CLINICAL ARTICLE

Surgical Treatment for Posterior Rim Separation of the Lumbar and Sacral Vertebrae

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Objective: The posterior rim separation of the lumbar and sacral vertebrae has been ascribed to various mechanisms. The procedure of operative treatment is still controversial. The authors' objective was to study the therapeutic methods of posterior vertebral rim separation.

Methods: Thirty-four patients, including 23 males and 11 females whose ages ranged from 24 to 65 years (mean 41.3 years), were treated for posterior vertebral rim separation by various methods. All patients had discectomy and removal of bony fragment. Wide fenestration or hemilaminectomy was performed for 24 type I-III lesions, laminectomy for four type II and one type III lesion, and bilateral fenestration for 5 of 17 type II lesions. Posterior lumbar interbody fusion (PLIF) was performed in 11 patients using autogenous iliac bone or poly (ether-ether-ketone) (PEEK) spacer implant.

Results: Follow-up studies were performed for all patients ranging from 11 months to 4.6 years with an average period of 2.7 years. There were no serious intra-operative or postoperative complications. Satisfactory results were achieved in all patients except two with type III lesions, mostly because of a long history of hypaesthesia of the leg and a drop foot. Eleven patients who had PLIF exhibited bony fusion at final follow-up.

Conclusions: Early operative treatment should be performed on patients after a brief trial of conservative treatment. A proper surgical operation must be based on the type and location of the separated bony fragment and clinical symptoms.

Key words: Lumbar vertebrae; Posterior lumbar interbody fusion; Posterior rim separation; Sacral vertebrae

Introduction

Posterior vertebral rim separation is defined as a defect in the margins of the vertebral body with a detached bony fragment within the spinal canal and sclerosis of the surface of the bone defect. Several terms are applied to this lesion, such as lumbar vertebral apophyseal ring fracture¹⁻⁴, posterior marginal node⁵, vertebral limbus fracture⁶, posterior bony avulsion, and lumbar vertebral epiphysis dislocation^{7,8}. The physiopathology still remains controversial: avulsion related to disc herniation, pure traumatic avulsion, or variants of marginal cartilaginous nodes may all be related to the etiology. The lesion was first considered to occur only in adolescents and to be purely traumatic^{2,8-10}; however, it may also affect young adults and can occur without trauma or

even strenuous physical activity^{11,12}. Many authors have emphasized the need for operative treatment for this lesion, but the procedure of choice remains controversial^{3,7,13-15}. The condition needs special study and surgical techniques. Between 2000 and 2010, 34 patients were operated by different surgical methods based on their clinical presentations and the results are presented and analyzed in this report.

Materials and Methods

Patient Data

Thirty-four patients, 23 males and 11 females, with posterior vertebral rim separation, ranged from 24 to 65 years (mean

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41.3 years) were evaluated. Eighteen patients were 24 to 40 (52.9%), 12 were 40 to 50, and 4 were over 50 years old. Only five patients had histories of trauma, and there were no clear histories of trauma in the remaining 29 cases. The course of disease ranged from 8 months to 32 years.

The primary presenting symptom was low back pain in all cases with reduced lumbar movements and associated unilateral or bilateral radiating pain (unilateral in 22 cases, bilateral in 12 cases). Intermittent claudication was present in 21 patients, positive straight leg raising sign in 31 patients, lower extremity radicular sensory disturbances in 32 patients, cauda equina dysfunction in 2 patients, and diminished tendon reflexes in 26 patients. The severity of the clinical finding was assessed using the Japanese Orthopaedic Association (JOA)'s assessment of treatment for low back pain¹⁶. The extent of recovery was calculated using the formula, (postoperative score – preoperative score) ÷ (29 – preoperative score) × 100 (%).

