Imaging Current Spine Hardware: Part 1, Cervical Spine and Fracture Fixation

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OBJECTIVE. The goals of this article are to review the indications for use, the materials, and the designs of hardware more commonly used in the cervical spine; to discuss alternatives for each of the different types of hardware; to review normal postoperative imaging findings; to describe the appropriateness of different imaging modalities for postoperative evaluation; and to illustrate examples of hardware complications. This article will also review vertebral body fracture fixation.

CONCLUSION. Stabilization and fusion of the spine with intervertebral disk replacement, artificial ligaments, spinous process distraction devices, plate-and-rod systems, dynamic posterior fusion devices, and implants composed of new types of material are increasingly more common in the contemporary surgical practice. These spinal hardware devices will be seen more often in radiology practice. Successful postoperative radiologic evaluation of spinal hardware necessitates an understanding of the fundamental design of the hardware, the physiologic objective of the hardware, normal and abnormal postoperative imaging appearances, and complications unique to the hardware.

Keywords: cervical spine, disk replacement, fusion

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Approximately 1.2 million spinal surgeries are performed annually in the United States [1]. The largest increase has occurred in the number of spinal fusions performed, which has increased from a prevalence of 0.1 per 1000 Medicare enrollees in 1992 to 1.1 per 1000 enrollees in 2003 [2]. There have been marked innovations in surgical technique and devices over the past decade, with industry sales estimated at less than $100 million in 1990 to more than $6 billion in 2007 [1]. These increases translate into more pre- and postoperative imaging studies for radiologists to interpret. There is a 23% prevalence of neck and low back pain, which will likely surge as the elderly population increases in number in the coming years [3, 4].

The choice of surgical technique and device is dependent on patient symptoms and anatomy and on the surgeon's preference. Surgical fusion is the reference standard for cervical disk–related symptoms [5]. Techniques of dynamic posterior stabilization and disk replacement were introduced to reduce the potential for adjacent segment degeneration that occurs after spinal fusion. Additionally, new materials for interbody fusion and low-profile hardware designs were created to reduce nonunion and hardware-related complications, respectively. New materials are also available for use in treatment of vertebral body compression fractures. With these new materials and designs, there are potentially new complications to detect on radiography, CT, and MRI.

Thus, knowledge of the new techniques, devices, and related complications of spinal surgery is imperative for the radiologist to provide a meaningful contribution in the radiology report. This article, the first in a series of two, will provide a review of new and modified hardware used in the cervical spine, including normal and abnormal appearances on radiography and cross-sectional imaging, and will provide updates on vertebral body fracture treatment. The second article in this series [6], which will appear in the September issue of the *AJR*, will highlight new and modified hardware used in the lumbar spine including disk replacement, spinous process distraction, and dynamic posterior stabilization.

Choice of Imaging Modality

Radiography is the modality of choice for long-term surveillance of spine hardware.

Radiographs allow determination of device position and migration, hardware-related complications, progression of fusion, fracture, and segment degeneration.

Although radiography is the first choice for surveillance of the postoperative spine, it does not allow visualization of the spinal canal and nerve roots or of paravertebral soft-tissue fluid collections. Cross-sectional imaging is often used for symptomatic investigation. MRI assists in the characterization of fluid collections and of the extent of infection and identification of possible epidural communication. MRI is also used for determining integration of nucleus disk replacement. In the presence of metallic hardware, MR images can be optimized by increasing bandwidth, using spin-echo and turbo spin-echo sequences rather than gradient-echo sequences, and by reducing TE to increase the signal-to-noise ratio and minimize magnetic susceptibility artifact [7]. The metal artifact reduction sequence is another means of optimizing images for reduction of metal artifact. In this sequence, the section-selection gradient and bandwidth are increased with a narrow slice thickness and increased read gradient, and the view angle tilting is used [8].

CT is useful for evaluating osteolysis related to polyethylene wear and foreign body soft-tissue reactions, fluid collections, and subtle fractures. Three-dimensional reconstructions also help to assess the spatial position of interspinous distraction devices. CT myelography is useful in patients with contraindications to MRI who require evaluation of the nerve roots and spinal canal in relation to postoperative infection, adjacent segment degeneration, hardware impingement, and postoperative fibrosis [9, 10]. CT myelography is also useful in determining the location of a postoperative CSF leak [9, 10]. It has been shown to more accurately define the degree of spinal and neural foraminal stenosis compared with MRI [11]. However, CT myelography requires a lumbar puncture with contrast administration and is associated with risks of epidural injection, infection, contrast allergy, and bleeding [10].

Ultrasound can be used for the evaluation of superficial soft-tissue collections. However, extension of the process to the spinal canal may be difficult to visualize. Nuclear medicine is used less often in the evaluation of the postoperative spine. It primarily serves as a complementary modality in the diagnosis of postoperative spine infection. Technetium-99m methylene diphosphonate whole-body bone scanning has high sensitivity for postoperative spine infection and increased specificity when combined with ^{67}Ga citrate. This combination is the nuclear medicine test of choice for evaluation of spine infection [12]. PET/CT is highly sensitive; however, it is not very specific for infection.

Cervical Spinal Fusion and Instrumentation

Current trends in spinal fusion include new surgical routes of access, the use of less invasive hardware, and the use of new radiolucent materials for grafts. Fusion is indicated for patients with discogenic pain, nerve root compression, or both. The goals of cervical fusion include restoring and maintaining disk space height, decompressing the neural foramina indirectly, maintaining normal lordosis, and increasing the stability of the involved segment [13]. Anterior cervical diskectomy and fusion (ACDF) are performed with bone graft material with or without an interbody spacer and hardware for support and stability. In the cervical spine, an anterior metal plate has historically been used for support rather than a posterior approach, which would risk injury to the spinal cord and associated nerves [1].

Cervical cages are small, porous, hollow, and cylindric implants designed to restore physiologic disk height and allow bone growth through the implant with consequent bony fusion. Cage implants have historically been stainless steel or titanium with bone graft. The past decade has shown that cages composed of polyetheretherketone (PEEK) impacted with autologous bone graft (Fig. 1) have interbody fusion with high rates (92–100%) and good-to-excellent clinical outcomes [14–16]. PEEK is a biocompatible polymer with a modulus of elasticity closely resembling that of cortical bone, possibly causing more load sharing and better stress distribution [17]. It withstands high temperatures and radiation, is stronger than many metals, and does not cause artifact on MRI and CT.

Another potential new material is the radiolucent resorbable implant poly-L-lactide-co-D,L-lactide (PLDLLA). This material is a manufactured biopolymer introduced to hopefully reduce the complications of stress shielding and corrosion associated with metal cages [18]. However, one study showed significant clinical superiority of PEEK to PLDLLA and three cases of mild-to-moderate osteolysis in the PLDLLA groups [18].

