Posterior lumbar vertebral rim fracture and associated disc protrusion in adolescence

GEORGE EHNI, M.D., and STEVEN J. SCHNEIDER, M.D.

Department of Neurosurgery, Baylor College of Medicine, Houston, Texas

Two cases of posterior lumbar vertebral rim fracture and associated disc protrusion in adolescents are presented. Disc compliance and developing vertebral structure were thought to be primarily responsible for this unusual injury. Occurring primarily in adolescent males, this entity most commonly affects the L-4 vertebra. One of the cases involved disc rupture at three levels. This injury is thought to be due in part to union of the anuli by the posterior longitudinal ligament, and in part to rim fracture and limited prolapse rather than frank single-level herniation in an adolescent. A review of the embryology, literature, and theoretical mechanism for occurrence at multiple levels is included.

KEY WORDS · vertebral fracture · herniated nucleus pulposus · spinal fracture · adolescence

Lumbar disc disease in the adolescent age group is extremely rare. Individuals less than 20 years of age are estimated to comprise 1% to 3% of all patients with lumbar disc protrusions. Posterior lumbar vertebral rim fractures in adolescence, sometimes referred to as "posterior apophyseal ring fractures," are rarer still. A total of 20 cases in adolescents have been reported previously. Two cases of posterior lumbar vertebral rim fracture and associated disc protrusion are presented. Both were in adolescent boys, at one level in one and at three levels in the other. A review of the embryology, literature, and theoretical mechanism for their occurrence at multiple levels is presented.

Case Reports

Case 1

This 13-year-old boy was well until he injured his back while performing a backflip on the trampoline. While in the air and in the process of turning over, he experienced a sudden severe pain in the lower back to the right of midline at belt level. He landed on his feet, suffering no direct blow to the back, but the pain was so severe that he had to lie down. He remained seated and flexed for several hours until he was brought to a physician where plain roentgenograms were reported as normal. Subsequent treatment consisted of heat and recumbency on bed boards without any relief. The pain was exacerbated by extension and Valsalva maneuvers, with radiation into the upper buttock, iliac crest, and groin.

Examination. Physical examination demonstrated a list to the left, limited extension, and right lateral flexion, tenderness of the lower lumbar region, a positive straight-leg raising test bilaterally, and minimal subjective hypalgesia down the front of the right shin. Motor strength, tone, and reflexes were normal. Plain x-ray films demonstrated a bone fragment in the spinal canal opposite the posterior aspect of the L-4 vertebral body with a defect at the inferior margin of the body. Lumbar Pantopaque myelography showed a partial myelographic block at the L4-5 disc level with compression of the thecal sac by the bone fragment.

Operation. Bilateral exposure of the L4-5 disc was performed by removal of the lower portion of the L-4 laminae and yellow ligaments. A bone fragment from the lower edge of the L-4 body and herniated disc fragments were found within the canal and removed. Residual anular attachments of the bone fragment to the upper edge of the L-5 body were noted. The L4-5 interspace was emptied of residual nuclear material and the thecal sac was well decompressed.

Postoperative Course. Postoperatively, the list to the left and the pain improved, but the patient had some persistent paresthesia over the right shin. The paresthesia eventually resolved, but he continued to experience intermittent low-back and right hip pain after prolonged standing or basketball playing. Follow-
Vertebral rim fracture with ruptured disc

Case 2

This 16-year-old boy was well until his back was injured when the automobile in which he was riding overturned into a narrow ditch, pinning both doors and trapping him inside. Some efforts to move him produced a feeling of stiffness in his back. Once freed, he was able to walk, but for several days he experienced severe muscle spasms in his back with radiation into the left leg. Plain x-ray films performed at another hospital were reported as normal. With improvement, he participated in spring football practice; however, the coach began to notice that he exhibited a list to the left. The team physician thought he had a discrepancy in leg length, and he was referred to an orthopedic surgeon. With the exception of the list, the patient was found to be asymptomatic, with legs of equal length. Plain x-ray films and a computerized tomography (CT) scan of the lumbar spine were markedly abnormal. The patient was referred to our institution for evaluation and treatment.

