An Empirical Study of Osteoporotic Vertebral Fracture Review

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ABSTRACT

Osteoporotic vertebral fractures (OVF) are most common injuries seen in elder people. The OVF are different to a general traumatic spinal fractures in mechanisms, treatment principles and prognosis. In the textbook, Denis's classification usually describe the North American thoracolumbar spinal injury, a little different to Asia people, especially in Taiwanese. Besides, Denis's classification was not exactly match OVF, thus it generated a communication problem between medical doctor and patients. Due to the diversity of OVF, Denis's classification also hard to be collected in all types of spinal fractures. Fortunately, in recent decades, percutaneous vertebral augmentation with bone cement had been reported as a satisfactory approach to managing osteoporotic compression fractures. However, most studies lack details about the patterns of the fracture, thus the purpose of this study was to develop a novel classification system using empirical study approach for OVF and treatment strategy. The data were collected from July 2008 to December 2008. The 289 patients (434 vertebrae levels) were diagnosed as osteoporotic vertebral fractures. There were totally 128 males and 161 females; the average age was 78.4 yr (95 % confidence interval (CI) range was 50-97 yr). Female elder people were easily happen than male in OVF. They all evaluated by X ray and MRI. Osteoporotic vertebral fractures are complex and varied, and it is difficult to develop one standard classification to cover all dimensions of the fracture patterns. This study classified four types of osteoporotic vertebral fractures within 434 vertebrae levels. 110 (25.35%) were non-active lesion and others were 324 (74.65%) were active lesion. 14 (3.23%) were type I; 109 (25.12%) were type II; 196 (45.16%) were type III; and 5 (1.15%) were type IV.

Keywords: Common injuries, elder people, empirical medicine study, female study, osteoporotic verterbral fracture

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INTRODUCTION

Osteoporotic vertebral fractures (OVF) are most common injuries seen in elder people (1). The OVF are different to a general traumatic spinal fractures in mechanisms, treatment principles and prognosis. In the textbook, Denis's classification (2), usually describe the north American thoracolumbar spinal injury, a little different to Asia people, especially in Taiwanese. Besides, Denis's classification was not exactly match OVF, thus it generated a communication problem between medical doctor and patients. Due to the diversity of OVF, Denis's classification also hard to be collected in all types of spinal fractures. Fortunately, in recent decades, percutaneous vertebral augmentation with bone cement had been reported as a satisfactory approach to managing osteoporotic compression fractures (3, 4). However, most studies lack details about the patterns of the fracture, thus the purpose of this study was to develop a novel classification system using empirical study approach for OVF and treatment strategy.

MATERIALS AND METHODS

The data were collected from July 2008 to December 2008. The 289 patients (434 vertebrae levels) were diagnosed as osteoporotic vertebral fractures. Besides, these were received regular supplementary calcium and anti-absorptive agents, such as bisphosphonate or calcitonin at out patient departments (OPD). The patients all had histories of significant back pain with or without nerve compression syndrome. They also evaluated by Xray and MRI.

Excluded condition were incomplete radiologic cases, lack of dual-energy X ray absorptiometry (DXA), multiple myeloma, spinal infections and metastatic spinal tumor. There were totally 128 males and 161 females; the average age was 78.4 yr (95 % confidence interval (CI) range was 50-97 yr).

The DEXA results showed the condition ranging were from osteopenia to osteoporosis. The mean score was -2.57 (CI range: -1.5 to -4.9), the average bone density was 0.63 g/cm^2 (CI: 0.374 to 0.789 g/cm^2). Twenty two patients with 32 vertebrae levels underwent vertebroplasty; five patients who were associated with neurological symptoms had posterior decompression, instrumentation, and spinal fusion surgery. The average time between the appearance of symptoms until surgery was 3.57 months (CI: 2 days to 3 years).

