Acta Radiologica Open
6(3) 1–6

DOI: 10.1177/2058460117695855
journals.sagepub.com/home/arr

Cervical vertebral injuries associated with the ossification of the posterior longitudinal ligament: Imaging features

Tetsuo Nakayama[1,2] and Shigeru Ehara[1]

Abstract

Background: Spinal injuries associated with ossification of the posterior longitudinal ligament (OPLL) have been characterized. However, the imaging features of traumatic cervical spine fractures in patients with OPLL have not been assessed adequately.

Purpose: To characterize the patterns of traumatic cervical spine fractures associated with different types of OPLL.

Material and Methods: We retrospectively analyzed the patterns of fractures resulting from cervical spine injury in patients with OPLL of different types and assessed the fracture patterns in patients with ankylosed segments.

Results: Twenty-six patients (23 men, 3 women; median age, 67.0 years; age range, 43–87 years) were included. Fall from a height <3 m was the most common trauma. Contiguous type OPLL was seen in 11 patients (42%), segmental type in 11 (42%), and mixed type in four (15%). Four of the contiguous OPLL and one of the mixed OPLL patients had ankylosed segments. The incidence of cervical fractures was 69% (16/26): seven (64%) in contiguous OPLL, five (46%) in segmental OPLL, and in all four patients with mixed OPLL. Unilateral interfacetal fracture-dislocation was most common (4/16); the others were bilateral interfacetal fracture-dislocation, fractures through the ankylosed segment, transdiscal fractures, isolated facet fractures, and compression fractures. Cervical fractures were exclusively observed in the C4 to C7, except in one case occurred at the C2 level.

Conclusion: Interfacetal fracture-dislocation in the lower cervical vertebrae constitutes the most common injury resulting from minor trauma.

Keywords

Ossification of the posterior longitudinal ligament (OPLL), cervical spine, fractures, ankylosed spine

Date received: 27 October 2016; accepted: 3 February 2017

Introduction

Ossification of the posterior longitudinal ligament (OPLL) is commonly seen in the cervical spine and is usually associated with spinal canal narrowing and increased rigidity of the affected vertebrae, leading to acute spinal cord injuries from minor trauma. Vertebral column rigidity also increases with age because of biomechanical and metabolic changes in the vertebrae and associated spondylotic changes. Such changes reduce the range of motion of the spine and its mechanical resistance to compression, tensile, and rotational forces, leading to an increased risk of vertebral fractures (1). The spinal cord injuries associated with OPLL have been characterized in previous reports (2–4). However, the imaging features of traumatic cervical spine fractures in patients with OPLL have not been adequately characterized. The objective of this study was to elucidate and analyze the traumatic cervical spine fracture patterns that occur in patients with OPLL.

Material and Methods

This study was approved by the institutional review board. Because of the retrospective, observational

[1]Department of Radiology, Iwate Medical University School of Medicine, Morioka, Japan
[2]Department of Radiology, Tane General Hospital, Osaka, Japan

Corresponding author:
Tetsuo Nakayama, 1 19-1, Uchimaru, Morioka 020-8505, Japan.
Email: nakayama0110@yahoo.co.jp

nature of this study, the need for informed patient consent was waived.

Patient selection

Medical and imaging records of OPLL patients, admitted to our hospital between 2010 and 2013, were retrospectively reviewed. The inclusion criteria were evidence of OPLL confirmed by plain radiography and/or computed tomography (CT), an episode of trauma, and clinical symptoms associated with cervical spine trauma. Reports from our departmental radiological information system were searched to find cases of cervical spine injuries in patients with OPLL, using "cervical spine," "fracture," and "OPLL" as keywords. From the recovered records, patients were included if OPLL was confirmed by cervical spine radiography, CT, and/or magnetic resonance imaging (MRI); and if traumatic changes to the vertebral column were seen on CT and/or MRI, they were correlated with a trauma history.

Traumatic episodes

Traumatic episodes were divided into three categories: (i) traffic accidents, either as an automobile occupant or as a pedestrian; (ii) hit by falling objects; and (iii) falls. Traumatic episodes due to falls were further divided into two groups: falls from heights <3 m, including falls from a standing position or down the stairs, and falls from heights >3 m. The prevalence of each type of trauma episode was assessed.

