

Osteoplasty in Acute Vertebral Burst Fractures

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Objective : Acute vertebral burst fractures warrant extensive fixation and fusion on the spine. Osteoplasty (vertebroplasty with high density resin without vertebral expansion) has been used to treat osteoporotic vertebral compression fractures. We report our experiences with osteoplasty in acute vertebral burst fractures.

Methods : Twenty-eight cases of acute vertebral burst fracture were operated with osteoplasty. Eighteen patients had osteoporosis concurrently. Preoperative MRI was performed in all cases to find fracture level and to evaluate the severity of injury. Preoperative CT revealed burst fracture in the series. The patients with severe ligament injury or spinal canal compromise were excluded from indication. Osteoplasty was performed under local anesthesia and high density polymethylmethacrylate (PMMA) was injected carefully avoiding cement leakage into spinal canal. The procedure was performed unilaterally in 21 cases and bilaterally in 7 cases. The patients were allowed to ambulate right after surgery. Most patients discharged within 5 days and followed up at least 6 months.

Results : There were 12 men and 16 women with average age of 45.3(28-82). Five patients had 2 level fractures and 2 patients had 3 level fractures. The average injection volume was 5.6cc per level. Average VAS (Visual Analogue Scale) improved 26mm after surgery. The immediate postoperative X-ray showed 2 cases of filler spillage into spinal canal and 4 cases of leakage into the retroperitoneal space. One patient with intraspinal leakage was underwent the laminectomy to remove the resin.

Conclusion : Osteoplasty is a safe and new treatment option in the burst fractures. Osteoplasty with minimally invasive technique reduced the hospital stay and recovery time in vertebral fracture patients.

KEY WORDS : Burst fracture · Indication · Osteoplasty · Vertebral fracture · Vertebroplasty.

Introduction

Fracture involves both anterior and middle column of the spine in vertebral burst fractures. Spinal fixation and fusion surgery has been a standard procedure for burst fractures for decades. Extensive fixation and fusion surgery on the spine carries high surgical morbidity and complication¹³, especially in old patients. Vertebroplasty has been used extensively in osteoporotic compression fracture^{1,8,10}, although it was originally used in vertebral hemangiomas to prevent vertebral crushing. Progressive kyphotic deformity and spinal cord compression by the bone fragment in thoracolumbar osteoporotic compression fracture cause back pain, cosmetic deformity, and neurological compromise after conservative treatment and long-term bed rest results even more complications. Vertebroplasty has been reported to result in substantial and immediate pain relief^{1,7,10,19}, although this procedure has been contraindicated in burst fractures due to the risk of cement leakage. Recently,

Osteoplasty (vertebroplasty with high density resin using large cannula-low pressure delivery system without vertebral expansion) is developed to reduce the risk of cement leakage¹⁷. The low pressure delivery system reduces the risks of cement leakage by injecting high viscosity cement. Osteoplasty has been used in osteoporotic compression fracture. We used Osteoplasty with minimally invasive techniques in both osteoporotic and non-osteoporotic burst fractures for early ambulation and recovery.

In this study, we report our experiences of osteoplasty for acute vertebral burst fractures.

Materials and Methods

Patient population

We performed osteoplasty in 28 patients of acute vertebral burst fracture from January 2002 through November 2004. There were 12 men and 16 women. The mean age at surgery was 45.3 years (range 28-82) (Table 1). All patients complained

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Table 1. Demographic data and case summary of the patients

No	Age	Sex	Level	Kyphosis angle(°)		VAS score (mm)	
				Preop.	Postop.	Preop.	Postop.
1	28	M	T12	8	16	85	53
2	30	F	L1	10	13	76	29
3	34	M	L3	26	20	72	25
4	35	F	T11, T12	15	23	87	69
5	31	F	T10	3	-2	68	52
6	33	M	T12	16	23	65	43
7	82	F	L2, L3	6	19	81	65
8	64	F	L1	20	22	88	66
9	55	F	L3	20	15	75	52
10	75	F	T12, L1, L2	23	20	79	45
11	46	M	T11	25	26	94	73
12	63	M	L2	14	18	88	65
13	33	M	L2, L3	26	21	72	65
14	46	F	T12, L2, L3	12	14	90	92
15	38	M	L3	8	15	82	73
16	35	F	L4	28	22	80	53
17	40	M	T12	12	15	88	42
18	55	F	L4, L5	25	24	94	45
19	42	F	L1	2	13	88	72
20	52	F	L3	5	8	78	67
21	36	M	T12, L1	7	14	92	77
22	40	F	L1	18	26	78	62
23	50	M	L1	17	17	90	67
24	39	F	L3	10	19	78	43
25	47	F	T12	22	14	82	29
26	39	M	L4	24	26	84	41
27	44	M	T11	15	22	88	59
28	56	F	T12	32	24	80	57

