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Conservative treatment for stable low-energy thoracolumbar vertebral fractures in nonfused segments among elderly patients with diffuse idiopathic skeletal hyperostosis

A matched case-control study

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Abstract

Diffuse idiopathic skeletal hyperostosis (DISH) is the spontaneous osseous fusion of the spine with anterior bridging osteophytes. It is well-known that conservative treatment for vertebral fractures of fused segment among DISH spines is associated with worse clinical outcomes. However, the prognosis of conservatively treated stable vertebral fractures in neighboring nonfused segments among DISH spines is still unknown. The purpose of this study was to analyze the results of conservative treatment of stable low-energy thoracolumbar (TL) vertebral fracture in nonfused segments among patients with DISH lesions.

A total of 390 consecutive patients who visited an emergency department by ambulance with spinal trauma between 2013 and 2017 were retrospectively reviewed. The diagnosis of DISH was determined based on fused spinal segments with bridging osteophytes in at least 3 adjacent vertebrae. For each case of stable TL vertebral fractures in nonfused segments of the DISH spine, we identified 2 age-, sex-, and fracture lesion-matched non-DISH controls who underwent conservative treatment for low-energy TL vertebral fractures during the same period.

Of the 33 identified cases of TL fractures with DISH, 14 met our inclusion criteria. The bony union rates of the DISH group and control group were 57% and 75% at the 3-month follow-up examination ($P = .38$) and 69% and 100% at the 6-month follow-up examination ($P = .02$), respectively. Among the 13 patients with fractures below the TL junction, fused segments were not diagnosable based on the initial standard radiographs of the lumbar spine for 61.5% of patients.

Although this study design was exploratory and the sample size was small, our results suggest that with conservative treatment, stable fractures in nonfused segments in the DISH spine might have a worse prognosis than ordinary osteoporotic vertebral fractures. The diagnosis of coexisting DISH lesions can be missed when only radiographs of the lumbar spine are used to determine the diagnosis.

Abbreviations: AS = ankylosing spondylitis, ASD = adjacent segmental disease, CT = computed tomography, DISH = diffuse idiopathic skeletal hyperostosis, TL = thoracolumbar, TLICS = Thoracolumbar Injury Classification and Severity score.

Keywords: conservative treatment, delayed union, diffuse idiopathic skeletal hyperostosis, nonfused segment, stable fracture

1. Introduction

Diffuse idiopathic skeletal hyperostosis (DISH) is a relatively common clinical condition among elderly individuals. The main characteristic of the disease is spontaneous osseous fusion of the spine with anterior bridging osteophytes.[1,2] The prevalence of this disease has been reported to be 3.5% to 42% and varied according to the study.[3–8] However, the risk of DISH increases with age[3,4,8]; therefore, it is becoming an emerging issue in many aging societies.

In addition to ankylosing spondylitis (AS), DISH has been recognized as a major ankylosing spinal disorder.[9] An ankylosing spine acts like a long bone, and any fracture in the ankylosing segment induces significant instability. This fracture is considered a high-risk fracture because it is often complicated by secondary displacement, neurological deterioration, delayed union, or nonunion.[9–12]

Currently, discussions regarding thoracolumbar (TL) fractures associated with DISH have been almost exclusively focused on

Editor: Danny Chu.

The authors have no conflicts of interest to disclose.

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Medicine (2019) 98:24(e16032)

Received: 26 October 2018 / Received in final form: 29 April 2019 / Accepted: 21 May 2019

http://dx.doi.org/10.1097/MD.0000000000016032

unstable fractures in the fused segment, and little is known about the effects of fused segments due to DISH on the results of treatment for stable TL fractures in nonfused segments.

This study aimed to identify the results of conservative treatment for stable low-energy TL vertebral fractures in nonfused segments among patients with DISH lesions and to determine if the fused segment can be diagnosed with lateral lumbar spine radiographs.

