Sacral fractures after multi-segmental lumbosacral fusion: a series of four cases and systematic review of literature

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Abstract Spine surgeons are becoming increasingly aware of sacral insufficiency fractures as a complication after lumbosacral fusions. We present four patients who suffered from sacral fractures after multi-segmental posterior lumbosacral fusion together with a systematic review of the literature that yielded six papers reporting on 12 cases. Summarizing these 16 cases, the typical patient suffering from this complication is a female, elderly individual [66.4 ± 12.3 (mean $\pm$ SD) years of age, 95% confidence interval 57.89–71] undergoing multilevel fusion of 4.9 ± 3.4 (95% CI 3.1–6.8) segments. Due to nonspecific clinical complaints and inconclusive imaging there has been a median delay in diagnosis of 5 (IQR 3–6, range 1–49) weeks after onset of pain. It remains unclear whether this complication is rare or rather under-diagnosed. Fortunately, these fractures are predominantly benign conditions that respond well to conservative management in the majority of cases, depending on location.

Keywords Sacral insufficiency fracture · Lumbosacral spinal fusion

Introduction

It is a well-documented fact that spinal fusion substantially alters spine biomechanics resulting in peaking stresses, thus facilitating adjacent segment degeneration [3].

Histological analyses of canine and human subjects have proven that preexisting osteoporosis is considerably aggravated by spinal fusion similar to bone loss due to stress shielding [10]. Hence the structural integrity of the spine seems sufficiently weakened to being predisposed to insufficiency fractures. Etebar and Cahill, in 1999, reported a number of adjacent vertebral body insufficiency fractures following rigid lumbar fusion [4]. Wood et al. [12] and Grimm et al. [6] reported on mostly pelvic fractures in their patients. Fractures of the sacrum are less frequent. At our department, we observed four such cases, and a systematic review produced 12 more [5, 7–9, 11]. It is the objective of this work to present these cases and to review risk factors, diagnosis, and management of this infrequent complication.

Case 1

This patient was a 77 year-old female with a history of low back pain, and neurogenic claudication refractory to conservative management. Plain x-rays showed multi-segmental lumbar osteochondrosis, disc space narrowing, L4/5 spondylolisthesis as well as left-sided convex rotational degenerative scoliosis. T12–S1 posterior fusion with poly-axial pedicle screws and double rods (XIA[®], Stryker[®]) was performed with posterolateral autologous bone augmentation from the resected laminae and spinous processes at age 75. The postoperative course and mobilization showed good progress until the patient reported bilateral buttock pain 2 weeks postoperatively without precedent trauma. The pain was alleviated by an orthosis, but did not subside completely. A CT scan revealed a S2 fracture 5 weeks after surgery. Due to protracted pain and increasing instability, the fusion was extended to S2 and

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the iliac wings, 3 months after the first operation. The patient ambulated well and was without pain at 2.3 years follow-up. DEXA showed normal bone density measured at the hip, during the whole follow-up period. The most recent imaging studies showed a healed fracture (Fig. 1a–c).

Case 2

This is a 65 year-old obese (BMI = 33.96) female patient with a long-standing history of radiating low back pain and severe osteoporosis with a vertebral fracture at L3. Imaging studies additionally showed degeneration from L3 to S1, kyphosis and absolute spinal stenosis. L2–S1 posterior lumbar fusion with intervertebral cages and pedicle screws

L2–L5 (VSP[®], DePuy[®]) was performed. At this time, the patient suffered from osteopenia (BMD 0.841 g/cm², T-score –1.9, Z-score –0.4). The patient had to be revised because of superficial wound dehiscence and necrosis 2 weeks later. During the course of the first postoperative weeks, the patient was free of pain, but it recurred about 6 weeks postoperatively with the maximum intensity into the buttocks and radiating into the thigh. After inconclusive plain x-ray imaging, a sacral fracture in the lateral mass of S1 was diagnosed after 4 months postoperatively, by a CT-scan and confirmed by a bone scan. The patient responded well to conservative treatment and ambulated well but needed analgesic medication at 3 years follow-up. During this time, the bone density of the patient decreased to osteoporotic levels (BMD 0.589 g/cm², T-score –3.1, Z-score –1.2), which might explain continuing discomfort.

