



The treatment of osteoporotic thoracolumbar severe burst fractures with short pedicle screw fixation and vertebroplasty

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Objective : To investigate the clinical and radiological results of short pedicle screw fixation and vertebroplasty in osteoporotic thoracolumbar severe burst fractures.

Methods : From September 2006 to August 2010, 19 consecutive patients sustained osteoporotic thoracolumbar severe burst fractures with or without neurologic deficit and were included in this prospective study. All patients underwent short pedicle screw fixation and vertebroplasty. Segmental kyphosis, AVBHr and PVBHr, and Canal compromise were calculated on radiographs pre-operatively, post-operative and at final follow up. VAS, ODI and SF-36 were calculated pre-operatively and at final follow up.

Results : Mean operative time was 70.8 min (range 60~100 min) and mean blood loss was 92 ml (range 60~160 ml). The mean duration of their hospital stay was 4.5 days (range 3-7 days). The operative incisions were healing well. Average follow up time was 40.1 months (range 24~72 months). The AVBHr was corrected from preoperative (48.1 ± 6.8) % to post-operative (94.1 ± 1.7) % ($P < 0.001$). The PVBHr was corrected from preoperative (62.7 ± 4.8) % to post-operative (92.8 ± 1.8) % ($P < 0.001$). Canal compromise was corrected from preoperative (37.3 ± 5.8) % to postoperative (5.9 ± 2.3) % ($P < 0.001$). The segmental kyphosis was corrected from preoperative (20.6 ± 5.3) degree to postoperative (2.0 ± 3.2) degree ($P < 0.001$). VAS scores were reduced from preoperative 7.21 ± 0.86 to 2.21 ± 0.98 at final follow up ($P < 0.001$). SF-36 Bodily pain was reduced from preoperative 75.31 ± 13.85 to 13.74 ± 13.24 at final follow up ($P < 0.001$), and SF-36 Role Physical was reduced

from preoperative 59.21 ± 26.63 to 19.74 ± 22.94 at final follow up ($P < 0.001$). The ODI scores were reduced from preoperative 81.68 ± 4.44 to 15.37 ± 5.54 at final follow up ($P < 0.001$). All 4 patients with partial neurological deficit initially had improvement. Cement leakage was observed in 3 cases (two anterior to vertebral body and one into the disc without sequelae). There were no instances of instrumentation failure and no patient had persistent postoperative back pain.

Conclusions : Vertebroplasty and short pedicle screw fixation has the advantages of both radiographic and functional results for treating osteoporotic thoracolumbar severe burst fractures using a purely posterior approach.

Keywords : spinal fracture ; pedicle screw ; short internal fixation ; vertebroplasty.

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INTRODUCTION

Vertebral fractures usually become evident because of pain which may affect a patient's quality of life, including back pain, functional limitations, depression, disability, height loss caused by vertebral collapse and spinal instability (13,25). Osteoporosis was the most common cause of vertebral fractures, especially in women above 50 years old. Thoracolumbar burst fractures may be treated with anterior, posterior, or combined of them. Consequently, anterior instrumentation with strut grafting, mesh cage and plates have been introduced to augment the anterior vertebral column and have proved to be effective. However, an anterior approach is more invasive and is associated with prolonged operation and hospitalization time, blood loss, donor site complaints and increased morbidity, especially in osteoporotic old patients. Short-segment pedicle screw instrumentation is a well described technique to reduce and stabilize thoracic and lumbar spine fractures (4,5). Osteoporosis, inadequate anterior column support in osteoporotic thoracolumbar severe burst fractures results in poor fixation and thus is regarded as the potential causes of failure (18,9). Many patients with acute burst fractures have recently undergone vertebroplasty to benefit from the advantages of this procedure (18,9,30,1). Polymethylmethacrylate (PMMA) vertebroplasty involves risk of cement leakage (11,27), whereas no other side-effects have been adequately documented.

The hypothesis of this prospective clinical investigation in patients with osteoporotic thoracolumbar burst severe fractures was that vertebroplasty with PMMA supplemented with short segmental pedicle-screw fixation could sufficiently and permanently restore fractured vertebral body and reduce segmental kyphosis.

