Short-Segment Pedicle Screw Plating for Thoracolumbar Spinal Burst Fractures

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ABSTRACT

A prospective analysis of internal fixation of thoracolumbar spine burst fractures using pedicle screws and dynamic compression or spinal notched plates was performed. This article details the result of 43 patients who were followed for an average of 21 months. For stabilizaton of burst fractures, only 3 vertebrae or 2 motion segments were immobilized. Transpedicular bone grafting was performed in all patients except one Posterlolateral fusion was done only in patients with unstable (3 column failure) burst fractures. For stable burst fractures (2 column failure) which were pure bony lesions the posterolateral fusion was not undertaken. Pain was absent or mild in 95.6 per cent. Most patients with neurologic injuries (16 out of 18), the neurological signs were noted to improve at least one Frankel grade. There were overall correction of kyphosis at follow-up of 8 degrees after a loss of 6 degrees from operative correction. No neurologic or vascular complication occurred.

Burst fractures results from failure under axial load.[1] Most authors now believe that burst fractures is unstable. According to Whitesides[2] and McAfee[3] the burst fractures are classified, on the basis of the integrity of the posterior column, into stable and unstable burst fractures. A stable burst fracture is the one in which the anterior and middle columns fail, with no loss of posterior elements or column. An unstable burst fracture is the one in which the anterior and middle column fail in compression and the posterior column is disrupted. The stable burst fracture is considered by Denis[1] that it has neurologic instability as further vertical collapse of fractured vertebra may lead to more retropulsion of bone into the canal. The unstable burst fracture has both mechanical and a neurlolgic instability. From his clinical experience, he found 20 per cent of posttraumatic spinal stenosis after conservative treatment[4]. Of the patients with acute thoracolumbar burst fractures in the absence of neurologic deficit, 17 per cent of the nonoperative group developed neurologic problems[5]. Although the stable fractures without neurologic deficit can be treated conservatively, the patients have to lie in the horizontal posture on a turning frame until the fracture heals[2,6]. For improvement of the spinal alignment, decreased deformity, early mobilization and rehabilitation of the patient as well as decrease in the complications of prolonged bed rest and back pain, the opative treatment is advocated. In addition to anterior approaches and combined anteroposterior procedures, posterior techniques are most commopnly used for the stabilization of injuries to the thoracic and lumbar spine in Europe and in our country. The pedicle screw-rods systems as AO-Internal fixator[7,9] and Cotrel-Dubousset instruments[10] are rapidly gaining acceptance and popularity in the highly developed industrial countries, including the developing countries as Thailand. These systems can provide rigid fixation with reducing numbers of instrumented vertebral mothion segments. However, the implant cost is very high (about 2000 US.Dollars/implant), millions of US.Dollars were beeing spent each years on using these instruments.

MATERIALS AND METHODS

The purpose of the study is to search for a short-segment pedicle screw instrumentation which is cost effective and readily available. We used the Daniaux's posterior technique[11] which consists of transpedicular bone graft and pedicle screw plates, including only two motion segments or three vertabtae.

Between March 1988 and September 1994, 57 consecutive patients with burst fractures of the thoracolumbar

spine (T11-L5), treated with the short-segment pedicle screw plates were studied with an average follow up of 21 months (range 6-50 months).

Early in this study the AO-DCP Plate with 4.5 mm. cortex screws was used because an AO-notch plate was not available at that time. In addition, a pre-loaded wire loop placing around the spinous process as recommended by Jdaniaux[11,12] was also used to augment the stability against flexion forces. After the AO-notch plate was available, we found no differnce between the AO-notch plate with and without pre-loaded wire loop, in regarding to the maintainance of reduction. The wire loop was therefore discarded.

