Spinous Process Fractures in Osteoporotic Vertebral Fractures: A Cross-Sectional Study

Toshio Nakamae[1)], Naosuke Kamei[1)], Yoshinori Fujimoto[2)], Kiyotaka Yamada[2)], Satoshi Ujigo[2)] and Nobuo Adachi[1)]

1) Department of Orthopaedic Surgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Japan
2) Department of Orthopaedic Surgery, JA Hiroshima General Hospital, Hiroshima, Japan

Abstract:

Introduction: The purpose of this study was to assess radiological features and clinical scores of osteoporotic vertebral fracture (OVF) accompanied by spinous process fracture (SPF).

Methods: We included painful patients with single-level OVF with intravertebral cleft. SPF was detected using magnetic resonance imaging (MRI) and/or computed tomography (CT). The plain radiographs of the vertebral fractures were evaluated based on the wedging angle of the fractured vertebrae and vertebral instability. We investigated the clinical parameters of age, gender, visual analog scale (VAS) score for low back pain (LBP), Oswestry Disability Index (ODI), and the period from the onset of acute fracture.

Results: MRI and/or CT indicated among 195 patients of OVF with LBP, 41 patients (20.5%) had SPFs. SPFs were observed one level above the fractured vertebral body in 35 patients (85.4%) and at the same level as the fractured vertebral body in 6 patients (14.6%). The prevalence of vertebral fracture of thoracic spine in the SPF-positive group was significantly greater than that in the SPF-negative group. There were no significant differences in age, gender, VAS, ODI, the time period from the onset of acute LBP, wedging angle, and vertebral instability between the presence or absence of SPFs.

Conclusions: SPFs occurred in 20.5% of patients with OVF and LBP. In addition, SPFs often occurred one level above the fractured vertebra, and SPFs with OVF tended to be located in the thoracic spine.

Keywords:

Osteoporotic vertebral fracture, Spinous process fracture, Spine, Low back pain, Aging

Spine Surg Relat Res 2022; 6(2): 139-144
dx.doi.org/10.22603/ssrr.2021-0066

Introduction

Osteoporotic vertebral fractures (OVFs) are becoming a significant socio-economic problem as the population of elderly individuals increases, especially in developed countries. Although OVF is considered to have a benign natural history, some patients with OVF do not respond adequately to standard conservative therapy, which can cause long-term deterioration in patients' health[1-3)]. In patients with long-lasting low back pain (LBP) and OVF, dynamic plain radiographs with the patients in sitting and supine positions, magnetic resonance imaging (MRI) and computed tomography (CT) have been reported as useful diagnostic tools; these images indicate that some patients had vertebral instability, intravertebral cleft, and signal changes of the vertebral bodies[4-7)].

When diagnosing patients with OVF, some classification systems are used depending on the morphological changes in the fractured spine[8,9)]. Although some studies have focused on the fractured vertebral body, there are few reports on spinous process fractures (SPFs) in the osteoporotic spine[10,11)]. Moreover, to the best of our knowledge, there are no studies examining the relationship among the SPFs, clinical symptoms, and radiological findings. In this study, we aimed to assess radiological features and clinical scores of single-level OVF accompanied by SPF.

Corresponding author: Toshio Nakamae, toshinakamae623813@yahoo.co.jp
Received: March 31, 2021, Accepted: May 7, 2021, Advance Publication: June 30, 2021

Figure 1. Sagittal MRI indicating spinous process fractures (SPFs) (a, b: L1 osteoporotic vertebral fracture [OVF] with T12 SPF. a: T1-weighed image [WI]. b: T2-weighed fat-saturated image. c, d: T11 OVF with T10 SPF. a: T1WI. b: T2-weighed fat-saturated image).

Materials and Methods

Patients

A cross-sectional observational study was performed at our hospitals. We analyzed the information obtained from patients referred to our institutes with single-level OVF with pain consistent with the spinal level of local tenderness. Osteoporosis was diagnosed based on a T-score ≤−2.5 on dual-energy X-ray absorptiometry on lumbar spine. OVF with intravertebral cleft was detected using plain radiography with the patients in sitting and supine positions, CT, and MRI. For inclusion in the study, the duration and severity of LBP experienced by patients was required to be more than 3 months, and the patients had to have a score of greater than 40 mm on the visual analog scale (VAS; range, 0-100 mm). They also had to be refractory to standard medical treatment, comprising bed rest, analgesic administration, and/or external back bracing from the previous doctor. Patients with spinal cancer, active infection, or high-energy trauma were excluded. This study was approved by our institutional review board.