The criteria for a diagnosis of osteoporotic vertebral fracture were: (1) clear fracture lines and loss of body height in a vertebral body on x-ray films and signal change in vertebral body in MRI; (2) no history of trauma or only minor trauma history, such as a sprain, a slip or fall; or (3) significant rarefactions of trabeculae seen on plain films. This study used four criteria to define the active lesion of osteoporotic vertebral fracture. First, there was a clear fracture line in the vertebral body on plain x-ray films. Second, cleft vacuum phenomenon (pseudoarthrosis) could be seen on x-ray films. Third, signal changes were noted on magnetic resonance imaging (MRI) (a lower signal change in the T1 wedge, higher signal change in T2 wedge, and post-contrast encashment). Fourth, patients reported significant back pain and local tenderness that correlated with the findings on x-ray films and MRI. Otherwise, the vertebral fracture was regarded as a non-active lesion.

All patients had plain x-ray films of the thoracolumbar spine, which were taken with the patient supine (anteroposterior view) and in the lateral decubitus position (lateral view) and thoracic-lumbar MRI. After examining the films, this study indentified 70 vertebrae levels, which were all significant intravertebral vacuum cleft signs (pseudoarthrosis). The distribution of fracture level were from T6 to L5. Most of the lesions were at the thoracolumbar junction, included: L1 (128 patients) ; T12 (108 patients) ; L2 (60 patients) ; T11 (39 patients) ; L3 (32 patients) ; L4 (20 patients); T10 (16 patients) ; T9 (12 patients) ; T8 (9 patients) ; L5 (6 patients); T6 (3patients) and T7 (1 patient).

This study classified the fracture pattern depending on the morphology of the vertebral body seen on the lateral view of the plain film. MRIs were used to prove active, non-active lesion and location of fracture sites. The establish sub groups approaches were (1) the location of the fracture line or cleft phenomenon (pseudoarthrosis) on plain x-ray films; (2) the location of signal change in MRI. The non-active lesions were old method; the new method were using MRI to united fractures. This study defined a vertebral body fracture without posterior wall involvement as a one-column injury, and a lesion with posterior wall involvement as a two-column injury. Fracture types I, II, III, and IV were defined by the morphology in osteoporotic vertebral fractures with active lesions, while the subgroup was defined according to lesion locations (Figure 1).

A type I fracture was defined as a vertebral fracture with minimal vertebral body collapse or no vertebral body collapse, as seen on plain x-ray films. There was no significant morphologic change and the active lesion could be seen on MRI. This fracture type may be caused by intravertebral microfracture or osteonecrosis, and may not be identified by plain x-ray films or CT scans (Figure 2).

Type II vertebral fractures involve the anterior two-thirds or middle third of the vertebral body only, with the posterior vertebral body wall intact (one-column collapsed fracture). The subtype IIa was defined as a one-column collapsed vertebral body, with the lesion located at or near the upper endplate. Type IIb was defined as a one-column collapsed vertebral body with a central lesion. Type IIc was defined as a one-column collapsed vertebral fracture, with the lesion located at or near the lower endplate.

A type III fracture is a type II fracture with involvement of the posterior body wall (two-column collapsed vertebra). The subgroups of this type are defined as: type IIIa, two-column collapse with a superior lesion; type IIIb, as two-column collapse with central lesion; and type IIIc, a two-column collapsed fracture with inferior lesion. Type IIId was defined as a vertebra plana, with decreased body height more than three-fourths of normal, and involvement of more than two-thirds of the body (Figure 3). Type IV is any type III fracture with symptomatic nerve root or cord compression.

RESULTS

Within 434 vertebrae levels that were detected, 110 (25.35%) were non-active lesion and others were 324 (74.65%) were active lesion. 14 (3.23%) were type I; 109 (25.12%) were type II; 196 (45.16%) were type III; and 5 (1.15%) were type IV. The location of the lesion (excluding non-active lesion, types I and type IV; 129 vertebral levels) were as follows: 165 (54.10%) were superior lesions; 65 (21.31%) were central lesions; 20 (6.56%) were inferior lesions; and 55(18.03%) were vertebrae plana (Table 1).

