

Complications exclusive to long strut grafts used following multilevel cervical corpectomy: Utilization of advanced imaging techniques

Pushpa B Thippeswamy, Sunitha P Kumaran, Vinay Hegde, Sanjaya Viswamitra

Department of Radiology, Sri Sathya Sai Institute of Higher Medical Sciences, Bengaluru, Karnataka, India

Correspondence: Dr. Pushpa B Thippeswamy, Department of Radiology, Sri Sathya Sai Institute of Higher Medical Sciences, Bengaluru - 560 066, Karnataka, India. E-mail: docpushpa@gmail.com

Abstract

When surgical decompression of cervical spine is considered, multilevel cervical corpectomy with long strut grafts is the preferred treatment. This procedure is used in a variety of pathologies including degenerative disease, tumors, trauma and infection. Corpectomy with interbody grafting helps in adequate spinal canal and neural decompression compared to multilevel discectomy, which could be difficult as well as inadequate. Fibular/iliac strut grafts are used for reconstruction along with a stabilizing hardware in this procedure. So far, complete imaging spectrum of complications exclusive to strut graft has not been reported in the literature. This pictorial essay presents complications exclusive to the strut graft, utility of advanced imaging in diagnosis and a brief note on the clinical management of complications.

Key words: Cervical spine; corpectomy; Computed tomography; magnetic resonance imaging; strut grafts

Introduction

When surgical decompression of the cervical spine is considered, multilevel cervical corpectomy with long strut grafts is the preferred treatment. This procedure is used in a variety of pathologies including degenerative disease, tumors, trauma and infection. Corpectomy with interbody grafting is preferred as it results in improved spinal canal and neural decompression compared to multilevel discectomy. Because the cervical spine does not bear weight significantly, long strut grafts, either from iliac or fibular, are used along with a stabilizing hardware. Owing to its length it is vulnerable for various complications. This

pictorial essay highlights complications exclusive to strut grafts, use of advanced imaging for the same, and a brief note on management.

Anterior Strut Grafting and Instrumentation

Graft helps in reconstruction following corpectomy which later fuses with the donor vertebral bodies by creeping new bone formation. Anterior plating is helpful for stability and balancing the axial load on the graft while it is healing. Posterior instrumentation is preferred mainly when posterior decompression is performed or when graft

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shows features of instability/anterior plating is failing in the postoperative period. Type of bone graft used depends on the number of vertebral bodies excised. For one or two-level corpectomies, iliac crest graft is used because it has natural curvature as in the cervical spine and has more cancellous bone which helps in early fusion. Fibular allograft is indicated when three or more cervical vertebrae need to be reconstructed.^[1] Middle third of the fibula is harvested in autograft to preserve normal ankle biomechanics. Vertebral bodies and graft bones are appropriately fashioned before fixing and further stabilized with anterior instrumentation.

Imaging in Postoperative Spine

Imaging in postoperative spine usually begins with plain radiographs. Cervical anteroposterior radiographs and flexion and extension lateral views are initial modality for evaluating postoperative spine. Plain films, however lack, information on soft tissue details and may be inadequate in patients with a short neck or large shoulder.^[2] Another disadvantage is the lack of inter-observer agreement in detecting subtle degrees of motion in flexion/extension views, which are indirect evidence of graft fusion and stability.^[3] Hence, most centers recognize these limitations of plain films and routinely include multidetector computed tomography (MDCT).

Multidetector computed tomography

MDCT has the advantage of fast acquisition time and submillimeter thin sections that allow high-quality, three-dimensional (3D) reformatted images, better depiction of graft, facet fusion, spinal alignment, hardware status, as well as soft tissue details.^[3,4] Beam hardening artefact, which was a significant problem with MDCT, can be reduced significantly by metal artefact reduction algorithms and scanning at dual energies. Metal artefact reduction uses multiple techniques including higher milliamperage, large focal spots and postprocessing filters.^[2,5]

Magnetic resonance imaging

The utility of magnetic resonance imaging (MRI) is improved soft tissue contrast and evaluation of marrow. Hence, it is used to address questions that relate to complications such as infection, tumor recurrence and pseudoarthrosis. Metal artefact reduction techniques are also routinely available to reduce the susceptibility from surgical hardware.^[2]

Because MRI-compatible hardware was used in our hospital, imaging was possible even within 2–3 postoperative days for above mentioned indications.

