Eur Spine J (2000) 9 (Suppl 1): S126–S130
© Springer-Verlag 2000

ORIGINAL ARTICLE

Gary L. Lowery
Samir S. Kulkarni

Posterior percutaneous spine instrumentation

Received: 3 September 1999
Accepted: 4 September 1999

G. L. Lowery (✉) · S. S. Kulkarni
Research Institute International Inc,
9934 SW 52nd Road,
Gainesville, FL 32608, USA
e-mail: gllmdphd@usa.net,
Tel.: +1-352-271 8302,
Fax: +1-352-271 8303

Abstract Eighty consecutive cases of suprafascial pedicle screw stabilization were reviewed. Intraoperative fluoroscopy aided the percutaneous screw placement after structural anterior interbody graft(s) were placed. During routine outpatient hardware removal, all intradiscal fusions were stressed via the Shanz screws under fluoroscopy. Anterior reconstruction via a mini open approach coupled with this minimally invasive posterior approach led to a 96% successful fusion rate.

Key words Minimally invasive · Posterior instrumentation · Percutaneous · Suprafascial · Pedicle screw

Introduction

Endoscopic surgery has led to the development of numerous new techniques in spine surgery. Accompanying this has been a dramatic shift in our thought process, encouraging the philosophy of minimally invasive spinal surgery, both anteriorly and posteriorly. The emphasis has to be placed on safely performing the surgery with the least amount of tissue destruction in order to maximize the patient's functional recovery.

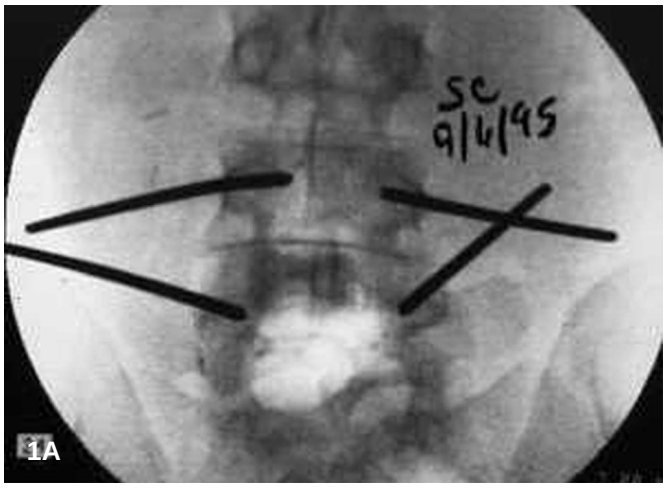
Traditionally, a posterior spinal fusion with instrumentation requires a moderate amount of muscle dissection for placement of the bone graft. This muscle dissection, accompanied by denervation of facet capsules and weakening of other supportive structures, gives rise to the concept of "fusion disease" and the concomitant lingering effect of less than optimal functional recovery. Airaksinen et al. demonstrated that even a simple laminectomy can lead to atrophy of the muscle and a poor clinical result [2]. There are numerous reports, of cases of solid posterior arthrodeses that do not correlate with an excellent clinical result as well as numerous reasons why. However, many authors feel that we often fall short of our expectations when we, of necessity, decrease the functional recovery through our surgical approach.

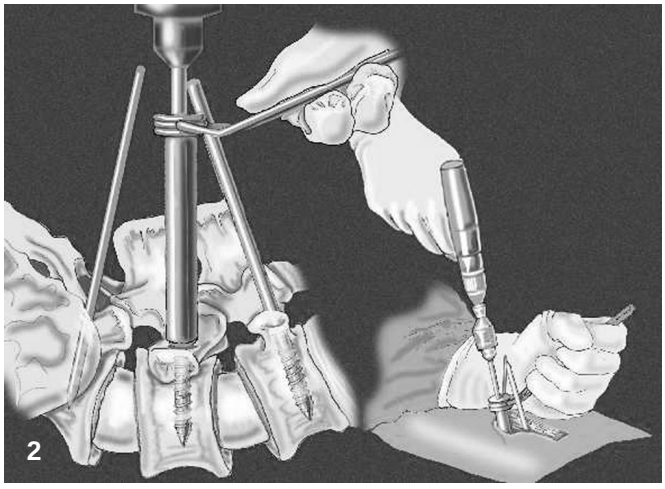
Posterior fluoroscopically guided pedicle screws are challenging and have been utilized in cases of external spondylolisthesis reduction [1, 5] and in cases of acute spinal trauma or spinal osteomyelitis [14]. They have been used as a test to evaluate whether the likelihood of spinal stabilization through arthrodesis will lead to a successful clinical result [8, 16, 19]. Percutaneously placed pedicle screws with concomitant percutaneous posterolateral "soft" interbody fusion has been described by several authors [9, 13, 15]. However, long-term follow-up on their results from these initial evaluations is lacking.

