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Management of unstable thoracolumbar spinal injuries by posterior short segment spinal fixation

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Abstract Fifty patients with thoracolumbar fractures were treated operatively between July 2000 and December 2001. The average age of the patients was 33.6 years (range: 20–50 years), 36 were males and 14 were females and the follow-up averaged 59 months (range: 49–68 months). A fall from a height, usually a tree, was the most common cause of injury. Twenty six patients had unstable burst fractures and 13 had translational injury. There were 15 patients with complete neurological deficit, 17 had partial neurological lesions, while 18 had no neurological deficit. All patients were treated by posterior short segment fixation (Steffee VSP). The average pre-operative kyphotic angle was 21.48°, which improved to 12.86° in the immediate post-operative period. The loss of kyphosis averaged 3.46° (0–26°) at the final follow-up. The average pre-operative anterior vertebral body height was 44.7% (range: 36–90%), which improved to 72.0% (range: 55–97%) in the immediate post-operative period. The loss of body height averaged 3.0% (range: 1–15%) at the final follow-up. No neurological deterioration was seen, and in 24 cases a one grade or better improvement was observed. The mean pain score was 1.6, and the mean functional score was 2.8. We found that the application of posterior instrumentation resulted in a reasonable correction of the deformity with a significant reduction in recumbency-associated complications; there were, however, significant other complications.

Résumé Cinquante patients présentant une fracture thoracolombaire ont été traités entre juillet 2000 et décembre 2001. L'âge moyen était de 33.6 ans (20 à 50). Il s'agissait de 36 hommes et 14 femmes. Le suivi moyen était de 59 mois (49 à 68). La chute d'une hauteur habituellement d'un arbre était la cause la plus connue. Vingt-six patients avaient une fracture instable et 13 un traumatisme avec translation. Quinze patients avaient un déficit neurologique complet, 17 un déficit neurologique partiel et 18 aucun déficit neurologique. Tous les patients ont été traités par une fixation postérieure (Steffee VSP). L'angulation sans cyphose préopératoire a été de 21.48° en moyenne, celle-ci s'est améliorée de 12.86° en postopératoire immédiat. La perte de cyphose a été de 3.46° (0–26) au suivi final. La hauteur vertébrale de 44.7% (36–90) s'est améliorée à 72% (55 à 97) en postopératoire immédiat. La perte de hauteur du corps vertébral a été de 3% (1–15) au suivi final. Aucune dégradation neurologique n'a été constatée. Une amélioration a été retrouvée dans 24 cas le score douleur moyen a été de 1.6 le score fonction de 2.8. Une instrumentation postérieure permet une correction raisonnable de la déformation avec une réduction significative des complications.

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Introduction

The debate over the management of thoracolumbar fractures continues, with controversy remaining as to whether treatment should be non-operative or operative [1, 3, 12] and – in the case of the latter – whether a posterior or anterior approach is indicated to achieve the desired results [3, 10, 13, 14].

Advocates of surgical treatment cite improvement in spinal alignment, decreased deformity, early mobilisation and rehabilitation of the patient and a decrease in complications arising from prolonged bed rest and back pain [4, 5, 9]. Advocates of the non-operative option, such as Bedbrook [1] and others [19], have reported equivalent