SURGICAL TECHNIQUE

The patients were placed in prone lordotic position. Standard posterior approach to the spine was used to expose one level above and below the site of injury. In this study, a vertical bony crest was used as the landmark for a pedicle entry point which is situated on the vertical bony crest at the point 1-2 mm. medial to the lateral border of the cranial articular process. Starting from this point, a 2-mm. drill bit is driven with a hand-drill into the pedicles of the vertebra above and below the injured vertebra, parallel to the end plates and convergent 10-15 degrees towards the midline. To avoid the perforation of the pedicle, only the hand-drill is used. For performing the transpedicular bone grafting as described by Daniaux[11], a pedicle on one side of the injured vertebra is also drilled. A 1.6-mm. guide-pin are then inserted into the 2-mm. drill holes and a radiograph is taken is the lateral plane to check guide-pins positions. To prepare the hole for transpedicular bone grafting, a 2-mm. hole in the pedicle of the injured vertebra is gradually reamed with Steimann-pins with increasing in diameter until reach 5-mm. in diameter. To perform the reduction, 3.5 mm. cortex screws are driven into the pedicles above and below the fractured vertebra on one side. With the use of a pelvic reduction clamp, applying over the protruded end of the screws, the vertebral height is restored and the retropulsed bony segment was reduced back into the vertebral body by distraction force (Fig. 1). As the distraction is maintained by using the pelvic reduction clamp, a custom-made punch is brought into the pedicle of the injured vertebral body. The upper end plate and the anterior column are then reduced. After reduction of the compressed vertebral body, defects in the cancellous bone are resulted. These defects are filled with an autogenous bone graft placing through the pedicle (Fig. 2). Later in this series, after reduction, an intraoperative myelography is routinely carried out in cases with neurologic defictit. This markedly reduced the need for laminectomy. Using intraoperative myelography, it was found that in some cases, particularly when canal clearance was not carried out in the first 5 days after injuries, the posterior distraction for indirect reduction of the displaced posterior fragment was not effective in clearing the spinal canal. In these cases the retropulsed bony fragments can be reduced back into the posterior wall by pressing it with an impactor after laminectomy has been done. The next step, kyphotic deformity is corrected by prebending the plates, contoured to the spinal curvature, with a minor overcorrection. While the distraction force is maintained with the pelvic reduction clamp on one side of the spine, an AO-notch plate is applied on the another side. Only the entry point of the screw holes is overdrilled with a 3.2 mm. drill bit to facilitate the insertion of the 4.5-mm. cortex screws which are inserted about 80-90 per cent depth of the vertebral body. The plate is then placed over the guide-pins in the pedicle holes. Only three vertebrae or two motion segments are included in the fixation. After the screws have been tightened, the kyphosis is corrected and the reduced vertebral height is maintained. The pelvic reduction clamp and the 3.5 mm. cortex screws are remmoved and replaced with a plate and 4.5 mm. cortex screws (Fig. 3). In the case of stable burst fractures which

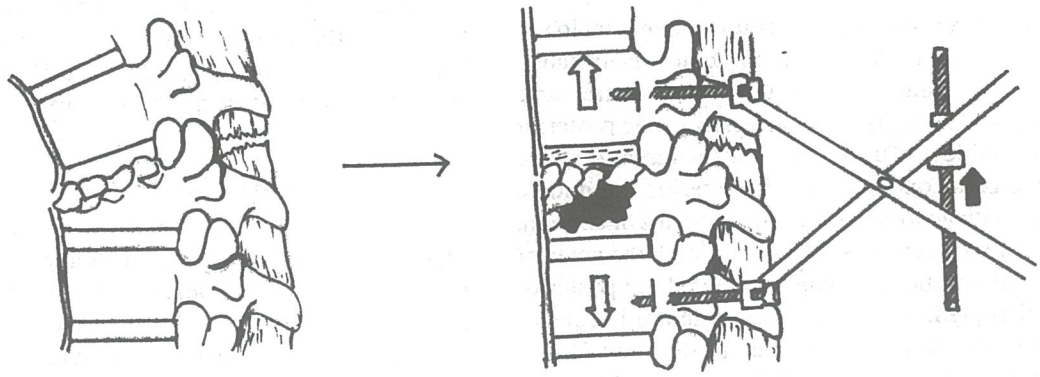


Fig. 1 Restoration of vertebral height and reduction of intracanal fragments in burst fractures, by applying the distraction force, achieving by the use of pelvic reduction clamp.