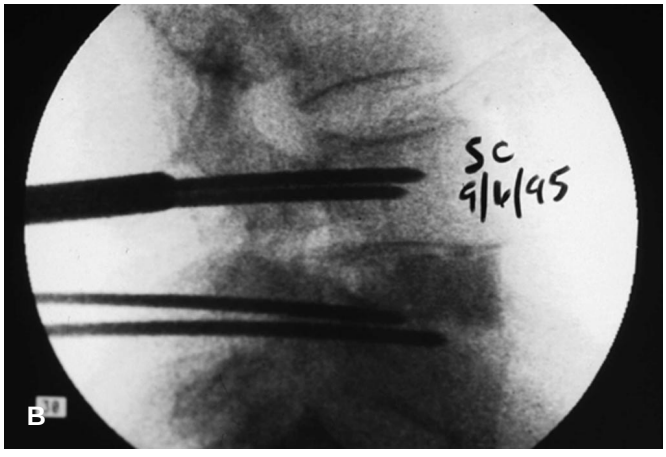
We embarked on the use of percutaneous pedicle screws stabilization of interbody fusions in 1994. However, we believe that a structural intradiscal graft is need, and routinely perform this trough a mini anterior lumbar interbody fusion (ALIF) approach, as described by Fraser et al. [6]. We have also evolved from two lateral incisions posteriorly to a midline skin incision, for better soft tissue coverage of the implant as well as better cosmesis. No muscle cutting or stripping is performed, either anteriorly or posteriorly, which in theory affords the opportunity for normal muscle function once the implants are removed in an outpatient setting. We describe the surgical technique and briefly report on our results.

Materials and methods

Clinical and radiographic examinations were performed on 80 consecutive patients treated with the suprafascial pedicle screw tech-







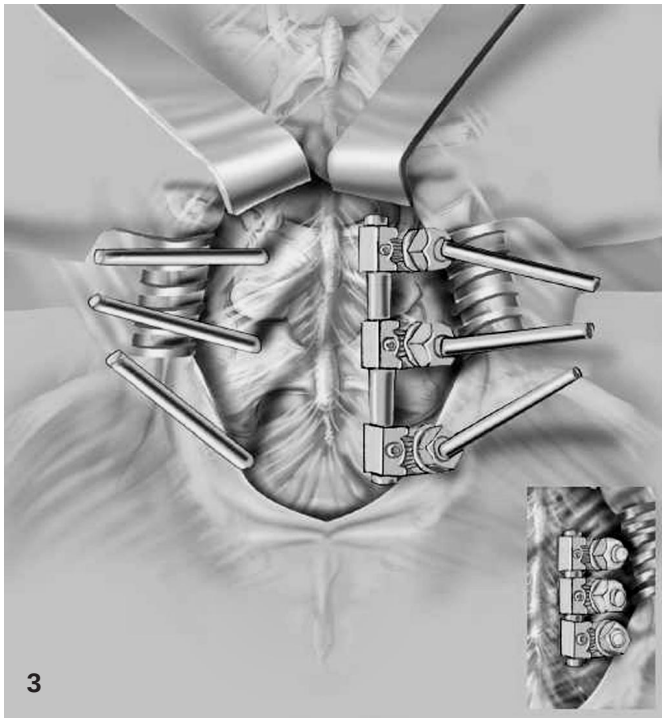


Fig. 1 Fluoroscopic confirmation of placement of pins: AP **A** anteroposterior, **B** lateral

Fig. 2 Pedicle screw placement

Fig. 3 Titanium USS rod application and (*inset*) compression to provide lordosis

nique between April 1994 and December 1998. The average follow-up was 12 months (range 6–54 months) and the follow-up percentage was 98%. There were 39 men and 41 women with an average age of 45 years (range 25–80 years).

