Imaging Characteristics of Diffuse Idiopathic Skeletal Hyperostosis With an Emphasis on Acute Spinal Fractures: Review

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Objective
The educational objectives of this self-assessment module are for the participant to exercise, self-assess, and improve his or her understanding of the imaging of diffuse idiopathic skeletal hyperostosis (DISH), with emphasis on acute spinal fractures.

Conclusion
Understanding the pathomechanics of the fractures in the ankylosed spine is important in the differentiation of the acute spinal fractures in DISH and ankylosing spondylitis. This article emphasizes the imaging features of spinal DISH and acute spinal fractures in DISH, distinguishing them specifically from those in ankylosing spondylitis.

Introduction
DISH [1], often referred to as Forestier disease [2], is a common disorder of unknown cause characterized by intermittent pain and stiffness in areas of bony changes of the spine. The incidence of DISH has been reported to be seven in every 100 men and four in every 100 women older than 30 years [3]. This disorder produces characteristic spinal or extraspinal manifestations [2]. Spinal DISH is typically characterized by the presence of “flowing” ossification of variable thickness (up to 2 cm) along the anterolateral margins of at least four contiguous vertebral bodies [2–4] (Fig. 1).

The main differential diagnosis of spinal DISH includes spondylosis deformans, ankylosing spondylitis, reactive arthritis, and psoriatic arthritis [2]. Fusion of the facet joints, costovertebral joints, and sacroiliac joints, which are characteristic of ankylosing spondylitis, are not seen in DISH [2].

Pathologic features of spinal DISH include focal and diffuse calcification and ossification of the anterior longitudinal ligament, paraspinal connective tissue, and annulus fibrosis; degeneration in the peripheral annulus fibrosis fibers; anterolateral extensions of fibrous tissue; hypervascularity; chronic inflammatory cellular infiltration; and periosteal new bone formation on the anterior surface of the vertebral bodies [5].

Acute spinal fractures associated with DISH are not common but can lead to serious complications, including nonunion, deformity, neurologic injury, and death [3, 6]. Acute spinal fractures that occur in DISH may be mistaken for or misinterpreted as those of ankylosing spondylitis. Different patterns of spinal fractures in patients with DISH and in those with ankylosing spondylitis can be explained by differences in the pathomechanics of these diseases [3].

Clinical Manifestations of Spinal DISH
Clinical symptoms in spinal DISH are usually mild and include spinal stiffness and mild intermittent and nonradiating thoracolumbar pain that becomes evident in middle age. Generally, no significant change occurs in normal spinal mechanics, and the clinical findings are usually mild in comparison with the extent of the radiographic abnormalities. With progression of the disease, pain and stiffness may involve the lumbar and cervical segments [2]. Occasionally, patients with DISH may have severe limitation of spinal mobility and associated postural abnormality as is seen with advanced ankylosing spondylitis [7]. Prominent flowing ossifications of DISH in the cervical spine can cause dysphagia [2, 4, 8]. However, many patients with DISH are asymptomatic and their disease is discovered incidentally [4]. The association of ossification of the posterior longitudinal ligament (OPLL) and ossification of the ligamentum flavum with DISH may explain, in part, the occasional presence of neurologic findings in patients with DISH [2, 9]. Sharma et al. [10] showed in retrospective analysis that 15% of patients with DISH presenting to a particular neurosurgical unit had serious neurologic manifestations requiring neurosurgical intervention.
Imaging Characteristics of Spinal DISH

The diagnosis of DISH in most patients is made with radiography and, if needed, further characterization may be provided by cross-sectional imaging, including CT and MRI. CT and MRI are useful in the evaluation of trauma and in the rare cases of spinal stenosis in patients with DISH that are caused by ossification of spinal ligaments or hypertrophy of the apophyseal joints [2].

Three strict radiographic findings in the spine serve as a prerequisite for the diagnosis of DISH. First, flowing calcification and ossification along the anterolateral aspect of at least four contiguous vertebral bodies with or without associated localized pointed excrescences at the intervening vertebral body–intervertebral disk junctions separate this condition from typical spondylosis deformans (Figs. 1 and 2). Second, relative preservation of the intervertebral disk height in the involved vertebral segment and the absence of extensive radiographic changes of degenerative disk disease, including vacuum phenomena and vertebral body marginal sclerosis, distinguishes DISH from intervertebral (osteo)chondrosis. Last, the absence of apophyseal joint ankylosis and costovertebral joint fusion (Fig. 3), as well as the absence of sacroiliac joint erosions, sclerosis, or intra-articular osseous fusion in the synovial portion of these joints, differentiates this entity from ankylosing spondylitis [2]. However, in DISH, asymmetric intraarticular osseous fusion may occur in the proximal fibrous portion of the sacroiliac joints [2].

Osteoporosis is not a feature of DISH [2]. Association of DISH and OPLL, which is most commonly encountered in the cervical spine, is common and may be noted in up to 50% of the patients with DISH. Ossification of the ligamentum flavum is commonly associated with DISH [2, 9, 11, 12].