MATERIALS AND METHODS

The clinical study proposal was approved by the medical ethical committee of the authors' institution. From September 2006 to August 2010, 19 consecutive patients with an average age of 66.4 years, who sustained osteoporotic thoracolumbar burst fractures with or without neurologic deficit, were included in this study. All patients were confirmed as a single recent thoracolumbar

burst fracture Type A3 according to a comprehensive classification of thoracic and lumbar injuries (19) demonstrated on both radiographs and computed tomography (CT) scan. All the fractures were considered osteoporotic according to T value of Bone density test less than -2.5. Polytraumatized patients, patients with preexisting spinal deformity (scoliosis, previous vertebral fracture in the area of interest), and patients with previous spinal operation were excluded.

There were 7 male and 12 female. The mechanism of injury was fall from a height in 6 patients, Slip in 6 patients, road traffic accident in 5 patients and burden in the remaining 2 patients. Non-serious associated injuries (distal radius fractures in three patients, Calcaneal fractures in two patients, and rib fractures in three patients), were recorded but they did not require additional surgery. Neurological assessment was made for each patient using a rating system based on that of the American Spine Injury Association (ASIA) impairment scale (2). Radiographic assessment was performed using anteroposterior and lateral roentgenograms, CT scan of the area of injury. Bone density test was performed using Dual-energy X-ray absorptiometry and T value was record in each patients. The vertebral kyphosis was measured from the superior end-plate of the intact vertebra cephalad to the fracture to the inferior end-plate of the vertebra caudal to the fracture. Anterior vertebral body height ratio (AVB-Hr) was measured from the average of the anterior vertebral body of the vertebrae above and below the fractured vertebra divided by the anterior vertebral body height of the fractured vertebra. Posterior vertebral body height ratio (PVBHr) was measured from the average of the posterior vertebral body of the vertebrae above and below the fractured vertebra divided by the posterior vertebral body height of the fractured vertebra. Canal Compromise was determined using CT by directly measuring the anteroposterior canal dimension at the maximum area of the retropulsed osseous fragment or fragments and was reported in millimeters. This figure was then compared with the average of similar dimensions measured at the levels above and below the injury level. The result of this comparison was reported as percent of anteroposterior canal compromise at the injury area. Back pain intensity was recorded on visual analog scale (VAS). Functional outcome was measured using The Oswestry Disability Index (ODI) (14) and the SF-36 domains Role Physical and Bodily pain (23).

On admission, 4 (21%) of 19 patients had incomplete neurologic impairment. The time from injury to surgery varied from 1 d to 4 d (mean 2.7 d). 19 patients located 2 at T11, 5 at T12, 8 at L1 and 4 at L2. The mean preopera-

tive load-sharing classification of spine fractures was 7.1 (range 6~8) (21). The mean preoperative thoracolumbar injury classification and scoring was 5.2 (range 4~8) (29). Based on the ASIA neurologic grading system, preoperative neurological function was grade D in 4 cases and E in 15. All patients underwent short pedicle screw fixation and vertebroplasty within four days of admission, to reduce segmental kyphosis and restore vertebral body height. All patients received a calcium supplementation (1000 mg of elemental calcium daily) and vitamin D (400~600 UI of vitamin D). Two patients received hormonal replacement therapy (estrogens and progestin). Bisphosphonates were given to 12 patients (zoledronate, $n = 3$; alendronate, $n = 9$). Miacalcic were given to 5 patients. Their implants were removed within one year and were prospectively followed for at least two years.

All patients were made to sign an informed consent after being informed about the procedure. All surgical procedures were performed under general anesthesia with endotracheal intubation. Patients were placed in a prone position on four bolsters placed on a radiolucent operating table with the abdomen freely suspended. Somatosensory and Motor Evoked Potentials and Triggered EMG were recorded intraoperatively in all patients. The manual lordotic manoeuvre was first performed to correct kyphosis. Using a paraspinous approach, Expedium pedicle screws (Deputy Spine Inc.) were inserted into a vertebral body one level above and below the injured vertebra and single side at the level of fracture. Cements were injected to pedicle screw hole before inserting pedicle screws of 7 of 19 patients to reduce the implant failure. Following a 6-mm diameter trocar (Kyphon, Inc, Sunnyvale, CA, USA) in a cannula was inserted into opposite pedicle at the fractured vertebra. The position was controlled by an image intensifier, which was then enlarged with the use of an access cannula with a trocar. Once the cannula reached the optimal position, after removing the trocar, PMMA cement was injected into the defect of the fractured body through the cannula under continuous fluoroscopic monitoring (Fig. 1). The PMMA insertion was considered complete when it reached the posterior third of the vertebral body. Operation time, estimated blood loss and PMMA volume were recorded.