Primary diagnostic criteria for surgery were: painful degenerative disc disease in 52 patients, failed lumbar laminectomy in 25 patients, and three patients had failed previous anterior interbody fusion. Thirty-nine patients (49%) were smokers.

The anterior surgical approach was minimally invasive in the majority of the patients. Anterior grafting was performed laparoscopically (transperitoneal) in six patients and 57 patients underwent the mini-ALIF approach. A formal open retroperitoneal approach was utilized in onyl 17 patients.

A variety of materials were employed for the anterior composite conduit graft (carbon fiber spacer in 55%, titanium wedged spacers in 18%, femoral ring allograft in 27%). Autograft was employed to fill the spacer or the interspace in 81% of the patients. Custom hydroxyapatite dowels (Interpore Cross, Irvine, Calif.) were used inside the spacers in 31% of the patients, and 10% of the patients had femoral ring allograft alone. Posterior stabilization involved the application of titanium Shanz screws (Universal Spine System, Synthes, Paoili, Penn.) into the pedicles. Rods and couplers were added to make a final fracture module construct. The majority of the patients (60%) had two levels stabilized.

Surgical technique

The ALIF is performed first, using a suitable intradiscal graft construct. The patient is then turned prone on a table in which anteroposterior (AP), oblique and lateral fluoroscopic images can easily be obtained. The lumbar area is next prepped and draped in a sterile fashion. A limited skin incision (5–8 cm) is made. Dissection is carried out through the subcutaneous tissue to the lumbodorsal fas-