VAS : Huskisson's visual analog scale, Preop : preoperative, Postop : postoperative

of back pain and/or low-back pain and no patient has neurologic deficit. Preoperative CT was performed in all cases and revealed burst fracture by showing the fracture line involves at the posterior cortex of vertebral body. Preoperative MRI performed in most cases showed the fracture line involve at the posterior cortex of vertebral body to find the acute fracture in patients with multiple fracture patients and to evaluate the severity of injury. We selected target level which showed low intensity on T1 weighted image in multiple level fractures. The patients who had fractures involving the posterior column or had severe neurologic deficits with spinal cord compression were excluded. The patients with severe ligament injury were also excluded from indication. Eighteen patients had osteoporosis with T score under -3 on DEXA(Dual-Energy X-Ray absorptiometry). The kyphotic angle in the patients was measured by angle between the superior and inferior endplates of the fractured vertebra from the plain lateral radiographs. The average preoperative kyphosis angle was 16.0°(range 2 to 32 degrees). The clinical symptoms and surgical results were assessed by asking the patients to quantify their degree of pain

on Huskisson's visual analog scale (VAS : 0mm=no pain; 100mm=highest possible degree of pain). Kyphotic angle and VAS were checked before and immediately after procedure, and followed up 1 month, 3 month and 6 months after surgery.

Operation technique

We used local anesthesia in all cases. The patient was positioned in hyperlordosis for positional reduction. Biplanar fluoroscopic control was used in most patients. A punch incision is made with #15 blades at entry point. Under anterior-posterior fluoroscopy, 11 gauge pin was inserted at 8 o'clock (left) or 4 o'clock (right) on the lateral border of the pedicle outline aiming upper endplate of involved body where most fracture takes place. The tip of the needle placement requires frequent checking with the fluoroscopy. Osteoplasty tube was inserted to the most anterior part of the vertebral body and high density polymethylmethacrylate(PMMA) was injected with an injector until it reaches the posterior vertebral margin on lateral fluoroscopic control. Injection is stopped immediately when any sign of leakage is noted or the cement filling is adjacent to posterior wall. The procedure was performed unilaterally in 21 cases and bilaterally in 7 cases. The patients were allowed to ambulate right after surgery. No brace was recommended after surgery. Most patients discharged within 5 days and followed up at least 6 months. Postoperative plain X-rays were taken immediate pre, post-operatively, and 1 month, 3 months after surgery.

Results

There were 28 patients with thoracolumbar spinal burst fractures. Most patients discharged within 5 days and all patients were followed up at least 6 months after procedure. Five patients had 2 level fractures and 2 patients had 3 level fractures. Osteoplasty procedures were done on 37 vertebral bodies. The fractured level was T12 in 9 cases, L1 in 7 cases, L2 in 5 cases, L3 in 8 cases, T11, L4 in 3 cases and T10, L5 in 1 case each(Table 1). The average injection volume was 5.6 cc per level. Pain improved usually after within 24 hours. Average VAS improved from 82.2mm before surgery to 56.5mm after surgery. The mean local kyphotic deformity measured 18.1 degrees(range -2 to 26 degrees) after procedure, indicating that the mean postoperative aggravation was 2 degrees(range -8 to 11 degrees) per level and 4 degrees on last follow up measurement. The immediate postoperative X-ray showed 2 cases of filler spillage into spinal canal and 4 cases of leakage into the paraspinal space. One patient with intraspinal leakage was underwent the laminectomy to remove the resin due to neurologic deficit, and the others did not need operation, because there were no symptom and signs.