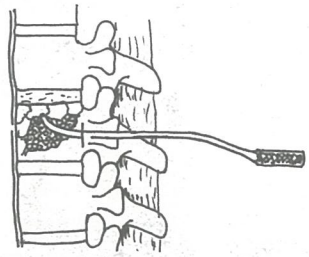


Fig. 2 Transpedicular cancellous bone grafting as described by Daniaux, after the depressed upper end plate has been elevated by a punch, introducing through the pedicde of the injured vertebra.

are pure bony lesions, a posterolateral fusion was not performed. The posterolateral fusion was done in the case of unstable burst fractures which comprise the ligamentors lesions (Fig. 4). Prophylactic antibiotics with first generation cephalosporin is given preoperatively and continued for 48 hours postoperatively. The stability obtained permits the patients to early mobilize, usually about 10 days after surgery (after the stitches have been removed). Patients were instructed to wear light-brace when ambulating (Taylor-brace for thoracolumbar and lumbosacral support for the lumbar lesions) for about 3 months after surgery.

RESULTS

The study included 57 patients. Of these, 14 were excluded because of insufficient follow-up, leaving 43 patients who were followed prospectively with a minimum follow-up time of 6 months. The mean follow-up was 21 months (range 6-50 months). There were 26 males and 17 female patients, mean age 30 years (range 17-55 years). In 42 patients, the average time from the injury to the time of surgery was 9.8 days (range 0-29 days), in the remaining one patient, it was 60 days due to late transfer from the provincial hospital. All fractures were between T11-L5.

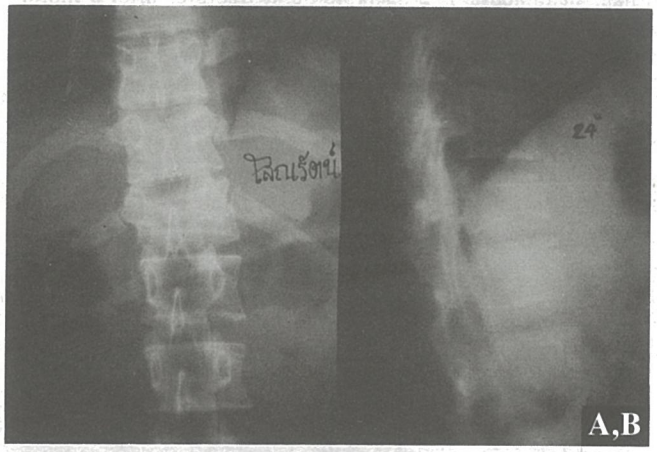
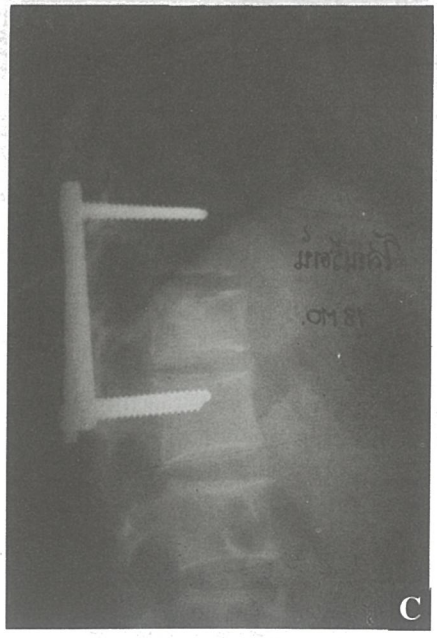
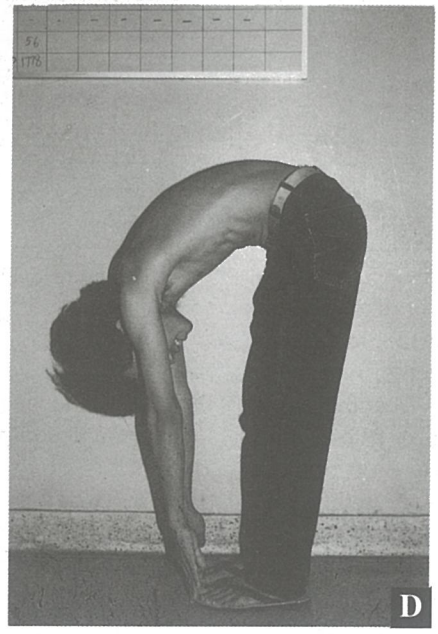