A neurologic examination was performed soon after patient recovered from anesthesia. Patients were encouraged to walk while wearing a three-point fixation brace on the following the third day after surgery, and radiographs anteroposterior and lateral and CT scan, were obtained to evaluate the reduction of the fracture, the distribution of the cement, and or any possible complications.

The vigorous work and strenuous physical activity were restricted up to 8 weeks postoperatively.

All patients were postoperatively followed clinically and radiographically at 2 days, three month, and one year around the time of rod removal and at every one-year interval thereafter. Patients were assessed for any neurologic complications. As for CT scan; all patients had it just after surgery and one year later. AVBHR, PVBHR and Segmental kyphosis were measured on the lateral radiographs. Canal Compromise was measured on CT scan. Differences between the pre-and post-operative and final follow up Canal Compromise, segmental kyphosis and vertebral body heights were analyzed. Patients returned for clinical evaluation at one, three, six and 12 months and annually thereafter. Segmental kyphosis, AVBHR and PVBHR, and Canal Compromise by radiographs were calculated pre-operatively, post-operative and at final follow up (Fig. 3-9). Neurological function, visual analog scale (VAS) and ODI and SF-36 were calculated pre-operatively and at final follow up. Statistical analysis was performed with paired t-test for changes of each radiographic and functional parameter.

RESULTS

Mean operative time was 70.8 min (range 60~100 min) and mean blood loss was 92 ml (range 60~160 ml). The mean duration of their hospital stay was 4.5 days (range 3~7 days). The operative incisions were healing well. The volume of PMMA required ranged from 4 to 7 ml. At the time of implant removal, there was no failure of posterior instrumentation including breakage, bending or toggling of the pedicle screw. Average follow up time was 40.1 months (range 24~72 months).

Radiographic assessment of the lateral plane demonstrated that mean Segmental kyphosis was (20.6 ± 5.3) degrees before surgery, was corrected to (2.0 ± 3.2) degrees postoperatively ($P < 0.001$), and slightly deteriorated to (2.4 ± 3.9) degree at final follow up. The AVBHR was corrected from preoperative (48.1 ± 6.8) % to postoperative (94.1 ± 1.7) % ($P < 0.001$) and (93.5 ± 2.1) % at final follow up. The PVBHR was corrected from preoperative (62.7 ± 4.8) % to postoperative (92.8 ± 1.8) % ($P < 0.001$) and (90.8 ± 2.0) % at final follow up. The CT images demonstrated a mean spinal canal narrowing of (37.3 ± 5.8) % before surgery,

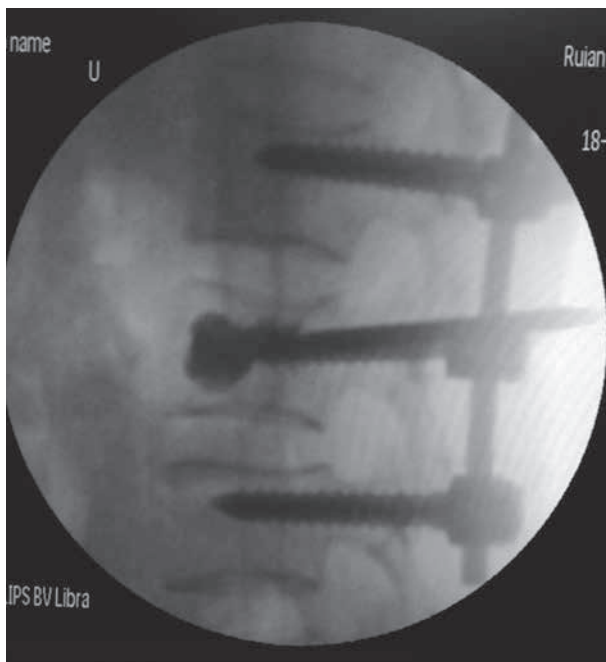
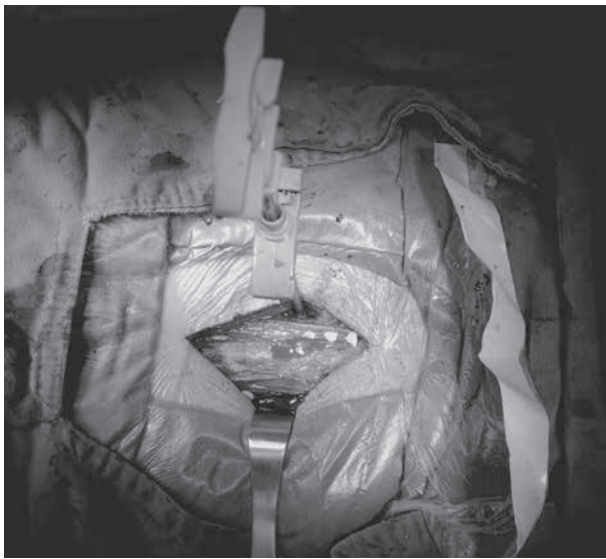