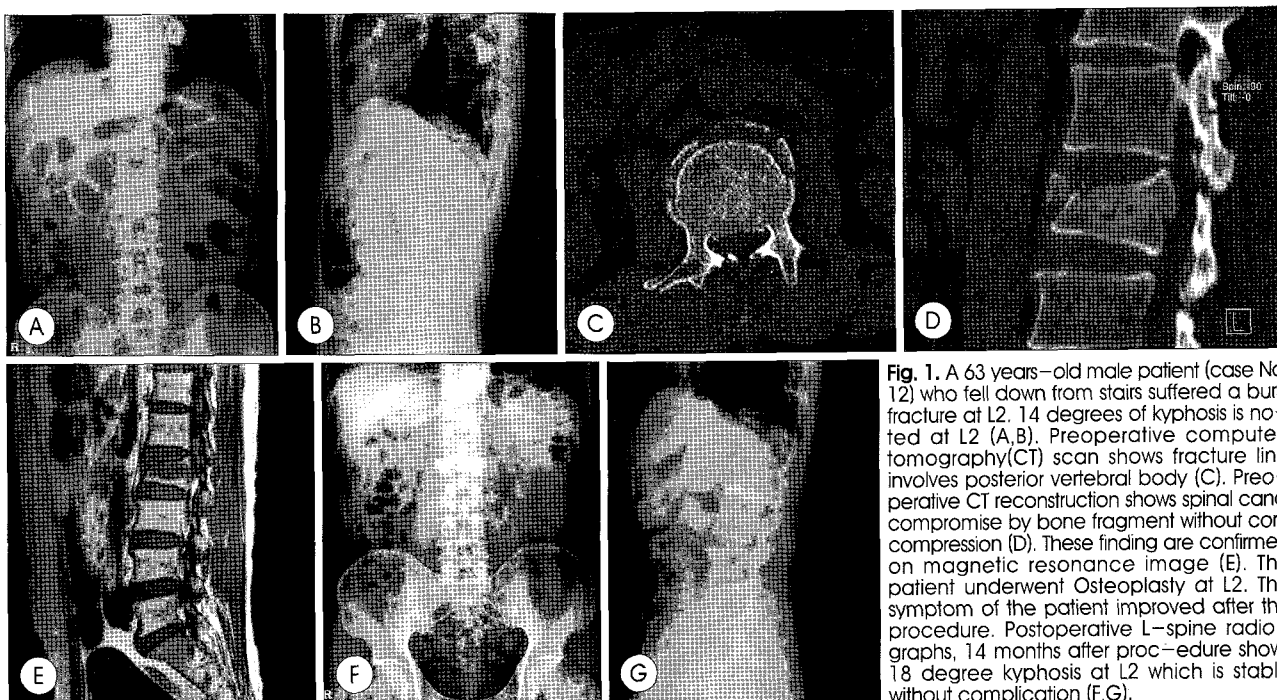


Fig. 1. A 63 years-old male patient (case No. 12) who fell down from stairs suffered a burst fracture at L2. 14 degrees of kyphosis is noted at L2 (A, B). Preoperative computed tomography(CT) scan shows fracture line involves posterior vertebral body (C). Preoperative CT reconstruction shows spinal canal compromise by bone fragment without cord compression (D). These findings are confirmed on magnetic resonance image (E). The patient underwent Osteoplasty at L2. The symptom of the patient improved after the procedure. Postoperative L-spine radiographs, 14 months after procedure shows 18 degree kyphosis at L2 which is stable without complication (F, G).

Case illustration(Fig. 1)

A 63 years-old male patient (case No. 12) who fell down from stairs suffered a burst fracture at L2. 14 degrees of kyphosis is noted at L2 (A, B). Preoperative computed tomography(CT) scan shows fracture line involves posterior vertebral body (C). Preoperative CT reconstruction shows spinal canal compromise by bone fragment without cord compression (D). These findings are confirmed on magnetic resonance image (E). The patient underwent Osteoplasty at L2. The symptom of the patient improved after the procedure. Postoperative L-spine radiographs, 14 months after procedure shows 18 degree kyphosis at L2 which is stable without complication (F, G).

Discussion

Vertebral burst fracture is a common injury related with fall from height and motor vehicle accident. The clinically important question of whether the spine is stable or unstable is evaluated by the "column" theories. The most popular theory is the three-column scheme first proposed by Denis in 1983⁹⁾. In his study, Denis found that disruption of the posterior ligamentous complex was insufficient to produce instability. Additional rupture of a middle osteoligamentous complex, consisting of the posterior vertebral body, posterior annulus fibrosis, and posterior longitudinal ligament, was consistent with clinical instability. The anterior column was defined as the anterior vertebral body, anterior annulus fibrosis, and anterior longitudinal ligament. The posterior column composed of the entire posterior osseous arch, inclu-

ding the facets, and posterior ligamentous complex. Denis divided the anterior and middle columns midway through the vertebral body, whereas Ferguson and Allen¹³⁾ modified the columns by including the anterior two thirds of the vertebral body and anterior two thirds of the annulus fibrosis with the anterior column, and by placing the posterior third of the vertebral body and posterior third of the annulus fibrosis with the middle column. This division of the columns seems to agree better with injuries observed in practice. Injury to the middle column can significantly alter the mechanical stability of the spine, even though anterior column failure resulted in rotational instability¹⁴⁾. According to three column theory, our patients' fractures were classified as burst fracture. These types of injuries result from axial loading and flexion and are characterized by the failure of both anterior and middle columns.

