MINI-SYMPOSIUM ON OSTEOPOROSIS

Vertebral deformities in the osteoporotic spine and early experience in vertebroplasty

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ABSTRACT

Of the 360 patients aged 65 and above admitted consecutively within a period of 3 years to a regional hospital because of genuine back pain, 288 of them were found to have osteoporotic spinal deformities. The radiological features of these vertebral deformities were reviewed by the author and grouped according to the classification detailed by the European Vertebral Osteoporosis Study Group. Three major types were identified: the wedge, biconcave, and the crushed. The wedge and crushed types can be further defined according to their fracture patterns, their distribution on different curvatures of the spinal column, and their likelihood of complications. Wedge deformity of the thoracolumbar junction was the most common. It affected either a single level (D12 or L1), or two levels (D11 and L1), with a spared level in between. The present study in the pattern of osteoporotic deformities has helped in selecting the vertebrae for vertebroplasty, a procedure aimed at alleviating back pain in relation to osteoporotic spinal deformities.

Key Words: Bone cement; Deformity; Fracture; Osteoporosis; Spine

中文摘要

骨質疏鬆性脊椎體變型的形態與脊椎體填充矯型術的初步體會

麥勤興、郭迪官、黃淦剛

作者從1998年4月至2001年3月以X射線檢查了360例65歲以上患腰背痛的病人，其中288例的脊椎體有明顯骨質疏鬆性變型。各種椎體的變型，根據European Vertebral Osteoporosis Study Group 分類，有三種不同的形態：楔形（Wedge），魚尾形（Biconcave），及壓扁形（Crushed）。其中楔形及壓扁形可以依據它們的骨折種類，在各脊柱的彎弧體位，及它們誘發併發症的機會而再另行識別。在胸腰接合區域產生楔形性骨折為最常見的椎體變型。受影響的以單一節胸椎12，或腰椎1為主；或是兩節受影響：胸椎11及腰椎1，而靠在其中的常常會是正常的椎體。作者分析各類骨質疏鬆性椎體的變型，發現對進行脊椎體骨水泥注射填充矯型術有識別適應症的作用。我們報告了10例脊椎體骨水泥注射填充矯型術手術的初步經驗及體會。

INTRODUCTION

With the advance in health care and the provision of social security benefits, longevity is no longer unusual. People tend to live and remain active for more years than in the past. The invention of machinery and electronics spares people from exerting their musculoskeletal appendages. Our bone and muscle are no required to work as hard in labour and daily activities. Osteoporosis is an endemic pathology in all developed countries. Ageing leaves both men and women exposed to a higher risk of osteoporotic fracture; because women live longer, the lifetime risk of a vertebral fracture from age 50 years onward is 16% in white women and only 5% in white men. Vertebral fractures affect approximately 25% to 30% of postmenopausal women. Unlike other osteoporotic fractures, spinal fractures have re-
Osteoporotic compression fractures are uncommon. This study aimed at looking into the magnitude of osteoporotic back pain among local women who were otherwise active, at identifying patterns of vertebral deformities in their spinal columns, at considering their chances of neurological complications, as well as at reviewing our early experience in vertebroplasty, a procedure aimed at relieving back pain related to osteoporotic vertebral collapse.

**METHODS**

There were 360 women aged 65 years and over who were admitted consecutively from April 1998 to March 2001 to a local hospital through the Emergency Department because of back pain and paraesthesia in their lower limbs. The thoracolumbar vertebrae in these older women were examined radiologically for any osteoporotic vertebral deformities. Presence of pain and tenderness at levels corresponding to radiological deformities, vertebral fractures, or fracture progression were taken as genuine symptoms related to the vertebral deformity. Those subsequently found to have malignancies and infections were excluded from this study.

Various patterns of osteoporotic vertebral deformities were identified in 288 patients. The age of the patients ranged from 65 to 99 years with an average of 78.6 years. Patients who presented with acute cauda equina complications were noted and managed accordingly.

**Management**

Unlike wrist and hip fractures, persistent pain due to osteoporotic spinal fracture has not been receiving much attention. Many orthopaedists seem to believe that most of these fractures will heal up and that back pain can be controlled eventually, but some of these fractures have caused persistent symptoms related to the vertebral deformity. Those subsequently found to have malignancies and infections were excluded from this study. Various patterns of osteoporotic vertebral deformities were identified in 288 patients. The age of the patients ranged from 65 to 99 years with an average of 78.6 years. Patients who presented with acute cauda equina complications were noted and managed accordingly.