Graft with Optimal Fusion

In our institution, scans are obtained at 3, 6, 12 and 24 months after a fusion procedure or until solid arthrodesis has been achieved. The initial third month scan is obtained

to rule out peri-hardware lucencies that would indicate loss of fixation. The structural stability of the graft can also be confirmed if there is no subsidence or sinking of the implant into the vertebral body above/below.^[3]

Signs of bony fusion in the form of bridging bone should occur by 6–9 months.^[6] There are six criteria for assessing the solidity of fusion at radiography defined by Ray [Table 1].^[7] Computed tomography (CT) shows fusion in the form of new bone formation in and about the graft with recipient endplates. Graft shows normal pattern of mineralization. The vertebral body and disc height will be preserved [Figure 1].

Pseudoarthrosis

Chronic pain and instability 6 months to 1 year post-operatively could be secondary to fibrous union instead of bony bridging, also called pseudoarthrosis.

Smoking, long-term use of nonsteroidal anti-inflammatory drugs and underlying conditions such as scoliosis and osteoporosis are common risk factors for its

Table 1: Criteria for radiographic assessment of bridging osseous fusion

1. Less than 3° of intersegmental position change on lateral flexion and extension views
2. No lucent area around the implant
3. Minimal loss of disk height
4. No fracture of the device, graft or vertebra
5. No sclerotic changes in the graft or adjacent vertebra
6. Visible bone formation in or about the graft material



Figure 1: Optimal graft fusion 9 months following C4 corpectomy and iliac strut graft with anterior stabilizing hardware. MDCT coronal and sagittal reformatted images show excellent graft incorporation in the form of new bone formation in and around the graft resulting in fusion of the graft with recipient endplates. Graft shows normal pattern of mineralization. The vertebral body and disc height is maintained. Intersegment position change on lateral flexion and extension view radiographs was less than 3° (not shown here)

development.^[1,4] Early detection is crucial for preventing instrument failure.^[4]

Findings: Pseudoarthrosis is diagnosed on radiographs by increased motion on the flexion–extension lateral views and presence of lucency between the graft and adjacent vertebral body, with sclerosis of the endplates of the vertebrae.

MDCT shows pseudoarthrosis as distinct sclerotic cortical margins on either side of the graft as well as recipient vertebral bodies. It also shows residual graft material for advantage [Figure 2]. On MRI, pseudoarthrosis appears as high signal intensity on T2-weighted sequences and shows enhancement following contrast.^[4,6] In symptomatic pseudoarthrosis, patients undergo repeat surgery and reconstruction or posterior decompression and stabilization by hardware.

Dislodgment

Graft dislodgment is one of the early postoperative complications and is more common in long anterior strut grafts. This can happen even when anterior stabilizing hardware is used, however, less common compared to without the use of stabilizing hardware. Dislodgement can occur with improper preparation of the graft ends and the recipient vertebral bodies, not preserving the anterior and posterior vertebral cortical ridges. Graft migration can be complete or incomplete, anterior or posterior.

Findings: CT shows graft malalignment with the rest of the cervical spine. Depending on anterior or posterior displacement, compression on critical anterior soft tissues such as esophagus, trachea or spinal cord can be seen. CT scan also shows hardware loosening as lucency around the hardware or complete dislodgement of the screws from the bones [Figure 3]. MRI shows similar findings with the advantage of depicting cord changes secondary to

dislodgement. If the dislodgement is partial and movement in flexion–extension radiographs is not more than 3°, it is conservatively managed. Complete dislodgement is managed surgically.^[1]

Graft fracture

Graft fracture is more likely when the graft is harvested with an osteotome instead of a saw.^[8] Findings: CT shows linear lucency with sclerotic or nonsclerotic border within the graft. In chronic cases, there can be new bone formation at the end of the fracture which may result in compression on the anterior structures in the neck or structures in the spinal canal [Figure 4]. Fracture with significant displacement causing cord compression or compression on critical anterior neck structures and kyphotic deformity requires repeat surgery and additional stabilization. However, minimal displacement with maintenance of the