All patients underwent both conventional lumbar radiography and computed tomography (CT). Separation of the posterior vertebral rim could be indentified on lateral plain films in 19 cases. CT identified the lesion in all 34 cases; in addition, CT identified associated lumbar disc herniation in 29 cases. CT demonstrated an arcuate, hyperdense bony ridge located within the whole anterior part of the spinal canal posterior to a defect in the vertebral body. The margin of the vertebral defect was lobulated and surrounded by a sclerotic rim; the bony fragment had a dense peripheral margin. Sagittal reformat sections were useful to demonstrate the detached bony fragments and narrowing of the spinal canal in selected cases. Eighteen patients underwent magnetic resonance imaging (MRI) and the MRI showed a defect in the posterior vertebral rim. The fragment was seen as an arcuate or angular low signal area lying posteriorly but could be difficult to identify. The lesions involved the posterior inferior rim of L₃ in one case, the posterior superior rim of L₄ in two cases, the inferior rim of L₄ in 10 cases, the posterior superior rim of L₅ in six cases, the inferior rim of L₅ in seven cases, and the posterior superior rim of S₁ in eight cases. The forms of separation of the posterior vertebral rim were classified by Takata into three types¹⁰: Type I, simple separation of vertebral cortical margin; Type II, larger avulsion with cancellous bone; Type III, small localized avulsion. Using this system, our cases included three type I lesions, 17 type II lesions, and 14 type III lesions. Associated disc herniation were absent in one patient with a type I, one with a type II, and three with type III lesions. Radiological findings of Schmorl node were noted in the lumbar spine in eight patients (23.5%). In two cases, there was associated L_{4,5} spondylolisthesis.

Surgical Technique

The operations were performed according to the type and location of the separated fragment and clinical symptoms of nerve root irritation. For cases where the herniated mixtures were lateral, wide fenestration or hemilaminectomy was

applied to the symptomatic side; for cases that mixtures were central or paracentral with bilateral root irritation, the same treatment was applied to both sides; cases associated with large bony fragment and lateral crypt narrowing were treated with laminectomy and posterior lumbar interbody fusion (PLIF). All patients had surgery consisting of 19 unilateral wide fenestration, five bilateral fenestration, five hemilaminectomy, and five laminectomy (Table 1). Wide fenestration or hemilaminectomy was performed for 24 type I-III lesions, whereas laminectomy was required for four type II and one type III lesions, and bilateral fenestrations were performed for five of 17 type II lesions. PLIF was performed in 11 patients using autogenous iliac bone or poly (ether-ether-ketone) PEEK spacer implant. Pedicle screw instrumentation was used in six patients.

The surgical treatment consisted of discectomy and removal of the separated bony fragments. Extended posterior exposure of the dural sac could provide better access to the lesion and disc, including transaxillary dissection. A total or partial laminectomy at the affected levels was suggested with consideration of the clinical symptoms, the fragment types, and the location of the separation. Wide fenestration was carried out through an extended laminotomy of the inferior part of the lamina superiorly until the ligamentum flavum could be resected. The superior part of the caudal lamina was also resected. When the lesion extended laterally within the canal and impinged on a nerve root, it generally required resection of one-third to one-half of the medial facet in order to obtain adequate exposure of the dural sac, root sleeves, and bone fragments. Early resection of disc material and entry into the interspace provided better access to the fragments. If the disc has been completely resected the interspace can be evacuated, and then, the movable fragments can be displaced easily to the interspace. Fragment resection by transaxillary approach could be performed using the deep laminectomy rongeur, curette, and small chisel through the vertebral body and the posterior longitudinal ligament. Safe and complete removal of bony fragments was facilitated by using these techniques that permitted protection of both root sleeves and the dural sac; especially, when the sharp curettes were used to remove the lesions.

TABLE 1 Operation procedures

Operation	Type of lesion		
	I	II	III
Wide fenestration	2	8	9
Hemilaminectomy	1*	0	4
Bilateral fenestration	0	5*	0
Laminectomy	0	4*	1*

*With posterior lumbar interbody fusion (PLIF).

Results

The surgical findings did not suggest recent fracture. The pathological examination of the fragments of bone showed degenerative cartilage associated with bone. The defect in the corner of the vertebral body was filled with degenerative disc material and a calcified network of connective tissue.

All patients had been followed up for 11 months to 4.6 years with a mean duration of 2.7 years. There were no serious intra-operative or postoperative complications, such as infection, nerve injury, dural sac laceration, cerebrospinal fluid leakage, loosening and breakage of internal fixation or pseudoarthrosis.