Radiological investigation

The findings of plain radiographs were assessed based on wedging angle of the fractured vertebrae (measured as the angle between cephalic upper and lower endplates on a lateral radiogram with the patient in the sitting position), vertebral instability of the affected vertebra (measured as the difference between wedging angle on lateral radiograms with the patient in the sitting and supine positions), and the presence of diffuse idiopathic skeletal hyperostosis. SPF was diagnosed when a low-signal-intensity band connecting two parts of the cortex of the spinous process was seen on a sagittal MRI (Fig. 1) and/or when there was a fracture line connecting two parts of the spinous process on a sagittal CT (Fig. 2)[10]. The patients were divided into two groups according to presence or absence of SPF (the SPF[+] group and the SPF[−] group). Observers with more than 15 years' experience (NK and KY) performed radiological examinations twice per patient, with the average values of the two observers being used in this study. The examiners were blinded to the patients' data.

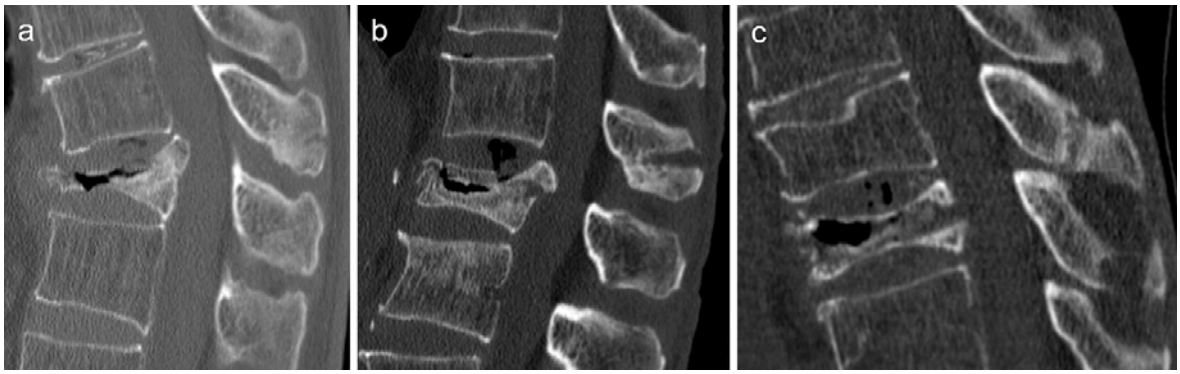

Figure 2. Sagittal CT indicating spinous process fractures (SPFs) (a: T11 osteoporotic vertebral fracture [OVF] with T10 SPF. b: L1 OVF with T12 SPF. c: T10 OVF with T9 SPF).

Table 1. Patient Characteristics Data of Spinous Process Fracture.

	Spinous process fracture
Number	41/195 patients (20.5%)
Location	
just one level above the fractured vertebral body	35 patients (85.4%)
same level as the fractured vertebral body	6 patients (14.6%)

Clinical investigation

The hospital records were reviewed by an independent observer to determine demographic characteristics including age, gender, VAS score for LBP, Oswestry Disability Index (ODI; range, 0%-100%)[12], and the period from the onset of acute fracture. The VAS and ODI questionnaires were self-administered to avoid interviewer bias.

Statistical analysis

To analyze the clinical and radiological data of the SPF (+) and SPF(−) groups, we used the Mann-Whitney U test. Associations between SPF and parameters were analyzed using multivariate logistic regression analyses. Statistical significance was defined as $P<0.05$ for a two-sided hypothesis. All values were expressed as the mean±standard deviation.

Results

Patients

There were 195 patients (50 men and 145 women) with single-level OVF and LBP. The mean age and time period from the onset of acute LBP were 77 years (range, 57-93 years) and 38 weeks (range, 12-144 weeks), respectively. Plain radiographs, MRI, and CT indicated that all patients had an intravertebral cleft. OVFs were detected from the T8 to L5 level and occurred at the thoracolumbar junction in 80% of the patients. The mean VAS and ODI scores were 87±14 mm and 59.1%±7.2%, respectively.