DISCUSSION

According to Denis's three-column theory, spinal trauma can be classified as compression fracture (anterior column injury), burst fracture (two-column injury), flexion-distraction injury, and fracture distraction (three-column injury) (2). This classification is usually used in cases of high-energy trauma, which may be associated with different degrees of soft-tissue trauma to the ligamentum flavum, interspinal ligament, joint capsule and intervertebral disc. The term "compression fracture" is usually used to describe an osteoporotic vertebral fracture. In Denis's classification, compression fracture of the vertebral body is defined as injury to the anterior half of the vertebral body. However, in our study, we found that more than half (62.04%) of the osteoporotic vertebral fractures involved the posterior half of the vertebral body. According to Denis's classification, these should be referred to as "burst fractures". On the other hand, most of these patients had only minor trauma or no trauma history at all, and there was no soft tissue involvement. It is thought that osteoporotic vertebral fractures are a unique group of injuries that have a pattern different from that of regular fractures. Thus, referring to all osteoporotic vertebral fractures as "compression fractures" is not appropriate. Therefore, Denis's classification may be not suitable for describing osteoporotic vertebral fractures.

Eastell et al. classified osteoporotic vertebral fractures into three types: wedge deformity, biconcave deformity, and compression deformity (5). In this classification, vertebral fractures were simply classified according to their morphology, without mention of active or inactive lesions, lesion location or nerve injury or canal compromise, which is caused by two-column fracture. Their classification also made no mention of the type I lesion, in which the morphology of the vertebral body may be normal on plain x-ray films and that can only be detected by MRI or bone scan.

Faciszewski and McKiernan suggested that the classification of osteoporotic vertebral fractures should cover six dimensions: (1) morphometry, (2) chronicity, (3) reparative activity, (4) dynamic stability, (5) intervertebral trabecular disruption, and (6) violation of the posterior cortical wall (6). However, they did not offer a feasible and practical classification that could be applied in clinical practice. In another study, Wu et al. classified the fracture according to the dynamic flexion-extension view, and with or without posterior body wall involvement (7). In that study, type I is a compression fracture involving the anterior column only, while type II is a fracture involving both anterior and middle columns. Each type is divided into two groups: fractures with union and those with non-union. Again, there is no mention of the unique type I and type IV fractures, as in our classification.

There were some assumptions in this study. It did not include the factor of dynamic stability in the classification. The reason for this is that if the lesion has dynamic instability, as in the case of a fresh fracture or pseudoarthrosis, the vertebral body's height can be easily corrected by posture reduction during the procedure. If the lesion was stable or a partial union, the reduction of vertebral body height would be difficult, even when performed with kyphoplasty. In Wu's study, the vertebral body height could be significantly increased in patients with dynamic instability after vertebroplasty. Although kyphoplasty may produce a higher vertebral body correction rate than does vertebroplasty, there is no evidence showing that better correction leads to a better outcome (8). Even if the correction of local kyphosis (fractured vertebra) after vertebroplasty or kyphoplasty was significant, the overall sagittal alignment may not be improved (9). It is thought that the main purpose of vertebral body augmentation is to reduce pain rather than to restore a few millimeters of body height or a few degrees of kyphotic deformity. On the other hand, patients with symptomatic vertebral fractures are usual elderly, and their very painful fractures make taking dynamic x-ray films very difficult.

The advantages of using MRI studies include better sensitivity in diagnosing different spinal lesions, more accurate localization of the active lesion, and better definition of the degree of the canal compromised or of nerve compression. Tsukasa et al., using MRI, divided osteoporotic vertebral fractures into six types, according to the location of signal change in T1-weighted images (total, anterior, posterior, superior, central and inferior body signal change) (10). However, their study did not mention the importance of the morphology of the fractured vertebral body or nerve or canal compromise.