CT imaging of OPLL and fractures

CT was performed with 16- and 64-multi-detector CT scanners (Asteion and Aquillion; Toshiba Medial System, Tokyo, Japan) using a routine cervical spine protocol or whole body trauma protocol; contiguous axial images and sagittal reformatted images of the cervical spine were generated from imaging dataset using a dedicated workstation. The reconstructed images were of 3-mm and 2-mm thickness for axial and sagittal images respectively, with both bone and soft-tissue kernels.

OPLL of the cervical spine was defined as any ossification in the posterior aspects of the cervical vertebrae, distinct of osteophyte formation; cervical vertebral fractures were defined as fractures involving any of the cervical vertebrae, C1 to C7. Location and distribution of OPLL in the cervical spine were evaluated by consensus using serial axial and reformatted sagittal images. The types of OPLL were classified as contiguous, segmental, and mixed, as per the criteria set by Research Group on the Ossification of the Spinal Ligament in Japan (5).

MRI

MRI was performed using a 1.5-T system (Signa HDx; General Electric, Fairfield, CT, USA). Imaging sequences included spin-echo, sagittal T1-weighted (T1W) images (repetition time/echo time [TR/TE] = 520/12); sagittal fast spin-echo, T2-weighted (T2W) images (TR/TE = 3000/130, echo train length = 12); or axial fast spin-echo, T2W images (TR/TE = 3000/130, echo train length = 12). The field of view was 25×25 cm on sagittal images and 18×18 cm on axial images; the matrix was 256×192–224, with a slice thickness of 4 mm. Plain cervical vertebral radiographs, CT scans and MRI were also performed within three days of the incidence of trauma. The diagnoses of OPLL, cervical vertebral fractures, diffuse idiopathic skeletal hyperostosis (DISH) were based on analyses of radiological imaging and medical records correlated with clinical signs.

Results

Twenty-six patients (23 men, 3 women; median age, 67.0 years; age range, 43–87 years) with cervical vertebral injuries associated with OPLL were included in this study. The ratio of patients aged >60 years to those aged ≤ 60 years was 20:6, with patients aged 60–69 years being the most frequently affected (11/26, 42%). Falls from a height <3 m were the most common cause of traumatic cervical spine injury (62%). Fall from a height >3 m and injury from falling objects were the cause in three (12%) patients each, and traffic accidents were the cause in two patients (7.7%). Contiguous OPLL was seen in 11 patients (42%), segmental type in 11 patients (42%), and the mixed type in four patients (15%). The mean number of vertebral segments with ossification was 4.7 in the contiguous type, 2.5 in the segmental type, and 5.3 in the mixed type. Two to three vertebrae were affected in most patients (50% of cases) with the segmental type, whereas more than five vertebrae were commonly affected in contiguous and mixed OPLL patients.

Cervical spine vertebral fracture patterns associated with each type of OPLL are summarized in Table 1. In patients with contiguous OPLL, 7/11 cases (64%) had cervical spine fractures; there were 5/11 (46%) cases involving segmental OPLL; and all four patients (100%) with mixed type OPLL. Unilateral interfacetal fracture-dislocations were most frequently seen, accounting for 25% (4/16; one in the contiguous and segmental type, two in the mixed type) of the injuries (Fig. 1), followed by bilateral interfacetal fracture-dislocations (19%, 3/16; two in the contiguous type and one in the segmental type) (Fig. 2), fractures through the ankylosed segment (three in the contiguous type) (Fig. 3), transdiscal fractures (one each in the contiguous and mixed types) (Fig. 4), and compression fractures (one each in the segmental and mixed types). A hangman fracture in one patient with contiguous OPLL and a facet fracture in one patient with the segmental type were also observed. Higher incidence of lower cervical vertebral fractures was observed in the OPLL patients, with the fractures occurring at C2 (n = 1), C4 (n = 5), C5 (n = 6), C6 (n = 5), and C7 (n = 2).

Table 1. Pattern of cervical spine fracture in patients with OPLL without and with ankylosed segment.

Type of OPLL	Contiguous	Segmental	Mixed
Without ankylosed segment			
UID	1	1	2
BID	2	1	
Compression fracture		1	1
Hangman fracture	1		
Facet fracture		1	
With ankylosed segment			
Transvertebral fracture	3		
Transdiscal fracture	1		1

BID, bilateral interfacetal fracture-dislocation; UID, unilateral interfacetal fracture-dislocation.