Both ACDF using metal and ACDF using PEEK have potential complications of nonunion and subsidence (axial migration of the cage) (Fig. 2) into the vertebral body endplates that may result in narrowing of the neural foramen, nerve root compression, pseudoarthrosis, cervical instability, and adjacent segment degeneration due to the loss of lordosis [17, 19, 20]. Rates of subsidence for PEEK are similar to those for metal cages, reported at 25% for more than 2 mm of subsidence and 24.9% for more than 3 mm of subsidence [20]. Additional complications include nonunion, which is seen on imaging as a lack of osseous incorporation at 6 months after surgery. A potential complication observed with PEEK is particle wear of the material or breakdown of recombinant human bone morphogenetic protein type 2 (BMP-2) within the PEEK cage, leading to osteolysis [21, 22].

Life-threatening complications have been reported with use of the Medtronic Infuse Bone Graft/LT-Cage Lumbar Tapered Fusion Device, which is recombinant human BMP-2 used in combination with an absorbable sponge within a metal cage [23]. The device was approved by the U.S. Food and Drug Administration (FDA) only for use in the lumbar spine, but it is being used "off-label" in the cervical spine for ACDF or anterior corpectomy and fusion. Reported airway complications include airway obstruction requiring unplanned intubations and tracheotomies, hoarseness, dysphagia, and dyspnea [24]. Another study found prolonged hospital stays and readmissions within 48 hours of surgery due to respiratory complications and postoperative hematoma [25]. Thus, the off-label use of this device is currently not recommended and is a source of medical lawsuits.

Additional potential complications of ACDF include adjacent-level degeneration in up to 53% of patients, hardware loosening or fracture (Fig. 3), pseudoarthrosis, graft extrusion, donor site pain, infection (Fig. 4), and dural tear [12]. Dysphagia is an early postoperative problem in up to 67% of patients [26] and is a chronic symptom in 3–21% of patients [27]. In an effort to prevent dysphagia, the Zero-P (DePuy Synthes) device was developed as a low-profile implant for stand-alone anterior interbody fusion of the cervical spine [28]. The Zero-P device consists of a preassembled interbody spacer composed of PEEK material and a radiolucent plate that does not protrude past the anterior wall of the vertebral body (Fig. 5). It is held in place with locking, self-tapping screws.

In recent studies, investigators reported similar rates of early dysphagia with the Zero-P device as with metal plates but found resolution of dysphagia at 3- and 6-month follow-ups in patients with the Zero-P device [28–30]. Low rates of subsidence, loosening, adjacent level ossification, screw pullout, and nonunion have also been reported [28–30].

Some surgeons prefer posterior decompression and fusion for patients with large lateral disk herniation or cervical kyphosis or for patients undergoing fracture fixation and stabilization. Lateral mass screws (LMSs) have been used for more than 20 years with the advantages of use with a laminectomy, use in multiple levels quickly and easily, multiplanar contouring capability, biomechanical stability, and low complication rate [31]. A retrospective analysis of 1662 LMSs showed a 6.2% reoperation rate, with only six cases of pseudoarthrosis, three cases of screw pullout, two cases of hematoma formation, and five cases of nerve root palsy [31].

A more recent alternative to LMSs in the subaxial spine is cervical pedicle screw (CPS) fixation. Pedicle screw fixation may be optimal for the treatment of unstable motion in a segment in which LMSs cannot be applied [32] and for patients at high risk of pseudoarthrosis or construct failure with LMSs [33]. However, CPSs have not routinely been used because of the complication of pedicle perforation, with incidences ranging from 1.1% to 29.8%, and the potential for vertebral artery injury, reported as 0.15% per screw and 0.61% per patient in a recent systematic review [33]. Currently, the American Academy of Orthopaedic Surgeons and FDA support CPS use at C2 and C7 but not from C3 through C6 because the smaller pedicle diameter at these levels is associated with an increased potential risk of perforation [34]. On imaging, LMSs have an upward orientation on lateral radiographs (Fig. 6A) and outward orientation on axial images without extension into the pedicle (Fig. 6B). Pedicle screws extend more anterior to the lateral mass and into the pedicle, with a more horizontal orientation on lateral imaging and inward orientation on axial images (Figs. 6A and 6C).

Cervical Disk Replacement

Total disk replacement (TDR) was designed as an alternative treatment to cervical fusion to maintain a normal range of motion at the spine, thereby decreasing the risk of adjacent segment degeneration. Goals include restoring disk space height and neural foramina height; maintaining local anatomic lordosis; allowing normal flexion, extension, and axial motion; and having lower rates of adjacent segment degeneration [35, 36]. The target patient has discogenic pain without involvement of the nerve roots. There must be at least 4 mm of residual disk height, a lack of significant endplate degeneration, and a lack of facet joint degeneration to have satisfactory anchorage of the disk replacement [37].

Most TDRs are of a ball-and-socket design, which differs from a native intervertebral disk. Thus, these devices are more rigid in the axial plane [38]. As a result, the initial clinical outcomes are not significantly improved for TDR compared with posterior spinal fusion [39–41]. However, compared with patients who undergo ACDF, TDR patients show more retained cervical motion, mainly in the sagittal plane (flexion and extension), and have preserved coupled sagittal and coronal motion during transverse plane motion [42]. Radiologists will encounter TDR in practice as more are approved and used and should understand imaging appearances.

The Prestige Cervical Disc (Medtronic) is a cobalt-chromium alloy metal-on-metal ball-and-groove articulation that allows all range of motion around the center of the elliptic ball component. The disk is attached via locking screws to the vertebral bodies above and below the disk [43] (Fig. 7). In 2-year follow-up evaluations of 15 patients, the prosthesis maintained intervertebral height as well as motion; however, stress shielding was noted [44]. Theoretically, metal ion release could occur with this metal-on-metal design.

The Bryan Cervical Disc System (Medtronic), approved by the FDA in 2012, consists of two titanium alloy shells with a polyurethane nucleus (Fig. 8). A polyurethane sheath surrounds the nucleus for an enclosed articulating environment. Sterile saline is injected into the sheath as a lubricant. Unique complications reported include anterior-to-posterior migration and anterolateral paravertebral ossification [45, 46].

The Mobi-C Cervical Disc (LDR Holding) consists of a cobalt-chromium alloy endplate with polyethylene insert (Fig. 9). It has mobile bearing technology, thus allowing a greater range of motion with 10° rotation, 1-mm translation in the *x*- and *y*-planes, and 6 degrees of freedom (two translational, three rotational, and one axial) [47]. There are two lateral stops on the inferior endplate limiting movement of the insert. The inlay is radiolucent. Small spikes stabilize the endplates to bone.

The Prodisc-C Total Disc Replacement (DePuy Synthes) is a ball-and-socket mechanism with metal endplates embedded into the bone with keels (Fig. 10). A polyethylene inlay is attached to the inferior endplate, making the device semiconstrained [48]. Clinical outcomes are similar to ACDF but with less loss of segment motion [49].