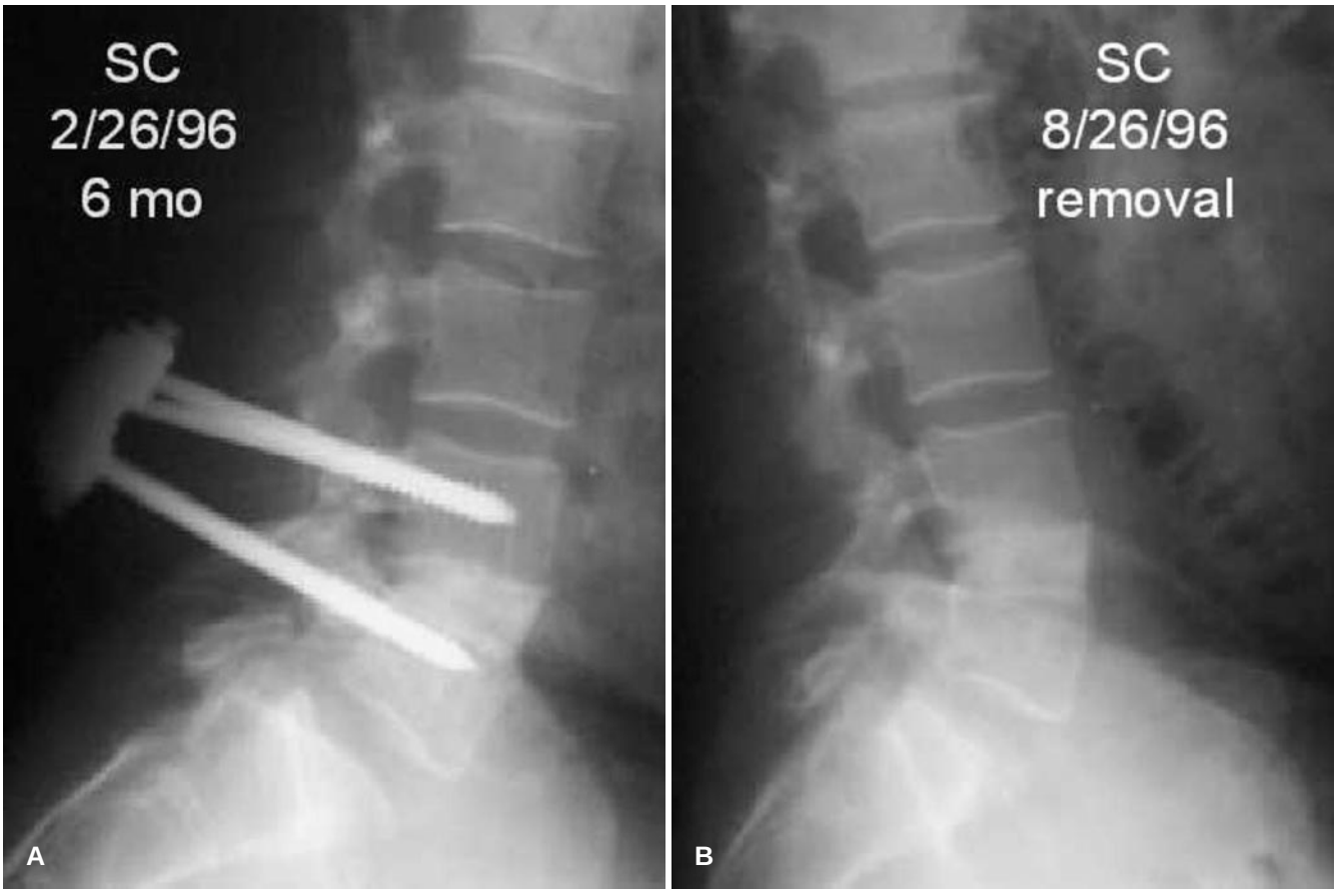


Fig. 4 A, B *Case example S. C.* **A** Six months after L4/5 interbody fusion and percutaneous suprafascial posterior stabilization. **B** One year after operation (6 months after instrumentation removal) with solid fusion and maintenance of lordosis

cia. The subcutaneous fat layer is bluntly swept off the fascia laterally from the midline (approximately 3–5 cm) avoiding violation of the lumbodorsal fascia and muscles. AP and oblique images are then obtained to localize the exact position of the pedicle. A Steinmann pin is then inserted through the fascia and the tip is directed to the center of the pedicle. Once accurately positioned, the Steinmann pin is gently docked into the bone with a small mallet. Our usual approach is to dock all pins (usually two or three) on one side of the spine using AP and oblique fluoroscopic spot checks. Next we turn to the lateral image to confirm the axis of the pedicle and gently tap all the Steinmann pins 50–80% into the vertebral body using spot lateral fluoroscopic checks (Fig. 1). A special cannula is then inserted bluntly through the fascia and docked onto the bony surface with a mallet. The existing pin is drilled out of the pedicle while maintaining the docking of the cannula. The hole in the pedicle is enlarged with a 4.5-mm drill bit via slow drilling analogous to reaming the isthmic shaft in a closed femoral intramedullary rodding. The drill's position is constantly monitored via lateral fluoroscopy. A long straight beaded-tip probe is next placed into the pedicle via the cannula and the pedicle walls are evaluated for possible infractions. A 7.0 mm USS Shanz screw is carefully placed into the pedicle either by hand or slow drilling. This step is again monitored with the use of lateral fluorosocopy (Fig. 2). AP, oblique and lateral images are then obtained to confirm the accurate placement of the Shanz screws. A similar procedure is repeated on the contralateral side. Titanium USS (Synthes Fracture Module) rods and connectors are attached to the screws (Fig. 3). The screws are compressed to maintain lordosis (Fig. 3 *inset*) and all connections are securely tightened. The rods and Shanz screws are trimmed and the wound is irrigated and closed. A final AP, oblique and lateral image is obtained prior to wound closure.

Results

At the time of outpatient hardware removal, the Shanz screws are manipulated (distraction/compression) and the fusion can be evaluated fluoroscopically. Routine hardware removal and fusion evaluation was accomplished in 49 patients (61%). Painful and prominent hardware was removed early in only two patients and five patients underwent hardware revision for either screw replacement or mild discomfort of their prominent hardware. The average time to hardware removal was 8 months (range 4–13 months), and 24 patients (30%) continue to have their hardware in place.