Discussion

In this study, cervical vertebral injuries caused by minor trauma incidents in patients with OPLL, such as falls from a height of <3 m (62%) and other trauma episodes, represented the most common causes of trauma in the general elderly population (73.6% due to falls) (6–8). The incidence of cervical vertebral fractures in the elderly population is estimated to be 2.6% (9); of that, the proportion of cervical vertebral fractures associated with OPLL in the elderly is unknown. Although we saw a fracture prevalence of 61.5% (16/26) in patients with OPLL after significant trauma, the true incidence of fractures in the overall OPLL patient population is unknown. The ability of the cervical vertebrae to withstand compression force depends on the patient's age, sex, and loading rate of the compression. Decrease in bone mineral content associated with aging correlates with the vulnerability of the cervical spine to axial loading. Development of degenerative changes in the ligaments and other supporting structures of the vertebral column also results in a decreased range of motion in the cervical vertebra (10). Such biomechanical changes and the development of cervical spondylosis in the elderly may be responsible for the increased risk of cervical vertebral fractures. In addition, increased spinal rigidity due to OPLL also contributes to vulnerability to trauma. For these reasons, elderly OPLL patients may have a higher incidence of cervical vertebral fractures.

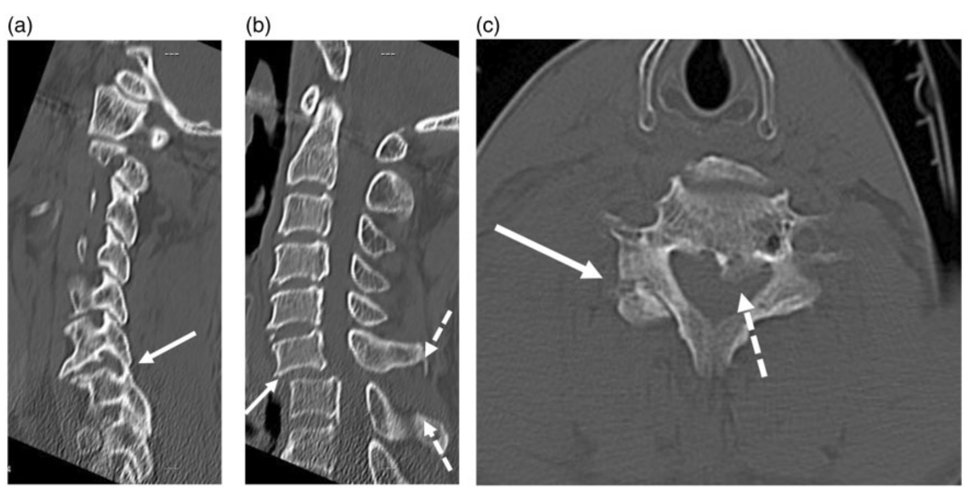

Fig. 1. Unilateral interfacetal fracture-dislocation with segmental type ossification of the posterior longitudinal ligament a 66-year-old man. (a) Right parasagittal CT reconstruction image. (b) Midline sagittal CT reconstruction image. (c) Axial image at the C6–C7 level. An abnormal small ossification of the posterior aspects of vertebral bodies (C3–C7) is shown on the midline sagittal reformatted image (b). Anterolisthesis of C6 is seen (white arrow) and widening of interspinous space between C6 and C7 is also demonstrated (white doted arrow). A distractive-flexion injury was considered. A right, parasagittal-reformatted image (a) reveals the right inferior articular process perched on the superior articular process of C7 (white arrow). An anterior dislocation of the right inferior articular process of C6 is seen on the axial image (c) (white arrow); in addition, a small ossification behind the C7 vertebral body is seen (white dotted arrow).

