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CASE REPORT

Percutaneous Radiofrequency-Targeted Vertebral Augmentation of Unstable Metastatic C2 and C3 Lesions Using a CT-Guided Posterolateral Approach and Ultra–High-Viscosity Cement

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Study Design. Case report.

Objective. To report the first technical note describing radio frequency–targeted C2 and C3 vertebral augmentation using a posterolateral approach and high-viscosity cement.

Summary of Background Data. Percutaneous vertebral augmentation is a minimally invasive procedure used for stabilization and pain control in vertebral compression fractures. Its use in the cervical spine, especially the upper cervical spine, is very limited mainly due to technical challenges.

Methods. We report the first use of an ultra–high-viscosity cement and posterolateral approach with computed tomography (CT) guidance and computed tomographic fluoroscopy in a patient with lytic lesions in C2 and C3 and a pathologic fracture of C2 for the purpose of stabilization and pain palliation.

Results. Technically successful vertebral augmentation of the C2 and C3 vertebral bodies was achieved. There were no complications. The patient reported pain relief and improved range of motion after treatment and the hard cervical collar was removed.

Conclusion. Computed tomography–guided radiofrequency-targeted vertebral augmentation of the cervical spine using a posterolateral approach and ultra–high-viscosity cement is a technically feasible procedure that may be used in patients with advanced osteolytic cervical spine metastases who are not surgical candidates for the purpose of pain palliation and fracture stabilization.

Key words: vertebroplasty, percutaneous, metastasis, cervical, CT fluoroscopy, high-viscosity cement, unstable, CT guidance, posterolateral, radio frequency.

Level of Evidence: N/A

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The literature on cervical vertebral augmentation is limited and includes a few reports of vertebroplasty using anterior/anterolateral, lateral, and transoral approaches.[1–3] The posterolateral approach is a recently described method with only 3 reports in metastatic disease.[4–6] In addition, energy-responsive, ultra–high-viscosity cement has recently been introduced for the treatment of vertebral compression fractures and has a potential role in reduction of cement leak compared with lower viscosity cements[7,8] and increased uniformity of cement filling.[9] There are very few reports of its application in the thoracic and lumbar spine[10] and no reports of its use in the cervical spine.

This is the first report of radiofrequency-targeted posterolateral approach vertebral augmentation for the management of a pathologic fracture and pain in osteolytic lesions of the upper cervical spine.

CASE REPORT

Cervical spine imaging of a 55-year-old female with osseous metastases from squamous cell carcinoma of the lung demonstrated unstable lesions involving C2 and C3 (Figure 1A–F) with pathologic fracture of C2 (Figure 1C, D). The patient's pain was disabling and poorly controlled. She was placed in a hard collar for stabilization. The patient was not a surgical candidate due to the potentially significant morbidity and had received maximum radiation therapy to the spine. Vertebral augmentation was requested for stabilization of the cervical spine and for pain palliation.

After obtaining consent, general anesthesia was initiated, and the patient was placed in the prone position with neutral craniocervical junction positioning on the computed

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The device(s)/drug(s) is/are FDA approved or approved by corresponding national agency for this indication.

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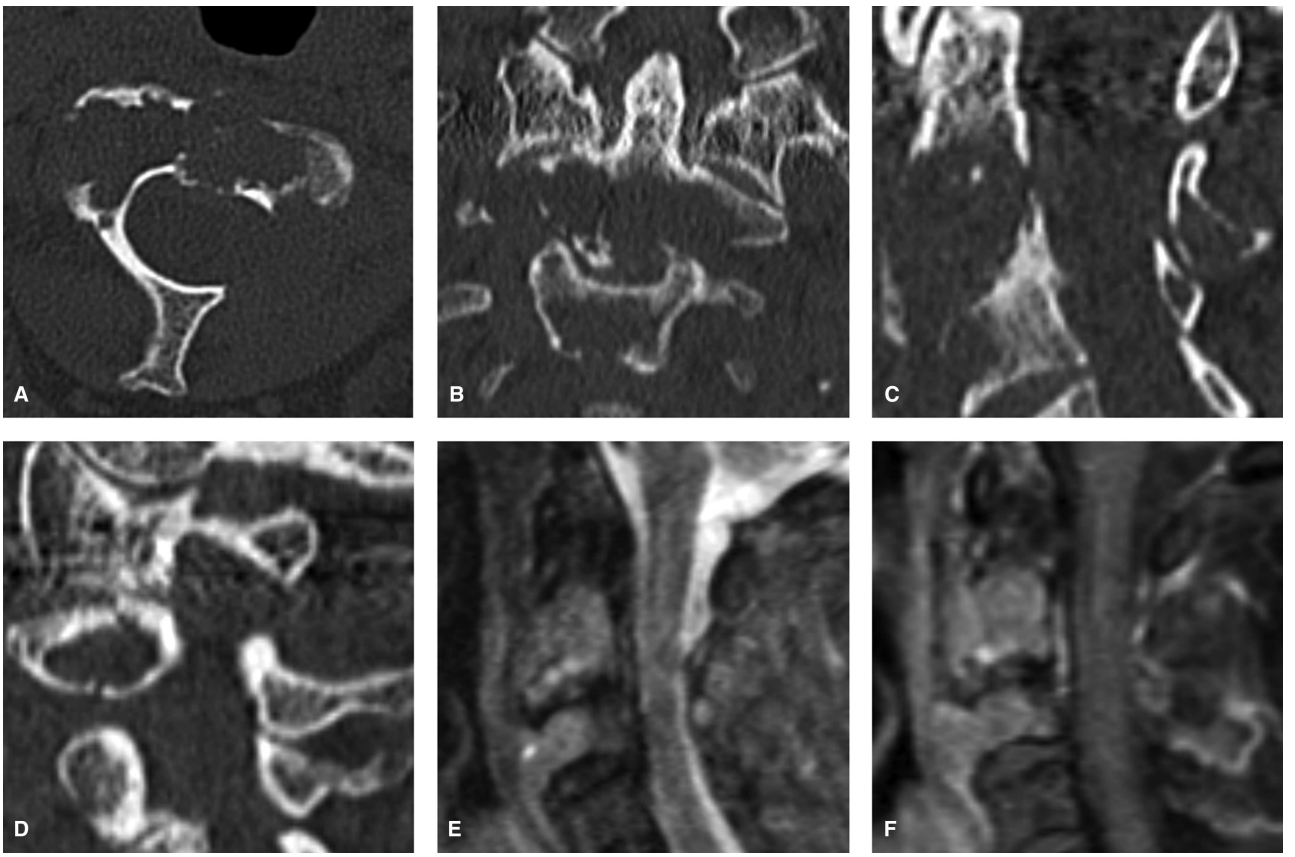