2. Methods

Institutional review board approval was obtained for this study. The need for written informed consent from each study participant was waived because of the retrospective nature of the study. The electronic charts of 390 consecutive spinal trauma patients who were transferred by ambulance to an emergency department of a single community-based hospital between January, 2013 and October, 2017 were retrospectively reviewed. During this study period, based on the institutional protocol for blunt trauma, all adult patients with blunt trauma who were transferred to the emergency department by ambulance and suspected to have a TL spinal injury according to their history and physical examination underwent whole TL spine helical computed tomography (CT) scans and radiography of the suspected regions.

The diagnosis of DISH was determined based solely on the spinal manifestation and was defined as fused spinal segments with bridging osteophytes (grade 2 or grade 3 according to the Mata scoring system[13]) in at least 3 adjacent vertebrae as "likely DISH" by Weinfeld et al.[4] Multiplane reconstruction images of the CT scan were utilized to confirm the diagnosis. Based on the results of a biomechanical study of adjacent segmental disease (ASD) after surgical fusion that indicated that increased intradiscal pressure was observed in discs 1 to 3 levels above the fused segments, we defined a nonfused level fracture as a fracture located within 3 levels from the upper or lower fused vertebrae.[14]

The decision to use surgical or conservative treatment during the study period was determined according to the Thoracolumbar Injury Classification and Severity score (TLICS; 1–3, conservative; 4, surgeon's choice; ≥5, surgical treatment).[15] We only included patients with a TLIC score of 1 to 2 points, AO classification type A, and no neurological symptoms[16] during the initial hospital visit, regardless of whether the classification and TLICS score might have changed after the initial visit because differentiating compression or burst fractures in the osteoporotic vertebrae is often difficult during the initial diagnostic studies. Patients with fused vertebrae only in the cervical spine, a history of symptomatic TL fracture, a history of TL spinal fusion surgery, high-energy trauma, suspected pathological fracture, or a known diagnosis of AS were excluded. A matched control group was extracted from patients who were treated during the same period, met the same inclusion criteria, and did not have a DISH lesion (1:2 matching with age, sex, and fracture regions: thoracic, T3–10; TL junction, T11–L1; lumbar, L2–5).

Conservative treatment during the study period was performed on an outpatient basis and comprised minimum bed rest, analgesics, a brace, and osteoporosis treatment according to the treating physician's discretion. All patients were instructed to visit the outpatient clinic monthly or more frequently until bony union was confirmed.

Bony union status was evaluated as the primary outcome. Bony union is defined as obvious consolidation or bridging callus formation at the fractured vertebra with no radiographical instability or vacuum phenomenon at the fracture site or mechanical back pain. Neurological complications and malunion (>30° kyphosis) were recorded as secondary outcomes.

Among patients who had a fracture below T11, we assessed whether the fused segment could be diagnosed with standard lateral lumbar spine radiographs (in which the imaging area is usually contained in the T11 vertebra or lower) by first blindly interpreting the lateral lumbar spine radiographs regarding the presence of fused vertebrae then assessing the CT images afterward. All radiographic assessments were independently conducted by 2 orthopedic fellow surgeons and one board-certified orthopedic spine surgeon, neither of whom were affiliated with the direct care of the patients.

Statistical analysis was conducted using R software (R for 3.1.0 GUI 1.64). A paired *t* test for continuous variables and Mantel-Haenszel test for categorical variables were used. The log rank test was also conducted to compare the cumulative probability of bony union. Statistical significance was set as $P < .05$.

3. Results

A total of 167 TL spinal column fractures were identified. Of the 33 cases (19.7% of all TL fracture) of DISH lesions identified, 24 had fractures in the nonfused segments (upper segments, n = 5; lower segments, n = 19) and 17 were treated conservatively (upper, n = 1; lower, n = 16). Three patients were excluded because they were followed-up at other hospitals, and 14 cases were included in the analysis (upper, n = 1; lower, n = 13). All fractures were classified as A1 with a TLICS of 1 point at the initial visit. Twenty-eight matched control patients were selected.

