Diffuse idiopathic skeletal hyperostosis (DISH) is characterized by calcification and ossification of soft tissue and is diagnosed according to the Resnick and Niwayama criteria: bridging ossifications in at least 4 continuous vertebrae, preservation of the intervertebral disc space, and absence of involvement of the sacroiliac or facet joints.28,36 The presence of DISH limits the motion of the spine, tends to increase overall kyphosis, and increases the risk of fractures. Minor trauma in patients with DISH, or other disorders limiting spinal motion, such as ankylosing spondylitis (AS), can lead to severe 3-column injuries.

Cervical spine fractures are associated with significant morbidity and present multiple challenges. Unstable fractures across the cervicothoracic junction are associated with significant morbidity and require fixation, which is commonly performed through a posterior open or percutaneous approach. The authors describe a novel, mini-open anterior approach using intraoperative cone-beam CT scanning to place lag screws followed by an anterior plate in a 97-year-old patient. This approach is less invasive and faster than an open posterior approach and can be considered as an option for management of cervicothoracic junction fractures in elderly patients with high perioperative risk profile who cannot tolerate being placed prone during surgery.

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KEY WORDS diffuse idiopathic skeletal hyperostosis; spinal fracture; cervicothoracic junction; minimally invasive surgery; navigation-assisted surgery; intraoperative cone-beam computed tomography; mini-open

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locations, such as the CTJ, in patients with degenerative disorders, trauma, and deformity. This system can provide useful information and guide accurate implant placement even in cases with limited surgical exposure or in those involving minimally invasive approaches. It is also very useful when instrumenting levels that are difficult to visualize fluoroscopically, such as the CTJ. Here, we describe this technique utilizing an ICBCT-navigated anterior mini-open approach to place lag screws and an anterior plate in an illustrative case of a 97-year-old man with DISH who suffered a 3-column spinal fracture of the CTJ.

Case Report

History and Examination

A 97-year-old man was admitted to our institution with neck pain after a fall from the standing position. He had a history of hypertension, diabetes mellitus, and prostate cancer. He did not experience loss of consciousness or posttraumatic amnesia. He had no numbness, weakness, or bowel or bladder dysfunction. On neurological examination, he had full strength and sensation throughout all extremities. He had a negative Hoffmann sign, normal deep tendon reflexes, and downgoing toes. He had midline posterior cervical tenderness over the lower cervical and upper thoracic spine. At baseline, he was high functioning, lived by himself, was independent in activities of daily living, and ambulated without the aid of a walker or cane.

Cervical spine CT showed an acute fracture through bilateral C-7 pedicles (Fig. 1A and B), extending into the posterior inferior corner of the C-7 vertebral body (Fig. 1A). The patient had nearly complete autofusion of the cervical and thoracic spine due to DISH. Cervical spine MRI showed fracture extension through the C7–T1 intervertebral disc space and anterior and posterior longitudinal ligamentous disruption (Fig. 1C). It also showed that there was anterior translation of C-7 on T-1 compared with the imaging done a few hours prior, reflecting the instability of the fracture.

Conservative treatment consisting of external fixation and bed rest was considered initially given the patient’s age and medical comorbidities. However, due to the unstable nature of the fracture, the patient, with support of his family, elected to undergo surgical fixation. Prone positioning was considered but was deemed high risk by the anesthesia team given documented labile hypertension following admission and his medical comorbidities.

Operative Technique

See Video 1 for a depiction of the surgical technique.

VIDEO 1. Surgical technique. The video presents the case illustration and shows the surgical setup in the operating room, the intraoperative photographs/videos, navigation screenshots/live images, surgical techniques, and follow-up radiographs. Copyright University of California, San Francisco. Published with permission. Click here to view.

The patient was positioned supine. Fiber optic intubation was performed, maintaining a neutral neck position. Baseline motor evoked potential, somatosensory potential, and free-run electromyography signals were monitored. His shoulders were taped to the end of the bed to better expose the CTJ. A reference frame arm was attached to the head of the bed and positioned just left and superior to the patient’s head for a right-sided neck approach. The patient was prepared and draped in the normal sterile fashion. An intraoperative O-arm spin was performed and uploaded for navigation. A vertical incision was made just medial to the sternocleidomastoid border. The platysma was opened vertically along the fibers. The fascial plane medial to the sternocleidomastoid was bluntly dissected to the prevertebral fascia, which was opened. The C-6 vertebral body was identified with the navigation system.

Self-retaining retractors were placed. Two trajectories crossing the C6–7 and C7–T1 intervertebral spaces were planned, running from an anteromedial entry point in a posterolateral direction (Fig. 2A). A power drill was used in the navigated drill guide to drill two pilot holes to a depth of 32 mm (Fig. 2B). The trajectory was confirmed with the neuronavigation. Two K-wires were placed in the holes and a tap was used to enlarge the previously drilled pilot holes. Bilateral 4.0 × 36–mm cannulated lag screws were placed through the tapped holes from the C-6 verte-
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Bral body, through the C-7 vertebral body, across the fracture, and into the T-1 vertebral body. This was done to gain compression perpendicular to the plane of the fracture and to realign and reduce the fracture fragments. The lag screws were placed with 7-mm washers. The screws were noted to have good purchase. The K-wires were removed.

We selected a 30-mm anterior locking plate to supplement the lag screws and prevent screw backout. We bent the anterior plate to match the patient’s hyperlordotic cervical spine. We drilled, tapped, and placed 4.0 × 17-mm variable-angle screws into the C-6 and C-7 vertebral bodies with the plate overlying the lag screws to prevent lag-screw backout (Fig. 3A).