In most symptomatic vertebral fractures, the fracture line or vacuum cleft phenomenon can be identified with plain x-ray films and the results are sufficient for classification. The degree of vertebral body collapse and number of involved columns are easier to detect on the lateral view than on the anteroposterior view on plain films. When the diagnosis is ambiguous, as with lesions at multiple levels, without an obvious fracture line, or pseudoarthrosis, MRI could be added for further evaluation and differential diagnoses.

In the subgroups, this study found that most of the fracture lesions were superior (54.1%), and inferior lesions were the least common (6.56%). Plana deformity was not uncommon (18.03%). When surgical intervention is necessary, such as vertebroplasty or kyphoplasty, pinpointing the lesion is important for guiding the injection needle. However, most cases the needle could be inserted parallel to the upper endplate because the superior lesion (under the upper endplate) is the most common type. If the lesion was located near the lower endplate, the cement injection needle should be directed more caudally. In the case of vertebra plana (type IIId), performing vertebroplasty is technique demanded because the insertion of the needle into a narrow space of the vertebral body could be difficult and cement leakage rate may be higher because the fracture line may be patent into the spinal canal.

In some cases, such as the lesion level or lesion location in the vertebral body cannot be detected with plain x-ray films, type I lesions or lesions without obvious pseudoarthrosis (vacuum cleft). In such circumstance, either bone scan or MRI can be used to detect the active lesion (11). However, bone scans may also produce poor differentiation of different diseases, such as tumor or infection. On the other hand, bone scans cannot demonstrate the exact morphology of the vertebral body, and thus cannot be used for establishing the precise subgroup of the lesion.

In the non-active lesion of osteoporotic vertebral fracture, back pain may be the result of muscle fatigue and spasm, or ligament stretching due to kyphotic deformity. Correcting the deformity can be one treatment option for a large kyphotic deformity (12). However, we think that disregarding vertebroplasty or kyphoplasty and using cement injection for vertebral body augmentation is contraindicated in non-active lesion because this procedure can neither correct such fixed deformities nor eliminate the pain source of muscle spasm or ligament stretch.

In active lesions, from type I to type III, conservative treatment should be tried first. If this fails, surgical intervention, with vertebroplasty or kyphoplasty, can be considered. However, in type IV lesion, when a significant nerve compression is present, decompression with instrumentation and fusion should be considered (13) (Table 2).

This study posed several problems. All images were taken with patients in the supine or lateral decubitus position, and the classification is based on static but not dynamic examination, such as flexion – extension views or standing views. It is not known whether the type of pattern will change or not in such dynamic views. However, as we mentioned before, many of the aged patients in the study had multiple underlying diseases, difficulty complying with tests, and had a great deal of pain when they visited the hospital. It was very difficult to require these patients to undergo dynamic examination. On the other hand, the fracture type may change with time. For example, type I may change into type II or type III if not treated, or when treatment is delayed, or when there is additional minor trauma. The timing of type change and relation between each type are unknown. In our classification system, the type of fracture pattern is based on the time point when the fracture was diagnosed and treated. Third, we think that a lesion with an intravertebral body vacuum cleft, which was detected in 21.6% of patients in this study, is actually meaning instability, and can have a higher vertebral body restoration rate after vertebroplasty (14). So a more detailed description may be offered when the pseudoarthrosis or vacuum cleft phenomenon exists; for example, this can be termed ”type IIIa fracture with vaccum or without vaccum phenomenon”.

In conclusion, osteoporotic vertebral fractures are complex and varied, and it is difficult to develop one standard classification to cover all dimensions of the fracture patterns. Although the clinical outcome of each fracture type is still uncertain, and needs further investigation, we think that our suggested classification system deals with most dimensions of vertebral fractures. Our hope is that such a system for classifying vertebral osteoporotic fractures could lead to a consensus of communication between physicians and aid future research into these fractures.

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Table 1. Numbers and percentages of each type of osteoporotic vertebral fracture.