Examination. On physical examination, there was evidence of translation to the left while standing and a diminished left patellar reflex. A straight-leg raising test was negative. The original plain x-ray films and CT scan were reviewed and demonstrated bone fragments with discal retropulsion impinging on the spinal canal at the L2–3, L3–4, and L4–5 levels (Fig. 1). Defects in the margins of the posterior vertebral bodies were also noted. Magnetic resonance imaging confirmed three consecutive disc protrusions with multilevel canal ste-

Fig. 1. Preoperative studies in Case 2. Left: Plain film, which was initially interpreted as normal, in fact shows intervertebral disc space narrowing at multiple segments, as well as apophyseal fragments at L3–4 and L4–5. Right: Computerized tomography scans of the lumbar spine showing both apophyseal ring fragments and “stripped-up” posterior longitudinal ligament at multiple levels.
nossis and a high-grade block at L2–3. The cerebrospinal fluid protein content was elevated at 89 mg%.

Operation. The patient was taken to surgery where bilateral exposure of the L2–3, L3–4, and L4–5 discs was performed via a midline incision, leaving intact the majority of the neural arches, spinous processes, and interspinous ligaments. At each level, the adjacent laminar edges, yellow ligaments, and median facets were removed, affording generous decompression of the dural sac and roots. The discal protrusions were visually examined and palpated at each level. They were firm without evidence of annular rupture or extruded nuclear material. The bone fragments were incorporated into these ridges at each level and were inseparable.

Postoperative Course. The patient's list to the left resolved and his patellar reflex returned. His strength and sensation remained normal. At examination 8 months after surgery he remained asymptomatic and planned to return to playing football in the spring.

Discussion
At approximately 25 weeks' gestational age, the cartilage over the cephalic and caudal surfaces of the osseous vertebral body assumes a columnar arrangement and is destined to become the growth plate. The cells most distant from the growth plate are flattened and have the characteristics of hyaline articular cartilage, forming the disc. Between the vertebral disc and the body exists the apophyseal bone ring, or vertebral rim, which growth occurs. The ring is attached only through the cartilage of the growth plate until calcification appear in the rims at the age of 6 to 8 years in girls and 7 to 9 years in boys, but have been reported as early as 2 years of age. At the age of 13 to 15 years in girls and 15 to 17 years in boys, the vertebral rim ossifies and begins fusion with the body. The lumbar spine is the last region to fuse. Complete fusion of the rim to the body is reported to occur at about 20 years of age. Fracture of the posterior lumbar vertebral rim was first described in an adult by von Meyenburg in 1946. Since that time an additional 27 cases have been reported, 20 of which occurred in the adolescent age group. The relationship of this disorder to trauma, its presenting signs and symptoms, the surgical findings and procedures, and outcomes of 17 documented cases are listed in Table 1. The three case reports by Garrido, et al., describe only the levels of fracture and are not included in this summary. Of the 17 cases, only two occurred in girls. Trauma was implicated in 10 of the cases. All 17 patients presented with pain in the back and/or one or both legs; neurological deficits ranged from none to paraparesis. Frank discal rupture or protrusion was reported in all cases. The inferior rim of L-4 at the L4–5 interspace was involved in at least 14 of the 17 cases. No cases of multiple involvement have previously been reported. Surgery was performed on 15 of the 17 patients, and consisted of laminectomy (partial or complete), discectomy, and removal of the bone ridge. The immediate postoperative results were good, with resolution of symptoms in those patients for whom follow-up data were available. A follow-up period of 6 months or more was described for nine of the 17 patients.

Several mechanisms by which these injuries occur have been postulated. These include initial rim fracture with avulsion of the disc, initial disc rupture with avulsion of the rim, transosseous disc rupture with rim separation, and disturbances in ossification. Close association between fractures and disc herniation probably arises from the firmer attachment of the posterior rim to the disc as noted above. The partially ossified, unfused vertebral rim of an adolescent is more susceptible to displacement than the firmly fused rim of an adult.