Figure 2 (A and B): Pseudoarthrosis presenting as recurrence of neck pain 1 year following C6 corpectomy and iliac strut graft reconstruction with anterior stabilizing hardware. (A) Sagittal images immediate after the surgery. Graft and anterior stabilizing hardware are *in situ* and in satisfactory position; (B) 1 year later there is reduction in the height of the graft, no evidence of new bone formation, lucency between it and the endplates on either side (arrow) with sclerosis between the graft end, and vertebral endplate suggesting pseudoarthrosis



Figure 3 (A-C): Graft dislodgement in a 60-year-old man who underwent C3, C4 central corpectomies, C2-3, C3-4, C4-5 discectomy, and C2-5 fusion with iliac crest bone graft and a plate. Posterior stabilization was performed 3 months later due to graft dislodgement. (A) Preoperative MRI shows ossification of posterior longitudinal ligament C2-4 levels causing severe cord compression (B) CT image at 3 months shows graft dislodgement superiorly (asterisk) with partial extrusion of the superior screw (arrow), increased motion noted in flexion–extension radiograph. (C) Repeat radiograph 6 months after posterior stabilization shows fusion of the graft without any further dislodgement of hardware and no spinal cord compression on MRI (not shown here)

alignment can be treated with a halo vest and judicious observation.^[1]

Infection

Surgical site infection can be early or delayed, superficial or deep, and is reported in 1–11% of the cases. Detection of post-operative infection is usually based on clinical and laboratory evaluation. Superficial infections are easily detected clinically, whereas suspected deep infection is evaluated by CT or MRI.^[6,9] However, neither can differentiate between infected and sterile fluid collections. Indirect evidence includes (a) loosening of the metallic hardware (b) lucency/osteoporosis of the graft material

on CT scan suggesting infection in appropriate clinical settings [Figure 5]. MRI also shows collection with increased signal intensity on T2 and fat-saturated images with contrast enhancement and diffusion restriction; however, hemorrhage within the operated site may also result in false positive restricted diffusion. Fluid aspiration or surgical exploration of the site is ultimately required for diagnosis.^[9] Infection is usually treated by aggressive wound exploration, extensive flushing, debridement of necrotic tissue and closed irrigation system with antibiotic therapy.^[10]

Tumor Recurrence and Radiation Necrosis

Spinal tumors are usually adjacent to the crucial neurovascular structures that can limit complete excision. Cortical breach commonly occurs in spinal lesions, which further complicate resection. Most vertebral lesions are treated by marginal or intralesional resection followed by local radiotherapy. Cement and metallic cages are used for reconstruction because using bone graft may result in recurrence within the graft or delayed/inadequate incorporation of the graft due to radiotherapy.^[11] Baseline immediate postoperative CT/MRI is followed by imaging every 4 months for 2 years and thereafter every 6 months for 5 years.

Findings: Recurrence is typically best demonstrated by areas of nodular replacement of the marrow within the graft, as well as destruction of the bone on CT scans. The signal intensity of the tumor will also be similar as primary lesion on MRI scans [Figure 6].^[12]