Fracture type	Numbers of fracture	Percentage (%) of patients
Non-active	110	25.35
I	14	3.23
IIa	80	18.43
IIb	17	3.92
IIc	12	2.76
IIIa	85	19.59
IIIb	48	11.06
IIIc	8	1.84
IIId	55	12.67
IV	5	1.15
Total	434	100

Table 2: Classification of osteoporotic vertebral fracture and treatment modalities for each type.

Non-active fractures			Conservative treatment Correction of deformity
Active	Type I: No collapse		Vertebroplasty
	Type II: One-column collapse	a: superior lesion b: central lesion c: inferior lesion	Vertebroplasty Kyphoplasty
	Type III: Two-column collapse	a: superior lesion b: central lesion c: inferior lesion	Vertebroplasty Kyphoplasty
		d: vertebra plana	Technique (depends)

Type IV: Any type III lesion with nerve compression	Decompression and instrumentation +/- fusion

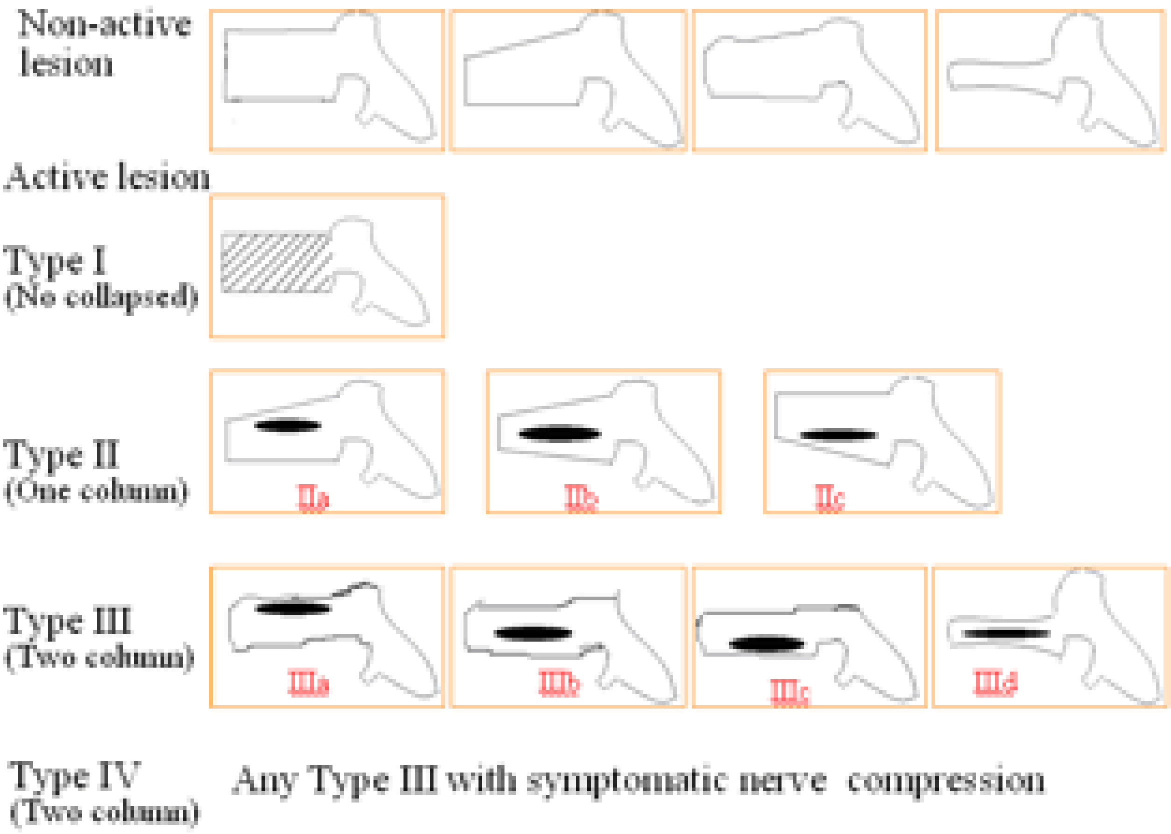

Fig. 1: Classification of osteoporotic vertebral fractures. The oblique line and black block indicate the active lesion.