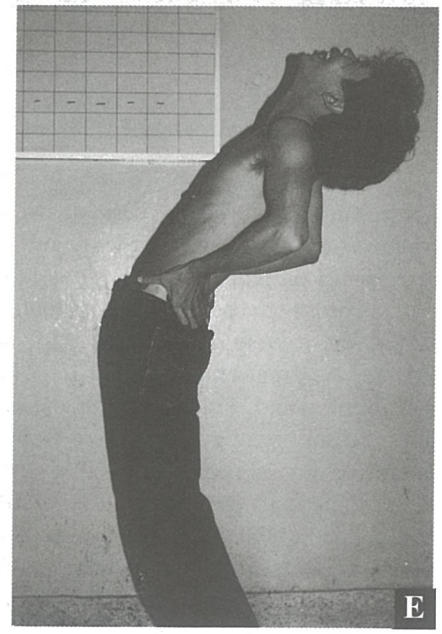
Fig. 3 A,B Preoperative anteroposterior and lateral views of a 25-year-old man who sustained a T12 stable burst fracture in a motorcycle accident. Lateral roentgenogram demonstrates a 24 degrees kyphosis.

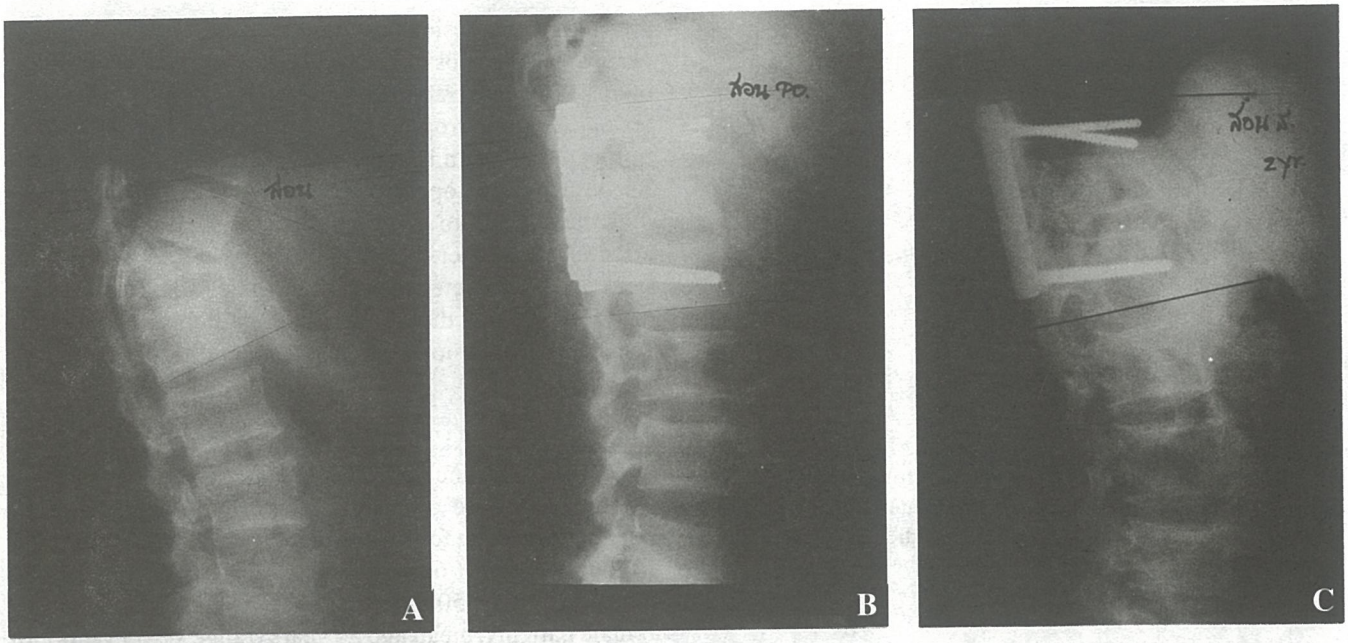
Fig. 3 C 18-month follow-up radiograph shows good restoration of vertebral body height and position of implant, the kyphotic angle was 18 degrees of kyphosis.