Vertebroplasty

Percutaneous bone cement injection to the painful, deformed vertebra was tried to stabilise the endplate and thus relieve pain and improve mobility in a group of patients with persistent and disabling back pain. Based on our understanding of the pattern of osteoporotic vertebral fractures and their evolution, we have identified five criteria for injection: (1) new vertebral fractures responsible for back pain and not responsive to conservative management for more than 2 to 4 weeks; (2) back pain due to a newly involved level in the presence of previously documented old fracture levels; (3) no more than two levels of old vertebral deformity; (4) the collapse patterns confined to wedge-shaped or bi-concave types; and (5) no radiological evidence of pseudoarthrosis or vacuum sign in the level to be injected.

We did not use magnetic resonance imaging to define the chronicity of the fracture nor to select vertebrae for injection.

**Methods in transpedicular vertebroplasty**

With the patient in prone position under C arm, the levels to be injected were marked and 2% lignocaine was infiltrated. Local anaesthesia was used and the entry point was taken from the superolateral cortex of the pedicle. Craig's spinal biopsy needle was initially used until the Vertebroplasty needle (Stryker Howmedica Osteonics, Mahwah, NJ, US) became available.

Insertion of the trocar and the sheath was performed manually under fluoroscopy. The medial and the inferior cortices had to be avoided until the needle was totally inside the vertebral bodies. Injection can begin only when the needle has advanced to the center of a body.

For those with persistent back pain after 2 to 4 weeks, particularly on change of posture while lying in bed, vertebroplasty, injection of bone cement into the body of a deformed vertebra through the pedicle, was considered. It was performed in 10 patients. Indications of the procedure and their progress in 1 year's follow-up are reported.
with the polymer catalyst. The cement is backfilled to four 1-mL and one 5-mL syringes when it is in fluid state.

Injection with the 5-mL syringe was made initially, followed by injections with two to three 1-mL syringes. With adequate pressurisation, cement should fill up the anterior body, crossing the midline to the other side, and then to the posterior part of the body.

Occasionally, some cement that leaked outside the lateral cortex or that had gone through the superior endplates was observed. This usually occurred in those patients who suffered from superior endplate fracture. These leaks were of no major clinical consequence. When cement starts to fill the body behind the needle, it is time to stop pushing bone cement in. The syringe with the needle is then turned two to three times to allow breakage of the cement column, before it is pulled out.

Unless the filling of the body is not satisfactory, only one pedicle is usually used for injection. The needle should aim at the anterior third of the vertebral body.

Venogram
In our early cases, vertebral venogram with contrast was performed before cement injection in order to detect any communication with a major vein. We did not find leakage to be a common phenomenon, and because the retention in the vertebral body can interfere with the visualisation of the injection, we abandoned this practice. Vasconcelos and Murphy had not found venogram necessary in their evaluation of 205 consecutive procedures.7

RESULTS
Radiological features of vertebral bodies
There were 570 osteoporotic vertebral deformities identified on the plain radiographs of 288 patients. Levels affected spanned from the fourth thoracic to the fifth lumbar spine. The vertebral bodies of the D11, D12, L1, and L2 were most frequently affected. On the average, each patient had two vertebral bodies affected.

Different patterns of deformities were found in the spinal columns. Levels affected clustered around the thoracolumbar junction. According to the classification described by European Vertebral Osteoporosis Study Group,4 three different patterns of osteoporotic vertebral deformities can be identified: wedge, biconcave, and crushed. Their radiological features can represent different stages of the fracture, or a reflection of the stress taken up by the affected vertebral bodies locally.

Type A: wedge-shaped fracture
Wedge compression of the vertebral body (Fig. 1) was the first and the most common fracture developed in the osteoporotic spines, especially for the levels around the thoracolumbar junction, where the center of gravity is anterior to the vertebral body (Fig. 2) and creates a relatively greater load on the anterior column. The osteoporotic vertebral body effectively gives in to the local stress at the thoracolumbar junction. Compression, collapse, and shortening of the anterior column (A1) or fracture and sinking of the superior endplate into the vertebral body (A2) can effect wedging of a vertebra. The fractured endplate is driven into the vertebral body (Fig. 3) through a mechanism similar to those in Schmorl’s nodes. Wedge compression (A1) was more common than fracture of the superior
endplate (A2), which was commonly found in lumbar levels that are related to axial loading (Fig. 4).

**Type B: biconcave deformity**
Typically found in lumbar levels where the loading is axial, biconcave deformities were seen when the central vertebral body appeared shortened with relatively preserved anterior and posterior vertebral cortices (Fig. 5). In early osteoporosis, the cortical bone is affected to a lesser extent than the trabecular bone in-

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**Figure 2** The vertical axis of the spine is anterior to the vertebral body at the thoraco-lumbar junction and through the vertebral body in lumbar lordosis. It is responsible for anterior wedge loading and the axial loading stress producing the respective wedge and biconcave deformities.