The Secure-C Cervical Artificial Disc (Globus Medical) is another recently FDA-approved (September 2012) TDR. The device consists of cobalt-chrome metal endplates with serrated keels with a central polyethylene core [50] (Fig. 11). The TDR is selectively constrained to allow up to 15° of flexion and extension, 10° of lateral bending motion, unlimited axial rotation, and 1.25 mm of sagittal plane translation. The superior interface is spherical and the inferior is cylindric in an attempt to mimic the natural biomechanical motion of the cervical spine [51].

For all of these devices, there is risk of subsidence, particle disease, fracture, dislocation, adjacent segment degeneration, and severe heterotopic ossification (McAfee grade 3 or 4) in up to 17.4% [52] (Fig. 12).

Vertebral Body Fracture Treatment

The incidence of vertebral body compression fracture in postmenopausal women is 25% [53]. Kyphoplasty and vertebroplasty are now widely accepted methods of minimally invasive, imaging-guided treatment of osteoporotic and neoplastic vertebral body compression fractures without neurologic impairment [54]. Vertebroplasty involves percutaneous injection of polymethylmethacrylate cement mixed with barium sulfate (for opacification) into the vertebral body via a transpedicular approach [55] (Fig. 13A). Newer devices, such as the StabiliT Vertebral Augmentation System (DFine) include curled osteotome tips that allow site-specific cement delivery via a unipedicular approach (Fig. 13B). Kyphoplasty involves percutaneous placement of an inflatable balloon device into the vertebral body to restore height and realign the spine [56]. After balloon deflation, polymethylmethacrylate with barium sulfate is injected into the vertebral body [54]. On postoperative imaging, the radiodense cement should be contained within the vertebral body.

Both short- and long-term clinical outcome studies have shown no significant difference in pain relief or visual analog scores between patients undergoing vertebroplasty and those undergoing kyphoplasty [57–59]. Kyphoplas-

ty can restore the height of the central aspect of the vertebral body by approximately 3 mm, so it is recommended over vertebroplasty for kyphotic deformity correction. Vertebroplasty is less expensive, costing $5000 less on an inpatient basis and $4000 less on an outpatient basis [60]. Part of the reason for the cost difference is that vertebroplasty is typically performed while the patient is under local anesthesia or conscious sedation, whereas kyphoplasty is performed while the patient is under general anesthesia [61].

Potential complications of vertebroplasty and kyphoplasty include cement extrusion into the epidural venous plexus (Figs. 13C and 13D), paravertebral soft tissues, intervertebral disk, spinal canal, and neuroforamen [54]. The clinical symptoms depend on the site of extrusion. Cement extrusion into the adjacent disk can result in new fractures of the adjacent vertebra or vertebrae [62]. Other reported complications include infection, allergic reaction, pulmonary embolism, hemorrhage, rib fracture, and pneumothorax [55]. Both vertebroplasty and kyphoplasty have comparable rates of fracture of adjacent segments [57]. However, the cement leakage rates for vertebroplasty are 2–67% compared with lower rates of 1–13.5% for kyphoplasty [58, 61]. Although cement leaks often are not clinically significant, they sometimes require surgical intervention.

A new option currently in clinical trials is the KIVA VCF Treatment System (Benvenue Medical). The surgery consists of a unilateral, transpedicular, percutaneous approach in which a PEEK implant in the form of a nesting, cylindric column implant is inserted using a guidewire [61, 63]. The cement is delivered through the lumen of the implant to increase the height of the vertebra while maintained within the implant, hopefully decreasing the risk of extrusion (Fig. 14). The study is still in clinical trials, so few complications are yet recorded; however, failure of the cement to maintain the height is possible (Figs. 14C and 14D).

Conclusion

Innovations in hardware designs and materials over the past 5–10 years were made to provide clinical outcomes similar to spinal fusion while improving segment motion and decreasing adjacent segment degeneration. The initial clinical outcomes are similar to those of spinal fusion with low complication rates. Radiologists will likely encounter these devices in practice and should be cognizant of normal imaging appearances and unique complications related to hardware materials and designs.

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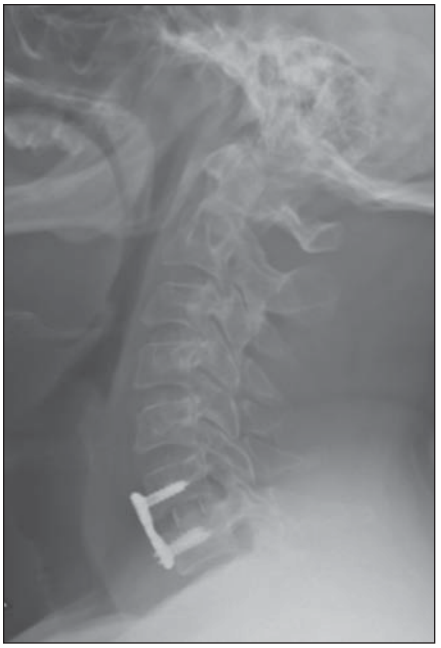


Fig. 1—Anterior cervical diskectomy and fusion (ACDF) with polyetheretherketone (PEEK) in 58-year-old woman. Lateral radiograph of cervical spine shows ACDF at C6–7 level with metal anterior plate, interbody fusion cage of PEEK with bone graft with radiopaque markers, and metal screws. PEEK cage is radiolucent.