**DISH in the Thoracic Spine**

The thoracic spine is most commonly involved, particularly T7–T11 [4] (Fig. 1). Ankylosis is more commonly seen in the thoracic than in the cervical or lumbar spine. Ankylosis is frequently incomplete, with interdigitating areas of protruding disk material in the flowing ossifications [2] (Fig. 4). CT parallels the radiographic findings. The superb spatial resolution of CT allows accurate assessment of the facet joints, which is important in the differentiation of DISH and ankylosing spondylitis (Fig. 3).

In the thoracic spine involved by DISH, bridging ossifications are commonly seen along the right lateral aspect of the thoracic spine [4] and not on the left lateral aspect, probably related to an inhibiting effect on ossification by pulsation of the descending thoracic aorta (Figs. 1 and 2). Patients with situs inversus develop flowing ossifications on the left side [2, 4].
Fig. 2—44-year-old woman with spondylosis deformans. 
A and B, Anteroposterior (A) and lateral (B) radiographs of thoracic spine show disk space narrowing and marginal endplate osteophytes at multiple levels without bridging ossifications.

Fig. 3—Absence of apophyseal joint ankylosis and costovertebral joint fusion with diffuse idiopathic skeletal hyperostosis, which is present with ankylosing spondylitis. 
A, Axial CT image of thoracic spine in 66-year-old man with diffuse idiopathic skeletal hyperostosis shows normal apophyseal joints with no evidence of fusion (long arrow) and mild osteoarthritic changes of costovertebral joints that are not fused (short arrow). 
B, Axial CT image of thoracic spine in 59-year-old man with ankylosing spondylitis shows fused apophyseal joints (long arrow) and fused costovertebral joints (short arrow).
Diffuse Idiopathic Skeletal Hyperostosis

Ossifications at the posterior aspect of the thoracic spine are rare [2]. Flowing ossifications produce a bumpy contour of the thoracic spine (Figs. 1 and 2). Under these ossifications, radioluencies are seen along the anterior aspect of the vertebral bodies (Fig. 5). These radioluencies end at the level of the vertebral endplates where horizontal struts of new bone deposit are seen. This is related to the anatomy of the anterior longitudinal ligament, which adheres tightly to the vertebra at its central point and less tightly near the endplates [2] (Fig. 5). The anterior extension of disk material produces additional radioluencies in the bridging ossifications at the level of disk spaces of various shapes (L-, T-, and Y-shaped) (Fig. 4). There is usually no significant thoracic disk space narrowing. Intervertebral disk calcifications may occur [2] (Fig. 6). Ossifications about and between the spinous processes may be seen [2, 4] (Fig. 6B). Thoracic spine DISH may be accompanied by cortical thickening and hyperostosis of the posterior aspect of the ribs [2, 4]. However, the apophyseal joints and costovertebral joints are spared and not fused in DISH.

DISH in the Cervical Spine

Involvement of the cervical and lumbar spine with DISH is common. Lower cervical segments are more commonly involved. Progressive bone depositions along the vertebral bodies extend over the disk spaces and form either smooth or bumpy flowing ossification [2, 4]. Radiolucent areas along the anterior aspect of the cervical vertebral bodies are less frequent than in the thoracic spine [2]. Radiolucent disk extension may be observed in the cervical spine, which may isolate a small triangular ossicle in front of the disk space [2] (Fig. 7).

Degenerative changes of the cervical apophyseal joints, ossifications of the nuchal ligament, posterior spinal osteophytes, and calcification or ossification of the posterior longitudinal ligament may be seen. Hyperostosis about the atlantoaxial joint and hyperostosis at the occiput can occur [2].
DISH in the Lumbar Spine

The upper lumbar segments are more commonly involved. The radiographic abnormalities along the anterior aspect of the lumbar spine are similar to those in the cervical spine [2, 4]. Unlike the thoracic spine, flowing ossifications are equally frequent on the right and left sides of the lumbar spine [2]. Ossifications about the spinous processes and interspinous ligaments may be observed [2]. Degenerative disk space narrowing is typically mild to moderate. Degenerative changes of the apophyseal joints may occur in the lower lumbar spine and at the lumbosacral junction, but no fusion is seen [2, 4].

DISH in the Sacrum and Sacroiliac Joints

Bridging ossifications are observed about the anterior articular margins of the sacroiliac joints, resulting in paraar-
Diffuse Idiopathic Skeletal Hyperostosis

Fig. 7—Sagittal reformatted CT image of cervical spine in 73-year-old woman with diffuse idiopathic skeletal hyperostosis shows radiolucent disk extension (arrow) that isolates small triangular ossicle in front of disk space.

Fig. 8—Axial CT scan shows bridging ossifications at anterior aspect of sacroiliac joints in 81-year-old man with diffuse idiopathic skeletal hyperostosis (arrows).