Ten patients (12.5%) had malpositioned screws as determined by postoperative CAT scans and needed revison. Screws were repositioned in seven patients and removed in three patients. In these three patients (3.8%), there were two persistent foot drops and one transient foot drop. Other than routine hardware removal, five patients under-

went foraminal decompression for isolated radicular symptoms through a limited and minimal soft tissue dissection at the time of hardware removal.

Other complications included iliac vein injury (n = 1), arterial thrombus (n = 3) and transitional syndrome above/below the fusion (n = 8). One diabetic patient who had an arterial thrombosis died from rhabdomyolysis and kidney failure. There was one case each of mild cage displacement and mild cage subsidence. Eight patients had wound infections; two were deep and six superficial. All were successfully treated. The superficial infections occurred primarily early in the series, when we were making two lateral incisions for screw placement. The incision was later moved to the midline for better wound management and for improved cosmesis.

Based on patients with a minimum of 6 months follow-up, 87 patients (96%) were determined to have solid fusions. Only three patients had obvious intradiscal nonunions. Axial pain relief, as determined by visual analog scale, was 90% or greater in 21% of the patients, while 49% of the patients had reduction in axial lumbar pain in the range of 40–100%. An additional 28% of the patients had mild reduction (20–40%). No reduction in axial lumbar pain was observed in 23% of the patients.

Discussion

Although axial lumbar pain may affect nearly 80% of the population at some point in their lifetime, chronic lingering pain affects 10–30%, and is very costly in health dollars. The precise etiology of this pain is varied as are the suggested treatment options. It is clear that the etiology is multifactorial, which in part explains why a successful arthrodesis does not always correlated with a successful clincial outcome.

However, if one selects arthrodeses as the treatment option, it is imperative to find the most successful means, with the highest safety margin. For a speedier functional recovery, and perhaps a more complete recovery, least invasive spinal surgery has become recently popularized. Endoscopic and percutaneous techniques have the advantage of not destroying normal anatomical structures in the approach for surgical decompression or fusion.

The pseudoarthrosis rate for instrumented posterior fusions vary from 0 to 32% [18, 21]. An instrumented posterior lumbar fusion has been shown to be consistently 95–100% successful [3, 4]. However, both techniques require stripping of posterior structures in the approach.

Although the anterior approach via a mini-open or laparoscopic technique results in minimal or no damage to muscles, the succes of one- and two-level stand-alone ALIF's varies widely, from 50 to 95% [11, 10, 17].

The anterior approach allows for a better correction of lumbar lordosis and yields excellent neuroforaminal distraction. The intradiscal space is a highly vascularized arena with a large surface area for graft incorporation. Each vertebra is itself a "living vascularized bone graft". Our results suggest that this disc height and lordosis can be maintained via posterior segmental instrumentation. Our fusion success of 96% suggests that one an successfully stabilize the forces on the disc, allowing control of the local environment for fusion. When performed percutaneously, no destruction of the posterior musculature occurs and there exists the opportunity for improved functional recovery after removal of the temporary implants. Our fusion success parallels the other reports in the literature for instrumented intradiscal fusions.

The rate of screw malposition (12.5%), although very worrisome, falls within the range of 4–40% reported using percutaneous or formal open approaches or using computer-assisted surgery [7, 8, 16, 19]. We believe that with the advent of computer-assisted surgery not only will we be able to eliminate the amount of radiation exposure to the patient and, or personnnel, but the incidence of malpositioned screws should approach zero.

Conclusion

Percutaneous pedicle screw stabilization of formal ALIFs resulted in a 96% fusion rate in our series. Disc height and lumbar lordosis were maintained after the temporary implants were removed. Approximately 50% of the patients obtained good to excellent relief of their axial pain using this prodecure. Although technically demanding, philosophically this procedure is a means of least invasive spine surgery allowing for improved functional outcome. Future advances, such as computer-assisted surgery, should help further refine this approach.