Fig. 1 Shows **a** an x-ray and **b** a CT-scan of a sacral fracture below the S1 pedicle with anterior subluxation. Due to protracted pain and instability, this patient had to be revised and the fusion was extended to S2 and **c** the iliac wings

Imaging showed that the fracture had healed nonetheless (Fig. 2).

Case 3

This case is a 79 year-old female who originally was treated for lumbar spondylosis and spinal stenosis with a L2–L5 semi-rigid instrumentation. The hardware was removed due to loosening and a T10–S1 fusion was done using a poly-axial pedicular screw and double rod system (XIA[®], Stryker[®]) at age 77. During the course of postoperative mobilization, the patient suffered from increasing lower back pain that initially subsided after application of a lumbar orthosis. Due to recurrence of pain in the lower back and buttocks, a CT scan was done and revealed a sacral fracture. The patient responded well to further conservative management. After 1.6 years follow-up, she showed adequate reduction of symptoms with conservative measures. DEXA revealed no indication of an increased risk of fracture. Complete healing of the fracture was seen in imaging (Fig. 3).

Case 4

This 80 year-old patient is the only male in our series. After L2–L4 laminectomy, this patient developed spinal instability from L2 to S1 with concurrent vertebral disc degeneration. At age 78, T11–S1 fusion was done with the XIA[®] (poly-axial pedicular screws, double rod system, Stryker[®]) system. Most of the patient's pain subsided shortly after surgery with only minimal low back

discomfort remaining. The postoperative course was normal until the gradual emergence of bilateral radiating pain starting about 2–3 weeks postoperatively. A CT scan was done 5 weeks postoperatively and confirmed a suspected sacral fracture at S1. DEXA showed neither an increased risk of fracture nor an abnormal BMD. This patient was followed for 1.5 years, his condition responded well to conservative treatment with a lumbar brace. The most recent imaging studies showed a healed sacrum (Fig. 4).

Systematic review of the literature

We performed a systemic review of the literature using online databases and by hand, searching print issues of relevant journals. PubMed and EMBASE were searched for exploded keywords “sacral”, “sacrum”, “fracture”, “insufficiency”, and “postoperative”. The search produced 162 results in PubMed and 64 results in EMBASE. Reviewing these results excluding duplicates and irrelevant papers yielded six clinically fairly homogenous reports in English and German. Khan et al. and Mathews et al. reported on 3 and 2 female patients sustaining sacral fractures after multilevel lumbosacral fusion and iliac crest graft procurement [7–9]. Dwyer et al. [2] presented four cases of traumatic spondylolisthesis after spinal fusion at the 2001 Scoliosis Research Society meeting. The case Koh et al. [8] reported is more complicated since his patient had to be revised 11 times within 9 years after L4–S1 decompression and posterolateral fusion, resulting in a functional T10–S1 fusion alternately anterior and posterolateral. Pennekamp et al. [11] and Fourney et al. [5] performed lumbosacral

Fig. 2 Shows lateral x-ray and CT-scan of “Case 2”. The fracture can hardly be seen on the CT but was confirmed by a bone scan

Fig. 3 Shows lateral x-ray and CT scan of “Case 3”. The fracture can be clearly seen on the CT study

Fig. 4 Shows a fracture at S1, which cannot be appreciated on the plain anteroposterior and lateral x-rays, but is clearly visible on the CT-scan

fusion with iliac crest grafting and observed one sacral fracture each. Summarized, the patients suffering from this complication ($n = 16$) were averagely 64.4 ± 12.3 years old (mean $\pm$ SD; 95% CI 57.9–71) and underwent 4.9 ± 3.4 (95% CI 3.1–6.8) segment fusions. The common chief complaint was back pain with

radiation to the buttocks leading to the diagnosis of sacral fractures 8.3 ± 11.4 (95% CI 2.3–14.4) weeks later. There is no uniform description of the quantity of osteoporosis or other predisposing medical conditions throughout these cases. All reported patients responded well to conservative treatment (Table 1).