Fig. 1,2. — Intraoperative view : insertion of 5 pedicle screws in the adjacent vertebrae and at the fracture level via a paraspinal approach, and vertebroplasty with PMMA in the fractured vertebra.

(5.9 ± 2.3) % postoperatively ($P < 0.001$) and (6.0 ± 2.1) % at final follow up.

VAS scores were reduced from preoperative 7.21 ± 0.86 to 2.21 ± 0.98 at final follow up ($P < 0.001$). SF-36 domains Bodily pain was reduced from preoperative 75.31 ± 13.85 to



Fig. 3. — Lateral roentgenogram of 67-year-old male patient showing a burst fracture of L1.

13.74 ± 13.24 at final follow up ($P < 0.001$), and domains Role Physical was reduced from preoperative 59.21 ± 26.63 to 19.74 ± 22.94 at final follow up ($P < 0.001$). ODI scores were reduced from preoperative 81.68 ± 4.44 to 15.37 ± 5.54 at final follow up ($P < 0.001$).

Based on the ASIA neurological grading system, all 4 patients with partial neurological deficit initially had improvement. Cement leakage was observed in 3 cases (two anterior to vertebral body and one into the disc without sequelae). There were no instances of instrumentation failure and no patient had persistent postoperative back pain.

DISCUSSION

Thoracolumbar burst fracture is a two- or three-column injury (10) and usually associated with a fall from a height or motor vehicle accident. Osteoporosis is a progressive, systemic disease that results in low bone mineral density and weakened bone micro architecture. Patients with osteoporosis are

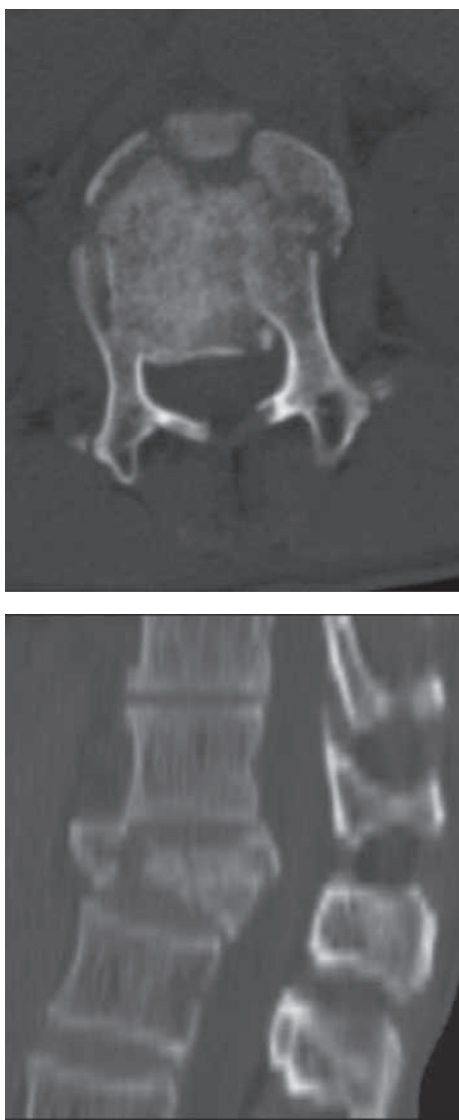


Fig. 4, 5. — Preoperative CT-scan (plain and sagittal reconstruction image) of the patient showing the burst fracture with spinal canal encroachment.

susceptible to low-impact vertebral fractures that are a major cause of morbidity and disability in elderly populations. The management of osteoporotic thoracolumbar burst fractures has not been properly coded to date. However, surgical treatment of these fractures seems to reduce pain and mobilize the patients more quickly, and the duration of the hospital stay is therefore shorter in this case. In this study, we were able to demonstrate the feasibility and relative safety of this technique to reduce the fractured