Patients were divided into four outcome categories: excellent, good, fair, and poor. Excellent: recovery completely and return to previous activities. Good: minimal residual radicular or cauda equina dysfunction and return to previous activities. Fair: partial improvement in neurological symptoms and signs. Poor: no relief of symptoms, or worse. Twenty-four patients demonstrated excellent outcomes. Eight patients had good outcomes, including two with cauda equina dysfunction associated with type II lesions. Thirty-two patients (94%) had satisfactory results. Two patients had fair outcome, mostly because of a long history of hypaesthesia of the leg and a drop foot. Postoperative outcomes were dependent on the severity of the preoperative deficit. The JOA scores on admission ranged from 4 to 17 points (mean, 12.4), JOA score at follow-up improved to between 19 and 29 points (mean, 27.2). The degree of recovery ranged from 60% to 100% (mean, 93.8).

Illustrative Cases

Case 1

A 46-year-old female had a 17-year history of unprovoked low back pain and pain radiating to the back of right thigh and the lateral aspect of right calf and foot. Physical examination revealed positive straight leg raising sign at 30° and positive well leg raising test at 50°, hypaesthesia at the lateral aspect of the right calf and foot, paresis of the dorsiflexion of the foot and toe, and diminished Achilles tendon reflexes.

Plain radiography showed a bony fragment of the posterior inferior margin of the fourth lumbar vertebra associated with L₄₋₅ spondylolisthesis, and more prominent in flexion (Fig. 1a) than in extension (Fig. 1b). CT showed a narrow spinal canal caused by a crescent shaped fragment with a defect of the vertebra (Fig. 1c). The separation of bony fragment was classified as type II. MRI showed dural sac compression by the herniated disc (Fig. 1d). PLIF was performed at L₄₋₅ using PEEK spacer implant with pedicle screw instrumented fusion. At one year follow-up, the patient recovered completely and returned to her original occupation without limitations (Fig. 1e,f).

Case 2

A 65-year-old man complained of back pain radiating to the bilateral lower extremities, especially to the left buttock and

lower extremity. On examination, the left straight leg raising test was positive at 40° and right at 60°. He had mild weakness in the dorsiflexion of the left foot, hypaesthesia at the lateral aspect of the left calf and foot, and diminished left ankle reflex. No neurological deficit was present at right leg.

On plain radiography, no bony fragment was identified (Fig. 2a). CT showed posterior displacement of the posterior fragment of L₅ with a defect of the vertebra and anterior Schmorl nodes (Fig. 2b,c, open arrow). MRI showed L₄₋₅ disc herniation, a corner defect in the posterior superior margin of L₅, and a small bony density projecting into the spinal canal (Fig. 2d). Left wide fenestration was performed and postoperatively, the patient had complete relief of pain (Fig. 2e).

Discussion

Posterior rim separation of the lumbar and sacral vertebrae is an uncommon lesion. Patients usually present with low back and leg pain, reduced lumbar movements, and intermittent claudication, similar to lumbar disc herniation and spinal stenosis with motor and sensory deficits. The pathophysiology of this abnormality still remains controversial. The diagnosis of the lesion is solely based on radiological findings. Conventional radiographs can be difficult for detection of the bony fragment, especially at the L₅ or S₁^{10,17}. In this series, we identified 19 cases (55.8%) on plain lateral films especially in flexion, which may show the abnormalities more clearly. On the other hand, CT best defines the extent of the bony defect in the vertebral body with the appearance of the separated fragment along with the degree of spinal canal compression and any associated disc herniation. MRI is in fact inferior to CT in detection of the posterior vertebral rim separation^{6,17}. Diagnosis and classification according to Takata and Epstein is based only on CT signs^{6,10}. CT has been proven to be the gold standard diagnostic examination technique for detection of the separated fragment and it provides essential information for pre-operative planning to achieve optimal outcomes^{2,10,14}.

