Short-Segment Pedicle Fixation of Traumatic Low Lumbar Fractures (L3–L5)

Report of 36 Cases

Christina M. Moawad, BS, Harel Arzi, MD,† Anant Naik, BS,* Rashid Bashir, PhD,‡ and Paul M. Arnold, MD, FACS†*

Study Design: Prospective review.

Objective: The aim was to assess the efficacy and safety of short-segment pedicle fixation of low lumbar fractures (L3–L5).

Background: Low lumbar fractures are relatively uncommon, and limited data exists regarding the management of these injuries. No previous studies have specifically examined the surgical management of L3–L5 fractures exclusively with pedicle fixation.

Materials and Methods: We reviewed prospectively collected data of 36 patients who underwent short-segment pedicle fixation for low lumbar fractures at our institution between 1993 and 2018.

Results: There was no worsening of neurological status following surgery, and three patients regained motor or sphincter function. Thirty-one (86.1%) patients went on to successful fusion. Three (8%) patients required reoperation. Four (11%) patients had surgical complications.

Conclusions: This large series provides information regarding the safety and efficacy of surgical management of low lumbar fractures with pedicle fixation. Following surgery, there was no neurological worsening and some patients regained neurological function. Low complication rates, low reoperation rates, and low pain levels at final follow-up provide evidence that the surgical management of low lumbar fractures utilizing short-segment pedicle fixation is safe and efficacious.

Key Words: fractures, low lumbar, fracture fixation, internal/methods, L3–L5, lumbar vertebrae/surgery, pedicle fixation, short-segment fixation, spinal fractures/surgery, spinal fusion/methods

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Low lumbar fractures (L3–L5) are relatively uncommon, accounting for ~1%–12% of all traumatic spinal fractures.[1–3] As these injuries are infrequent, only a limited number of reports exist regarding their optimal management.[4] A host of unique anatomic and biomechanical characteristics of the low lumbar spine may complicate management of fractures in this region, including larger vertebral bodies, more supporting musculature, increased mobility, and the majority of anatomic lordosis. Because of these unique characteristics, management of low lumbar fractures is considerably different from management of the more common thoracolumbar fractures (T10–L2). Failure to restore physiological sagittal alignment may compromise overall vertebral mechanics, leading to pain and neurological dysfunction.

Challenges in treating low lumbar fractures were described as early as 1949 by Nicoll.[5] However, few studies have specifically examined the surgical management of these injuries. Most of our knowledge regarding these injuries has been reported in case reports or small series grouped together with other fracture types. Moreover, little has been written on low lumbar fractures since the advent of pedicle screws, and no existing study specifically examines the management of L3–L5 fractures using pedicle fixation exclusively.

The goal of this study was to assess the safety and efficacy of the surgical management of low lumbar fractures. We present the largest series of surgically managed low lumbar fractures to date in the civilian population, and the first series managed exclusively with pedicle fixation.

MATERIALS AND METHODS

Following approval by our Institutional Review Board, we reviewed prospectively collected data of 36 patients who underwent lumbar fusion surgery with short-segment instrumentation for traumatic low lumbar fractures (L3–L5) at our facility between 1993 and 2018. Patients with non-traumatic etiologies were not included. Thirty-one patients were male and 5 were female; the average age at presentation was 38.62 ± 17.5 (± SD; range: 14–70 y). The most common etiology was motor vehicle accident (19 patients), followed by fall (13 patients). (Table 1) There were 19 patients with L3 fractures, 13 patients with L4 fractures, and 5 patients with L5 fractures. (Figs. 1A–C) Concomitant injuries were

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From the *Carle Illinois College of Medicine; †Department of Neurosurgery; and ‡Department of Bioengineering and Basic and Translational Sciences, Grainger College of Engineering, Carle Illinois College of Medicine, University of Illinois, Urbana Champaign, IL.
The authors declare no conflict of interest.
Reprints: Paul M. Arnold, MD, FACS, Department of Neurosurgery, Carle Illinois College of Medicine, Carle Neuroscience Institute, 610 North Lincoln Avenue, Urbana, IL 61801 (e-mail: Paul.Arnold@carle.com).

