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Diagnosis, Risk Factors, and Management of Sacral and Pelvic Fractures After Instrumented Lumbar Fusions: A Systematic Review

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Abstract

Study Design: Systematic literature review.

Objectives: To evaluate risk factors, diagnosis, and management of sacral and pelvic fractures (SPFs) after instrumented fusions.

Methods: A systematic review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines was performed using the PubMed database. Articles with patients with an SPF after a lumbar instrumented fusion were included. The articles addressing specifically proximal junctional kyphosis were excluded. Eleven small cases series (level of evidence IV) were reviewed.

Results: The incidence of SPF was 1.86% in one study. The risk factors reported were elderly patients, multilevel surgery, long fusions stopping at L5 or S1 instead of the ilium, osteoporosis, obesity, and sagittal imbalance. Computed tomography scan was the preferential image modality for diagnosing. Nonsurgical treatment may be used in patients with tolerable pain and non-displaced fracture. Persistent pain was an indication for surgery, as well as fracture displacement. The most common surgical treatment reported was an extension of the fusion to the iliac using iliac screws.

Conclusion: SPFs after lumbar instrumented fusion are rare but clinically meaningful complications. The risk factors, diagnosis, and management of SPFs are described in our review.

Keywords

sacral fractures, pelvic fractures, lumbar fusion, diagnosis, management

Introduction

Lumbar instrumented fusions are one of the most common procedures performed by spine surgeons to treat degenerative spinal disease around the world.¹ The number of spinal fusions increased tremendously in the last decades not only in the United States but also around the world.¹ The most affected population with lumbar degenerative disease includes older patients, many with comorbidities and increasing fusion-related complications.¹ Spinal fractures after fusions are part of the multitude of complications, and proper evaluation is necessary to improve the outcome of patients who suffer these complications.

Many studies have reported that the areas adjacent to a fusion are at risk of higher stress forces and, consequently, a higher potential risk of disc degeneration, spondylolisthesis, stenosis, and fractures.²⁻⁴ The rigidity associated with

instrumentation and fusion alters the normal force distribution in the spine, potentially causing failure of adjacent segments, especially in patients with poor bone quality and sagittal misalignment.⁵ Treatment of fractures in the context of previous instrumented fusions is a diagnostic and treatment challenge with uncertain patient outcomes.²⁻⁵ Sacral fracture distal to a lumbar arthrodesis are further complicated by issues of lumbosacral alignment, pelvic morphology, global alignment, and

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bone quality. Although these fractures generally occur in the sacral bone, they may also affect the pelvic ring (composed of 3 bones, the paired innominate bones and the sacrum also).

In this context, understanding the risk factors for postfusion fracture, the diagnostic evaluation, and the principles of treatment is critical. In the current article, we perform a systematic review of the risk factors, diagnosis, and management of distal fractures after instrumented fusions mainly involving the lumbosacral region.

Methods

A systematic review of the PubMed database was performed. We performed an individual search using the following keywords in September 2017: “sacral fractures,” “pelvic fractures,” and “instrumented fusion.” The guideline for systematic review and meta-analyses described by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was followed.⁶ Articles with patients with a spinal fracture after a lumbar instrumented fusion were included. Fractures treated conservatively or surgically were included. The articles addressing specifically proximal junctional kyphosis or only fractures above the fixation level were excluded. A total of 99 articles were obtained and 11 were reviewed and included.^{5,7-15,17} Studies were then classified according to their level of evidence using the Oxford Centre for Evidence-Based Medicine Table.¹⁶

This review identified only small case series (level of evidence IV), all with less than 10 cases, as well as some case reports.

Results

Yasuda et al¹⁷ evaluated the lumbosacral junctional failures after long spinal fusions for adult spinal deformity considering the distal instrumented vertebral. A retrospective study of 53 adult patients who underwent a posterior long (more than 5 levels) fusion for spinal kyphoscoliosis, with at least 2 years of follow-up, were grouped in 2 groups according to the distal fusion level: L5 or S1 (noniliac group) and ilium (iliac group). Their main goal was to investigate complication status (instability, pseudarthrosis, screw loosening, sacral and rod fractures) in the lumbosacral junction.

The 2 groups were similar according to age and preoperative radiological parameters. There were 25 cases (L5 with 6 and S1 with 19) in the noniliac group versus 28 in the iliac group. There were 6 revisions (1 case at L5 and 5 cases at S1, with a revision rate of 24%) in the noniliac group versus 2 cases (revision rate of 7.1%) in the iliac group due to rod fracture. Three of 6 (50%) cases ended at L5 had lumbosacral failure, and 15 of 19 cases ended in S1 had a radiolucent sign around S1 pedicle. The only complication in the iliac group was the 2 cases with rod fractures. The authors concluded that long lumbar fusions (at least 5 levels) had lesser failures when stopped at the ilium when compared with stopping at L5 and S1, avoiding sacral fractures.