The lesion has peculiar pathogenetic, anatomic, and radiological features. Conservative therapy is usually ineffective in many cases^{1,3}, and an operation is often recommended but the choice of surgical procedures remains controversial. The effect of standard discectomy or decompression alone is often not satisfactory. Some patients still continued to have low back pain after surgery if the bony fragment had not been removed and they may require a second surgery¹. Most authors recommend removing the free bone fragment together with the intervertebral disc^{1,7,13,18}, although an associated disc herniation is not found in all patients, to relieve the compression on the nerve root or cauda equina and to avoid irreversible damage to nerve tissue. According to CT, MRI, and surgical findings, associated disc herniations were absent in five cases in our series, possibly due to the short length of time elapsed since the bony fragment occurred, or small and insignificant detached fragment to the vertebral body, however vertebral rim separation may at any time favor the onset of a posterior disc herniation at the same level. Type III lesions are lateral and localized fragments that significantly displaced to the cephalad

Fig. 1 Type II lesion, and posterior lumbar interbody fusion (PLIF) was performed at L₄₋₅. (a,b) Lateral flexion and extension radiographs reveal bony density projecting into the spinal canal at the lower L₄ level (arrow). (c) Computed tomography. Crescent shaped fragment with osseous defect of the vertebral body. (d) Sagittal T₂ weighted MRI showing evidence of cord compression opposite the L₄₋₅ disc level. (e, f) Anteroposterior and lateral radiographs one year after PLIF.

or caudad pedicular levels. Ordinarily, this requires unilateral wide fenestration or hemilaminectomy to obtain adequate exposure of the dural sac. Decompression range often has to extend to the cephalad or caudad pedicle level with resection of the one-third to one-half of the medial facet to obtain better exposure of the root sleeves and bone fragment. The impact of surgery on the posterior column is not serious as patients still are able to maintain biomechanical stability of the lumbar spine^{19,20}. In our series, postoperative follow-up confirmed there was no case of lumbar spinal instability in these cases. Type I and type II separated fragments were found much more medially. Those lesions often required unilateral or bilateral wide fenestration, hemilaminectomy, and laminectomy. In patients suffering from symptoms of unilateral nerve root irritation, wide fenestration was applied to the symptomatic side. For cases with bilateral root irritation, the same treatment was applied to both sides. For cases with large bony fragment, spinal canal stenosis including 1 type III, and lumbar spondylolisthesis, the treatment of choice was laminectomy with PLIF, and pedicle screw fixation.

PLIF surgery was applied to the patients with a large fragment, occupying most of the anterior spinal canal, and

lateral recess stenosis. PLIF with its associated laminectomy allowed the lateral recess and nerve root canal to be fully released, and the fusion of the anterior column and middle column prevent the risk of lumbar instability. In 11 patients with PLIF, they achieved bony fusion without screw breakage or loosening or any other complication at the final follow-up.

Early resection of disc material can provide an evacuated interspace; a trough could be created around the fragment in the interspace to allow the movable fragments to be displaced easily to the interspace. The trough provides the surgical corridor to apply various surgery apparatus and provide access to the fragments. With the creation of the trough, resection of the fragment is not only more convenient, but it also avoids nerve root and dura sac injuries.

All patients in this series were adults. The results of surgical treatment were very good, except for two patients with type III lesion. The two patients had been treated with conservative therapy in other hospitals and had recurrent symptoms with a prolonged history of hypaesthesia of the leg, and a drop foot. The final results indicated that perhaps operation treatment should have been applied to the patients as early as possible when conservative therapy had no obvious effect.

Fig. 2 Type II lesion. (A) Plain radiograph. No recognizable fragment at the posterior superior margin of L₅. (B,C) Computed tomography. Bony fragment and anterior Schmorl nodes (white arrow). (D) MRI showed L₄₋₅ disc prolapse and a small bony density projecting into the spinal canal. (E) Postoperative CT. The bony fragment has been completely removed.

In conclusion, operative treatment should be applied to patients as early as possible when conservative therapy had no obvious effect. Different operative methods should be used according to the type and location of the separated bony fragment and clinical symptoms. Preoperative accurate diagnosis and understanding of the type and location of the separated fragment were essential to successful surgical treatment. The

condition needs special surgical technique to resect the fragment and intervertebral disc, and the complete releasing of the nerve root and cauda equina compression. Fusion may be appropriate if postoperative segmental spinal instability is a major concern. TLIF could treat compression of spinal canal and spinal instability, and it is an effective operation for the lesion.

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