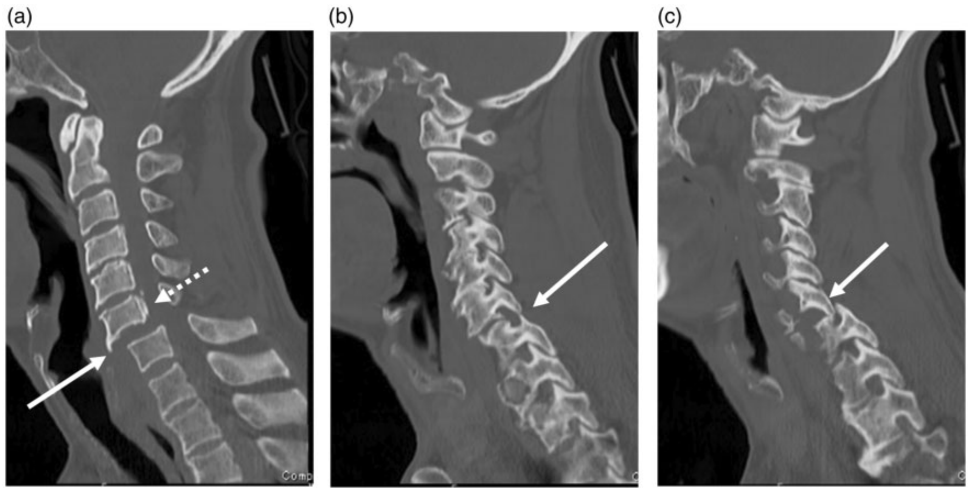

Fig. 2. Bilateral interfacetal dislocation with segmental type OPLL in a 63-year-old man. (a) Midline sagittal CT image. (b) Right parasagittal CT image. (c) Left parasagittal CT image. A mid-sagittal reformatted image (a) shows anterolisthesis of C5 and disc space widening of C5 and C6 (white arrow). Ossification of posterior aspect of C5 vertebral body (white dotted arrow) is also seen. On right parasagittal image (b), perched articular processes of the right C5/6 facet joint (white arrow) is seen. On the left parasagittal image (c), an anterior dislocation of the inferior articular process of C5 with respect to the superior articular process of C6 (white arrow) is demonstrated.

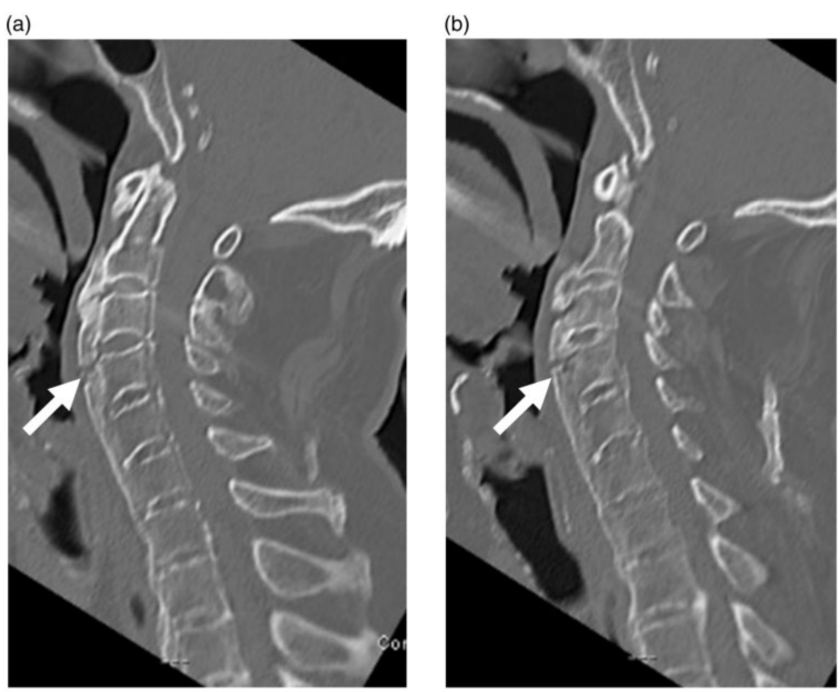

Fig. 3. Transvertebral fracture in an 80-year-old man of mixed type OPLL with ankylosed segment. Mid-sagittal reformatted CT image (a) and right parasagittal image (b) demonstrate a transverse fracture below the superior endplate of C4 (white arrow) and discontinuity of ossification the anterior longitudinal ligament at the same level (white arrow).

Distribution of cervical vertebral fractures among OPLL patients has not been previously analyzed. Our results indicate that there is a higher incidence of fractures in the lower cervical vertebrae (94%, 15/16 cases) in OPLL cases, whereas in the general elderly population, upper cervical vertebral injuries are more common, especially at the C2 level. Daffner et al. proposed that the higher incidence of cervical vertebral injury at the C2 level in elderly patients might be due to age-related biomechanical changes (6). Age-related