Figure 1. Preprocedural cervical spine computed tomographic scans and magnetic resonance images assessing the extent of metastatic disease in the cervical spine. Axial computed tomographic scan of C2 vertebral body (**A**) demonstrates a lytic lesion involving the body and right lateral mass of C2 breaching the anterior cortex. Coronal (**B**) and sagittal (**C** and **D**) reformatted images show lytic lesions involving the bodies of C2 and C3 with posterior cortical disruption at C2 (**C**) and a C2 right lateral mass fracture (**D**). Sagittal short TI inversion recovery image (**E**) and T1 post-contrast fat saturated (**F**) images demonstrate increased fluid signal within the lesion and enhancing lesions involving most of C2 and C3 vertebral bodies with small epidural mass component and prevertebral soft tissue extension.

tomography table. For computed tomographic (CT) guidance, a 16-row Siemens CT scanner equipped with CT fluoroscopy was used (CARE Vision CT, Siemens Health- care, Erlangen, Germany). Fluoroscopic images were acquired with low-dose technique and images were displayed in real time on an additional in-room monitor in front of the operator (Figure 2). In-room monitor and fluoroscopy pedal facilitated efficient handling of the procedure.

Using a posterolateral approach, the C2 vertebral body was entered *via* the right pedicle with a 10-gauge DFINE (StabiliT Vertebral Augmentation System, San Jose, CA) introducer needle using the technique described in thoracic/lumbar spine[10] using a pathway that avoided critical structures including the vertebral arteries. The needles were placed under intermittent CT guidance into the midline of the C2 and C3 vertebral bodies. An osteotome was used to create channels across midline for cement to flow to the contralateral side to avoid a bipedicular approach. Cement (DFINE ER^2, San Jose, CA) was prepared and with the use of CT fluoroscopy, 5 mL of cement was injected in the C2 vertebral body with filling of the large lytic lesion and the left lateral mass pathologic fracture (Figure 3A, C, E–G). In the C3 vertebral body, 1 mL of cement was injected with cement filling a lytic lesion within the anterior aspect of the vertebral body (Figure 3B, D, E–G). After completion of cement delivery, the

Figure 2. Photograph of the operating room with the patient positioned prone on the computed tomographic table for the procedure. In-room monitors (*) and fluoroscopy pedal (#) are demonstrated.