**Figure 3** An 81-year-old man was admitted because of acute retention of urine. The findings were type A2 fracture of superior endplate of L3; lumbar spine in kyphosis; and old collapse fractures of L1 and L4 (type C). Magnetic resonance imaging showed no cord compression on all lumbar levels.
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side the body and the relative turgidity and compliance of the lumbar intervertebral discs distended into the centre of the endplates. The incidence of biconcave deformities was higher in the lumbar than the thoracic spine, and it did not decrease at lower lumbar levels (Fig. 6).

Typically, several contiguous segments were affected, appearing as intervertebral discs bulging between fish-tailed vertebral bodies (Fig. 7).
Early compression fracture in the centrum of the lumbar vertebral bodies can be easily missed, but these fractures may represent repeated episodes of microfractures and recurrent attacks of low back pain in these osteoporotic women (Fig. 8).

The upper lumbar levels that first present with a type B fracture pattern invariably progress to type C fracture because of the stress locally and the decreased mobility in the thoracolumbar junction.

**Type C: crush**
Crushed vertebral bodies represented the final deformity that osteoporotic vertebrae can adopt (Fig. 1). The entire vertebral body is collapsed. Fortunately, the posterior vertebral cortex is usually intact and seldom protrudes into the spinal canal. There is a localised kyphosis. Neurological complications in osteoporotic spinal fracture are only seen occasionally. In our 3-year series, we have seen and managed eight patients.

**C1: vertebral planus**
Vertebral planus was the most common deformity clustered around the thoracolumbar junction (Fig. 9), where the vertebral bodies became thin slices of bone (Fig. 10). There was a localised kyphos that had evolved from the wedge compression. Very often, the intact posterior walls could still be identified.

**C2: crushed body and displaced anterior column**
Crushed vertebral body and displaced anterior column was occasionally seen in the lumbar levels. It was the progression of either the wedge fracture with fractured superior endplate, or the biconcave deformities. The
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Figure 10  C1, vertebral planus in D11. The 79-year-old woman presented with back pain and some weakness of left lower limb: Vertebral planus also present in mid-dorsal spine with exaggerated lumbar lordosis and type B fracture in the L2 vertebra.

Figure 11  Type C2 deformities. A woman aged 88 years with back pain. Type C2 deformity of L1 with anterior displacement of anterior body was present. Type B deformity was present at D9.
anterior column of the vertebral body was extruded and bulged anteriorly (Fig. 11).

**C3: burst fracture with retropulsion**

In this study, it was least frequent to see that the middle column had burst into the spinal canal and caused mechanical compression to the dural content or the emitting nerve roots. The posterior cortex seldom retropulsed into the spinal canal (Fig. 12). This condition was found only in the thoracolumbar junction, T11, T12, L1, and very occasionally L2 and was related to the mobility of the junction and the local stress.

**Single-level lesions**

Nearly half (46.5%) of our patients had only one spinal level affected, and the most common single-level deformity was seen at L1 (40%), the second-most com-
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Table 1. Commonest combinations in two levels deformities were D11/L1, L1/L3 and L2/L3. The lumbar combinations were usually Type B deformities.

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mon at D12 (20%). These were predominantly wedge compression with collapse and shortening of the anterior column. The remaining first osteoporotic fracture involved the other lumbar levels indiscriminately. They were mainly type B deformities with ballooning of the intervertebral discs.

**Double-level lesions**
Seventy-one (24.6%) of our patients had two spinal levels affected. There were different combinations of type A1 and A2 fractures. Deformities affecting consecutive segments were uncommon in the thoracolumbar junction. Collapse of a level in the thoracolumbar junction may have relieved the stress on its adjacent levels. For example, if D11 were in a wedge shape, then D12 integrity could usually be preserved, and the first lumbar level would be collapsed instead. In our study, wedge fracture of the D11 and L1 was the most common association (Table 1).

In the lower lumbar segments, biconcave collapses (type B) in adjacent levels were common. The most frequently involved level was L3. It had collapsed with either L1 or L2. The vertical loading on this vertebra in lordosis may have contributed to this pattern of the deformity.

**Multiple-level lesions**
Multiple-level lesions were found in patients with repeated episodes of back pain, at times related to a fall. There were new fractures among some deformities that had evolved from previous collapse patterns. Vertebral planus (type C1) fracture patterns were invariably found in the thoracolumbar junctions among some lumbar levels affected by ballooned discs (type B).