Fig. 3 D,E In this case the posterolateral fusion was not performed, the patient is pain free and fully capable of working.









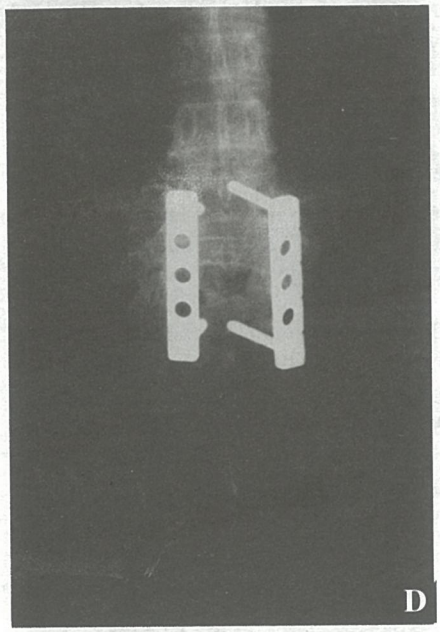


Fig. 4 A A 25-year-old man sustained a T12 unstable burst fractures after a motor-vehicle (Tuk-Tuk) accident with complete paraplegia (Frankel A). Lateral roentgenogram demonstrates a 45 degrees kyphosis:
Fig. 4 B Postoperatively the kyphosis could be corrected to 0 degrees and vertebral height was restored.
Fig. 4 C At 24 months after surgery the kyphotic angle was 6 degrees of kyphosis. The upper disc space was collapsed, but the vertebral height was maintained.
Fig. 4 D The anteroposterior roentgenogram demonstrates a solid bony fusion. The patient has no pain but the neurologic status remained unchanged.

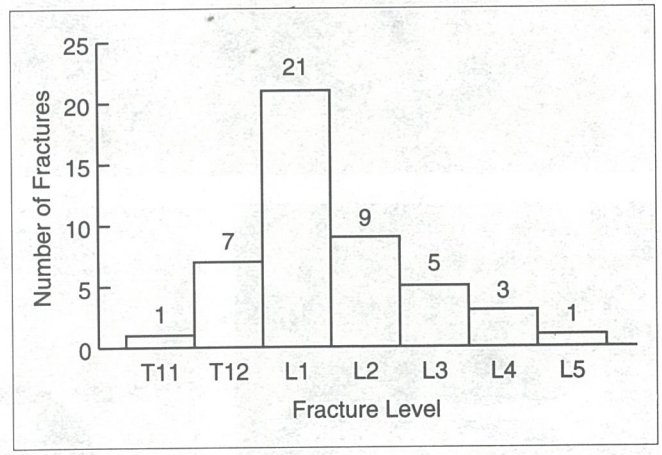


Fig. 5 Fracture level in the study group of forty-three patients (47 fractures)

Most were fractured L_1 vertebra (Fig. 5). Stable burst fractures occurred in 30 patients and unstable burst fractures in 13 patients. Neurologic compromise was classified according to the system described by Frankel[13]. In this series, there were 18 patients with neurologic deficits: Frankel A, 3 patients; Frankel B, 5 Patients; Frankel C, 9 Patients; and Frankel D, 1 patient. Decompressive laminectomy was performed in 9 patients whose intraoperative myelograms showed no passage of contrast-medium beyond the fractured level after the indirect decompression with the distraction force had been done. All of 13 patients with unstable burst fractures underwent porterolateral fusion. In two patients with stable burst fractures the posterolateral fusion were performed because the decompressive laminectomy had been done.