However, there has been considerable controversy regarding the management of burst fracture^{2,5,12,23)}. In the past, thoracolumbar fracture was treated with conservative methods of cast or brace immobilization with long term bed resting^{4,11,20)}. The constant pain, loss of independent function changes in physical appearance, feelings of isolation and vulnerability, and an uncertain future characterize the patients. Conservative medical treatment includes bed rest. Prolonged bed rest cause rapid bone loss and require long time to recovery, although the resting time is short^{15,18)}.

With the introduction of pedicle screw instrumentation, surgical management with various fixation and fusion methods became widespread to manage the vertebral instability.

The goals of surgical treatment in burst fracture are decompression of neural element, restoration of vertebral height and alignment, stabilization and early mobilization in order to acquire maximal recovery from neurological and functional deficits in the long run. Although new techniques and instrumentation systems now facilitate a more aggressive surgical approach in treating such injuries, potential risks and complications remain. Extensive fixation and fusion surgery on the spine carries high surgical morbidity and complication³⁾, especially in old patients. Osteoporosis decreases the success rate of fusion surgery in aged patients.

Previous vertebroplasty has some problems, which is related to low viscosity of cement leakage, pulmonary embolism, and sudden cardiac arrest^{6,8,10,16,19,21,24,25)}. These complications inherit considerable dangers from leakage of the resin into venous system or accumulation of resin within the spinal canal. Bone cement leakage and damage to various neural structures by compressive or thermal effects during the polymerization of PMMA^{1,8,22)}.

The risk of cement leakage into the spinal canal is greater in burst fractures because low viscous cement leak through the vertebral fractures. The osteoplasty is the vertebroplasty using large cannula-high density resin-low pressure delivery system recently developed for safe cement delivery. The low pressure delivery system reduces the risks of cement leakage and embolic event by injecting high viscosity cement.

However, osteoplasty is not absolutely safe in all burst fracture. Osteoplasty should be limited to those fractures in patients with both the anterior- and middle-column damage without neurological deficit or spinal cord compression. The posterior extrusion of bone cement into the spinal canal can be avoided by placing the needle at the most anterior position, maintaining a steady injection rate, and continuous fluoroscopic monitoring of the injection procedure. Several studies^{3,17)} have recommended injection of PMMA in a thick viscous or partially polymerized consistency through large-bore cannula to reduce early cement leakage. Cement leakage into the spinal canal and posterior vertebral cortical bulging should be carefully observed with high resolution fluoroscopic control at all times during the procedure. 6(16%) levels out of 37 procedure had leakage in our series and only one patient necessitated removal of resin compressing nerve root. Paraspinal or intradiscal leakage is typically asymptomatic. Careful monitoring without over zealous injection should decrease the leakage incidence.

Conclusion

We achieved satisfactory result in thoracolumbar burst fractures with osteoplasty. Prompt pain relief, the early

mobilization and effective rehabilitation could be achieved in burst fractures with minimally invasive technique. Osteoplasty can eliminate the need for, and risk of, major spinal surgery in carefully selected burst fractures. Osteoplasty is a reliable and new treatment option in the acute burst fractures.

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Commentary

The authors reviewed their clinical experiences of osteoplasty in 28 patients with vertebral burst fractures. Vertebroplasty is currently indicated for osteoporotic compression fracture. Certain burst fracture is relative contraindication of vertebroplasty because of technically difficult and complications.

In vertebroplasty, cement leakage is more common in burst fracture than compression fracture. When vertebroplasty performed at the acute stage of burst fracture, the risk of cement leakage is increased. Venography helps to prevent the cement leakage and pulmonary embolism. In osteoplasty, the risk of cement leakage is lower than vertebroplasty

because of low pressure delivery system with high viscosity PMMA. So venography is not necessary before osteoplasty for protection of cement leakage. And osteoplasty with large cannula can obtain the specimen effectively in bone biopsy.

Of these cases, 13 patients were younger than 40 year of age. And 10 patients had non-osteoporosis with T-score above -3 on DEXA. In case of non-osteoporotic patients, cannula insertion and PMMA injection to vertebral body were difficult because of hardness of vertebra. Osteoplasty performed at the acute stage of burst fracture in this report. In non-osteoporotic younger patients, the usage of PMMA materials has controversial. Incidence of new adjacent vertebral fractures, spinal deformity, and the rate of infection due to foreign body reaction of the PMMA may be increased. Long-term clinical follow-up of efficacy and complications of osteoplasty with PMMA in non-osteoporotic younger patients are required.

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