A final O-arm spin was used to confirm the final hardware position placement (Fig. 3B). The spin confirmed screw position and final reduction of the fracture. A single Jackson-Pratt drain was placed in the wound, which was closed in the usual layered fashion. Estimated blood loss was 50 ml, and total time for the procedure was 2 hours.

Postoperative Course

The patient’s postoperative neurological examination was stable, with full strength and sensation. The patient tolerated swallowing thin liquids on the day of surgery, passed a dysphagia screen on postoperative Day 1, and was able to consume soft foods. He had no complications during his hospital course. His brace was removed at 3 months after cervical spine flexion-extension radiography confirmed good hardware fixation. At last follow-up, 12 months postoperatively, the patient was living on his own at home and was ambulating independently without neck pain. Cervical spine CT at that time demonstrated good bridging fusion across the interbody space and pedicles (Fig. 4). He remains independent in his activities of daily living.

Discussion

Management decisions for cases of unstable cervicothoracic fractures in elderly patients with high surgical risks can be challenging. There are multiple options for treatment including traction and bed rest, immobilization with a hard cervical collar or halo vest, and surgical fixation. Traction can be very useful for reduction of dislocated fractures. Bed rest is poorly tolerated in the elderly, who need mobilization to maintain functioning. Thus, once reduced, most fractures are managed with immobilization or surgical fixation. The halo vest system is traditionally thought of as the most efficacious form of cervical spine immobilization, but it is not without its own complications. These include pin loosening, pin-site infections, sensory nerve injury, pulmonary injury, pressure sores, and aspiration pneumonia. Additionally, a few studies have suggested that motion persists in unstable fracture areas despite the halo vest immobilization. Thus, surgical fixation in patients who can tolerate surgery is the treatment of choice for unstable cervical fractures.

Patients with DISH or AS, in particular, are at high risk...
for unstable low cervical fractures, and they tend to have better outcomes when surgical fixation is performed rather than immobilization alone.\textsuperscript{44} The incidence of DISH is 10.8%–25% in the healthy population.\textsuperscript{25,32,45} Elderly individuals and males are at higher risk of developing DISH.\textsuperscript{24} Spinal fractures in patients with DISH and AS are often unstable due to the substantial lever created by the fused spine; thus, surgical fixation is the mainstay in treatment. Indeed, in one study, patients treated conservatively had a higher rate of complications, and the 1-year mortality rate was significantly higher in patients treated nonoperatively versus operatively (51\% vs 23\%).\textsuperscript{3} A variety of surgical approaches have been used to treat these fractures including anterior, posterior, and combined anterior-posterior approaches.\textsuperscript{4,7,8,10,31,34,39,42}

Surgery for fractures in patients with DISH is associated with high surgical risks and morbidity, as these patients tend to have more medical comorbidities than a younger or healthier population.\textsuperscript{5,43,47} Surgical risks are also elevated in older patients who also have an increased incidence of DISH.\textsuperscript{37,46} Surgical risks, especially cardiopulmonary complications, are exacerbated by the prone positioning needed for posterior fixation.\textsuperscript{23,26} Thus, alternative approaches, whether minimally invasive or anterior-based approaches, are needed to minimize surgical morbidity and operative duration.

Minimally invasive spinal surgery has recently gained popularity and is used to treat patients with cervical fractures and DISH. The presence of DISH alone is an independent risk factor for death after spine fracture.\textsuperscript{46} Patients with spinal fractures and ankylosing disorders such as DISH/AS have also been treated with posterior percutaneous screw/rod fixation without bone grafts given the patients’ propensity for bone formation, with good results and low complication rates.\textsuperscript{10,41,50} However, the management of very elderly patients with several medical comorbidities who cannot tolerate prone positioning is problematic.

In this technical note, we described a novel anterior mini-open technique using intraoperative navigation-assisted lag-screw fixation. There are several advantages to this approach, particularly in patients like the gentleman in this case illustration. First, we avoid prone positioning and the associated cardiopulmonary risks. The supine position decreases operative duration and avoids the potential for delayed extubation. Second, the lag-screw technique provides stabilization across the fracture with compression force between the two fractured segments, which is important, given that anterior plating alone may not be sufficient to provide stabilization of the CTJ.\textsuperscript{35} Third, the
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intraoperative CT-based navigation system allows easy access and rapid navigation of the CTJ, an area that is difficult to visualize fluoroscopically due to bone obstruction and the autofused bones in patients with ankylosing spinal diseases.\textsuperscript{44} Finally, use of the intraoperative navigation system decreases radiation exposure to the surgeon and medical staff during spinal implant placement. Lag screws are commonly used to reduce odontoid fractures and to bring transpedicular fractures into union from a posterolateral approach.\textsuperscript{3,22} However, this is the one of the first reports using a lag screw and anterior plating system for cervicothoracic fractures. This construct worked well and allowed us to reduce potential operative morbidity that is associated with the prone position in an elderly patient with multiple comorbidities.

Conclusions

Rigid fixation is the gold standard for surgical management of patients with cervical fractures and ankylosing spinal diseases. Here, we present a novel anterior mini-open approach using intraoperative navigation-guided lag screw and plate construct, which can be considered as an option for stabilization of fractures at CTJ, even in a 97-year-old patient with medical comorbidities. This approach minimizes operative time and some of the potential morbidities associated with open posterior approaches in the prone position.

References


Disclosures
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Supplemental Information
Videos

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