PAIN RELIEF

The pain scale, used in this series was as followed: no pain; mild pain (occasional pain, need no analgesics); moderate pain (occasional pain, analgesics required); se-

vere pain (regular analgesics required). Pain was absent in 35 patients, mild in 6 patients and moderate in 2 patients. Total pain was absent or mild in 95.6 per cent.

ALIGNMENT

Kyphotic angle was determined by Cobb measurement on lateral radiographs. The average preoperative kyphosis of 16.4 degrees (range, 0-50) was reduced following instrumentation to 2.6 degrees (range, 17 lordosis to 25 kyphosis). The mean improvement on kyphotic deformity was 13.8 degrees. The follow-up mean Cobb angle was 8.8 degrees. And the mean loss of reduction was 6.2 degrees. Loss of reduction occurred in all patients and one patient showed loss in reduction of more than 15 degrees due to screw loosening before bone healing.

NEUROLOGIC DECOMPRESSION

Of eighteen patients with incomplete neurologic lesions, 16 improved neurologically and could be upgraded one or more Frankel grades (Table. 1). Patient with complete paraplegia occurred at T12, L1 respectively, showed no neurologically improvement. 14 of the 18 patients with neurologic lesions presented with loss of bowel and bladder function. All but two patients were improved and required no catheterization. Two patients with no improvement and required continuous catheterization were complete paraplegic.

UNION

Bony union occurred in all patients. The posterolateral fusion was solid in all patients.

COMPLICATION

There were no neurologic or vascular injury nor infection as a result of the instrumentation and Broken screws were noted in four patients or 2.3 per cent of total screws (4/176). All of them occurred in the stable burst fractures, in which no spinal fusion had been undertaken. Screw placement lateral to the pedicle occurred in four patients or 2.3 per cent of total screws (4/176). Both of these complications did not lead to another complication.

Frankel Functional Neurologic Level	A	B	C	D	E
Day of Injury	3	5	9	1	25
Follow-up	2	-	-	9	32

Table 1. Neurologic function of 43 patients after injury and at follow-up using Frankel & associates' for grades of function.
Note : 18 patients had an neurologic deficit preoperatively

Screw loosening before bone healing were noted in seven patients or 4.6 per cent of total screws (8/176), resulting in loss of reduction of more than 10 degrees in two patients.

DISCUSSION

The successful surgical treatment of thoracolumbar spinal fractures should consist of achieving stabilization over only few motion segments and allows early mobilization without the aid of a cumbersome cast. The pedicle screw-rod system has this capability[7-9] and has become very popular. More recently, the variable spinal plating (VSP) system of Steffee[18] has been available in this country. It also give rigid stabilization over the short motion segments. In addition to its expensiveness, complications with the variable spinal plating system were reported. The screw diamenter of the VSP are relatively large (5.5-7.0 mm.), even for the western populations[19]. Marshesi et al reported that 2.1 per cent of the 380 vertebral pedicles examined had horizontal diameter smaller than 4.5 mm., likewise the minimal pedicle diameter in Thai population is 5-6 mm.[21]. Owing to this relatively large screw diameter, nerve root impingement or compression due to bony impingement as a result of fragmentation of the pedicle on the medial wall was reported[19]. Screw breakage is still the problem because of lack of micromotion and the greater concentration of load at the rigid screw-plate interface[19,22-24]. Recent animal experiments have shown that for spinal fixation device the least stiffness that will still bring about union with attempted arthordesis is ideal[25]. Moreover, Goel et al[26] has reported that it is advantageous to decrease the rigidity of the VSP to promote healing of the fusion mass and to prevent stress induced osteoporosis secondary to stress shielding effect[26].