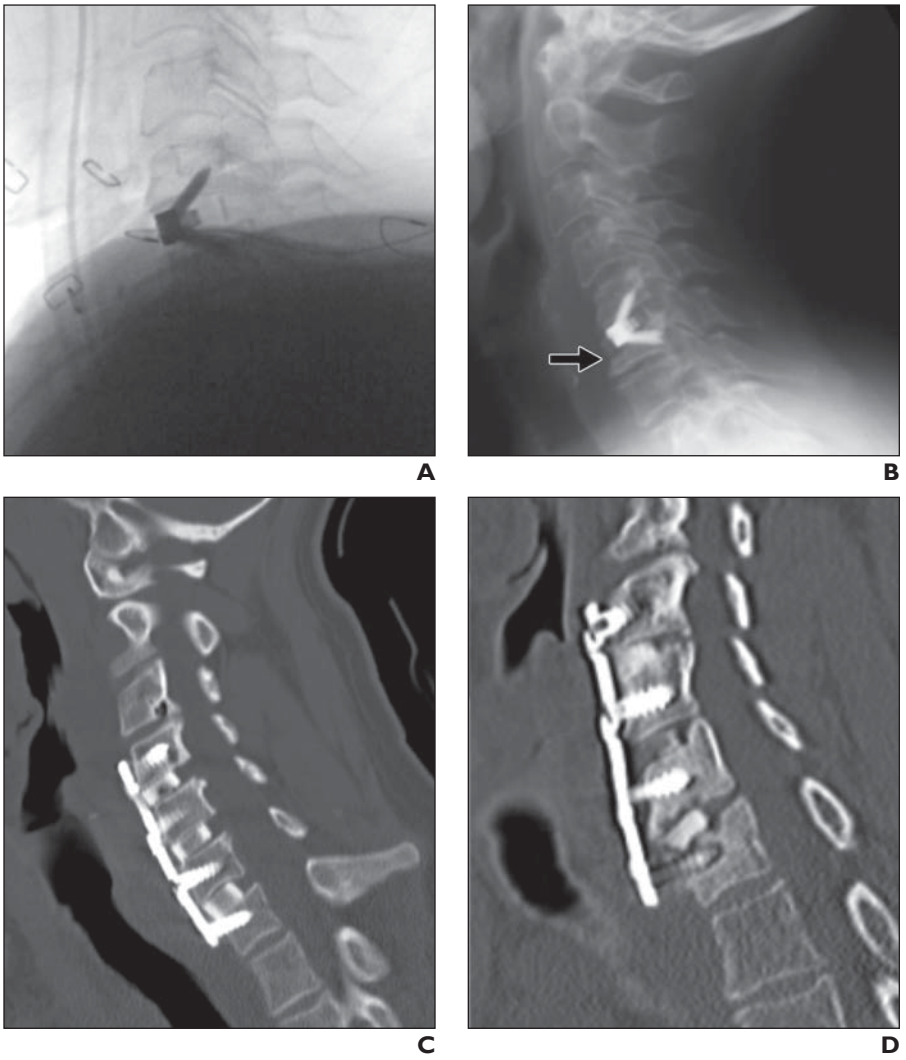


Fig. 2—Anterior cervical diskectomy and fusion (ACDF) complications: subsidence and migration.
A, Lateral intraoperative radiograph of cervical spine in 72-year-old man shows ACDF at C5–6 level in appropriate position with polyetheretherketone (PEEK) spacer maintaining height of intervertebral disk space.
B, Lateral radiograph of cervical spine obtained 3 months after **A** shows that interbody fusion hardware (*arrow*) has subsided into C6 vertebral body.
C and **D,** Initial (**C**) and 12-month follow-up (**D**) sagittal CT images obtained using bone algorithm show ACDF from C4 through C7 in 56-year-old man. Interval anterior migration and subsidence of interbody fusion at C6–7 and loosening of C7 screw and plate are noted. Partial fusion is seen in interval across C4–5.

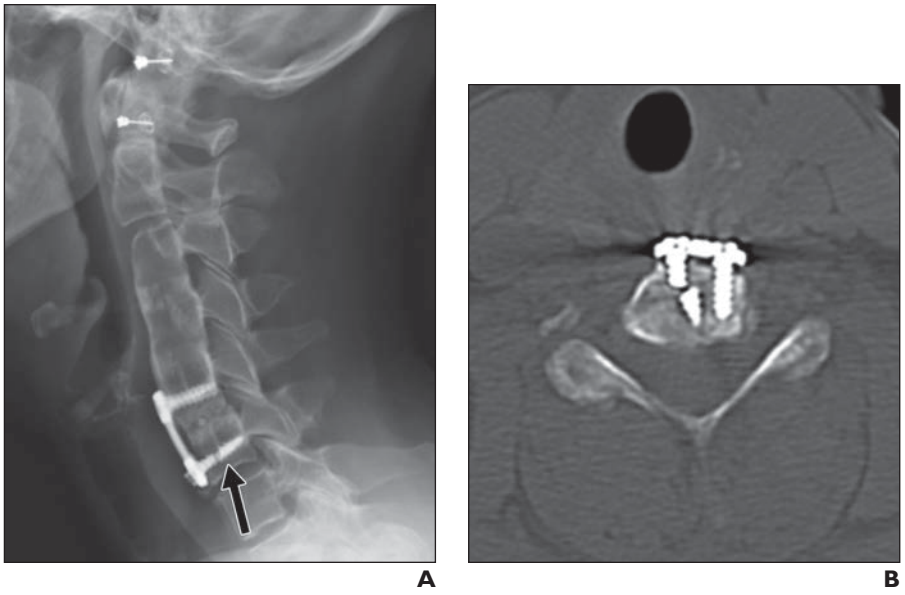


Fig. 3—Anterior cervical diskectomy and fusion (ACDF) complication: screw fracture.
A, Lateral radiograph of cervical spine in 53-year-old woman shows fracture of screw (*arrow*) at C6 level of ACDF. Patient has prior fusion from C3 through C5.
B, Axial CT image obtained using bone window settings in 45-year-old woman shows fracture of right-sided screw and mild pullout of anterior plate.

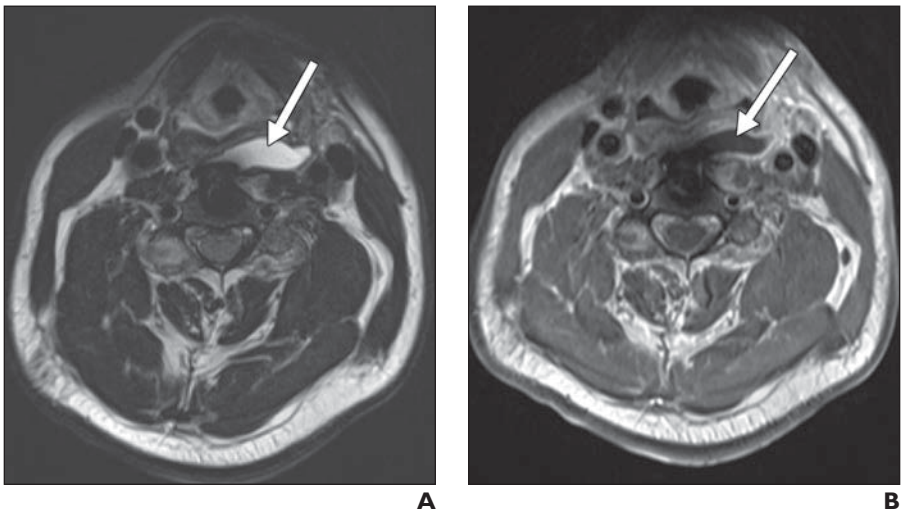


Fig. 4—Anterior cervical diskectomy and fusion (ACDF) complication: infection.
A and **B,** Axial T2-weighted (**A**) and axial T1-weighted contrast-enhanced (**B**) MR images of cervical spine at C4–5 level in 47-year-old man with ACDF shows collection (*arrow*) with rim enhancement anterior to hardware, representing postoperative abscess. Collection shows high signal on T2 image.