TABLE 1. Etiology of Injury, Patient Demographics, Neurological Deficits, and Pain Score of Patients Available at 1-Year Follow-up

Patient Factors	Patients (%)
Etiology of traumatic injury of 36 patient	
Motor vehicle collision (MVC)	19 (52.7)
Fall	13 (36.0)
Other	4 (11.1)
Patient demographics of 36 patient	
Male	31 (86.1)
Female	5 (13.9)
Low lumbar level of traumatic fracture	
L3	19
L4	13
L5	5
Fusion status of 36 patients	
Successful fusion	31 (86.1)
Stable-nonunion	5 (13.9)
Complications of 36 patients	
Surgical complications	4 (11.1)
Osteomyelitis	2 (5.6)
Urinary tract infection	2 (5.6)
Required reoperation	3 (8.3)
Lumbar fracture instability	1 (2.8)
Osteomyelitis	2 (5.6)
Elective hardware removal	1 (2.8)
Patient presentation of 36 patients	
Neurological deficit before surgery	19 (52.8)
Decreased rectal tone/weakness before surgery	8 (22.2)
Decreased sensation before surgery	7 (19.4)
No neurological deficit before surgery	17 (47.2)
Patient outcomes	
Decreased rectal tone/weakness	
Improved at 1 y follow-up	3 of 8 (37.5)
Regained function at 1 y follow-up	1 of 8 (12.5)
No change at year follow-up	4 of 8 (50.0)
Decreased sensation	
Regained sensation at 1 y follow-up	4 of 7 (57.2)
Neurological worsening at surgery	0 of 36 (0)
Neurological worsening at 1 y follow-up	0 of 35 (0)
Pain scores at 1-year follow-up for 34 patients	
No pain	24 (70.6)
Mild	5 (14.7)
Moderate	5 (14.7)

common, including closed head injury and fractures of the ribs, extremities, and pelvis. Furthermore, 8 patients had additional fractures of the spine. Four patients had cervical fractures, 1 patient had a thoracic fracture, and 5 patients had additional fractures of the lumbar region. Indications for surgery included neurological deficit, mechanical instability, and intractable pain. Three patients were operated on in a delayed manner as they had failed nonsurgical therapy. One patient was lost to follow-up at 1 month, and 35 patients remained in the study at 1-year follow-up.

Operative Technique

All patients underwent surgery with short-segment instrumentation using rods and pedicle screws, and all patients but 1 underwent fusion of the lumbar spine with autologous bone graft or allograft. (In this patient, no material was placed for fusion as it was thought that the fracture would heal in place on its own and the screws could be removed at a later time). A midline incision was made and dissection was continued to the level of the spinous process and fascia. In a subperiosteal manner, the fascia was opened with monopolar cautery and the muscles stripped away bilaterally to reveal the lamina. The pedicles were identified and marked, utilizing intraoperative imaging such as fluoroscopy or navigation. Where feasible, screws were placed in the fractured vertebra, as well as in the vertebral bodies 1 level above and below the injury. In a sequential manner, the marked pedicles were identified, and adequately sized screws were inserted. Laminectomy and/or foraminotomy was performed as needed to decompress the spinal canal and nerve roots (Fig. 2), Once this was complete, appropriately sized rods were shaped consistent with physiological lordosis, and loaded into the pedicle screws. After caps were applied on the top of the screws, a high-speed drill was used to decorticate the transverse processes bilaterally and the medial facet joints in the remaining pars and lamina. Two cross connectors of appropriate length were selected and placed (Fig. 2). When this was completed, the autograft/allograft was placed into the lateral gutters over the transverse processes and facets for fusion.