Discussion

Insufficiency fractures are possible complications of spinal instrumentation. The epidemiology of sacral fractures is still elusive, whilst fractures of the pelvic rami and vertebrae have been documented in literature [6, 12]. It is not clear, however, whether this fact derives from the scarcity of events or the low rate of detection.

The most commonly quoted risk factor is osteoporosis. Information on the severity of osteoporosis is incomplete in most reports, although clinical and radiological criteria are met and a correlation is insinuated by the age and gender of most patients. Pennekamp, however, is the only one reporting on BMD, which was significantly decreased in his patient. In our sample, however, two patients had fractures despite a normal BMD. Age and gender have also been associated with this diagnosis, but it is quite likely that these factors merely are surrogates of low bone mineral density, or vice versa. A number of mechanical factors also have been discussed. Iliac crest grafting has been proven to increase morbidity [1], but its meaning as a risk factor for sacral fracture remains uncertain. Furthermore, all patients had bicortical S1 screw fixation, yet only 25% (4/16 cases) of all patients had intervertebral cages at the L5/S1 level. This may reduce anterior stability and axial-pressure distribution. Bicortical screws, in turn, may act as stress risers in and across the sacrum, thus facilitating fractures, but less bone purchase could jeopardize stability in osteoporotic patients. From our experience, we cannot recommend prophylactic extension of the fusion to the iliac wings, but do so in revision surgery with extension of fusion. Further research might produce evidence for benefit in high-risk patients. The number of segments fused as a measure of the length of the lever arm, as well as the contour in the sagittal plane, have been proposed as further

risk factors. Due to the small number of cases and incomplete data, however, a statistically valid conclusion cannot be drawn at this point.

Diagnosis of sacral fractures is complicated and considerably delayed in almost every patient. Plain X-rays usually are inconclusive, and bone scans have been recommended repeatedly. However, CT-scans, especially with a 3-D reconstruction, are at least as sensitive, despite artifacts due to the implants, but have better resolution. MRI is less favorable due to its susceptibility to artifacts at significantly higher costs than a CT scan, although it might reveal bone marrow edema at “high stress sites”. A bone scan, however, is still the most sensitive method to diagnose non-displaced fractures. Due to the nonspecific complaints and the high number of differentials, a high level of clinical suspicion is needed nonetheless.

Fortunately, most of these cases responded well to conservative treatment. Horizontal fractures below the S1 pedicle, however, may lead to anterolisthesis and require surgical intervention. We revised one case with this constellation due to protracted pain and increased instability. Fractures at the level of a pedicle screw might compromise the stability of the vertebra. There is also a risk that these fractures loose sagittal alignment and develop kyphosis. Generally, however, it has to be noticed that just as the epidemiology of this etiology is neither yet fully understood, nor its natural history. Furthermore, osteoporosis, if not causing this problem, might interfere with and delay fracture healing. Treatment with an orthosis might support the bone mechanically, but as long as the precise mechanism of the pathology has not been untangled, there is only anecdotal evidence for this treatment. Despite its favorable response to conservative management, it should be kept in mind that sacral fractures can be considerably painful and further add to the morbidity of already significantly sick

Table 1 Shows the patient data of the 16 cases from international literature

	Gender	Age	Segments	Iliac crest bone grafting	Weeks till diagnosis	Author
1	F	61	1		4	Fourney et al. [5]
2	F	57	2	Left	2	Khan and Kang [7]
3	F	79	3	Left	6	Khan and Kang [7]
4	F	57	2	Left	6	Khan and Kang [7]
5	F		2			Koh and Lee [8]
6	F	74	3	Right	2	Mathews et al. [9]
7	F	70	5	Right	4	Mathews et al. [9]
8	F	57	2		1	Pennekamp et al. [11]
9	F	77	8		5	
10	F	63	6		13	
11	F	60	7		5	
12	M	79	7		5	
13–16		60 (36–78)	9 (3–13)		7 (5–12)	Dwyer et al. [2]

patients. This situation is aggravated if the fracture heals in a displaced and mechanically inferior position or even causes a reduction of the diameter of the spinal canal.

Conflict of interest statement None of the authors has any potential conflict of interest.

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