Case example

S.C., a 33-year-old heavy equipment operator, developed low back pain after being involved in a motor vehicle accident. Radiographs and MR images of the lumbar spine revealed an L5 spondylolysis and a degenerative L4/5 lumbar disc without evidence of herniation. He underwent anterior L4/5 interbody fusion with femoral ring allograft and left iliac crest autograft and posterior percutaneous limbar stabilization with titanium USS from L4 to L5. Six months after surgery he underwent removal of instrumentation on an outpatient basis, where a solid fusion was confirmed (Fig. 4 A). Twelve months later, the patients showed maintainence of lordosis with complete relief of symptoms (Fig. 4 B).

References

1. Aebi M, Etter C, Kehl T, Thalgott J (1988) The internal skeletal fixation system. A new treatment of thoracolumbar fractures and other spinal disorders. Clin Orthop 227:30–43
2. Airaksinen O, Herno A, Kaukanen E, et al. (1996) Density of lumbar muscles 4 years after decompressive spinal surgery. Eur Spine J 5:193–197
3. Brantigan JW, Steffee AD (1993) A carbon fiber implant to aid interbody lumbar fusion. Two-year clinical results in the first 26 patients. Spine 18:2106–2107
4. Buttermann GR, Glazer P, Bradford DS (1996) The use of bone allografts in the spine. Clin Orthop 324:75–85
5. Dick W (1987) The "fixateur interne" as a versatile implant for spine surgery. Spine 12:882–900
6. Fraser RD, Gogan WJ (1992) A modified muscle-splitting approach to the lumbosacral spine. Spine 17:943–948
7. Haaker RG, Eickhoff U, Schopphoff E, et al. (1997) Verification of the position of pedicle screws in lumbar spinal fusion. Eur Spine J 6:125–128
8. Jeanneret B, Jovanovic M, Magerl F (1994) Percutaneous diagnostic stabilization for low back pain. Correlation with results after fusion operations. Clin Orthop 304:130–138
9. Kambin P (1995) The role of minimally invasive surgery in spinal disorders. Mosby-Year Book 3:147–171
10. Kumar A, Kozak JA, Doherty BJ, et al (1993) Interspace distraction and graft subsidence after anterior lumbar fusion with femoral strut allograft. Spine 18:2393–2400
11. Kuslich SD, Ulstrom CL, Griffith SL, et al (1998) 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 23:1267–1278
12. Laine T, Schlenzka D, Makitalo K, et al (1997) Improved accuracy of pedicle screw insertion with computer-assisted surgery. A prospective clinical trial of 30 patients. Spine 22:1254–1258
13. Leu HF, Hauser R, Schreiber A (1997) Lumbar percutaneous endoscopic interbody fusion. Clin Orthop 337:58–63
14. Magerl FP (1984) Stabilization of the lower thoracic and lumbar spine with external skeletal fixation. Clin Orthop 189:125–141
15. Mathews HH, Long BH (1995) Endoscopy-assisted percutaneous anterior interbody fusion with subcutaneous suprafascial internal fixation: evolution of technique and surgical considerations. Orthop Int Ed 3:496–500
16. Olerud S, Sjostrom L, Karlstrom G, et al (1986) Spontaneous effect of increased stability of the lower lumbar spine in cases of severe chronic back pain. The answer of an external transpeduncular fixation test. Clin Orthop 203:67–74
17. Penta M, Fraser RD (1997) Anterior lumbar interbody fusion. A minimum 10-year follow-up. Spine 22:2429–2434
18. Steinmann JC, Herkovitz H (1992) Pseudoarthrosis of the spine. Clin Orthop 284:80–90
19. van der Schaaf DB, Limbeek JV, Pavlov PW (1999) Temporary external transpedicular fixation of the lumbosacral spine. Spine 24:481–484
20. Weinstein JN, Spratt KF, Spengler D, et al (1988) Spinal pedicle fixation: reliability and validity of roentgenogram-based assessment and surgical factors on successful screw placement. Spine 13:1012–1018
21. Zdeblick TA (1993) A prospective, randomized study of lumbar fusion. Preliminary results. Spine 18:983–991