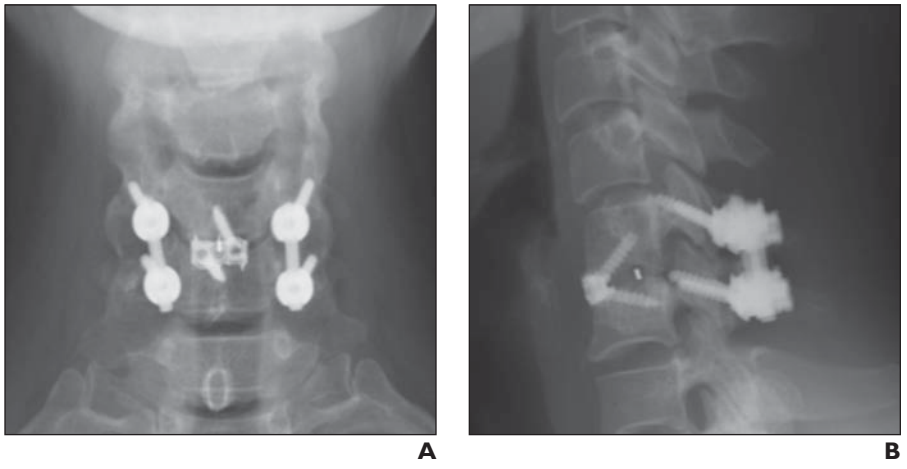
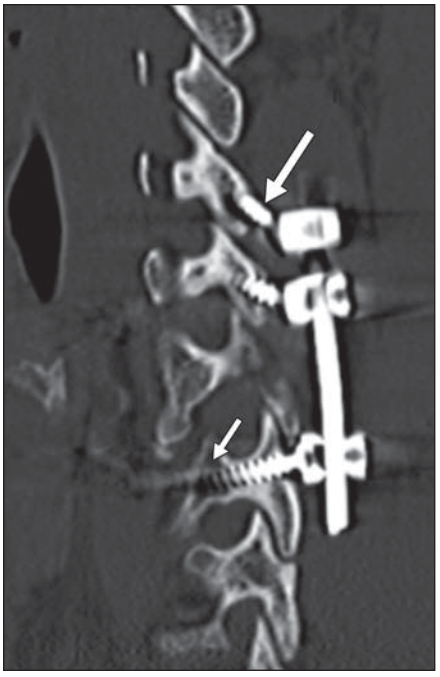


Fig. 5—Zero-P (DePuy Synthes) system.
A and **B,** Anteroposterior (**A**) and lateral (**B**) radiographs of cervical spine in 45-year-old man show Zero-P anterior spinal fusion system at C5–6 level. Polyetheretherketone (PEEK) interbody spacer with opaque marker is present and secured with anterior plate that does not protrude past anterior wall of vertebral body. Locking, self-tapping screws are used. Also noted in this patient is posterior fusion and compression at same level with lateral mass screws and posterior rods.



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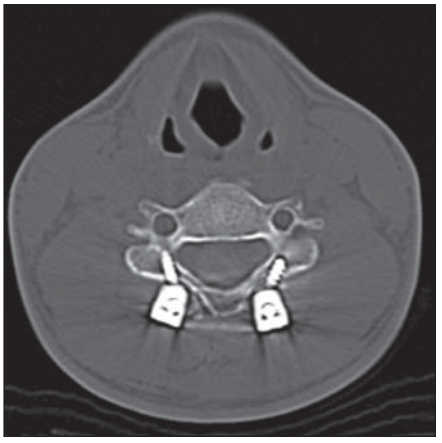

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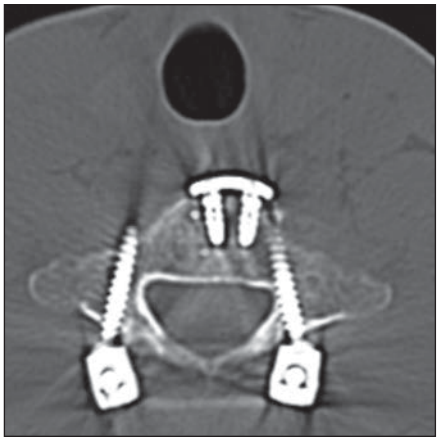
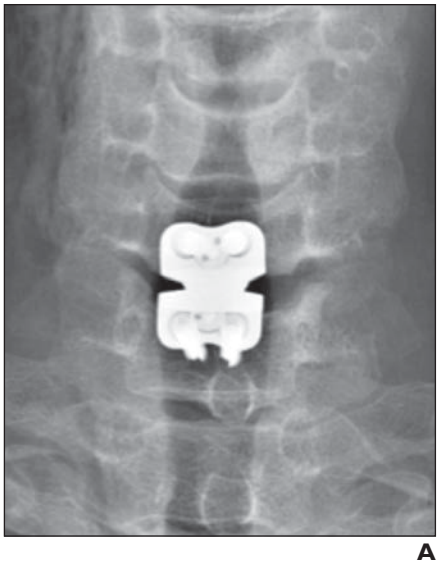


C

Fig. 6—Posterior cervical screws.
A, Sagittal CT image obtained using bone window settings of cervical spine shows lateral mass screws (LMSs) (*long arrow*) with upward orientation in upper cervical vertebra and pedicle screw (*short arrow*) with horizontal orientation extending more anteriorly in C7 vertebra.
B, Axial CT image obtained using bone window settings of LMS shows screw oriented outward and not extending anteriorly through region of pedicle.
C, Axial CT image obtained using bone window settings of C7 vertebra shows pedicle screws have more inward orientation and extend anteriorly adjacent to transverse foramen.



