Stress fracture of the pedicle after extensive decompression and contralateral posterior fusion for lumbar stenosis

Report of three cases

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Lumbar spinal stenosis can be effectively treated by performing an extensive ipsilateral spinal decompression, including a partial pediculotomy, and contralateral posterior bone fusion. Infrequently, complications can arise following radical decompression to alleviate symptoms of stenosis, and one such complication is a pedicle fracture. Three reports of pedicle fractures following extensive spinal decompression and contralateral posterior fusion are detailed. This complication is emphasized, and interventions are discussed.

Three patients presented with symptoms attributable to lumbar stenosis; they were initially treated with an ipsilateral decompression, achieved in part, through a partial pediculotomy followed by contralateral autologous bone fusion. Initially, all three patients improved postoperatively; however, they later developed neurological symptoms ipsilateral to the side of spinal decompression. Computerized tomography scanning demonstrated pedicle fractures on the decompressed side. This complication has not yet been reported in association with decompression and fusion for lumbar stenosis.

Two of the patients developed leg pain necessitating reoperation whereas the third experienced only mild transient symptoms. The fractured pedicle was removed in one patient; laminar and spinous process fusion was performed again. Another patient underwent a total laminectomy, removal of the fractured pedicle, and bilateral transverse process fusion. Reoperation yielded satisfactory outcomes. The third patient's symptoms resolved without intervention.

Pedicle fractures are a potential complication of extensive lumbar decompression and contralateral posterior fusion. Loading forces from the facets or transverse processes are possibly the cause of such fractures. Removal of the fractured pedicle, additional decompression, and enhanced bone fusion are recommended when the symptoms warrant surgical intervention.

KEY WORDS • spinal stenosis • pedicle fracture • pediculotomy • fusion • lumbar decompression

Lumbar spinal stenosis is a compression of neural elements in the spinal canal; ipsilateral spinal decompression and contralateral bone fusion safely and effectively alleviate symptoms of stenosis.^{8,16} Recently, extensive spinal decompression techniques including a partial pediculotomy have been described and appear to yield favorable results in both the lumbar and cervical spine.^{25,30,31} These and other methods currently used to achieve an adequate lumbar decompression vary greatly and may engender complications and controversy. Complications associated with lumbar decompression include acute cauda equina compression, lumbar spinal instability (olisthesis), lumbar spine osteolysis, and spinal hypermobility.^{3,4,17,22,29,33} Whether or not spinal stabilization is needed in patients undergoing a limited spinal decompression is also a subject of

much debate; fusion-related complications include infection, graft-site fatigue fracture, pseudarthrosis, and excessive scarring.^{20,23,27,28}

Pedicle fractures are commonly associated with trauma such as isolated C-2 laminar–pedicle hangman's fracture, unilateral spondylolysis and subsequent contralateral pedicle fracture, or pedicle screw/plate fixation complications.^{10,24,32} This is the first report of pedicle fractures in patients with stenosis who were surgically treated with extensive unilateral decompression achieved in part through a partial pediculotomy followed by a contralateral posterior autologous bone fusion.

CASE REPORTS

Case 1

This 77-year-old man initially presented with symptoms associated with L2–5 stenosis. His symptoms were

Abbreviation used in this paper: CT = computerized tomography.

noted to be worse on the left side. He was treated with left-sided decompression and contralateral posterior fusion in which autologous bone, a Steinmann pin, and Wisconsin wires were used. The spinal decompression included left-sided laminectomies, facetectomies, foraminotomies, and a partial L-5 pediculotomy. Nine months following his initial presentation, the patient returned with recurrent low-back pain and left lower-extremity pain. On physical examination, a positive straight-leg raising test and diminished ankle jerk on the left were demonstrated. The presence of an obliquely oriented fracture of the left L-5 pedicle was discovered on a CT myelogram (Fig. 1).

Surgical intervention was chosen to relieve symptoms associated with the pedicle fracture. The L3–S1 levels were exposed bilaterally, and the fractured left L-5 pedicle was removed. A fat graft was placed over the site where the pedicle was removed. The Steinmann pin and Wisconsin button and wires were removed, and the spinous processes were undercut. The contralateral fusion was noted to have a pseudarthrosis at the L4–5 level. The bone fusion mass was decorticated, and new bone and bovine graft were implanted. The patient has remained symptom free for the past 30 months.

Case 2

This 56-year-old woman presented with left lower-extremity pain, motor weakness, intermittent neurogenic claudication, and numbness and tingling below the left knee. A CT myelogram demonstrated the presence of stenosis at the L4–S1 levels. Initially, a left L4–S1 ipsilateral hemilaminar decompression was performed including pediculotomies and a contralateral right-sided posterior hemilaminar fusion in which bone marrow aspirate from the iliac crest was used. During the immediate postoperative period, the patient's neurological condition significantly improved. In particular, her back and leg pain had resolved, and she resumed her normal daily activities.

Twelve months postoperatively, the patient presented with worsening lower-extremity pain. This pain was worse on the left compared with the right side. A CT myelogram demonstrated right facet degeneration, degenerative subluxation of L4–5, poor contralateral bone fusion, and frac-

ture of the remaining left L-4 pedicle (Fig. 2). The patient underwent total laminectomies of L3–5 and resection of the fractured L-4 pedicle. Bilateral L3–5 transverse process fusion was performed using autologous iliac crest bone graft and Collograft (Zimmer; Warsaw, IN). At discharge, the patient was neurologically improved in terms of her pain, and she has remained pain free for 21 months.