The mean age of the patients was 77.7 years (standard deviation ±8.0) in the DISH group; 78.6% of the patients in the DISH group were men and 21.3% had a history of diabetes. The median number of fused vertebrae was 7.0 (range, 3–11). The patient demographics are shown in Table 1. The mean average follow-up period of DISH cases was 7.1 months (range, 1.5–24 months). No patients in either the DISH group or the control group had neurological symptoms at the initial encounter. No patient required conversion to surgical treatment during follow-up.

Table 1

Patient demographics of the diffuse idiopathic skeletal hyperostosis and control groups.

Variable	DISH (n = 14)	Control (n = 28)	*P*
Age (yr), mean ± standard deviation	77.7 ± 8.0	78.6 ± 7.9	.30
Sex, M:F (female %)	11:3 (21.4)	22:6 (21.4)	>.99
Injury level (%)			
Thoracic (T10 or above)	1 (3.8)	2 (3.8)	>.99
Thoracolumbar (T11–L1)	6 (46.2)	12 (46.2)	
Lumbar (L2 or below)	7 (50.0)	14 (50.0)	
Current smoker (%)	1 (7.1)	1 (3.6)	.62
Diabetes (%)	3 (21.4)	8 (28.6)	.64
Median number of fused levels (range)	7.0 (3–11)	NA	
Levels between the fracture and fused level (%)			
One level	7 (50.0)	NA	
Two levels	4 (28.6)		
Three levels	3 (21.4)		

DISH = diffuse idiopathic skeletal hyperostosis, F = female, M = male, NA = not available.

Table 2

Clinical results of the diffuse idiopathic skeletal hyperostosis and control groups.

Results	DISH	Control	P
Bony union			
At 3 months	8/14 (57%)	21/28 (75%)	.38
At 6 months	9/13 (69%)	28/28 (100%)	.02
>30° of kyphotic malunion	1/11 (9%)	0	
Neurological complication	0	0	
Fused vertebra not diagnosable with lumbar spine radiographs	8/13 (62%)	NA	

DISH = diffuse idiopathic skeletal hyperostosis, NA = not available.

One patient in the DISH group dropped out after 3 months of follow-up because of hospitalization due to medical conditions with no direct relation to DISH or fracture. Another DISH patient whose fracture had not healed by the time of the 6-month follow-up also canceled further follow-up appointments because his symptoms resolved after the 6-month follow-up. No patient in the control group dropped out before fracture healing occurred.

The summary of results is shown in Table 2. The bony union rates of the DISH group and control group were 57% and 75% at the 3-month follow-up ($P = .38$) and 69% and 100% at the 6-month follow-up, respectively ($P = .02$). The log rank test demonstrated significantly worse bony union probability for the DISH group (Fig. 1). One patient in the DISH group still had nonunion at the time of the 24-month follow-up (Fig. 2), but that patient refused any intervention because of minimal symptoms. No neurological complications were observed in either group. One patient in the DISH group showed 31° of kyphotic malunion (Fig. 3).

Among the 13 patients with fractures below T11, fused segments were not diagnosable in 61.5% (8/13) based on the initial standard radiographs of the lumbar spine. Among them, 4 patients had DISH lesions above the area of imaging and 4 patients had DISH lesions at least partially located in the area of imaging, but bridging osteophytes were not recognizable with lumbar spine radiographs.