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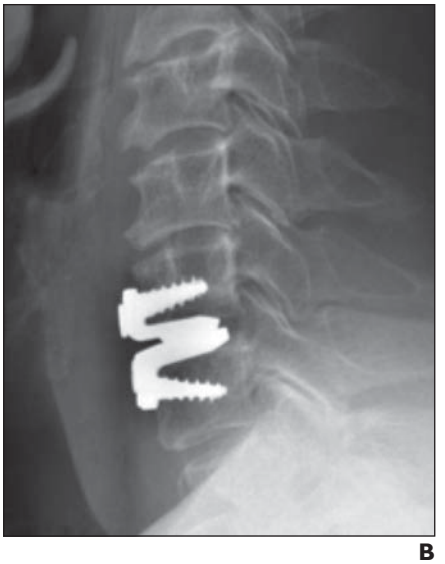
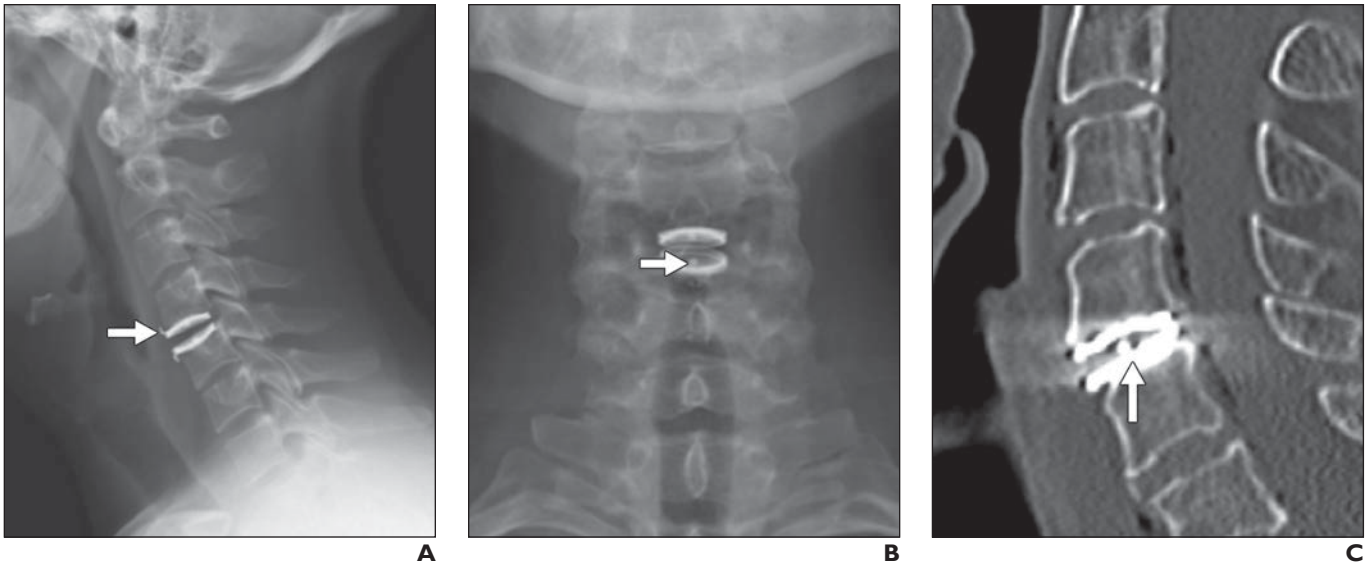


B

Fig. 7—Cervical disk replacement.
A, Anteroposterior (**A**) and lateral (**B**) radiographs of cervical spine in 47-year-old man show Prestige Cervical Disc (Medtronic) at C6–7. This implant is metal-on-metal replacement that is anchored to vertebral body by anterior locking screws.
B, Anteroposterior (**A**) and lateral (**B**) radiographs of cervical spine in 47-year-old man show Prestige Cervical Disc (Medtronic) at C6–7. This implant is metal-on-metal replacement that is anchored to vertebral body by anterior locking screws.



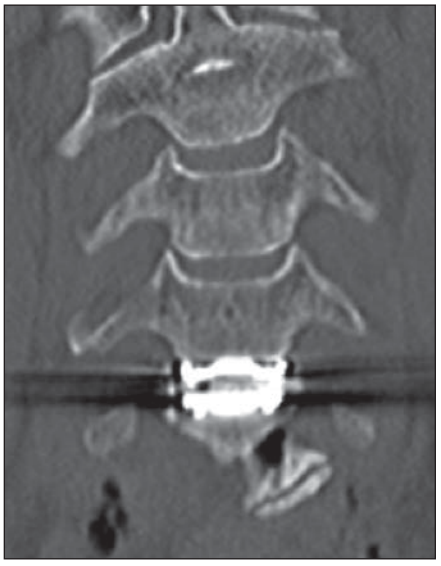


Fig. 8—Cervical disk replacement.
A and **B,** Lateral (**A**) and anteroposterior (**B**) images of cervical spine in 47-year-old man show Bryan Cervical Disc System (Medtronic) at C4–5 level. Device consists of two porous convex shells with anterior stops (*arrow*, **A**), central access port (*arrow*, **B**), and radiolucent nucleus.
C and **D,** Sagittal (**C**) and coronal (**D**) CT images obtained using bone window settings show Bryan disk replacement with central access port (*arrow*, **C**). Polyethylene liner is seen as focal area of attenuation between two metal disks.

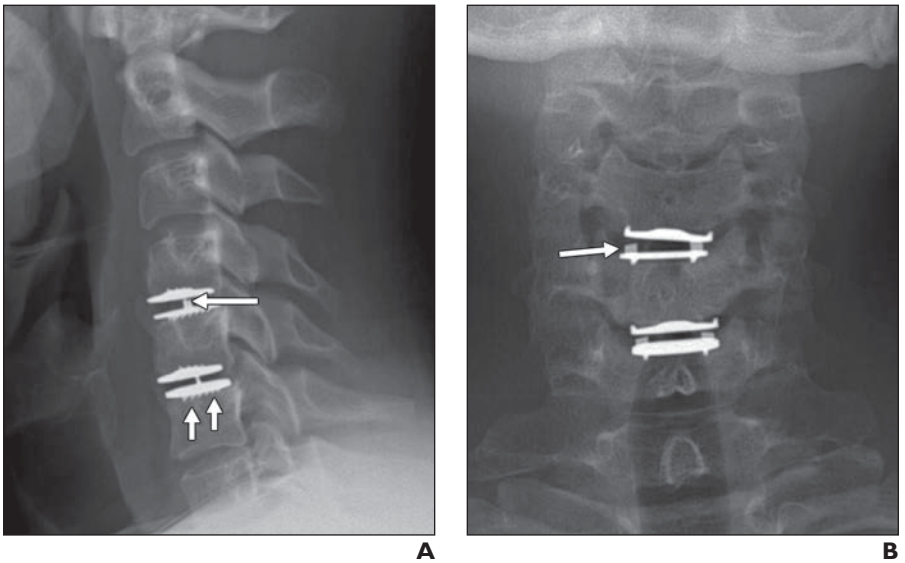


Fig. 9—Cervical disk replacement. (Courtesy of Hunter J, University of California Davis, Davis, CA)
A and **B,** Lateral (**A**) and anteroposterior (**B**) radiographs of cervical spine in 52-year-old man show Mobi-C Cervical Discs (LDR Holding) at C4–5 and C5–6 levels. Device consists of cobalt-chromium alloy endplates with radiolucent polyethylene insert. There are two lateral stops on inferior endplate of insert (*long arrow*) and small spikes (*short arrows*, **A**) that stabilize endplate to bone.

