Case Report

Vertebral Body Osteopenia in an Uninstrumented Spinal Fusion

Michael A. Cushner, MD
John A. Glaser, MD

With the advancement of bone densitometry technology, recent studies have documented vertebral body osteopenia in instrumented spine fusions. Human and canine studies often have concluded that rigid fixation of instrumented spine fusions leads to stress shielding and resulting osteopenia.

This article reports a case of an uninstrumented spine fusion with documented vertebral body osteopenia by both densitometry and histologic studies.

CASE REPORT

A 46-year-old man presented with back and above-the-knee anterior and posterior leg pain that gradually worsened over the proceeding 6 months. The patient had an L2-L4 posterior spine fusion at age 20 for a fracture of the third lumbar vertebra.

On physical examination, he had an antalgic gait, intact motor function, and pain with femoral stretch test but not with straight leg raise on the left side. Radiographs showed a kyphotic deformity at the old injury site and a solid fusion mass with no motion noted on flexion and extension views (Figure 1). Computed tomographic myelogram revealed thinning of the thecal sac in the area of the deformity. The patient reported no other chronic medical condition and was not taking any medication regularly.

Preoperative bone densitometry studies were performed on the lumbar spine in AP and lateral views (Figure 2). A Hologic QDR-1000/W machine (Hologic Inc, Bedford, Mass) was used with standard lumbar spine settings. The lateral view is a more accurate calculation because it eliminates the bone mass of the posterior fusion. The bone mineral density at L1 (outside the fusion mass) measured 0.950 g/cm². The densities of L2, L3, and L4 in the lateral view were 0.470, 0.590, and 0.579 g/cm² respectively.

Biopsies of the L3 vertebral body and posterior fusion mass were taken during the placement of femoral strut allograft and posterior osteotomy with instrumentation. Five specimens from each area were examined at different depths in the bone using Goldner’s trichrome stain (Figure 3). The average percentage of the L3 vertebral body sample was 10.3% ± 2.7% (SD) and the posterior fusion mass was 13.4% ± 2.2% (SD). The average percentage of calcified trabecular bone ranged from 15%–25%.

Femoral strut grafting, L3 corpectomy, and osteotomy were performed without complication. At 1 year postoperatively, the patient reported decreased pain and increased activity. Postoperative radiographs showed intact hardware and evidence of fusion mass.

DISCUSSION

Hadra’s use of silver wire in 1891 and Lange’s use of steel rods in 1902 marked the beginning of spinal instrumentation and the use of metal implants to stabilize the spine. Scoliosis, infection, fractures, and degenerative changes of the spine have all been treated with instrumentation. As this procedure has

Figure 1: Lateral radiograph of the spine showing kyphotic deformity and solid fusion mass.

Figure 2: Anterior (A) and lateral (B) DEXA scan of the lumbar spine.
increased in popularity, the controversy over the use of spinal hardware also has continued.

Risks of neural injury, wound problems, pseudarthrosis, nonunion, and implant failure have been examined in both instrumented and uninstrumented spine fusions. The use of rigid instrumentation in the spine has been shown to result in stress shielding and subsequent osteopenia of the vertebral body. Stress shielding can occur when a stiffer material works in conjunction with the stress riser resulting in a decrease in the physiologic stress on a biologic material. This case illustrates that even a biologic material such as a posterior bone mass may cause stress shielding of the more anterior vertebral body with resulting osteopenia.

Dual-energy x-ray absorptiometry (DXA) has expanded on the earlier technology of single- and dual-photon absorptiometry by using higher radiation and finer spatial resolution to determine bone mineral density. This is a useful tool for analyzing the existence of vertebral osteopenia in the spine. Examination of the lumbar spine in the lateral plane allows the posterior bone graft to be excluded and a true measurement of vertebral body bone density can be determined. Furthermore, lateral examinations within and outside the fusion mass avoid inclusion of the posterior elements in the densitometry measurement of the vertebral bodies.

Myers et al. reported vertebral osteopenia in instrumented spine fusions using DXA technology, but histologic studies were not performed. No long-term studies concerning bone mineral density in uninstrumented spines have been reported. Lipscomb et al. studied the vertebral bodies above the fusion mass and the fusion mass itself using dual-photon densitometry. Twenty-five uninstrumented spine fusions were measured preoperatively at regular intervals for 12 months. At 1 year, the density of the vertebra adjacent to the fusion mass increased in 60% of the patients; this is likely due to an increase in the patients’ activity. The fusion mass increased in density after an initial cyclic period of remodeling. No determination of the bone density of the vertebral bodies in the fusion area was made.

In our patient, the bone mineral density of vertebral bodies L2-L4 that we incorporated with the fusion ranged from 470-490 g/cm². They are more than one standard deviation below the average density for men of the same age and 42% less than the L1 value of .950 g/cm² that is outside the fusion segment. These results imply the existence of osteoporosis in the vertebral bodies of the fusion area of an uninstrumented spine fusion. Of relevant note is the fact that the patient had a post-traumatic kyphosis. By shifting the patient’s center of gravity more anterior, this alignment would place greater stress on the fused anterior column and should increase the bone density. In fact, the vertebral bodies in the fusion showed decreased bone density even with the benefit of the increased stress from the kyphosis.

The histologic samples show a decreased percentage of calcified bone in the L3 vertebral body but at the same time show a well-developed posterior spine fusion mass. These findings are consistent with the idea that the posterior fusion mass is receiving the majority of the stress decreasing the force across the vertebral bodies, thus causing stress shielding.

The consequences of this relative anterior weakness due to vertebral body osteopenia are not completely known. Computer models of instrumented spines have demonstrated that an intact anterior column helps decrease bending movements of the posterior column by 50%. The anterior load sharing thus decreases the motion and force through the posterior column. An intact anterior column (vertebral body) in the instrumented spine may prevent implant failure by minimizing the motion at the bone implant interface. An intact anterior column in the uninstrumented spine decreases force across the posterior fusion and may prevent fracture, malunion, and nonunion of the posterior bone mass.

REFERENCES