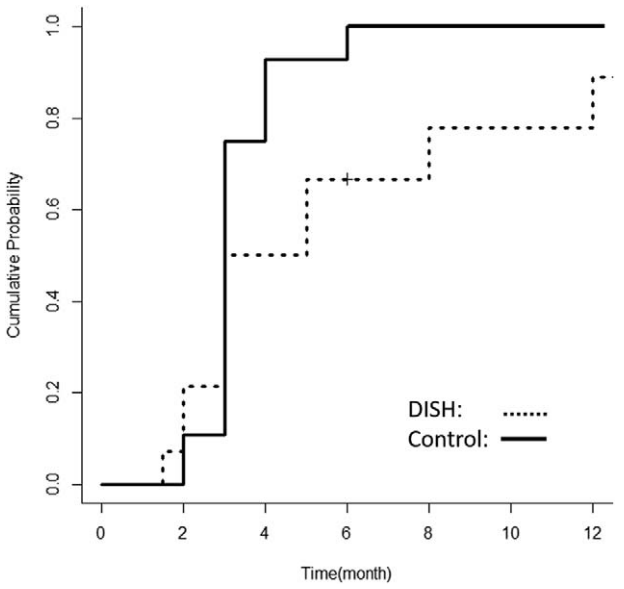

Figure 1. Cumulative probability of bony union. Kaplan–Meier plot demonstrating the cumulative probability of bony union in each group.

4. Discussion

In this study, our results suggested that the presence of DISH lesions can be a risk factor for delayed union in patients who undergo conservative treatment for low-energy stable TL fractures. Although most fractures eventually healed, the cumulative probability of bony union was lower in the DISH group. To the best of our knowledge, no study has examined the impact of DISH lesions on the outcomes of stable fractures in nonfused vertebra.

The outcome of conservative treatment for ordinary osteoporotic vertebral fractures has been reported to be excellent. One report showed that >95% of patients with uncomplicated vertebral compression fractures had success within 3 weeks of conservative treatment.[17] However, fractures in the fused part of the ankylosing spine usually demonstrate worse clinical outcomes,[9] and conservative treatment is limited to patients with surgical contraindications or simple type A fractures. Fractures in the ankylosed spine are prone to 3-column fractures, and stable type A fractures are relatively rare in the ankylosed part. Furthermore, differentiating type B or type C fractures from stable type A fractures is often difficult during initial examinations.[11] Therefore, fractures in fused segments are considered conditions that require surgical treatment in the majority of cases. There are no clear guidelines for stable fractures in the nonfused segments of the DISH spine. Matsumoto et al[18] reported a case of delayed fracture union in the fused segment of the DISH spine after conservative treatment that was successfully treated with daily teriparatide. Therefore, pharmacological augmentations, such as teriparatide, might be an option for nonfused segment fractures in the DISH spine.

One possible explanation for the worse outcomes among DISH patients is the alteration in the biomechanical property; concentrated mechanical stress in the nonfused segments caused by DISH might prevent bony healing of fractures in these segments. The effects of fused segments on the pathology of neighboring levels have been investigated among patients who underwent therapeutic spinal fusion procedures. Many studies concluded that increased biomechanical demands on other spinal segments after arthrodesis were considered possible causes of ASD after fusion surgery.[19] Chow et al[14] reported that intradiscal pressure in neighboring segments increased after experimental L4/5 and L4–S1 fusion, and these changes were observed even 3 levels above (L1/2). Moreover, DISH lesions alone can be a risk factor for ASD. Otsuki et al[20] reported that the presence of DISH lesions was associated with higher rates of additional surgery due to ASD or pseudarthrosis, even though the detailed mechanism remained unclear. ASD and delayed union among nonfused fractures in the DISH spine might share the same pathophysiology in terms of biomechanical characteristics.

Our study demonstrated that more than half of fused segments among patients who had fractures below the TL junction were missed with standard radiographs of the lumbar spine, which is the most economic and the first-choice modality for the diagnosis of vertebral fractures.[21] The most common site of DISH lesions in the TL spine is the mid-lower thoracic spine.[6,9,22] This regional trend of DISH lesions was the reason for potentially missed diagnoses for half of the patients because fused segments were located above the upper margin of the radiograph. Others