A “tethered chain” concept is proposed to explain this type of trauma-induced lesion. During loading, the spine first acts like a linked chain, distributing forces both cephalad and caudal. Once placed under sufficient tension, one site or link may break prior to the others, thereby identifying it as the weakest link. In the acutely stressed spine, one disc (and only one) ruptures prior to the others and relieves adjacent segments of injurious forces. This accounts in part for the fact that anular ruptures with extruded free fragments are rarely seen at more than one site; whereas, spondylotic prominences such as hard discs or ridges (denoting a more chronic degenerative pathology) are often multiple. To further develop the concept, the spine is envisioned as a primary chain paralleled by and tethered at each link by a second chain of equal or greater strength. This second chain remains unstressed so long as the first chain is intact. When one link of the primary chain incompletely breaks, the tethers then come into action and distribute these forces to adjacent levels of the second chain. These links may break if sufficient stress is applied, leading to a sequence of incomplete breakages without complete rupture at any one level. In the adolescent spine, the above possibility can arise where no one disc level undergoes complete anular rupture under a loading stress. This can occur because at certain stages of development (such as at the ages of 13 to 15 years) the apophyseal rings, having only cartilagenous attachment to the centrum, are retropulsed posteriorly along with the anuli to which they are firmly attached. In this immature spine, a protective “tether” by Sharpey's fibers allows the total stress to be divided or shared, as
Vertebral rim fracture with ruptured disc

TABLE 1

<table>
<thead>
<tr>
<th>Author &amp; Year</th>
<th>Age (yrs), Sex</th>
<th>Trauma</th>
<th>Signs &amp; Symptoms</th>
<th>Vertebral Level</th>
<th>Surgery &amp; Findings*</th>
<th>Follow-Up Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skobowytsh-Okolot, 1962</td>
<td>19, M</td>
<td>none</td>
<td>L-5-S-1 radiculopathy</td>
<td>L-4 (inferior rim)</td>
<td>laminectomy, discectomy &amp; partial bone fragment removal; HNP</td>
<td>asymptomatic at 5 mos, employed</td>
</tr>
<tr>
<td>*HNP = herniated nucleus pulposus.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

seen with two tethered chains. An additional mechanism may well involve the posterior longitudinal liga-
mament which firmly attaches each anulus to its neigh-
boring anuli, but not to the vertebrae. This could ac-
tount for additional stress distribution and eventual multilevel involvement.

Although trauma was implicated in both patients 
presented here, it is possible that in Case 2 (with mul-
tilevel disease) there was an underlying ossifica-
tion disturbance involving the vertebral rim posteriorly, 
such as Scheuermann’s disease. There was no evidence 
of other segments of the spine being involved, however. 
It could be argued that the case of multilevel disease 
represents posterior anular calcification as described by 
Reale and Gambocorta, 6 but the radiographic findings 
of posterior vertebral margin defects and findings at 
surgery strongly substantiate a component of rim frac-
ture and disc protrusion. Such lesions could arise from 
a combination of the above mechanisms rendering an 
individual with delayed or impaired ossification more 
susceptible to trauma.

The surgical treatment has usually consisted of ex-
tensive exposure via laminectomy, discectomy, and 
removal of the bone ridge. In our case of multilevel 
disease without frank rupture (Case 2), a more conser-
vative approach was selected. A generous decompre-
sion was obtained via laminotomies, flavectomies, and 
medial facetectomies without removal of the bone ridge 
or disc. It is proposed that preservation of as much of 
the posterior elements and unruptured discs as possible 
is essential, especially in an individual who will remain 
athletically active.

References

J. Neurosurg. / Volume 68 / June, 1988 915
Joint Surg (Am) 33:783–787, 1951


Manuscript received August 10, 1987.

This paper was presented before the International Society for the Study of the Lumbar Spine in May, 1986, and the Texas Association of Neurological Surgeons on May 16, 1987. Dr. George Ehni died on September 2, 1986.

Address reprint requests to: Bruce Ehni, M.D., The Neurosurgical Group of Houston, 6560 Fannin Street, Suite 1250, Houston, Texas 77030.