The pedicle screw plate in the present series is a stable, not rigid fixation device, therefore should promote bone healing or consolidation of the fusion mass. However, the pedicle screws are not mechanically rigidly link to the plate, the screws may be failed under physiological cyclic loading before the cavity in the reduced vertebral body refilled spontaneously with bone. Failure of implant at screw-bone interface before bone healing can be prevented by transpedicular bone grafting technique[11]. Roy-Camille pointed out that major bone lesion will heal with bony callus and will stabilize itself spontaneously: on the contrary significant lesions to the ligaments and discs will never stabilize spontaneously. Whitesides[2] had shown that in stable burst fractures the injury is in bone, spontaneous healing of the vertebral body can occur but in unstable burst fractures spontaneous healing is unusual. Based on these observations we therefore perform posterolateral fusion only in cases with injured ligaments and/or facet joints, as in the unstable burst fractures, and after decompressive laminectomy. Stable burst fractures is a pure bony lesions which can be directly repaired with the technique

of transpedicular bone grafting. It is therefore unnecessary to perform spianl fusion, except in cases in which the decompressive laminectomy has undergone. The spinal mobility is then naturally preserved and morbidity from the operation can be reduced.

The result of the present series is comparable with that of burst fractures treated with the AO-Internal fixator, regarding to the correction of kyphosis and maintainance of reduction. In 61 patients with burst fractures stabilized with the AO-Internal fixator Esses et al[16] found that the mean improvement in the kyphotic defirmity was 14 degrees postoperatively but he did not reported about the loss of reduction at the follow-up study. In the series of Linsey and Dick[14], the mean improvement of kyphotic deformity was 11 degrees after instrumentation and 3 degrees loss in reduction at 1 year, and 8 degrees after implant removal. In the present series, the mean improvement in the kyphotic deformity was 13 degrees after pedicle screw plating and loss in reduction at the last follow-up study was 6 degrees. Inplant removal was performed in about one-third of the patients and no difference in kyphotic angle before and after the removal was found. This finding is likely due to non-rigid screw-plate junction. The short-segment pedicle screw system in combination with the transpedicular bone graft gave the results superior to that yielded by Cotrel-Dubousset instrumentation. From the study of Carl et al[17] in which the majority of patients sustained burst fractures stabilized with the Cotrel-Dubousset instruments, the over-all correction of kyphosis at the follow-up study was only 1 degree. In the series of McLain et al[28] all of 13 patients with thoracolumbar burst fractures had an average of 10 degrees of loss in reduction, three of them had loss in reduction of more than 15 degrees. poor result associated with Cotrel-Dubousset instruments were attributed to untreated anterior instability. After the vertebral height has been restored with axial distraction, this leaves large defect in the vertebral body. Without three-point contact, bending moments are resisted only by the intrinsic stiffnees of the screw and rod. Screws may then be bent or broken, leading to kyphotic defirmity. Although the AO-Internal fixator is also the pedicle-screw rod system, as well as Cotrel-Dubousset instrument, its ability to maintain reduction is attributed to direct anterior repair with the transpedcular bone graft, as antegral part of the fixator[9]. The short-segment pedicle screw plating has three-point contact[12] to resist the bending moment for immediate stability and logn term stability is based on healing of the vertebral column enhanced by transpedicular bone grafting. Moreover, this simple and cheap implant is also less bulky than the pedicle-screw rod instruments and does not protrude as far dorsally, thus preventing damage to the paravertebral muscles.

All cases of screw loosening before bone healing or lateral to the pedicle occurred early in this study and was due to improper technique, still in the learning curve. All of broken screws occurred in the stable burst fractures in which no fusion had been done. This screw breakage may be reduced by early removal of implant about 1 year after surgery.

CONCLUSION

The transpedicular reduction technique is effective in forceful distraction for restoration of the vertebral height and clearance of the spinal canal in cases of the thoracolumbar burst fractures. The short-segment pedicle screw plating allows correction of kyphosis and effective stabilization of the burst fractures, requiring immobilization of only two spinal motion units. In combination with transpedicular bone grafting it can maintain sufficient stability until bone healing and/or fusion is achieved. The implants and instruments are cost effective and ready available at all centers equipped with AO-instruments sets. Stabilization without spinal arthordesis is possible in the case of stable burst fractures which are pure bony lesions, spinal mobility is therefore physiologically preserved. The posterolateral fusion is necessary in the cases of unstable burst fractures in which significant ligamentous disruptions present.

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