Fig. 9—55-year-old man with diffuse idiopathic skeletal hyperostosis. A and B, Coronal (A) and sagittal (B) reformatted CT images of thoracic spine show fracture involving superior endplate of T7 vertebral body on left and involvement and mild widening of T6–T7 disk space. This widening is consistent with anterior and posterior longitudinal ligamentous injury (arrows). Mechanism of injury was hyperextension.

ticular fusion [2, 4, 13] (Fig. 8). Asymmetric intraarticular fusion, when it occurs, predominates in the proximal fibrous portion of the sacroiliac joints [2].

Pathomechanics of Acute Spinal Fractures in Ankylosed Spine

The ankylosed spine is more prone to fracture than a normal spine, which has been reported in both DISH and ankylosing spondylitis. These fractures can occur after even minor trauma [2, 14]. Spinal fractures in ankylosing spondylitis are more common than those in DISH, probably because of osteoporosis associated with ankylosing spondylitis [14–16]. Fractures in DISH typically occur in patients with moderate to severe disease in which osseous fusion of the long spinal segments is present [2].

DISH produces exuberant, broad, and irregular bridging ossification, which encompasses the annulus fibrosis, anterior longitudinal ligament, and paraspinal connective tissue, with an anterior distribution. The bridging ossifications are thickest at the level of the disk space and attach to the adjacent vertebral bodies. Broad areas of the proximal and distal thirds of the vertebral bodies are covered by the ossifications, leaving the sites above and below their attachment with the least amount of hyperostosis [3].

Taking into consideration the pattern of ossification in DISH and the relative preservation of the disk space, it is logical to expect fractures to occur in the regions of least resistance, such as through the mid vertebral body above or below the attachment sites of flowing ossifications [2]. Another type of spinal fracture in patients with DISH involves the end of an ankylosed segment causing disruption of the disk space. These fractures occur at the level of the stress risers at the junction of the mobile and fused spine [3].

In contrast, the thin vertical syndesmophytes of ankylosing spondylitis form at the outer fibers of annulus fibrosis and bridge the adjacent vertebrae. Chondroid metaplasia, calcifications, and ossifications progress through and weaken the involved disk over time [3]. In the early stages of
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Fractures in DISH may involve the vertebral body in the ankylosed segment or may occur close to the endplate, with associated disruption of the intervertebral disk (Figs. 6, 9, and 10), but they can also occur through the intervertebral disk [16] (Fig. 11). Most spinal fractures in ankylosing spondylitis are transdiskal [3, 4] (Fig. 13), but they can also occur through the vertebral body, as was recently shown by Wang et al. [14].

Fracture through an ankylosed segment with continued motion at the site of fracture can result in pseudoarthrosis, which can also develop at the junction of the fused and mobile spine secondary to chronic abnormal stresses. This complication manifests radiographically as single-level intervertebral disk space destruction, vertebral endplate erosions, marked vertebral sclerosis, and large osteophytes, and can mimic infective spondylitis or neuropathic changes [20].

In most patients, the diagnosis of acute spinal fractures associated with DISH is made with radiography. Further...
characterization may be provided by CT (Figs. 7, 9, and 10) and MRI [4, 21–24] (Fig. 10).

MDCT with multiplanar reformatted images has superb spatial resolution and best defines not only the presence of fracture but also the full extent of the osseous injuries [21, 22].

MRI with its superb contrast resolution and multiplanar imaging capabilities enables detailed evaluation of the spinal column, including spinal cord and ligamentous injuries, as well paraspinal ligamentous injuries and soft-tissue hematomas. Because of the higher prevalence of spinal cord and soft-tissue injuries associated with acute spinal fractures with DISH, MRI plays a fundamental role in the assessment in these patients [21–23]. Posttraumatic intravertebral fluid collections associated with hyperextension injuries have been described in patients with DISH [24].

**Treatment of Spinal Fractures in DISH**

Early stabilization of the fractured spine is needed to preclude nonunion, osteolysis, late instability, and neurologic deficit. Operative stabilization is usually required for significantly
Fig. 12—53-year-old man with diffuse idiopathic skeletal hyperostosis. A–C, Sagittal reformatted CT image (A) and sagittal T1-weighted (B) and T2-weighted fat-suppressed (C) MR images of cervical spine show no evidence of fracture. MR images show no evidence of spinal cord injury. Note edema in posterior soft tissues and in region of interspinous ligaments, and mild edema in prevertebral soft tissues at C2–C3 level, consistent with musculoligamentous strain. Note also ossification in posterior longitudinal ligament at C6–C7 level (arrows, A and C) and bumpy contour of cervical spine related to flowing ossifications.

Fig. 13—59-year-old man with ankylosing spondylitis (same patient as in Fig. 3B). A–C, Sagittal CT reformatted image (A) and sagittal T1-weighted (B) and T2-weighted fat-suppressed (C) MR images of thoracic spine show transdiskal fracture at T8–T9 level that extends into subjacent superior endplate (arrow). On MR images, note bone marrow edema about inferior endplate of T8 and superior endplate of T9. (Fig. 13 continues on the next page)
References

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