Clinical and radiological investigation of SPF

In 195 patients of OVF with LBP, 41 patients (20.5%) had SPFs on MRI and/or CT. SPFs occurred in the thoracic spine, thoracolumbar transition, and lumbar spine with the sites of the fracture of the vertebral body being T7 (1), T8 (4), T10 (6), T11 (5), T12 (14), L1 (8), L2 (2), and L4 (1). SPFs were observed one level above the fractured vertebral body in 35 patients (85.4%) and at the same level as that of the fractured vertebral body in 6 patients (14.6%) (Table 1). SPFs occurred in the thoracolumbar transition (T11-L2) in 29 patients, in the thoracic spine in 11 patients and in the lumbar spine in 1 patient. The prevalence of vertebral fracture of the thoracic spine in the SPF(+) group was significantly greater than that in the SPF(−) group ($P<0.01$), and the prevalence of vertebral fracture of thoracolumbar transition in the SPF(+) group was significantly smaller than that in the SPF(−) group ($P<0.05$). The mean age of the SPF(+) group and the SPF(−) group were 78.0±5.7 years and 76.7±7.1 years, respectively. There were no significant differences in the age between the SPF(+) and SPF(−) groups. Moreover, there were no significant differences in gender, VAS, ODI, the time period from the onset of acute LBP, wedging angle, vertebral instability, and the presence of diffuse idiopathic skeletal hyperostosis between the SPF(+) and SPF(−) groups (Table 2). Multivariate logistic regression analyses revealed a significant association between SPF and the prevalence in thoracic spine (odds ratio [OR], 6.69; 95% confidence interval [CI], 2.48-18.04; $P<0.01$).

Table 2. Parameters in Patients with and without Spinous Process Fractures (SPF: Spinous Process Fracture, VAS: Visual Analog Scale, ODI: Oswestry Disability Index).

	SPF (+) (n=41)	SPF (−) (n=154)	P value
Age (years)	78.0	76.7	0.311
Gender (male, %)	31.7	24.0	0.318
VAS (mm)	85.9	86.3	0.831
ODI (%)	40.3	53.7	0.301
Period from the onset (weeks)	28.0	31.2	0.366
Vertebral instability (degrees)	7.5	5.5	0.213
Wedging angle (degrees)	29.5	35.1	0.378
Diffuse idiopathic skeletal hyperostosis (%)	9.76	9.09	0.447
Thoracic spine (%)	26.8	5.8	<0.01
Thoracolumbar transition (%)	70.7	82.5	<0.05

Discussion

This cross-sectional study found that SPFs occurred in 20.5% of patients with OVF and long-lasting LBP. In addition, the SPFs often occurred one level above the fractured vertebra and SPFs tended to locate in the thoracic spine.

Characteristics of osteoporotic vertebral fracture

With the aging of the population, the prevalence of OVF has been increasing; OVF can lead to severe deterioration in health and quality of life as it causes persistent debilitating back pain and reduced activity[1-3]. In the patients with OVF, vertebral mobility is reported as the cause of deterioration of LBP and disturbances in the activities of daily living[4-6]. For these patients, percutaneous vertebroplasty has been reported as a minimally invasive and generally effective method of vertebral augmentation for treating painful OVF with delayed union[13,14]. Although spinal fusion surgery is commonly used for the management of patients with OVFs with delayed union, instrumented arthrodesis for the treatment of OVF in the elderly is associated with a significant risk of complications and high cost of medical care. Thus, OVFs have become a growing public health problem with important socio-economic effects worldwide.