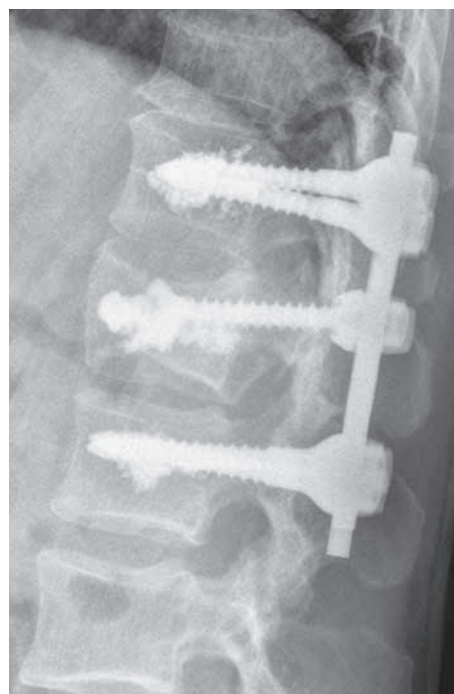


Fig. 6. — Lateral roentgenogram two days after surgery of the patient showing excellent alignment following short fixation and adequate vertebral body reduction.

vertebral body and reinforce the anterior column after posterior reduction and stabilization.

When treating thoracolumbar burst fractures, spinal stability and neurological status should be considered. Posterior, anterior and combined operative techniques have been used for operative stabilization of thoracolumbar burst fractures. Most surgeons prefer posterior instrumentation devices since most of them are familiar with these techniques. The development of pedicle screws has led to the use of “short instrumentation-short fusion” for treating unstable burst fracture to prevent immobilizations of uninjured segments. Posterior instrumentation has allowed a decrease in the number of fused segments and indirect reduction technique has enabled greater correction of kyphosis. Although clinical results are generally satisfactory, failure rates of posterior short-segment pedicle screw instrumentation ranged from 20 to 36% (6,7). In our series, severe burst fracture with osteoporotic lead to failed anterior column support and hardware failure. So, restoration of both anterior and middle

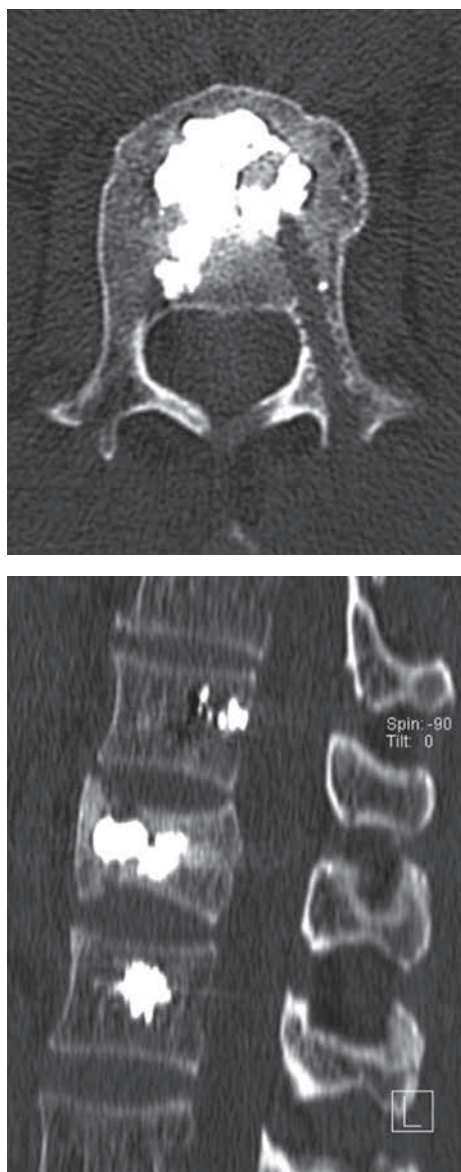


Fig. 7, 8. — CT-scan (plain and sagittal reconstruction image) of the patient 12 months after surgery showing reduced spinal canal encroachment and excellent alignment and adequate vertebral body reduction.

columns seems to be mandatory to safeguard stability of the injured spine.