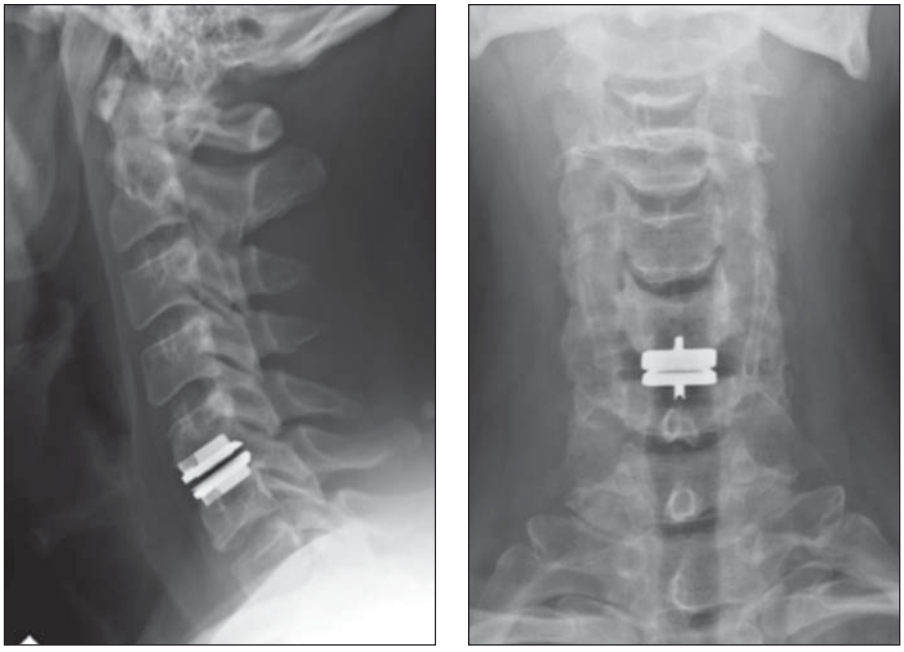


Fig. 10—Cervical disk replacement.
A and **B,** Lateral (**A**) and anteroposterior (**B**) radiographs of cervical spine in 48-year-old man show Prodisc-C Total Disc Replacement (DePuy Synthes) at C5–6 level. Device consists of two metal endplates with radiolucent polyethylene inlay attached to inferior endplate. There should be no osseous radiolucency, disk migration on flexion and extension images, or subsidence.

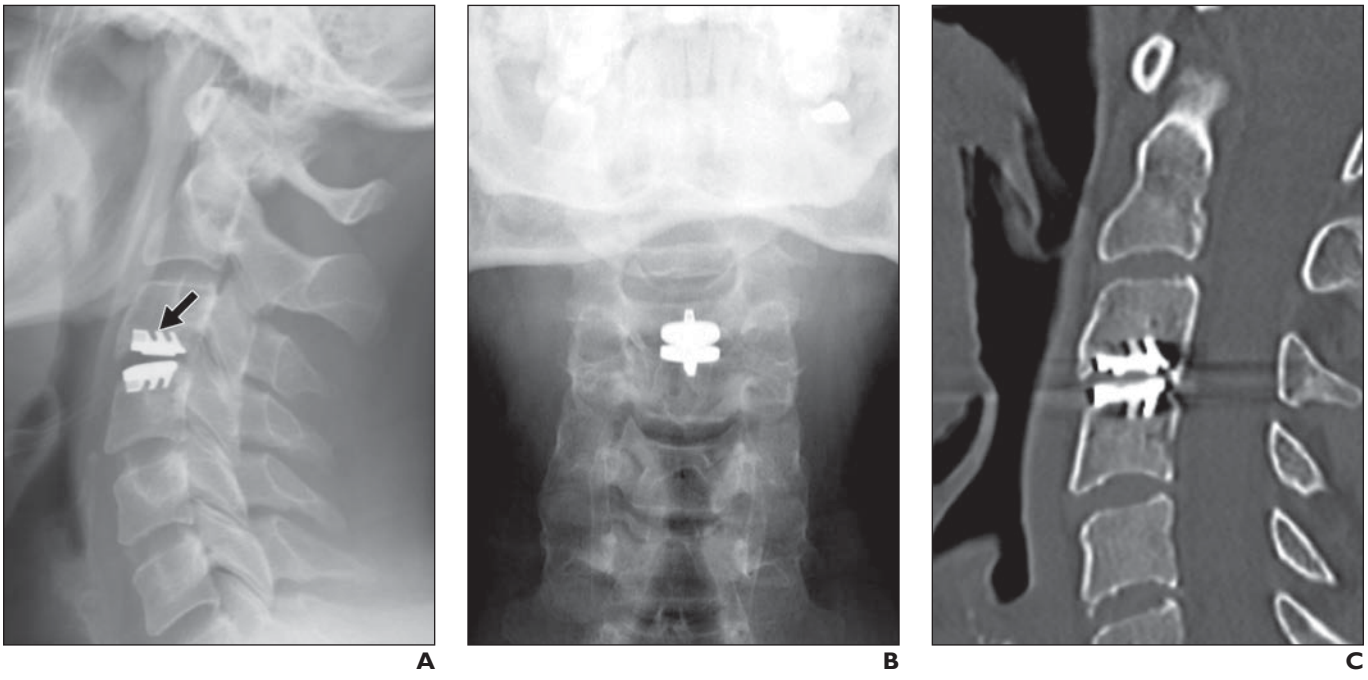


Fig. 11—Cervical disk replacement.
A–C, Lateral radiograph (**A**), anteroposterior radiograph (**B**), and sagittal CT image obtained using bone window settings (**C**) of cervical spine in 43-year-old man show Secure-C Cervical Artificial Disc (Globus Medical) at C3–4. Keels (*arrow*, **A**) anchor metal endplates into vertebral body. Radiolucent polyethylene inlay is present between metal components.

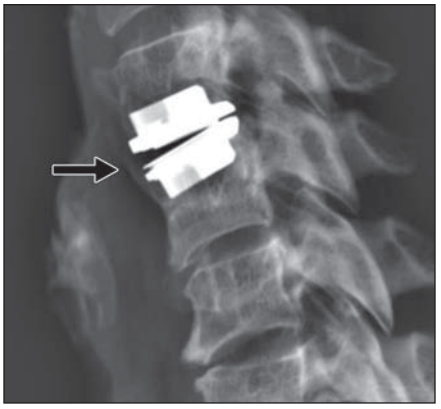
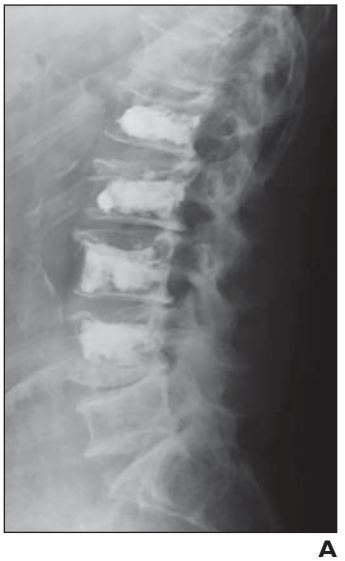


Fig. 12—Complication of cervical disk replacement. Lateral radiograph of 56-year-old man with Prodisc-C Total Disc Replacement (DePuy Synthes) arthroplasty at C3–4 shows anterior heterotopic ossification (*arrow*), nearly bridging. Patient reported some loss of segmental movement.