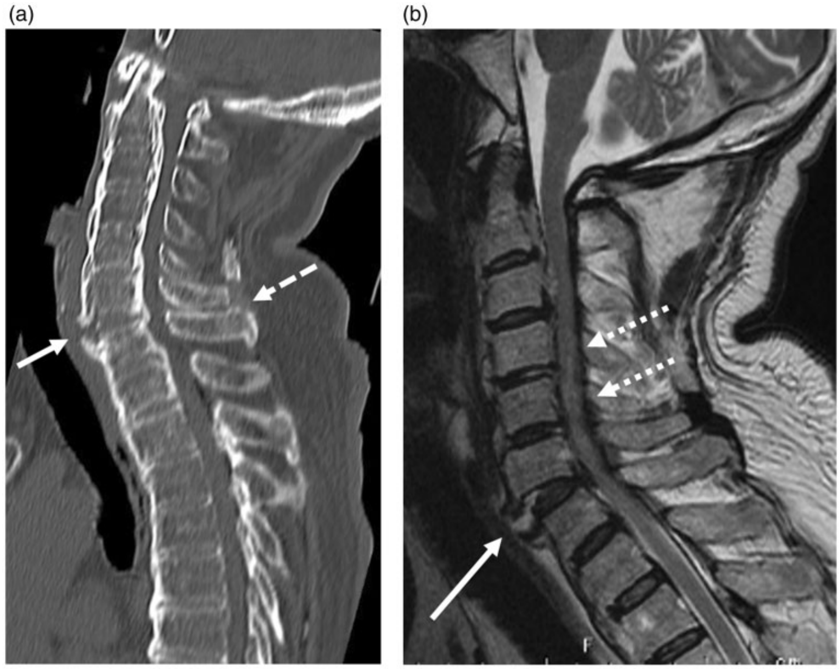

Fig. 4. Fracture at the margin of the fused segment in a 67-year-old male patient with contiguous type OPLL. (a) A midline, sagittal-reformatted CT image showing widening of the C6–C7 anterior disk space with the ankylosed segments of the C2–C6 vertebrae (white arrow) in combination with decreased interspinous space between C6 and C7 (dotted white arrows); a hyperextension injury with distraction of the fused segment is postulated. Wavy anterior ossification of the cervical and upper thoracic vertebrae is shown. (b) Sagittal T2W MR image reveals an abnormal high signal intensity at the anterior portion of the intervertebral disk of the C6–C7. Disk laceration with disruption of the anterior longitudinal ligament (white arrow) is evident. A narrowed spinal canal, with cord compression from C2–C6, represents compression injury of the spinal cord with high signal intensity (white dotted arrows).

degenerative changes in the lower cervical vertebrae makes these segments more rigid, on the other hand, C1–2 vertebrae have a wide range of motion, hyperextension in this segment due to concentrated traumatic force may lead to fractures of the C2 vertebra (6), whereas restricted motion at the C1–2 level due to higher spinal rigidity with preserved motion at the lower edge of the fused segments in the lower cervical vertebrae of OPLL patients may be the reason behind significantly higher lower cervical vertebral fractures.

In our study, cervical spine fractures were more commonly associated with contiguous (62%) and mixed type OPLL (100%) and lesser with the segmental type (46%). A lower number of involved vertebrae and shorter segments of fused vertebral in segmental OPLL compared to contiguous or mixed-type OPLL could be the reason for better spinal movement and less spinal rigidity, thus accounting for the difference in the fracture prevalence. However, other potential confounding factors, such as the extent of spondylotic changes, strength, and force vectors applied to the cervical spine, were not accounted for.

Our analysis suggests only a weak relationship between fracture morphologies and types of OPLL. Unilateral interfacetal fracture-dislocations, in the lower cervical vertebrae, caused by distractive flexion are seen in all types of OPLL (11). Bilateral interfacetal fracture-dislocations, caused by simultaneous distractive flexion and extension, are observed in the contiguous and segmental types (11). Two compression fractures were seen in each of the segmental and mixed type of OPLL. There was a facet fracture in a case of segmental OPLL, resulted by compression. A hangman fracture was seen in one patient with contiguous OPLL. A teardrop fracture was observed in one case with segmental OPLL. Thus, all the types of OPLL have fractures of various morphologies, therefore the patterns of cervical fractures in the patients with OPLL are more likely influenced by the nature of applied forces at the time of injury.