**Neurological complications**
Of the 288 patients who presented with back pain and osteoporotic spinal deformities, eight (2.8%) of them were complicated with neurological deficits, mainly cauda equina syndrome due to dural sac compression by the retropulsion of the collapsed posterior cortex at the thoracolumbar junction. Anterior decompression and stabilisation of the osteoporotic spinal column was often fraught with complications. Position and stabilisation of the implant and graft were difficult to maintain in osteoporotic bone. Limited posterior laminectomy offered relief in some patients.

**Our experience with vertebroplasty**
**Pain relief**
All patients had good relieve of pain after injection. There were often significant improvements with change of resting posture. Most researchers have reported significant pain relief with stabilisation of the fracture and internal support of the vertebral cortices, almost immediately after the injection. With control of pain, the patient’s chest expansion, respiratory function, and mobility were improved (Fig. 13).

**Recurrence of pain**
We did not see further collapse of the levels after injection. Three out of the 10 injected patients had recurrence of back pain within 1 year after injection,
Figure 14  An 80-year-old man presented with back pain for 3 months in February 2001. (A) X-ray showed only a wedge fracture of D12. (B) The back pain recurred 5 months later. There was a type B collapse of L3. (C, D) Back pain improved after injection of bone cement. (E) One year later, there was recurrence of back pain and X-ray demonstrated a new superior endplate fracture affecting the level above and below L2 and L4.
however. Recurrence of pain was due to recruitment of new levels, especially of the adjacent levels or the sandwiched levels (Fig. 14). Collapse of an adjacent level was especially common at the thoracolumbar junctions (Fig. 15). Follow-up studies also revealed a slight but significant increased risk of vertebral fracture in the vicinity of a cemented vertebra.3

**DISCUSSION**

**Choice of level for injection**

Until a more biocompatible bone-filling substrate is available, vertebroplasty cannot be taken as a standard treatment modality. Most osteoporotic fractures do heal without complications and the associated back pain usually improves with conservative treatment. When injection becomes necessary, either because of chronic or recurrent presentation, selecting the correct level for injection becomes a clinical dilemma. Douglas et al2 reported that new fractures suitable for injection were those with bone marrow oedema seen in magnetic resonance imaging, hypointensity or isointensity on the T1-weighted images, and a linear hyperintensity zone underlying the depressed endplate on short TI inversion recovery sequence.

We used local tenderness and reproduction of pain on change of posture as indications of which levels were responsible for symptoms. Any appearance of new deformities when compared with previous plain radiograph and those correlated with the duration of symptoms would be a reliable indicator of levels suitable for injection.

**Leakage of cement**

Leakage of cement was common, especially for spinal levels with marked compression collapse of the body. Cotton et al1 found an incidence as high as 75% They reported 15 epidural leaks, eight intra-discal leaks, and two venous leaks out of 40 treated levels. Only one out of the 15 paravertebral leaks produced transient femoral nerve palsy. Surgical intervention was necessary in two nerve root compressions out of the eight foraminal leaks. When we restricted injection to type A and type B fracture, leakage became uncommon. Occasionally, cement did leak into the intervertebral disc through the fractured superior endplate, but this was not found to be problematic. In other sites, although leakage had not been found to have major consequences, it could have definitely undermined the success of the procedure through the loss of filling material.

In order to minimise uncontrollable cement leakage, we excluded levels with pseudoarthrosis and those with vacuum sign on plain radiograph from injection. We do
not recommended vertebroplasty for deformities like vertebral planus and burst fractures (all type C fractures).

The future
For patients who are susceptible to osteoporotic fractures, multiple level injections may be the treatment that will strengthen the whole vertebral column and prevent compression collapse, especially at the thoracolumbar junction. The physical properties of bone cement, however, prevent its more liberal use in otherwise intact vertebral bodies. Development of a biocompatible calcium phosphate bone cement that is injectable, that can be resorbed and remodeled, and that preferably replicates osteo-inductive properties is essential before this procedure can be routinely recommended for the painful osteoporotic spine. There are further questions the need to be answered: how does injection of a collapsed level affect the distribution of stress to the adjacent levels? Will the reconstitution of a stable and strong vertebral body protect the adjacent levels from compression fracture? Or, since it is not uncommon to find an intact body in between collapsed levels at the thoracolumbar junction, does a collapsed segment at the thoracolumbar junction relieve the stress on the anterior bodies of the neighbouring levels? All these questions need to be answered before the role of vertebroplasty and the merits of kyphoplasty can be defined.

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