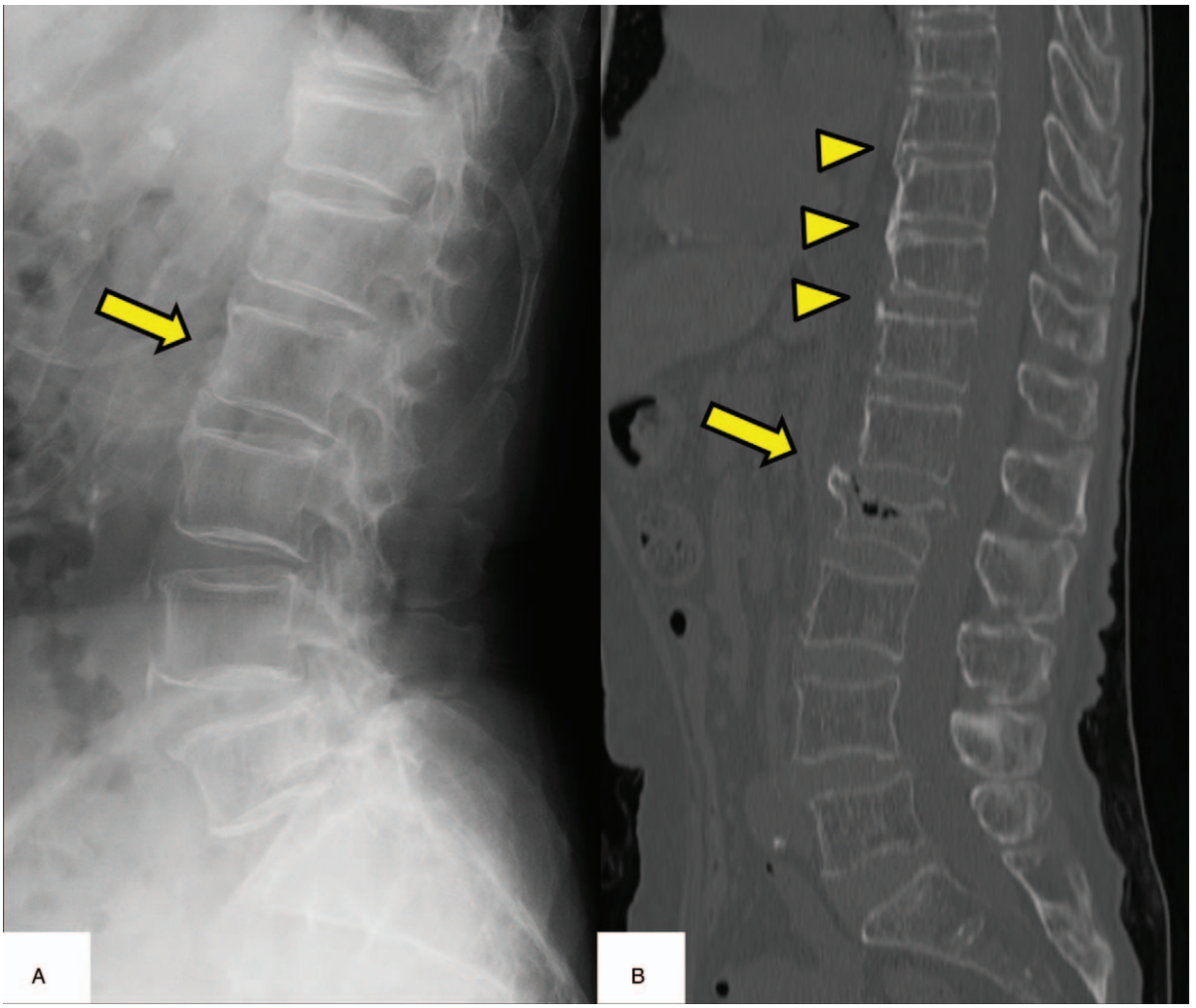

Figure 2. A representative case of a nonfused segment fracture in the diffuse idiopathic skeletal hyperostosis (DISH) spine. An 87-year-old man with an L2 fracture and a T9–12 fused lesion. (A) Lateral radiograph of the lumbar spine at the initial workup showing only subtle incongruity in the anterior wall of the L2 vertebra (arrow). (B) Multiplane reconstruction computed tomography image at the 6-month follow-up showing the vacuum phenomenon in the fractured vertebra and no bony union (arrow), as well as the fused segment with an anterior bridging osteophyte (arrowhead).

had fractures located within the area of the radiographs, but the fused segments were not recognizable with radiographs. Hirasawa et al[7] demonstrated that CT was more reliable for diagnosing DISH lesions than radiographs. They also reported that >30% of DISH cases diagnosed with CT were not recognizable when only radiographs were used for diagnosis. Although fused segments can be more accurately diagnosed with CT scans, it remains unclear whether CT should be recommended for all cases because of the possible harm of radiation exposure and the issue of resource utility. The use of a larger imaging field including the mid-thoracic lesion and limited usage of TL spine CT for delayed healing cases might be realistic options for this situation.

