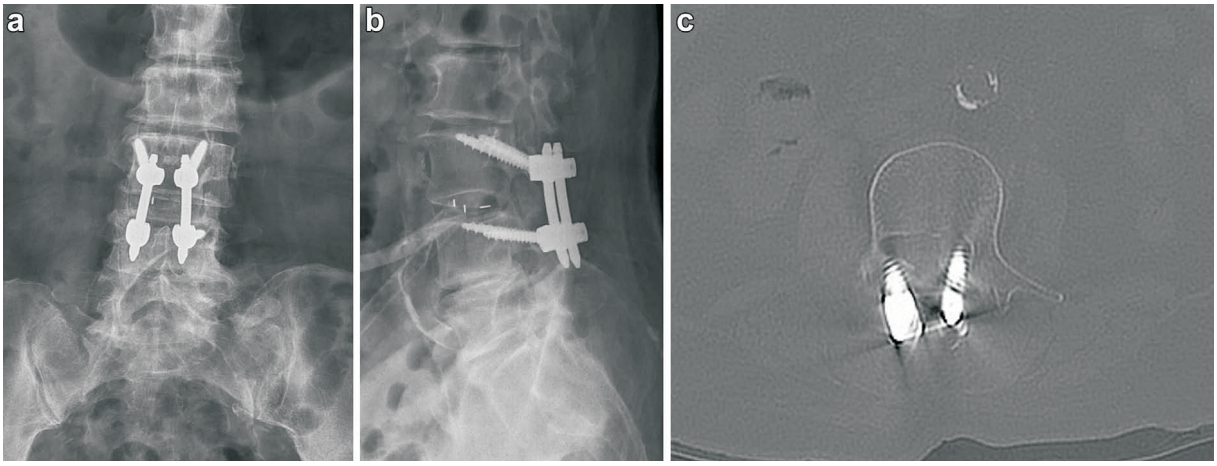

Fig. 2. Postoperative lumbar radiography (a, b) and computed tomography images (c) showing left-side screw malposition at L3.

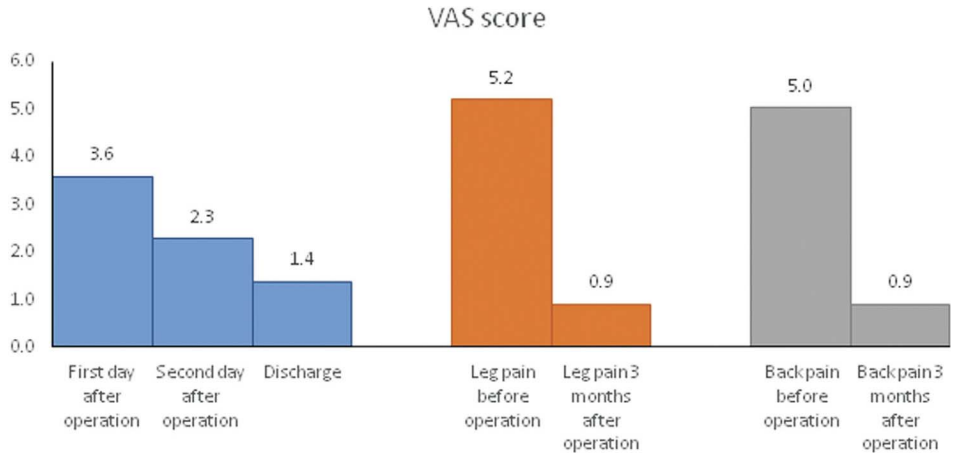

Fig. 3. VAS score.

was even statistically significantly lower in the CBT group.[1,11] Of our patients, only one patient had a screw malposition. After re-operation, neurological deficit recovered soon. Radicular pain also improved. Our series did not reveal other complications such as pars fracture or screw loosening, but a longer follow-up period may be needed.

However, literatures that quantify postoperative wound pain in the first and second postoperative days are lacking. By using the VAS, we compared lower back or radicular pain preoperatively and 3 months postoperatively to reflect operational efficacy. We further compared VAS scores on the first and second day after operation, and the day before discharge to describe the rate of wound pain improvement. We consider this as reflective of the degree of tissue damage. Our series shows that VAS score decreased soon in the first 48 h after operation. Hence, the patients ambulated several hours later after operation. For elderly patients, early ambulation diminished the occurrence of postoperative complications such as pneumonia, urinary tract infection, muscle wasting, and even bed sore. As for lower back and radicular pains, MIDLF provided satisfactory outcomes according to our study.

This study has some limitations, including the small number of patients and short follow-up period. The patients' data were collected retrospectively, and no head-to-head comparison with traditional transpedicular screws was conducted. However, evaluation of larger numbers of patients with longer follow-up durations is still ongoing. Further comparison with the traditional or even minimally invasive transpedicular screw technique is also being conducted.

5. Conclusion

In our experience, the MIDLF technique seemed to provide a better effect on reduction of postoperative wound pain intensity. Elderly patients can benefit from early ambulation. And even for osteoporotic patient, no screws loosening was found during regular follow up in our study. Nevertheless, longer observations in larger patient groups are needed to reliably evaluate the safety of the method and to compare with the traditional transpedicular trajectory.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijge.2018.03.009.

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