Vertebral osteolytic defect due to cellulose particles derived from gauze fibers after posterior lumbar interbody fusion

Case report

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Vertebral cystic lesions may be observed in pseudarthroses after lumbar fusion surgery. The authors report a rare case of pseudarthrosis after spinal fusion, accompanied by an expanding vertebral osteolytic defect induced by cellulose particles. A male patient originally presented at the age of 69 years with leg and low-back pain caused by a lumbar isthmic spondylolisthesis. He underwent a posterior lumbar interbody fusion, and his neurological symptoms and pain resolved within a year but recurred 14 months after surgery. Radiological imaging demonstrated a cystic lesion on the inferior endplate of L-5 and the superior endplate of S-1, which rapidly enlarged into a vertebral osteolytic defect. The patient underwent revision surgery, and his low-back pain resolved. A histopathological examination demonstrated foreign body–type multinucleated giant cells, containing 10-μm particles, in the sample collected just below the defect. Micro–Fourier transform infrared spectroscopy revealed that the foreign particles were cellulosic, presumably originating from cotton gauze fibers that had contaminated the interbody cages used during the initial surgery. Vertebral osteolytic defects that occur after interbody fusion are generally presumed to be the result of infection. This case suggests that some instances of vertebral osteolytic defects may be aseptically induced by foreign particles. Hence, this possibility should be carefully considered in such cases, to help prevent contamination of the morselized bone used for autologous grafts by foreign materials, such as gauze fibers.

This article contains some figures that are displayed in color online but in black-and-white in the print edition.
at L5–S1, with lumbarization of the S-1 vertebra. Decompression was achieved by removing the loose posterior element and the fibrocartilaginous callus at the foramen. After meticulous removal of the cartilage and soft tissue from the excised posterior element, morselized bone and a piece of block bone were prepared for autologous bone grafting. Two Capstone, polyetheretherketone (PEEK) cages (Medtronic Sofamor Danek) were packed with the morselized bone. After complete removal of the intervertebral disc material and cartilaginous endplates, residual morselized bone was inserted into the anterior portions of the intervertebral space. The cages were then inserted into the intervertebral spaces, with a strut bone block placed between the cages (Fig. 1).

Postoperative Course. The procedure and postoperative recovery were uneventful. The patient demonstrated postoperative improvement and was able to walk, without remarkable low-back or leg pain, within the first postoperative year; his VAS-BP, VAS-LP, and JOA scores at this point were 30, 20, and 27, respectively. However, fusion was not achieved, as noted on CT images (Fig. 2). Fourteen months after surgery, the patient began to complain of recurrent, severe, low-back pain while walking. His condition gradually worsened, and analgesics had no effect on the symptoms; his VAS-BP, VAS-LP, and JOA scores at this point were 90, 90, and 16, respectively. Magnetic resonance imaging of the lumbar spine revealed cystic lesions at the inferior endplate of L-5 and at the superior endplate of S-1. We suspected either bone cyst formation, caused by mechanical stress due to nonunion, or the presence of a low-grade infection. However, his white-cell, eosinophil, and basophil counts; C-reactive protein (CRP) level; erythrocyte sedimentation rate (ESR); and body temperature were all within the normal limits. A biopsy was impossible because of the inaccessibility of the cystic lesions.

Sixteen months after surgery, additional surgery to treat the pseudarthrosis seemed unnecessary due to the low probability of infection. However, between postoperative months 16 and 19, follow-up CT scans demonstrated rapid ballooning of the cystic lesions, without marginal sclerosis. This change was found to be a vertebral osteolytic defect that rapidly increased in size from 8 × 7 × 10 mm to 20 × 14 × 17 mm (Fig. 2) and almost reached the superior endplate of L-5. Although a firm explanation of this rapid expansion of the cystic lesions, mimicking osteolytic defect (Fig. 3); the other samples did not contain such particles. The samples were all microbiologically sterile.

Identification of the Foreign Particles. The foreign particles in the multinucleated giant cells were examined with a micro–Fourier transform-infrared (FTIR) spectrophotometer (IRUs Molecular Microanalysis System, Thermo Fisher Scientific). The system consists of a rapid scan FTIR spectrometer and infrared microscope integrated into one instrument. FTIR spectroscopy revealed the foreign particles had a similar spectral pattern to that of natural cellulose. The spectrum of the particles was obviously different from those of the PEEK cages and human hair proteins (Fig. 4). An examination of a sample of cotton gauze revealed an almost identical spectrum as observed in the recovered sample (Fig. 4). Based on the results of these tests, the cellulose particles were presumed to have originated from the cotton gauze fibers used during surgery.

Discussion

Vertebral osteolytic lesions that occur after PLIF of-
Vertebral osteolytic defect after PLIF

Ten result from surgical-site infections. However, in our patient, blood samples failed to reveal any infectious agent; the white-cell counts, CRP levels, and ESR were within normal limits; gross purulence was not observed during the reoperations; and the histological and microbiological assessments did not indicate signs of infection. Thus, an aseptic mechanism appears plausible. Moreover, the possibility of an allergic reaction was unlikely, considering that this patient’s eosinophil and basophil counts were within normal limits.