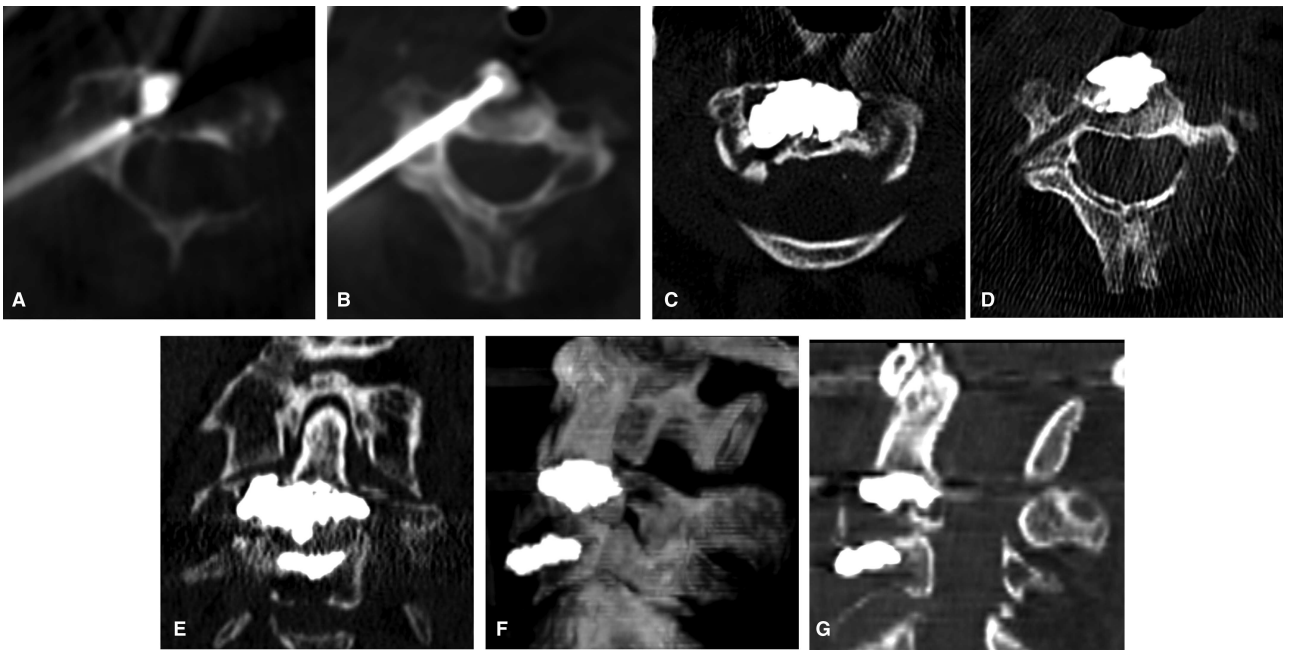

Figure 3. Intraprocedural computed tomography and computed tomographic (CT) fluoroscopy images demonstrating the C2 and C3 vertebral augmentations. Axial CT fluoroscopic images at C2 (**A**) and C3 (**B**) demonstrating the needles placed from a right posterolateral approach with cement filling the vertebral body lytic lesions. Postprocedural axial CT scans of C2 (**C**) and C3 (**D**) demonstrate cement filling the lytic lesions. Coronal (**E**) and sagittal (**G**) reconstruction and sagittal maximum intensity projection CT reconstruction (**F**) of C2 and C3 show filling of the C2 and C3 lytic lesions.

cement-driving cannula was removed and the stylet was reinserted to completely empty the locking delivery cannula. No cement leak was identified.

The patient was observed for 24 hours and showed no clinical complications, while reporting substantial pain relief (from numeric pain rating scale 9/10 to 5/10). The uncomfortable hard collar was also removed.

DISCUSSION

The posterolateral approach has the advantage of avoiding the carotid space and anterolateral vascular structures. The spinal cord and vertebral artery can be avoided by using CT guidance and respecting the cortical boundaries of the pedicle and foramen transversarium. Contrast-enhanced computed tomography or magnetic resonance imaging or computed tomography or magnetic resonance angiography could be performed for delineation of the course of vertebral artery. In our case, cervical spine magnetic resonance imaging with contrast was used for preprocedural planning.

Combining CT and CT fluoroscopy provides precise guidance for needle placement. Using CT fluoroscopy, cement injection can be monitored in near real time and cement leak can be promptly detected. In this case, specifically, CT fluoroscopy enabled us to safely place a much larger volume of cement in C2 than has been previously described. This is of critical importance in the cervical spine given the gravity of complications after leak of cement into the spinal canal or foramen transversarium. The targeted radiofrequency vertebral augmentation system used in this case has a remote control for the hydraulic cement delivery[10,11] that allows operator(s) to be up to 20 ft from the patient and thus, reducing operator's radiation exposure. Unipedicular approach made possible by site-specific channels created using a navigational osteotome may further reduce the radiation dose and invasiveness compared with traditional bipedicular approach.[11]

Newly developed ultra–high-viscosity cement (ER^2 bone cement, DFINE) contains particles of different sizes that decelerate polymerization time. Using high-frequency alternating current instantly prior to injection, polymerization is accelerated and constantly high cement viscosity is achieved during remote-controlled hydraulic injection.[10] Controlled delivery rate, flow to targeted-osteotome-created channels, and higher viscosity of the cement decrease the likelihood of cement leakage.[11]

In conclusion, minimally invasive, posterolateral approach radiofrequency-targeted vertebral augmentation of the upper cervical spine using CT guidance is technically feasible and may have advantages over other techniques in stabilization and pain palliation in patients who are not a surgical candidate.

➢ Key Points

- ❑ Radiofrequency-targeted vertebral augmentation of the cervical spine may be an option for pain control and stabilization in patients with end-stage metastatic disease who are not a surgical candidate.
- ❑ CT guidance and CT fluoroscopy may decrease the chance of cement leakage and vascular/organ injury.

- ❑ Rate-controlled delivery of radiofrequency-activated (high viscosity) cement at a fixed, low rate into channels created using a navigational osteotome could decrease cement leakage.
- ❑ Posterolateral approach may have advantages over other methods for cervical vertebroplasty.

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