Our results suggest that a meticulous examination utilizing multiple imaging modalities, if available, to find fused DISH lesions around the fracture site should be performed. Once the fused lesions are found, patients should be notified that the fracture might be associated with potentially worse outcomes. Although we could not determine any definitive conclusion regarding the required intervention for such cases with our current data, because of the reported worse outcomes of delayed intervention for vertebral fracture nonunion,[2,3] it is also recommended that more frequent clinical and radiological follow-up examinations should be performed so that the opportunity for further therapeutic interventions is not lost.

The exploratory nature of this study caused it to have several inherent limitations. First, the most important issue is that this was a retrospective study with a small number of patients. Second, only those patients who visited the emergency department by ambulance were included, and the results of our study might not be applicable to walk-in patients who can visit the physician's office independently. Additionally, although our criteria for bony fusion included the absence of mechanical pain, this study mainly consisted of imaging evaluations, and patient-reported outcomes were not evaluated. Furthermore, we did not assess the impact of incomplete bridging, which might restrict the motion of the segments. Moreover, we could not control all comorbidities as potential confounders. Finally, due to the small sample size and limited availability of required data, we could not utilize robust statistical methods such as correlation or

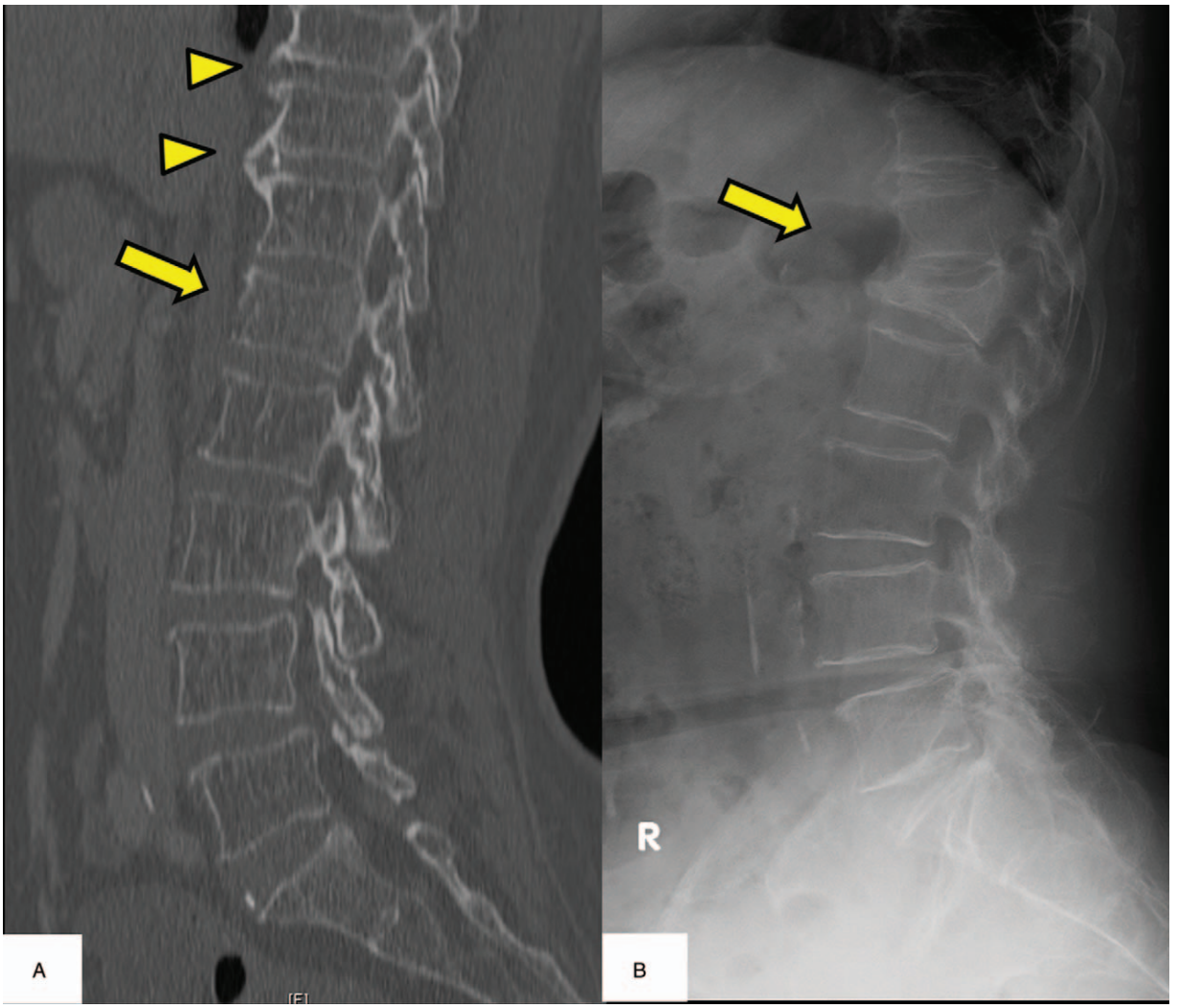

Figure 3. A representative case of a nonfused segment fracture in the diffuse idiopathic skeletal hyperostosis (DISH) spine. A 70-year-old woman with an L1 fracture and a T5–12 fused lesion. (A) Multiplane reconstruction computed tomography image at the initial presentation showing incongruity in the anterior wall of the L1 vertebra (arrow), as well as the fused segment with an anterior bridging osteophyte (arrowhead). (B) Lateral radiograph at the 4-month follow-up showing 31° of kyphotic malunion at L2 (arrow).

multivariate regression analyses. Further prospective studies are warranted to validate the generalizability of our results and to establish prevention, diagnosis, and treatment strategies regarding nonfused segment fractures in the ankylosed spine.

In conclusion, although this study design was exploratory and the sample size was small, our results suggest that stable fractures in the nonfused segments of the DISH spine might have a worse prognosis than ordinary osteoporotic vertebral fractures with conservative treatment. The diagnosis of coexisting DISH lesions can be missed when only radiographs of the lumbar spine are used to determine the diagnosis. Our results could be the basis of future confirmation studies to address the impact of DISH lesions on the prognosis of vertebral fractures in nonfused segments.

Acknowledgments

The authors would like to thank Editage (www.editage.jp) for English language editing.

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References

[1] Forestier J, Rotes-Querol J. Senile ankylosing hyperostosis of the spine. Ann Rheum Dis 1950;9:321–30.