Postoperative Management

Patients were fitted with a thoracolumbar sacral orthosis for 8 weeks postoperatively and encouraged to ambulate early after surgery as tolerated. Physical and occupational therapy were ordered as needed. Some patients completed a short stay in acute rehabilitation program before discharge. A few patients with more devastating injuries and neurological compromise (namely patients with concurrent fractures of the upper spine) underwent extended-stay rehabilitation. Follow-up visits were scheduled at 3-month intervals for 12 months after surgery. At each visit, posteroanterior and lateral radiographs were obtained, and patients were evaluated for pain, neurological function, wound healing, spinal alignment, and evidence of fusion (Fig. 3). Pain levels were classified as either none, mild, moderate, or severe, a scale previously used in examining low lumbar fractures,[6] and determined by the patients' reports in clinic at final follow-up.

RESULTS

Neurological Outcomes

In our series of 36 patients with low lumbar fractures 19 patients (52.8%) presented with neurological deficit (Table 1), and 8 patients presented with decreased rectal tone or weakness of the lower extremities and 7 patients reported decreased sensation. In addition, 2 patients presented with weakness related to concurrent fractures of the cervical or thoracic spine. Of the 8 patients presenting with motor or rectal deficits as a result of low lumbar fractures, 3 patients (37.5%) showed improvement of sphincter tone or muscle strength at final follow-up. One patient regained sphincter function. One patient who originally presented with paralysis of bilateral lower extremities regained full strength of the left leg. One patient regained sphincter function and lower extremity strength. Four additional patients reported regaining sensation. All 17 patients with intact neurological status upon presentation remained neurologically intact

FIGURE 1. A, Sagittal computed tomography of L4 burst fracture showing damage to all 3 columns. B, Axial view. C, Sagittal T2-weighted magnetic resonance imaging showing retropulsion of fracture fragments into the spinal canal.

following surgery. There were no reports of neurological worsening following surgery.

Complications and Reoperation Rate

A total of 4 patients (11.1%) had surgical complications. Urinary tract infection and osteomyelitis both occurred twice and were the most common complications. Both patients with osteomyelitis required reoperation to exchange infected hardware. One of these patients underwent reoperation to correct further worsening or instability of his low lumbar fracture. Finally, 1 patient underwent reoperation for elective hardware removal. In total, 3 patients (8%) required reoperation after the initial procedure. Mean follow-up time was 16.2 ± 11.7 months (range: 6–48 mo).

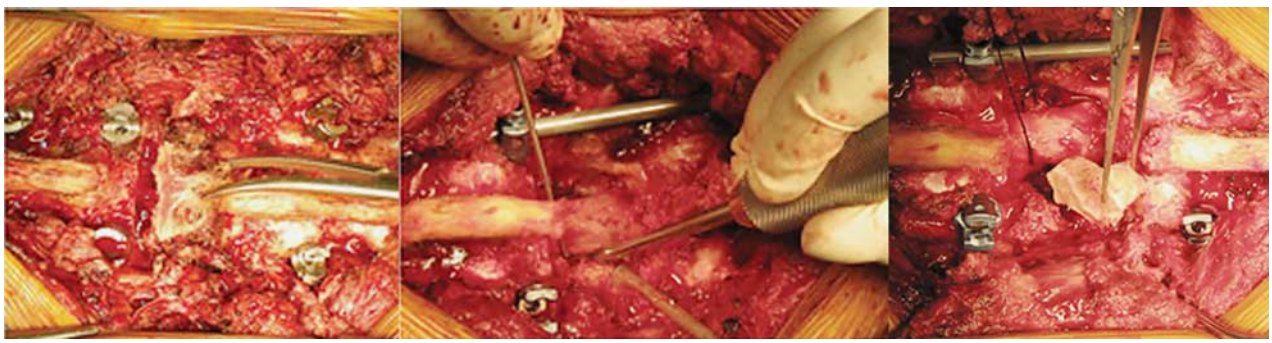

FIGURE 2. Intraoperative images of short-segment pedicle fixation procedure demonstrating decompression laminectomy. full color online

FIGURE 3. Follow-up radiograph demonstrating short-segment pedicle fixation of L4 fracture.