Klineberg et al⁷ performed a retrospective study of 9 patients with sacral insufficiency fractures (all had previous posterior lumbosacral fusion of 1 to 8 motion segments and no known traumatic events). The 9 patients were postmenopausal women (average age = 64 years; range from 48 to 81 years). The fractures were diagnosed at an average of 5 weeks after the index surgery in 6 patients (treated in the authors' institution). The other 3 patients treated in another institution had the diagnosis after an average of 8 months. Computed tomography (CT) scan was necessary to diagnosis all the fractures. Two patients received early surgery at the diagnosis (1 patient with a Roy-Camille type III fracture and the other because she was morbidly obese and could not be managed with a brace), whereas nonoperative treatment was performed in the remaining 7 patients. Of these 7 patients, 3 achieved fracture healing using a brace while 4 abandoned brace use for several reasons, such as unremitting pain, a new fracture after bone healing, neurologic deterioration, and nonunion. Surgical treatment was then performed using a posterior approach, decompression, hardware revision, and lumbopelvic segmental instrumentation. All surgical patients demonstrated fracture union and were able to walk but had postoperative complications (infections, implant failure, etc).

The incidence of sacral insufficiency fractures in the authors' institution after a short segmental fusion was 1.3% and after a long segmental fusion 3.1%. The authors concluded that sacral insufficiency is a rare complication after lumbosacral fusion but that it is in the differential diagnosis of low back pain after surgery. Nonoperative treatment may be used in patients based on clinical symptoms, neurological examination, and fracture alignment. Surgical treatment consists of lumbopelvic fixation and it is effective for healing.

Noh and Chedid⁸ reported a transverse type-2 Roy-Camille sacral fracture after a previous instrumented L4-S1 fusion for treatment of spondylolisthesis. A 64-year-old woman presented with severe low back pain and radiculopathy for 6 months due to the transverse sacral fracture. Of note, she had a normal dual energy X-ray absorptiometry scan. The patient was treated surgically with a revision including lag screw fixation with two 50-mm screws directly from S2 to S1 across the fracture line bilaterally.

Scemama et al reported 3 case examples of sacral stress fractures after lumbar and lumbosacral fusions.⁹ Additionally, a literature review was performed. The clinical symptoms of sacral stress fracture were characterized by nonspecific low back pain or buttock pain after some weeks or months of the index surgery. The diagnosis was preferentially made using CT scan. Surgery was recommended as an efficient alternative to treat these patients.

Three case reports were included. The first was of a 72-year-old female with osteoporosis who had a L2-S1 bilateral instrumented fusion using screws and local graft only. After 2 months, she had sacral pain and also L5 radicular pain. While X-rays were not definitive, a transverse S1 fracture was diagnosed on CT scan and a pseudarthrosis at L5-S1. She underwent posterior revision extending instrumentation to the ilium

bilaterally and L4-5 and L5-S1 anterior interbody fusion. After 6 months, she had important pain improvement. The second case was of a 77-year-old male unable to walk for 6 months due to low back pain and bilateral radicular pain. He had an L3-5 instrumented fusion 3 years before. Two years after the surgery, he had a revision (extension to L3-S1) due to adjacent segment disease at L5-S1 with bilateral S1 screws. Due to increased pain, after inconclusive plain radiographs, a CT scan was performed, showing a proximal sacral endplate fracture and S1 fixation failure. The patient was treated with a revision including bilateral iliac screws extension; the authors report improvement of low back pain but not the L5 radiculopathy. Finally, the third patient was a 67-year-old female, with low back pain and right L5 pain, rheumatoid arthritis, and osteopenia. She had a T12-S1 fusion for a degenerative scoliosis with bilateral iliac screw fixation. After 2 months, she developed a U-type, nondisplaced sacral fractures with a proximal implant failure. Proximal extension to T11 was performed, as well as distal extension with 2 iliac screws on the right side and 1 on the left side, followed by an anterior L12, 23, 34, 45, and 5S1 interbody fusion. After 1 year, she had sacral fracture consolidation and no residual pain.

Papadopoulos et al¹⁰ reported 5 cases of sacral fractures after thoracolumbar fusions to the sacrum. All patients failed conservative management and required surgical treatment. Surgery was performed at an average 3.25 months after the diagnosis. Three patients had also signs of failed arthrodesis at L5-S1. Treatment strategy includes fixation to the pelvis in all cases while 4 cases also had an anterior approach for anterior interbody fusion. Pain improved in all patients after surgery. The reported risks factors for sacral fracture were osteoporosis, obesity, and sagittal imbalance after the index operation. They concluded that surgery should be performed in patients with symptomatic (low back pain/buttock pain/radicular pain) sacral fractures that failed nonoperative treatment or when there is symptomatic pseudarthrosis at L5-S1.