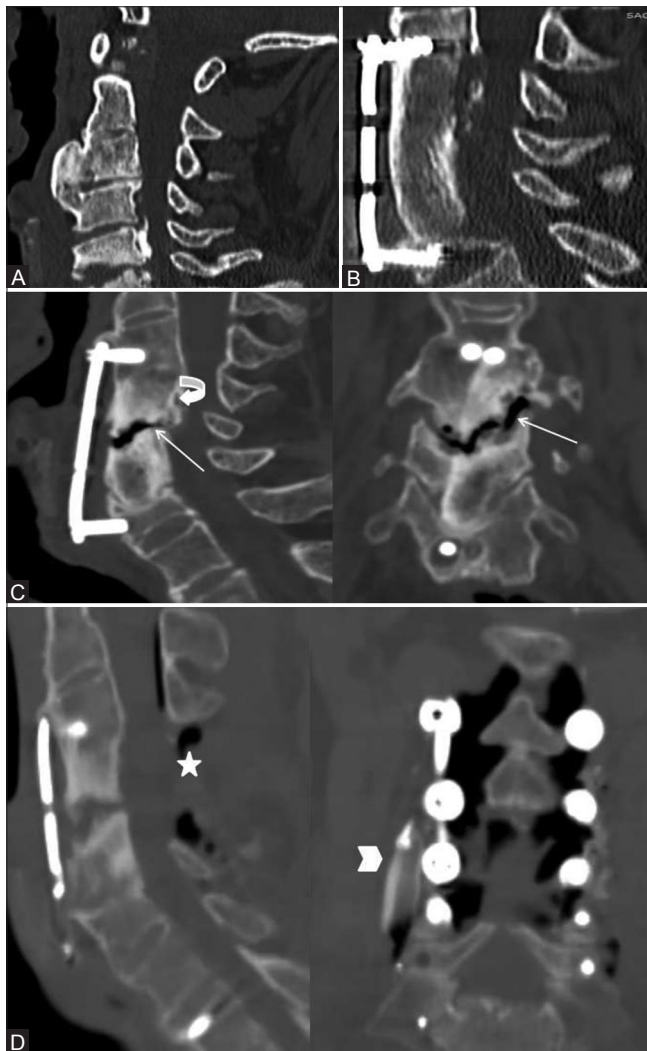


Figure 4 (A-D): Graft fracture. (A) Preoperative CT image shows primary cervical canal stenosis with secondary degenerative changes. (B) Immediate postoperative CT image with long strut graft. (C) CT images 3 months later show linear fracture in the center of the graft (arrow) with sclerosis on either sides and new bone formation along the posterior end of fracture causing compression on the cord (curved arrow). Graft is fused with vertebral bodies on either side. (D) Post-revision surgery (posterior decompression with stabilization), sagittal and coronal images show C4 and C5 laminectomy defects (asterisk) and posterior stabilizing hardware. Small iliac graft (arrowhead) is on the right side which is used for lateral fusion

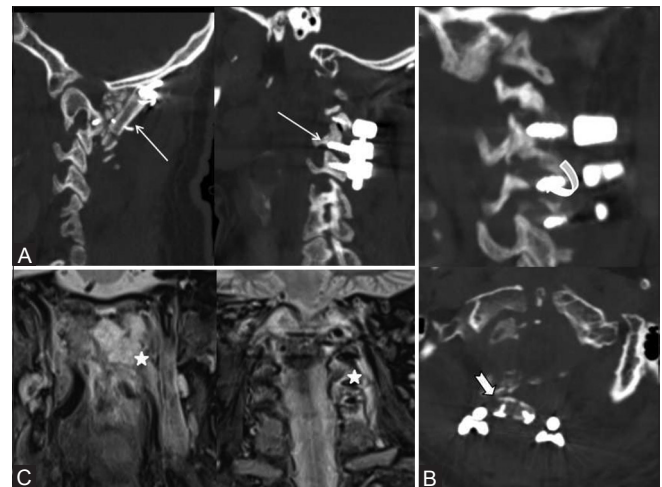


Figure 5 (A-C): Graft infection in a 35-year-old man who underwent odontoidectomy and fusion. One week later, he presented with gaping of both oral and neck wound, with redness of the skin and mucosa. Culture sample from the wound showed *Pseudomonas* which was treated with broad-spectrum antibiotics. (A) Preoperative CT images show the iliac graft (short arrow) and hardware (long arrow) in position. (B) CT images 1 week later show lucency around the lateral mass screws (curved arrow) and lucency around the screw within the iliac graft (arrow head). Bones also show periosteal reaction and irregular cortical margins. (C) STIR images show collection (asterisk) around the graft as well as around the hardware