Evidence of Fusion and Pain Levels

Thirty-five patients had material placed for fusion, and 1 patient had his hardware removed electively once his fracture healed. Thirty-one (86.2%) of these patients went on to fusion as determined by evaluation of follow-up radiographs. There were 4 (11.1%) stable nonunions. Pain information was available for 34 of 35 patients (97.2%) after 1-year follow-up, reported in Table 1. Twenty-four (70.6%) reported no pain at final follow-up, 5 patients (14.7%) reported pain as mild, and 5 patients (14.7%) reported moderate pain. Two of the 3 patients who were operated on in a delayed manner reported moderate pain at final follow-up.

DISCUSSION

Low lumbar (L3–L5) fractures have previously been reported to comprise <4% of all spinal fractures.[7] Low lumbar fractures are relatively uncommon injuries that are anatomically and biomechanically different from fractures of the neighboring thoracolumbar region (T10–L2). Multiple studies have reported on the thoracolumbar[8–13] and lumbosacral region,[14] but few studies exist specifically regarding the lower lumbar region. Previous literature reports these fractures are predominant in combat-related spine injuries in US military conflicts.[3] In addition, a recent study suggests in traumatic motor vehicle collisions, transverse process fractures predominate as the most common type of traumatic lumbar spine fracture, making up 70% of 277 lumbar spine fractures, as opposed to 2.4% compression fractures.[15] Furthermore, 2 epidemiological studies have reported that low lumbar fractures now comprise a larger portion of traumatic spinal fractures, with incidence ranging from 9.8% to 12.2%[13] Despite this higher incidence, there is a paucity of published literature regarding management of these injuries.

In addition to the limited data available in the literature on low lumbar fractures, considerable controversy exists regarding the proper management of these injuries. Several authors have noted the use of nonsurgical treatment of neurologically intact patients, and little has been written investigating the efficacy and safety of the surgical management of these injuries. In 2012, Lehman et al[3] reported that guidelines regarding definitive surgical management of low lumbar burst fractures remained unclear.

Before the late 1980s, management of low lumbar fractures consisted of either conservative management (including bed rest and bracing) for 6 weeks, or direct decompression and fusion without instrumentation, as instrumentation at that time was fraught with complications. In 1988, Levine and Edwards[7] described the successful use of pedicle screws and a modular fixation system for 8 patients with lower lumbar fractures. The authors concluded that for pedicle fixation, "the initial results are gratifying and would suggest that this may be a potential avenue for treatment of a complex fracture."

In 1992, An et al[6] compared conservative and surgical treatment of low lumbar burst fractures. This study concluded that the use of long segment instrumentation and fusion in treating these injuries should be avoided and that many of these fractures are amenable to conservative therapy, especially if the patient is neurologically intact. In 1993, Mick et al[16] reported on 11 L5 fractures that were assigned to either conservative treatment or surgical treatment with pedicle screw fixation, concluding that young patients with minimal canal compromise respond very well to conservative treatment, but surgical management allows for a higher chance of neurological recovery.

In 2002, Dai[17] retrospectively reviewed 54 patients with low lumbar fractures, 28 of whom were treated surgically. Interestingly, this study showed that patients who underwent surgical management reported less pain than those managed conservatively. The authors concluded that (1) surgical management is indicated only when compression of the vertebral body is >50% in compression fractures; (2) surgery for burst and flexion-distraction fractures without neurological deficit should be reserved for severe canal stenosis and kyphosis, and (3) fracturedislocations require surgery because of their inherent instability.

Lehman et al[3] examined the incidence of fractures of L3–L5 in US military conflicts. Over 50% of spinal column fractures in their series of 32 patients consisted of low lumbar fractures, presumably because of military body armor transferring more force to the low lumbar spine. Another report by the same institution investigated 24

patients undergoing operative treatment for combat-related low lumbar fractures.[18] In this series, 43% of patients had postoperative complications and 30% required acute reoperation. At 3-year follow-up, 83% of patients had chronic pain. As the authors noted, however, significant selection bias was present in this study, as these patients sustained their injuries through very high-energy mechanisms, suffered severe concomitant injuries, and underwent definitive low lumbar surgery in average of 16.8 days following initial injury.