Case 3

This 59-year-old woman presented initially with severe lower-back and lower-extremity pain that was worse on the right side. The patient underwent a right L3–5 posterior hemilaminectomy, foraminotomy, partial pediculotomy of L-3, and contralateral autologous bone fusion for lumbar stenosis. The patient tolerated the surgery extremely well and demonstrated full strength in her lower extremities postoperatively; however, the patient noted mild, intermittent right lower extremity pain and numbness postoperatively. One week postoperatively a lumbar CT scan demonstrated adequate decompression without evidence of neural compression or fracture.

Two months postoperatively on a routine CT myelogram obtained to assess the size of the bone fusion and adequacy of the decompression, the patient was found to have a stress fracture of the right L-3 pedicle and poor bone fusion mass on the contralateral side (Fig. 3). At present, more than 24 months postoperatively, no intervention is planned because the patient is currently asymptomatic.

DISCUSSION

In the spine, adjacent vertebrae articulate through the intervertebral disc and the superior and inferior articular facets. These three articulating elements share the spinal load and are interdependent. Hence, alteration through degeneration or surgery of any single articular element ultimately affects the biomechanics of the others. In the normal spine, the loading force on the facets can reach up to 30% of the total force in the anteroposterior direction.⁵ If the facets remain even partially intact on the decompressed side, the pedicle's share of the facets' load appears at times to be sufficient to fracture the pedicle. Biome-

Fig. 1. Case 1. Axial CT scan demonstrating an obliquely oriented fracture of the left L-5 pedicle.

Fig. 2. Case 2. Axial CT scan demonstrating a fracture of the residual left L-4 pedicle.

Pedicle fracture after decompression and posterior fusion

Fig. 3. Case 3. Axial CT scan revealing fracture of the right L-3 pedicle.

chanical studies have shown that a partial laminectomy significantly increases rotational motion during flexion of the spine at the decompressed level; the addition of a partial facetectomy results in increased translational motion of the decompressed level during lateral bending as well as the level immediately above the surgical site during flexion.^{11,12}

Based on mechanical testing of the neural arch, the pedicle has been determined to be the second weakest part after the pars interarticularis.^{6,7} The exact amount of stress across a pedicle situated along a posterior fusion is not known; however, the same biomechanical mechanism proposed for spondylolysis acquisita could conceivably result instead in a pedicle fracture.^{9,13,21} In fact, in a case in which pain persists postoperatively as a result of motion across an intervertebral disc, increased stress across a pedicle is likely.^{18,21} Thus, although extensive spinal decompression techniques involving partial pediculotomies have been advocated recently, these postoperative changes in spinal biomechanics coupled with a partial pediculotomy and/or poor bone fusion appear sufficient at times to fracture the residual pedicle (Figs. 1–3).^{25,30,31}

Even if the facets are totally removed, pedicle fracture might still occur as a result of stresses placed on the pedicle by the transverse process. The torque afforded by the moment arm of the transverse process when applied to the pedicle of a decompressed spinal level could be substantial. Spinal microinstability and pseudarthroses of the fusion mass could negate the stabilizing effect of the spinal fusion and further add to the force on the facets or transverse processes. Moreover, the frequently poor quality of bone at the fused levels can make it particularly susceptible to fracture.²

A single case of bilateral pedicle stress fractures within the proximal vertebrae after posterolateral lumbar fusion has been reported.²¹ Certainly given the cases presented here, pedicle fractures may be found not only following posterolateral but also posterior fusions. As for the rarity of this complication, it is likely due to a combination of the following: 1) the difficulty in radiographically de-

tecting pedicle fractures; 2) the increased weakness of the pars interarticularis relative to the pedicle; and 3) the shorter moment arm between the body and pedicle compared with that of the body and pars.

Each patient who developed a pedicle fracture had neurologically improved immediately following the extensive unilateral decompression with partial pediculotomy and contralateral autologous bone fusion; however, the patients exhibited poor bone fusion and/or pseudarthroses. The three pedicle fractures occurred a mean of 7.7 months following surgery. Two of the three patients experienced symptoms that necessitated further surgical intervention following the pedicle fracture. The two patients who required additional surgery exhibited leg pain ipsilateral to the original side of the spinal decompression. Removal of the fractured pedicle, further decompression, and spinal fusion enhanced with biomaterials (collagen or bovine graft) yielded pain free outcomes in both patients.

One way to avoid these fractures is to perform complete facetectomies along with any partial pediculotomy. Unfortunately, the removal of an entire facet or 50% of two facets has been shown to cause substantial spinal instability.¹ An increase in the instability of the spine following facetectomy might necessitate the placement of instrumentation for fusion. Another method for avoiding fractures would be to minimize the pediculotomy by drilling down only the inferior surface where the nerve root exits. Ultimately, better and faster bone fusion could help to avoid these complications by better distributing biomechanical forces along elements of the neural arch at multiple spinal levels. Advances in molecular biology and, in particular, bone morphogenetic protein research show promise for enhancing both the rate and biomechanical strength of bone spinal fusion.^{14,15,19,26}

CONCLUSIONS

Symptomatic or asymptomatic pedicle fracture is a potential complication following extensive decompression and posterior or posterolateral fusion. The complication can be identified by performing CT scanning and should be considered in patients with recurrence of low-back or lower-extremity pain. The occurrence of pedicle fractures emphasizes the complex biomechanical nature and interdependence of spinal elements in overall spinal stability and neurological functioning. Biomolecular augmentation of spinal fusion with osteoconductive and osteoinductive materials may help achieve more effective load distribution in the spine and reduce the occurrence of pedicle fractures.

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