Khan et al⁵ reported 3 cases of sacral insufficiency fractures after multilevel spinal fusion with instrumentation. Three patients had new onset of buttock pain after some weeks of an instrumented lumbosacral fusion—transverse sacral fractures below the fusion were documented. Nonoperative treatment was performed with fracture union in all the 3 cases.

Koh et al¹¹ reported a case report on transverse stress fracture of the pelvic wing-sacrum after an instrumented lumbosacral fusion. A 48-year-old woman had many revision surgeries (11 surgeries during 9 years) for collapse and instability at adjacent levels of her lumbar spine. After the last surgery, she presented with slowly progressive lower back and buttock pain. Seven months later, she was diagnosed with bilateral pelvic wing-sacrum stress fractures. The patient managed nonoperatively with a brace and pain management.

Khanna et al¹² reported 3 cases of sacral insufficiency fracture after lumbosacral instrumentation. One patient, a 69-year-old male, had low back pain and left side radiculopathy 6 months after a L3-S1 fusion. He was treated with a brace without pain control once he was diagnosed with a stress

fracture involving the anterosuperior portion of S1 vertebral body and pseudarthrosis. At 16 months after surgery, his back pain continued to progress and he was treated with debridement of the pseudarthrosis and structural fibular allograft and internal fixation (using a laminectomy at S2 and inserting a guide wire from S1 to the L5S1 disc). The patient had a good bone healing after 18 months. The second patient was a 57-year-old female who underwent a T12-S1 instrumented fusion. Six weeks after surgery, she reported a new pain in her lower extremity and also some soreness in the lumbar spine and new right groin pain. Some tenderness of the right sacroiliac joint was also noted. She had a nondisplaced sacral fracture confirmed by CT scan. She was then treated nonsurgically with a rigid thoracolumbar spine orthosis with thigh extension. After 7 months, as a nonunion persisted, she was also treated with a structural fibular allograft from L5 to S1. The instrumentation was also extended from T10 to S2. She had nearly complete resolution of her symptoms 12 months after surgery and sacral fracture healing.

The third patient was a 71-year-old female with osteoporosis. She had a T12 to S1 instrumented fusion, but 3 weeks later she had excruciating back pain across the buttocks while sitting and standing. She was treated with a rigid thoracolumbar spine orthosis brace with a thigh cuff extension and pain medication. Complete union and pain relief were obtained after 3 months.

Fourney et al¹³ reported a case of an early sacral stress fracture after reduction of spondylolisthesis and lumbosacral fixation (a 2-level surgery). There were sudden low back and buttock pain onset a few days after the lumbosacral fusion for a grade II spondylolisthesis with posterior interbody fusion. A transverse sacral fracture was found on plain X-rays 4 weeks later. The patient was treated with a brace and medical management for osteoporosis.

Mathews et al¹⁴ reported 3 cases of early sacral or pelvic stress after an instrumented lumbosacral fusion. They occurred about 2 to 4 weeks after surgery for multilevel lumbosacral fusions for degenerative disease. The first patient was a 74-year-old female who had a L3-S1 decompression and 2 weeks after surgery had a sacral fracture, as well as a right superior and inferior pubic rami fracture. She was treated nonsurgically, with pain medication. At 11 months she had only mild pelvic pain. The second patient was a 70-year-old female who had a L1-S1 decompression and instrumented fusion. One month after surgery she had increased low back pain. On plain radiographs, the authors diagnosed a displaced transverse sacral insufficiency fracture that was treated conservatively with bed rest. After 8 months, she had sacral healing, although in a forward displaced position. One and half years after surgery, she continued to report had low back pain and a posture abnormality. Finally, patient 3, a 70-year-old female, had a L4-S1 decompression and pedicle screw instrumentation and fusion. After 2 weeks, new onset of right buttock and groin pain was experienced. She had a superior pubic ramus fracture and a right iliac fracture, and 2 months later, she had a new superior pubic ramus contralateral fracture. She had chronic pelvic pain, which slightly improved over 2 years. The authors concluded that elderly osteoporotic patients who had multilevel surgery are at

increased risk for early pelvic and/or sacral stress fractures. The authors reported that these injuries lead to prolonged pain, postural imbalance, and late recovery. Nonsurgical treatment is one treatment option.