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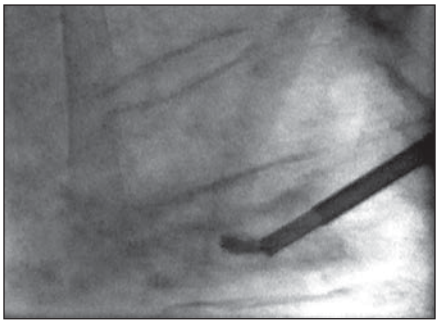

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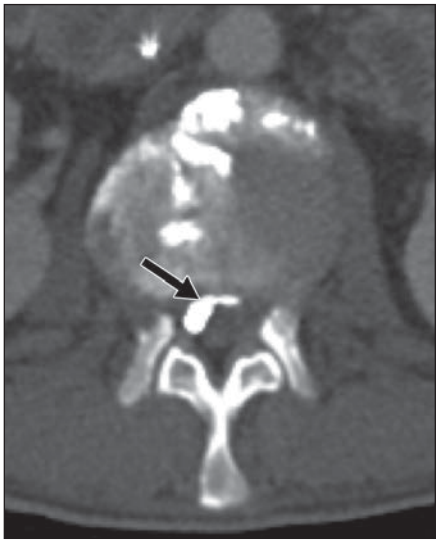

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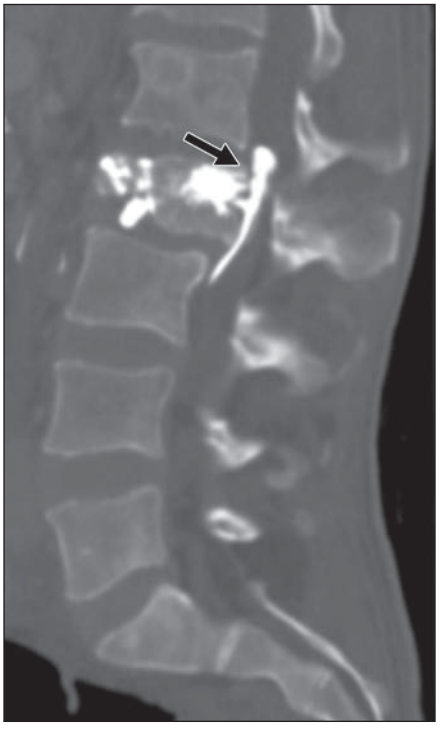

D

Fig. 13—Vertebroplasty.
A, Lateral radiograph of 63-year-old man with compression fractures from myeloma shows vertebroplasty changes in L1, L2, L3, and L4 vertebrae.
B, Lateral intraoperative radiograph of 69-year-old woman with osteoporotic compression fracture shows curved tip of osteotome of StabiliT Vertebral Augmentation System (DFine).
C and **D,** Axial CT image obtained using soft-tissue window settings (**C**) and sagittal CT image obtained using bone window settings (**D**) of 62-year-old man with prior L2 vertebroplasty show cement (*arrow*) has been extruded into epidural space.

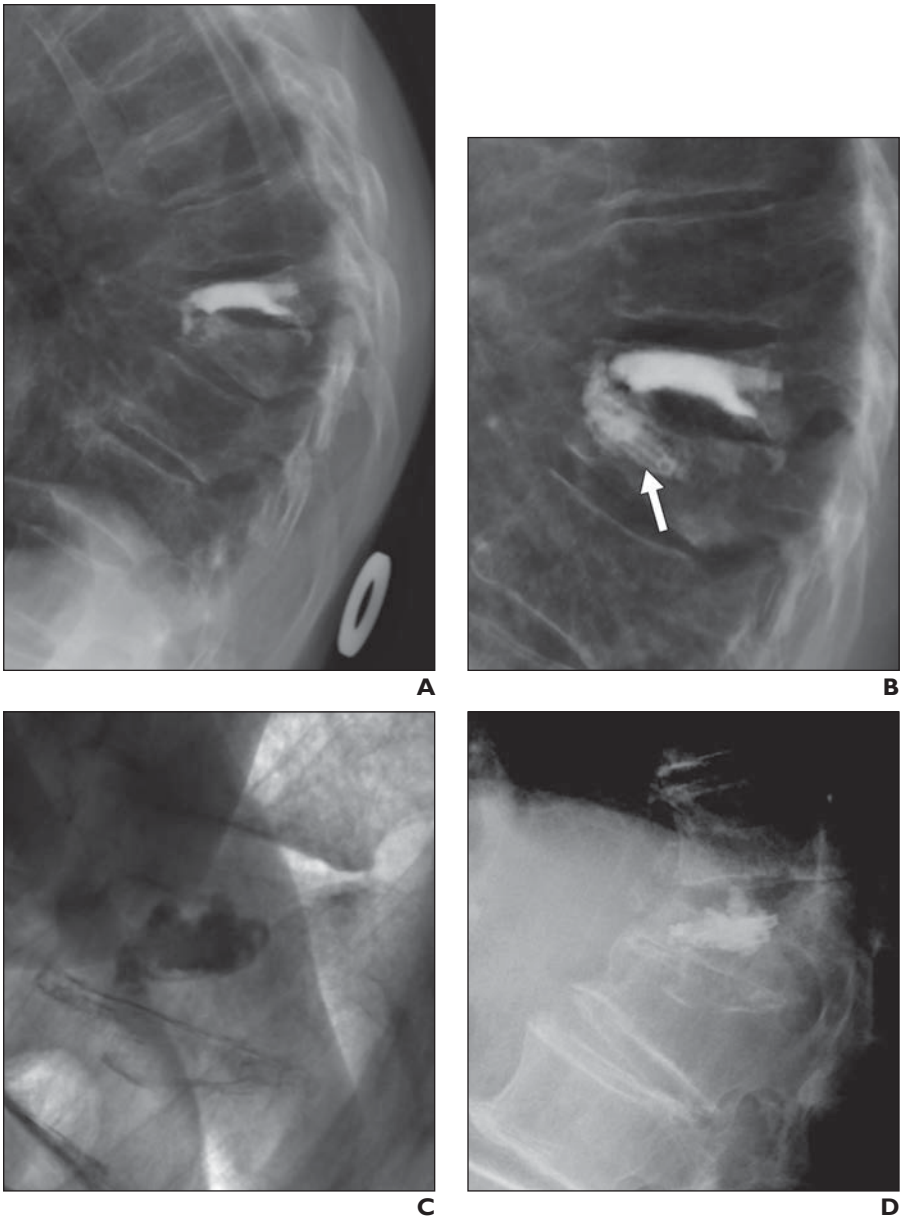

Fig. 14—Vertebral augmentation.
A, Lateral radiograph of 65-year-old woman shows vertebral body compression fracture below level of previous augmentation.
B, Lateral radiograph of thoracic spine in 71-year-old woman shows KIVA VCF Treatment System (Benvenue Medical) (*arrow*) increases anterosuperior height of vertebral body. Radiolucent polyetheretherketone cylindric implant containing cement is used to restore height in vertebral body compression fractures.
C and **D,** Intraoperative radiograph (**C**) and lateral radiograph obtained 2 months after surgery (**D**) in 73-year-old woman show interval compression of T12 vertebral body. This finding suggests potential failure of system.

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