Fujibayashi et al. showed that vertebral cysts, formed in cases where a titanium cage is present, could predict pseudarthrosis after lumbar fusion surgery. They assumed that mechanical stress caused these vertebral cysts, analogous to the cysts observed in knee or hip osteoarthritis, where stress-induced microfractures and subsequent bone resorption are believed to create cysts. However, the absence of sclerotic changes around the defect and the dramatic speed of cyst expansion observed in the present patient did not support the hypothesis that mechanical stress was the cause of the vertebral lesions.

Aseptic vertebral osteolysis has been previously reported. Frost et al. reported that 4 out of 9 patients (44%) developed particle-induced osteolysis around the bioabsorbable poly-/-l-lactide-co-d, l-lactide (PLDLLA) interbody cage at 11–16 months after PLIF (Table 1). The authors suggested that the PLDLLA fragments induced osteolysis. Jiya et al. also found that 2 (17%) of 12 patients undergoing PLIF with PLDLLA cages developed particle-induced osteolysis approximately 1 year postoperatively (Table 1). We believe that these cases were similar to our case in terms of the absence of sclerotic changes around the cystic lesion, the rapid growth of osteolytic lesions approximately 1 year after surgery, and the 10-μm size of particles phagocytized by the multinucleated giant cells. Particles, ≤ 10 μm in size, can cause particle-induced osteolysis, which is commonly noted in cases of periprosthetic

Fig. 2. Coronal (A–F) and sagittal (G–L) CT reconstructions and sagittal MR images (M and N) showing sequential changes in the vertebral endplate and the cystic lesions. At both 12 and 16 months after the operation, cystic lesions are evident on the inferior endplate of L-5 and the superior endplate of S-1. The clear zone around the pedicle screws is obvious, and fusion was not achieved. At 19 months postoperatively, the lesion is dramatically larger, without sclerotic changes around the vertebral osteolytic defect (arrows, D). Six months after the revision surgery, the defects are decreasing in size and bone regeneration is occurring. d = days; mo = months; p.o. = postoperative.

Fig. 3. Photomicrograph of a section of the sample obtained from just below the vertebral osteolytic defect. Note the presence of giant cells and phagocytized particles (arrows). H & E.
osteolysis associated with total joint arthroplasty.\textsuperscript{11} Kubo et al. showed that 11-μm polyethylene particles were more biologically active than larger particles. Their results also indicated that various other types of particles, in addition to polyethylene, could induce osteolysis;\textsuperscript{10} wear particles can be phagocytized and activate the macrophages to produce proinflammatory cytokines, chemokines, reactive oxygen species, and other mediators.\textsuperscript{6} Punt et al. reported that a wide range of particle numbers (from 1 to 1002 in 10 total hip arthroplasty patients) would elicit macrophage activation in patients requiring revision surgery, primarily for aseptic loosening;\textsuperscript{12} we observed 6 cellulose particles/mm\textsuperscript{2} in our patient with induced osteolysis.

We believe that the development of the vertebral osteolytic defect in our patient transpired in the following manner. First, postsurgical pedicle screw loosening and pseudarthrosis allowed micromotion between the vertebrae. The resultant intervertebral “grinding” process produced small particles from the cotton gauze fibers contaminating the morselized bone. When the particles were 10 μm or smaller, they were easily phagocytized by the macrophages that were thereby activated, resulting in the vertebral osteolytic defect. This may explain not only the delayed formation, but also the rapid expansion of the vertebral osteolytic defect. If the fusion had been successfully achieved within the first year after PLIF, the vertebral osteolytic defect might not have occurred.

Thus, although vertebral osteolytic defects are generally considered the results of infection, they may also develop aseptically. When preparing the bone graft, using bone cutting tools, we used cotton gauze to avoid slipping of the graft bone. We believe the contaminating gauze fibers were introduced during this step. Based on the presence

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>No. of Pts</th>
<th>No. of Pts w/ Osteolysis</th>
<th>Onset (mos)</th>
<th>Possible Etiology</th>
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<tr>
<td>Frost et al., 2012</td>
<td>9</td>
<td>4 (44%)</td>
<td>11, 15, 16, &amp; 16</td>
<td>PLDLLA fragments</td>
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<tr>
<td>Jiya et al., 2009</td>
<td>12</td>
<td>2 (17%)</td>
<td>12 &amp; 12</td>
<td>PLDLLA fragments, low-grade infection</td>
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* The inserted interbody cages were Telamon PLDLLA Hydrosorb (Medtronic Sofamor Danek). Pts = patients.
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dent case, preventing the introduction of contaminating foreign materials, such as gauze fibers, into the morselized bone used for autologous grafts is important.

Disclosure

Dr. Fuji reports a consultant relationship with Daiichi-Sankyo and receipt of royalties from Showa-Ika-Kogyo and Century Medical.

Author contributions to the study and manuscript preparation include the following. Conception and design: Takenaka. Acquisition of data: Takenaka, Tateishi. Analysis and interpretation of data: Takenaka. Drafting the article: Takenaka, Critically revising the article: Mukai, Hosono. Reviewed submitted version of manuscript: Mukai, Hosono. Study supervision: Fuji.

References


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