In 2010, Gelb and colleagues reported on 46 patients, of which 5 patients were posteriorly treated with short-segment posterior instrument between L3 and L5. Using the AO classification types and Load Sharing Classification points, the average loss of correction among the 5 patients was reported to be 6.2 degrees after an average of 8.42 months follow-up.[19] They found that short-segment posterior instrument was equally as successful in treating injuries at the lower lumbar levels as it was in treating the thoracolumbar junction. Despite highly comminuted injuries, this study suggested short-segment fracture fixation can also be used successfully in low lumbar fractures.

A review, by Cheng et al[20] 2013, assessing the benefits and risks of pedicle screw fixation for traumatic fractures in thoracic and lumbar spine concluded that evidence is insufficient to inform on the selection of different methods of pedicle screw fixation or on the use of fusion with pedicle screw fixation. This review included 8 trials of a total of 448 patients, with 5 different comparisons of methods of pedicle fixation in various participants while looking at a variety of outcomes at different time points. Of note, it is unknown how many in their review specifically pertain to the low lumbar region. Overall, evidence is insufficient to inform the selection of different methods of pedicle screw fixation or the combined use of fusion. In 2014, Wang et al[21] reported on 4 low lumbar burst fractures with posterior short-segment pedicle screw fixations as part of a larger study, suggesting in conjunction with thoracolumbar/lumbar interbody fusion it is a valid approach with less trauma and good results, especially in AO type A3, Denis type A, B, C, or E fractures.

Controversy still exists about whether short-segment pedicle screw instrumentation is a suitable method for unstable lumbar burst fracture.[21] In 2020, Ansar et al[22] published results from Royal Preston Hospital from 2013 to 2017 including 125 patients with 13 in the low lumbar region, investigating minimally invasive pedicle screw fixation similarly using fluoroscopic imaging to guide percutaneous placement of pedicle screws. The procedure was categorized into 3 categories: 1 level above and below the fracture, 2 levels above and below the fracture, and short pedicle screws at fracture level in addition to one level above and below. It is unclear the exact breakdown for the low lumbar region. Average regional sagittal angle preoperatively and postoperatively for the low lumbar region was −3.80 and −2.95, respectively, demonstrating satisfactory radiographic improvements. In addition to achieved vast majority decreased pain and they also showed improved functional outcomes and suggest minimally invasive fixation will predominate as the future technique of choice.

The results of our study contribute to the current literature regarding the surgical management of low lumbar fractures. As the first large series of civilian patients treated entirely with pedicle fixation, our data demonstrate the safety and efficacy of utilizing pedicle fixation for management of these injuries. Thirty-one (86.1%) of these patients went on to fusion and there was no neurological worsening following surgery. Three of 8 patients (37.5%) who presented with motor or sphincter dysfunction because of low lumbar fractures showed improved neurological function following surgery. The complication rate (11.1%) and levels of reported pain were low, although 3 patients (8.3%) required reoperation.

Although our data is encouraging, we recognize several limitations of our study. Since our cases span a range of 20 years, we were unable to use standardized instruments to measure outcomes across the entire study sample. Furthermore, kyphosis angle was not included to assess the angular deformity. Further research should include this data for complete assessment of the use of short-segment pedicle fixation. In addition, we were unable to ascertain the data for patients with low lumbar fractures that were treated conservatively during the same time period. Finally, long-term follow-up was not feasible with every patient because of the large catchment area from which our trauma population was drawn.

Despite these limitations, we report on a large number of patients with low lumbar fractures, a patient population that has been underrepresented in the literature. Further information is still needed regarding the management of these unique fractures. Our large series provides current safety and efficacy of low lumbar fracture managed exclusively with pedicle fixation. We recommend that future research in this area should be prospective in nature, with both surgical and conservative groups for comparison. Information over specific indications for the initial type of management (conservative or surgical) should be described in detail and include radiographic parameter measurements and be correlated with functional status at final follow-up with standardized measures.

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