Spinous process fractures

SPF is sometimes seen as a Chance fracture with high-energy injury, a horizontal fracture extending from the posterior to the anterior through the spinous process, pedicles, and vertebral body, or a Clay-shoveler's fracture, a stress fracture of the lower cervical and upper thoracic spinous processes[15,16]. However, there have been few reports of SPFs in the osteoporotic spine[10,11]. Seo et al. reported that SPFs were found in 3.5% of whole osteoporotic thoracolumbar fractures[10]. By contrast, Lee et al. reported that SPFs composed 15.1% of osteoporotic thoracolumbar fracture between T10 and L2[11]. The incidence of SPFs in our study (20.5%, 41 of 195 patients) is relatively higher than that seen in previous studies. The reason for the high incidence of SPFs in our study might be that we included the patients with OVF with long-lasting LBP with vertebral instability. According to the results of the current study, the incidence of SPFs in patients with OVF is not more than typically expected.

The mechanism of occurrence of spinous process fractures with osteoporotic vertebral fractures

The mechanism of occurrence of SPF with OVF is unclear. Chance fracture is thought to be caused by flexion-distraction injuries to the spine, especially in the ankylosing spine[15]. However, in our study, we found no significant differences in the presence of diffuse idiopathic skeletal hyperostosis between the SPF(+) and SPF(−) groups. Morphologically, SPF has been thought to represent flexion forces on the anterior column, and tensile forces on the posterior column induce fractures in the weak osteoporotic spinous process in cases where the middle column is relatively intact[11,17]. Repeated stress to the spinous process may induce absorption of the bone materials through the bone metabolism, followed by SPF. Moreover, patients with SPF had more severe kyphotic changes during the 1-year follow-up[11]. Considering that SPFs were sometimes revealed as the delayed union of the vertebral body, and SPF with OVF sometimes indicated bone union after vertebral augmentation; SPF with OVF might be the outcome of repeated stress to the spinous process and has resulted from the instability of the anterior column.

Occurrence level of spinous process fractures

Regarding the occurrence level of SPFs, previous studies reported that SPFs were located one level above that of the fractured vertebral body in all cases[10,11]. In the current study, SPFs were observed one level above the fractured vertebral body in 35 patients (85.4%) and at the same level as that of the fractured vertebral body in 6 patients (14.6%). Lee et al. reported that the spinous process is more caudally tilted in osteoporotic kyphotic spines, and the spinous process one level above the fractured body is located at the center of the tensile force on the posterior column[11]. In our study, the prevalence of vertebral fracture of the thoracic spine in the SPF(+) group was significantly greater than that in the SPF (−) group. It is reported that higher compressive principal stress values were seen in the midthoracic vertebrae when

thoracolumbar kyphosis in an OVF model created using a finite element analysis[18-20]. We should keep this in mind regarding SPFs seen when treating patients who have OVF in the midthoracic vertebrae.

Spinous process fracture and low back pain

In general, high-energy injuries such as falls and traffic accidents are the most likely causes of posterior column injuries such as those to the spinous process; the presence of posterior column injury significantly influences the severity of damage and spinal instability[15,17,21,22]. In our OVF study, there were no significant differences in the values of VAS and ODI between the SPF(+) and SPF(−) groups. In patients with OVF, vertebral instability has been reported as a cause of deterioration of LBP and disturbance in activities of daily living[4-6]. Although there were no significant differences in the values of VAS and ODI between the SPF(+) and SPF(−) groups in the current study, it is reported that the presence of SPF is associated with cement loosening after percutaneous vertebral augmentation, and we should pay attention to the presence of SPFs when treating patients who have OVF with LBP[23].

Limitations of this study

There are certain limitations to the present study. First, there was a lack of longitudinal evidence for the relationship between the SPF and clinical symptoms. Second, we only included the patients with OVF with an intravertebral cleft with long-lasting LBP against the conservative treatment and the time period from the onset of LBP was long. Third, a small number of patients were enrolled in this study. Future research should rectify this limitation by increasing the number of participants.

Conclusions

In elderly patients with LBP, 20.5% of patients with OVF had SPF on MRI and/or CT. This finding regarding SPFs should be kept in mind when patients who have OVF with LBP are treated.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Sources of Funding: There is no funding received for this work from any organizations, and there is no support, including pharmaceutical and industry support, for the researchers to conduct this study.

Author Contributions: Toshio Nakamae wrote and prepared the manuscript, and all of the authors participated in the study design. All authors have read, reviewed, and approved the article.

Ethical Approval: Institution: Hiroshima University. Approval code: E-1352

Informed Consent: Informed consent was given by all participants in this study.

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