Wood et al¹⁵ reported 5 cases of nontraumatic pelvic ring fractures after long spine fusions to the lumbosacral spine. They reported that the incidence of these injuries was 5 of 268 cases (1.86%). All fractures were on the left side of the pelvic ring, affecting primarily the pubic rami. All the patients were women and aged 50 years or older. Fractures occurred after 4 months to up to 7 years after the last surgery (mean of 28 months). Treatment consisted of protected weight bearing until patients reported pain improvement. Four patients reported that they did not have pain after a mean follow-up of 27 months and the last patient was pain-free after 31 months but had a new fracture in the contra lateral pubic rami after 2 months.

Discussion

This systematic review of the fractures of the sacrum and pelvis associated with lumbar or lumbosacral fusions demonstrates that, though rare, common patterns in clinical presentation, diagnosis, and treatment can be identified.

The incidence of spine fractures after fusions reported by Li et al¹⁸ was 11.6%. From this, 64.7% were adjacent to the fusion levels and the remaining were remote fractures. On the other hand, sacral and/or pelvic fractures were much less common. Wood et al¹⁵ reported that the incidence was of 1.86% in 268 surgically treated patients.

For sacral or pelvic fractures after lumbosacral fusions, the risk factors reported were similar: elderly patients, multilevel surgery, long fusions stopping at L5 or S1 instead of the ilium, osteoporosis, obesity, and sagittal imbalance after the index operation.^{10,14,17} The preponderance of osteoporosis in reported cases identifies potential areas of preoperative intervention; bone health assessment and treatment should be strongly considered in at-risk patients or at-risk procedures. However, there remains a degree of unpredictability as cases of sacral fractures were described in patients without osteoporosis and even after a 2 level surgery (lumbosacral fixation for reduction spondylolisthesis).¹³

Diagnosis

Although plain radiographs may diagnose the fractures, CT scan is more sensitive and specific and is capable of identifying fractures that do not show in the plain radiographs.⁷ Finally, CT scan is also useful to evaluate bone healing during patients' follow-up. For this reason, CT scan may be considered the preferred image modality for diagnosing a fracture above or below a lumbar fusion.

Treatment

In our review, there were cases where sacral and/or pelvic fractures were treated nonsurgically and others where surgical

treatment was necessary. While no high-level evidence exists to support one treatment over another, common principles of treatment can be identified.

Nonsurgical Management

Nonsurgical treatment may be used in patients with tolerable or controlled pain, preferentially without L5S1 pseudarthrosis and an aligned, nondisplaced fracture in patients without neurological deficit.¹⁰ Some authors reported that they did not prescribe a brace for nonsurgical management with successful healing, whereas others reported that a brace was used.^{5,11,13} Pain treatment and maintaining protected activity were also prescribed in the majority of the cases of nonsurgical care.^{5,11,13} One case reported that nonsurgical management of a displaced fracture resulted in a forward displaced position with postural imbalance, pain, and walking difficulties.¹⁴

The majority of the reported cases of patients treated nonsurgically did not preclude ambulation. Wood et al¹⁵ reported that the 5 cases of nontraumatic pelvic ring fractures were treated with protected weight bearing until patients reported that they were comfortable. The risk of weight bearing restrictions, such as deep venous thrombosis and infections, should be weighed against the risk of a new revision surgery keeping in mind that there is no definitive evidence.

Surgical Management

Persistent pain was an indication for surgery in the majority of the cases reported in our review.¹⁰ Fracture displacement was also more likely to receive a revision surgery. The most common surgical treatment reported for sacral insufficiency fractures was an extension of the fusion to the iliac using iliac screws.^{8,10} Many cases treated with iliac instrumentation also received an interbody fusion for pseudarthrosis, especially at L5S1 junction.

Besides iliac screw fixation, other surgical options were reported. Noh and Chedid⁸ reported the treatment of a transverse type-2 Roy-Camille sacral fracture treated with two 50-mm lag screws used directly from S2 to S1 across the fracture line, bilaterally. This was a new form of treatment for these injuries. Khanna et al¹² also reported that surgical treatment may consist in the use of debridement of the pseudarthrosis and structural fibular allograft and internal fixation (using a laminectomy at S2 and inserting a guide wire from S1 to the L5S1 disc).¹²

Conclusion

Sacral and pelvic fractures after lumbar instrumented fusion are rare but clinically meaningful complications. Risk factors include osteoporosis, long fusion constructs, sagittal balance, and obesity. Sacral and/or pelvic fractures are managed conservatively in patients with minimal symptoms, no neurological deficit, and nondisplaced fractures. Specifics on nonsurgical treatment include brace use and weight bearing

restrictions remain unclear. Surgical treatment is indicated in patients with severe pain, neurological impairment, failure of instrumentation, or displaced fractures.

The level of evidence of the studies included in this review are low, mostly based on small case series and case reports. Because of that, an individual evaluation of each patient is necessary, considering fracture morphology, degree of patient symptoms, medical comorbidities, risks of a revision surgical procedure, and surgeon experience.

Declaration of Conflicting Interests

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