Fig. 2: (A) Type I osteoporotic vertebral fracture at L1 level and type IIa fracture at L4 level. T12 and L2 old vertebral fracture with nonactive lesion. (B)The diagnosis was proved by MRI; the MRI showed lower signal change in T1-weight image at L1 and L4 levels.

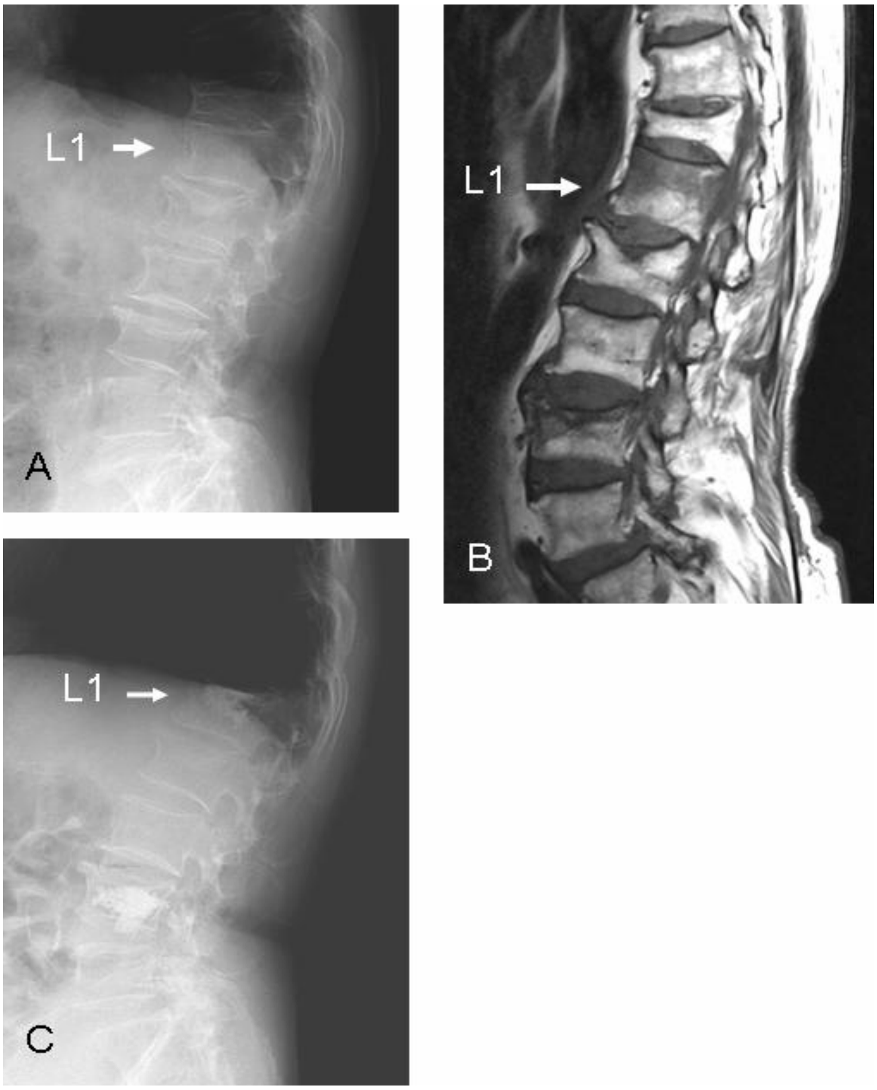

Fig.3: Image of type IIId osteoporotic vertebral fracture (vertebra plana), with pseudoarthrosis on plain film and MRI.