[2] Resnick D, Shaul SR, Robins JM. Diffuse idiopathic skeletal hyperostosis (DISH): Forestier's disease with extraspinal manifestations. Radiology 1975;115:513–24.
[3] Cassim B, Mody GM, Rubin DL. The prevalence of diffuse idiopathic skeletal hyperostosis in African blacks. Br J Rheumatol 1990;29:131–2.
[4] Weinfeld RM, Olson PN, Maki DD, et al. The prevalence of diffuse idiopathic skeletal hyperostosis (DISH) in two large American Midwest metropolitan hospital populations. Skeletal Radiol 1997;26:222–5.
[5] Boachie-Adjei O, Bullough PG. Incidence of ankylosing hyperostosis of the spine (Forestier's disease) at autopsy. Spine (Phila Pa 1976) 1987;12:739–43.
[6] Holton KF, Denard PJ, Yoo JU, et al. Diffuse idiopathic skeletal hyperostosis and its relation to back pain among older men: the MrOS Study. Semin Arthritis Rheum 2011;41:131–8.
[7] Hirasawa A, Wakao N, Kamiya M, et al. The prevalence of diffuse idiopathic skeletal hyperostosis in Japan - the first report of measurement by CT and review of the literature. J Orthop Sci 2016;21:287–90.
[8] Kagotani R, Yoshida M, Muraki S, et al. Prevalence of diffuse idiopathic skeletal hyperostosis (DISH) of the whole spine and its association with lumbar spondylosis and knee osteoarthritis: the ROAD study. J Bone Miner Metab 2015;33:221–9.
[9] Caron T, Bransford R, Nguyen Q, et al. Spine fractures in patients with ankylosing spinal disorders. Spine (Phila Pa 1976) 2010;35:E458–64.
[10] Westerveld LA, Verlaan JJ, Oner FC. Spinal fractures in patients with ankylosing spinal disorders: a systematic review of the literature on treatment, neurological status and complications. Eur Spine J 2009;18:145–56.
[11] Reinhold M, Knop C, Kneitz C, et al. Spine fractures in ankylosing diseases: recommendations of the Spine Section of the German Society for Orthopaedics and Trauma (DGOU). Global Spine J 2018;8:56s–68s.
[12] Schiefer TK, Milligan BD, Bracken CD, et al. In-hospital neurologic deterioration following fractures of the ankylosed spine: a single-institution experience. World Neurosurg 2015;83:775–83.
[13] Mata S, Chhem RK, Fortin PR, et al. Comprehensive radiographic evaluation of diffuse idiopathic skeletal hyperostosis: development and interrater reliability of a scoring system. Semin Arthritis Rheum 1998;28:88–96.
[14] Chow DH, Luk KD, Evans JH, et al. Effects of short anterior lumbar interbody fusion on biomechanics of neighboring unfused segments. Spine (Phila Pa 1976) 1996;21:549–55.
[15] Vaccaro AR, Lehman RAJr, Hurlbert RJ, et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous complex, and neurologic status. Spine (Phila Pa 1976) 2005;30:2325–33.
[16] Reinhold M, Audige L, Schnake KJ, et al. AO spine injury classification system: a revision proposal for the thoracic and lumbar spine. Eur Spine J 2013;22:2184–201.
[17] Lee HM, Park SY, Lee SH, et al. Comparative analysis of clinical outcomes in patients with osteoporotic vertebral compression fractures (OVCFs): conservative treatment versus balloon kyphoplasty. Spine J 2012;12:998–1005.
[18] Matsumoto T, Ando M, Sasaki S. Effective treatment of delayed union of a lumbar vertebral fracture with daily administration of teriparatide in a patient with diffuse idiopathic skeletal hyperostosis. Eur Spine J 2015;24 (suppl 4):S573–6.
[19] Radcliff KE, Kepler CK, Jakoi A, et al. Adjacent segment disease in the lumbar spine following different treatment interventions. Spine J 2013;13:1339–49.
[20] Otsuki B, Fujibayashi S, Takemoto M, et al. Diffuse idiopathic skeletal hyperostosis (DISH) is a risk factor for further surgery in short-segment lumbar interbody fusion. Eur Spine J 2015;24:2514–9.
[21] Kendler DL, Bauer DC, Davison KS, et al. Vertebral fractures: clinical importance and management. Am J Med 2016;129:221.e1–0.
[22] Nakajima M, Hirayama K. Midcervical central cord syndrome: numb and clumsy hands due to midline cervical disc protrusion at the C3-4 intervertebral level. J Neurol Neurosurg Psychiatry 1995;58:607–13.
[23] Minamide A, Maeda T, Yamada H, et al. Early versus delayed kyphoplasty for thoracolumbar osteoporotic vertebral fractures: the effect of timing on clinical and radiographic outcomes and subsequent compression fractures. Clin Neurol Neurosurg 2018;173:176–81.