In this study, we also analyzed the pattern of the cervical vertebral fractures in OPLL patients with ankylosed segments. Most cervical fractures were transverse fractures through the fused segments and some fractures occurred at the distal margin of the ankylosed segment. This pattern of cervical vertebral fractures is similar to that observed in patients with DISH. Hyperextension, among other mechanisms, is the most common mechanism of injury causing acute spinal fracture in ankylosed spine and tends to occur in the least resistant portion, such as the vertebral body above or below the attachment of ossification and at the junction of ankylosed and mobile segment (12,13). Bransford et al. reported that fractures through the intervertebral disk were the most common type in patients with DISH (14). The fracture patterns in our patients with OPLL and ankylosed segments were similar to those in the previously published reports of DISH. OPLL is commonly associated with DISH, and it is not excluded that OPLL in our patients with ankylosed segments may be a part of DISH because of lack of whole spine survey.

This study has some limitations, such as the small number of patients involved and its retrospective nature. Patient selection was based on radiology reports of OPLL patients with a history of trauma, but patients who experienced minor trauma but did not demonstrate trauma-related specific symptoms or did not display imaging abnormalities were excluded; thus, the sample in this study might not be an ideal representative for general OPLL population. Additionally, we did not include a control group of cervical spine injury patients without OPLL and DISH.

In conclusion, trauma causes a progression of symptoms in OPLL patients, a majority of whom are unaware of their OPLL prior to the trauma. Generally, vertebral injuries are difficult to detect because of overlapping spondylotic changes and irregular spinal curvature. As in elderly patients without OPLL, minor trauma events, such as falls from a height of <3 m are common precipitating causes of vertebral fractures in OPLL patients, However, fractures in OPLL patients are likely to occur more in the lower cervical region than the more common, C2 level, upper cervical spine injuries in the general elderly population. Fractures occurring through the ankylosed segment were common in our patients and these types of fractures are similar to those observed in DISH.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. MacMillillan M, Stauffer ES. Traumatic instability in the previously fused cervical spine. J Spinal Disord 1991;4: 449–454.
2. Onishi E, Sakamoto A, Murata S, Matsushita M. Risk factors for acute cervical spinal cord injury associated with ossification of the posterior longitudinal ligament. Spine 2012;37:660–666.
3. Chikuda H, Seichi A, Takeshita K, et al. Acute cervical spinal cord injury complicated by preexisting ossification of the posterior longitudinal ligament: a multicenter study. Spine 2011;36:1453–1458.
4. Koyanagi I, Iwasaki Y, Hida K, Imamura H, et al. Acute cervical cord injury associated with ossification of the posterior longitudinal ligament. Neurosurgery 2003;53: 887–891.
5. Tsuyama N. Ossification of the posterior longitudinal ligament of the spine. Clin Orthop Relat Res 1984;184: 71–78.
6. Daffner RH, Goldberg AL, Evans TC, et al. Cervical vertebral injuries in the elderly: a 10-year study. Emerg Radiol 1998;5:38–42.
7. Lomoschitz FM, Blackmore CC, Mirza SK, et al. Cervical spine injuries in patients 65 years old and older: epidemiologic analysis regarding the effects of age and injury mechanism on distribution, type, and stability of injuries. AJR Am J Roengenol 2002;178: 573–577.
8. Lieberman IH, Webb JK. Cervical spine injuries in the elderly. J Bone Joint Surg Br 1994;76:877–881.
9. Bub LD, Blackmore CC, Mann FA, et al. Cervical spine fractures in patients 65 years and older: a clinical prediction rule for blunt trauma. Radiology 2005;234:143–149.
10. Kuhlman KA. Cervical range of motion in the elderly. Arch Phys Med Rehabil 1993;74:1071–1079.
11. Allen BL Jr, Ferguson RL, Lehmann TR, et al. A mechanistic classification of closed, indirect fractures and dislocation of the lower cervical spine. Spine 1982;7:1–27.
12. Hendrix RW, Melany M, Muller F, et al. Fractures of the spine in patients with ankylosis due to diffuse skeletal hyperostosis: clinical and imaging findings. AJR Am J Roentgenol 1994;162:899–904.
13. Taljanovic MS, Hunter TB, Wisneski RJ, et al. Imaging characteristics of diffuse idiopathic skeletal hyperostosis with an emphasis on acute spinal fractures: review. AJR Am J Roentgenol 2009;193(Suppl. 3): S10–19.
14. Bransford RJ, Koller H, Caron T, et al. Cervical spine trauma in diffuse idiopathic skeletal hyperostosis: injury characteristics and outcome with surgical treatment. Spine 2012;37:1923–1932.