According to Load-sharing classification system, anterior instrumentation will be chosen when the score is more than 6 points. Anterior decompression allows decompression under direct vision (15), however, anterior approach is associated with increased



Fig. 9. — Lateral roentgenogram of the patient 48 months after surgery showing excellent alignment and adequate vertebral body reduction.

morbidity as compared to posterior approach especially in older patients (22). Furthermore, anterior surgery is suitable for patients with moderate to severe neurological deficits (ASIA C, B, A). Several studies have been conducted to assess the strength and stiffness of vertebral compression fractures after vertebroplasty with polymethyl methacrylate cement (17). For these reasons, all patients in our series were osteoporosis old patients, and neurologically intact or had minor neurological deficits (ASIA E, D), so we chose this technique which combined with posterior short pedicle screw fixation and vertebroplasty to treat osteoporosis thoracolumbar burst fracture. The most original feature of the method presented in this study is the fact that the fracture was reduced and the spinal column was stabilized using a purely posterior approach.

Transpedicular augmentation techniques (kyphoplasty and vertebroplasty) are gaining importance for treatment of osteoporotic vertebral compression fractures. Cementoplasty involves risks of complications, including cement leakage into the spinal

canal. In the context of traumatology, the risk of cement leaking into the spinal canal is greater when the posterior wall has been damaged, as in the case of our burst fractures (8). In a study by Ryu (24), the risk of leakage was assessed depending on the volume of cement injected and the level treated. Kyphoplasty can reduce the fracture using inflatable balloons, the reduced fracture can be consolidated by injecting cement as anteriorly as possible, which prevents the cement from entering the spinal canal (3). As demonstrated by Verlaan *et al* (30) reduction of the fracture by ligamentotaxis before performing vertebroplasty might also decrease the risk of cement leakage due to the resulting alignment of cortical bone fragments. We chose short pedicle screw fixation and vertebroplasty, and Cement leakage was observed in 3 cases without clinical symptom.

Several research have find that the calcium phosphate bone cements overcome possible long term side-effects of PMMA in relatively young patients with non-osteoporotic bone (20,28). We chose PMMA cement because it has been used for vertebroplasties in osteoporotic fractures since long with known biocompatibility and the availability of it. Cho *et al* (9) treated thoracolumbar burst fractures with polymethyl methacrylate (PMMA) vertebroplasty and short segment pedicle screw fixation and reported that PMMA vertebroplasty offers immediate spinal stability in patients with thoracolumbar burst fractures, decreases the instrument failure rate and provides better postoperative pain control than without vertebroplasty. The majority of patients with vertebral burst osteoporotic fractures are older than 70 years ; hence the use of PMMA cement is advocated.

The fracture was reduced and the spinal column was stabilized using a purely posterior approach. Applying a single posterior osteosynthesis is known to involve the risk of secondary kyphosis, corresponding to an angle of 5° in 68% of the patients in a series studied by Been (4). The mean loss of correction of kyphosis ranging from 3 to 12 degrees was reported in the clinical results of short-segment pedicle-screw fixation (16,12). In our series posttraumatic sagittal deformity (vertebral body height, Segmental kyphosis) revealed immediate improve-

ment after surgery, loss of correction was gradual. The mean loss of correction of kyphosis was 0.4°, and the average collapse in AVBHr was 0.6% and PVBHr was 2.0%.

It was reported that the rate of failure of posterior instrumentation including breakage, bending or loosening of the pedicle screw ranged from 9 to 54% (16,12,26). No instrumentation failure was observed in the present study, which was thought to be due to adequate support of the anterior column provided by PMMA grafting.

The average VAS at final follow up in this study was 2.2, SF-36 domains Bodily pain was 13.74, and no patients required chronic medication for incapacitating back pain. Only one had moderate pain, four had occasional pain not requiring medication and the remaining 13 had no complaint of back pain. The average VAS on the work scale was 2.5 points. Of the 19 patients, 13 (68%) could resume their previous work. SF-36 domains Role Physical was 19.74 at final follow up, and ODI score was 15.37 at final follow up, Of the 19 patients, 15 (79%) could resume their social activity.

The combined method involving both vertebroplasty and short pedicle screw fixation via paraspinal approach provides a useful strategy for dealing with Osteoporotic thoracolumbar burst fractures. This procedure seems feasible in combination with posterior instrumentation, taking care of all the three columns through one approach. In our opinion, this is a promising method of treating Osteoporotic thoracolumbar burst.

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