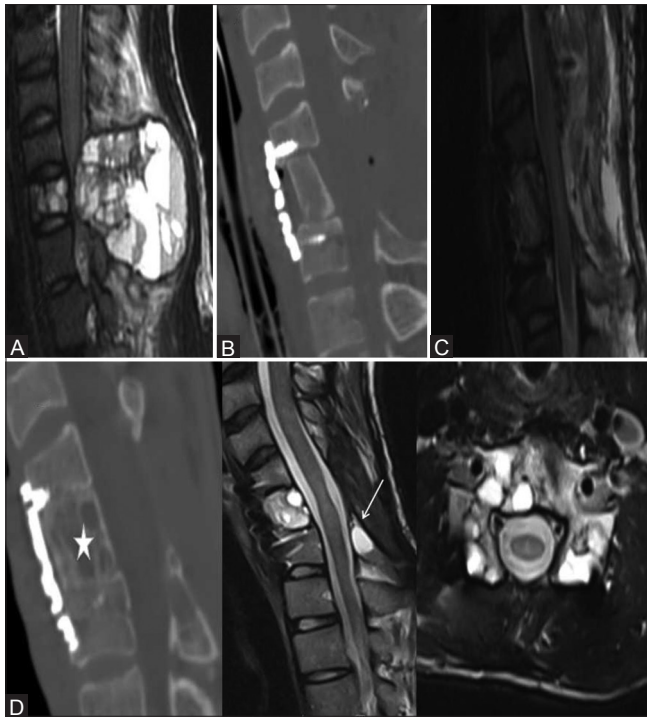


Figure 6 (A-D): Tumor recurrence in graft. A 35-year-old female underwent C6 corpectomy for aneurysmal bone cyst. Follow-up scan at 9 months showed recurrence in the graft and posterior elements of C7 vertebra. (A) Sagittal MRI shows cystic expansile lesion with multiple fluid-fluid levels involving the entire C6 vertebra. (B and C) Immediate postoperative CT and MRI images show complete excision of the tumor with adequate spinal canal decompression. Graft and anterior stabilizing hardware is *in situ*. (D) Although graft shows fusion with the recipient vertebrae on either side, there is recurrence in the graft (asterisk) and also in the spinous process of C7 vertebra (arrow), which was subtle in the preoperative scan

Radiation necrosis is seen as ill-defined areas of radiolucency along with areas of sclerosis and reduced graft height on CT scan [Figure 7].

Conclusion

Although metallic cages with bone grafts are gaining popularity, long strut graft placement with stabilizing hardware is still the preferred cost-effective method for reconstruction following multilevel cervical corpectomy in most developing countries. Along with routine assessment of spinal alignment and hardware status, it is imperative for radiologists to be aware of complications pertaining to the graft *per se* and CT/MRI imaging features of these complications. Background knowledge of management of complications helps the radiologist in proper communication to the clinicians.

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Conflicts of interest

There are no conflicts of interest.

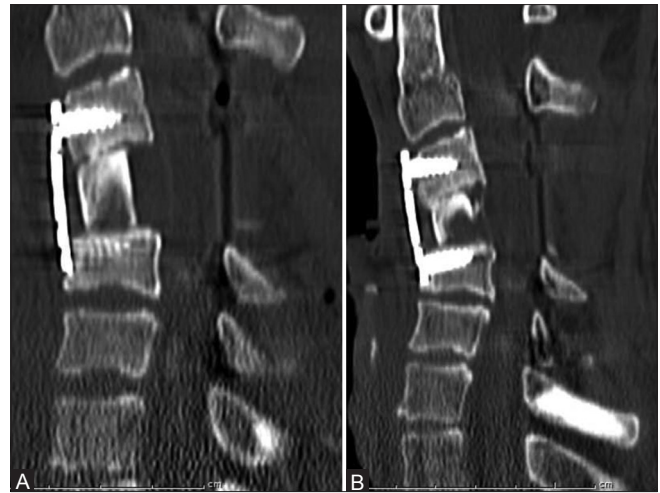


Figure 7 (A and B): Post radiotherapy nonunion and osteonecrosis in a 40-year-old man following C4 corpectomy for giant cell tumor. (A) Sagittal CT scan shows iliac graft and anterior stabilizing hardware *in situ*. (B) Six months following radiotherapy, there are areas of abnormal lucency, sclerosis, and reduction in graft height as well as features of nonunion in the form of lucency between the graft and vertebral endplates, along with no new bone formation in or around the graft

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