Table 1 Master chart of the patient, injury, treatment and evaluations

Patient no.	Follow-up (months)	Age (Years)	Gender	Mode of trauma[a]	Neuro pre-op. (Frankle)	Level	Type of injury (McAfee)[b]	Injury Adm. interval (days)	Injury surgical interval (days)	Kyphotic angle (°) Pre-operative	Kyphotic angle (°) Post-operative.	Kyphotic angle (°) Loss at FFU[c]	Neuro at FFU[c]	Complications[d]	Pain scale (Denis)	Functional scale (Denis)
1	68	50	M	FFH	E	L3	UB	3	9	19	9	5	E	HWF	1	1
2	68	22	F	FFH	A	D12	TRS	2	13	20	15	3	A	UTI	2	5
3	68	50	F	FFH	E	D12	UB	2	16	22	12	1	E		1	1
4	67	27	M	FFH	E	D12L1	TRS	2	13	33	19	2	E	DWI	2	2
5	67	34	F	FFH	A	L1	UB	2	10	31	5	1	C	HWF	2	5
6	67	26	F	FFH	C	D12	TRS	3	10	36	19	0	E		1	2
7	67	26	M	FFH	A	L1	TRS	2	6	28	12	7	A	HWF/UTI	2	5
8	67	35	M	FFH	A	D12	TRS	3	9	26	16	0	A	UTI	2	5
9	67	35	F	FFH	A	L1	FD	5	9	34	19	0	C		3	5
10	66	23	M	FFH	A	D12L1	TRS	3	5	23	7	0	C		2	5
11	66	50	F	FFH	E	L1	UB	2	14	18	14	10	E	HWF/SWI	1	1
12	66	48	M	Caving In	E	L2	UB	1	13	29	19	0	E		1	2
13	66	44	M	FFH	E	D11	UB	2	15	26	18	10	E	HWF	2	2
14	66	20	M	FFH	E	D12L1	TRS	1	16	40	20	1	E		1	2
15	66	28	M	FFH	E	L3	CHANCE	2	14	17	27	0	E		1	1
16	66	32	M	FFH	C	L2	FD	3	11	21	9	6	D	HWF	1	3
17	66	28	M	FFH	B	D12	UB	2	12	25	18	4	D		2	3
18	65	22	M	FFH	B	D12	UB	1	11	18	4	1	D		2	3
19	64	35	M	FFH	E	L3	UB	1	12	9	0	5	E	HWF	1	1
20	64	30	M	FFH	D	L1	UB	2	15	20	9	0	E	HWF	1	1
21	63	22	M	FFH	D	D12	UB	3	12	18	12	0	E		2	2
22	63	30	F	FFH	C	L1	UB	1	10	19	9	5	E	HWF	1	2
23	61	28	M	FOHO	D	L4	UB	1	15	19	28	0	E		2	1
24	61	35	M	FFH	C	L2	UB	2	14	17	11	7	D		1	3
25	60	34	M	RTA	E	L2	FD	1	10	24	7	5	E		1	1
26	59	30	M	FFH	A	D11	TRS	3	15	22	21	0	A	UTI/GSI	2	5
27	58	25	M	FFH	A	D12	UB	4	14	20	18	1	A	UTI/HWF	2	5
28	58	36	F	FFH	C	D12	UB	2	12	26	21	0	D		1	3
29	56	28	M	FFH	A	D11	TRS	1	14	27	20	0	A	SWI	1	5
30	54	38	M	FFH	E	L2	FD	2	7	26	15	3	E		2	2
31	54	31	F	FFH	B	D12	UB	3	9	35	29	0	D		1	3
32	54	37	M	FFH	C	L1	UB	4	13	24	14	10	E	HWF	2	2
33	53	28	F	FFH	A	D12	TRS	2	6	26	18	4	A	UTI	3	5
34	53	41	M	FFH	E	L1	UB	1	11	20	7	2	E		1	1

35	53	36	M	FFH	A	D11	TRS	3	9	27	23	1	A	UTI	2	5
36	53	24	M	FFH	B	D12	UB	2	14	36	26	2	D		1	3
37	53	45	M	FOHO	E	L2	FD	3	10	3	20	1	E		1	1
38	53	32	F	FFH	A	D12	TRS	1	13	20	13	26	B	HWF	3	5
39	53	30	M	FFH	E	L2	FD	2	12	20	20	0	E		1	1
40	52	39	M	FFH	A	D12	UB	5	9	36	23	2	C	HWF/GSI	2	5
41	52	41	M	FFH	E	L2	UB	3	11	8	23	1	E		1	2
42	52	26	M	RTA	D	L3	CHANCE	1	14	3	20	1	E		3	1
43	52	35	F	FFH	E	L2	FD	2	14	16	6	12	E	HWF	1	2
44	51	31	F	FFH	E	L2	FD	6	11	10	18	13	E	HWF	2	2
45	51	46	M	FFH	C	D11	UB	4	13	9	6	5	D		3	3
46	50	40	M	FFH	D	L2	FD	1	11	27	13	20	E	HWF/GSI	1	3
47	49	28	M	FFH	A	D12	UB	5	9	0	18	1	C		2	5
48	49	33	F	FFH	E	L4	UB	7	11	2	1	4	E	HWF	1	1
49	49	43	M	FFH	C	D12	UB	1	13	22	0	2	D	HWF	1	3
50	49	44	M	FFH	A	D12	TRS	3	9	15	12	12	B	bed sore	2	5

[a] FFH, Fall from height; FOHO, fall of heavy object; RTA, road traffic accident
[b] UB, unstable burst; TRS, translational injury; FD, flexion distraction
[c] FFU, Final follow-up
[d] UTI, urinary tract infection; DWI, deep wound infection; SWI, superficail wound infection; HWF, hardware failure; GSI, graft site infection

results, claiming satisfactory alignment of the spinal column and the maintenance of its stability by non-operative means. Biomechanical and clinical studies, however, have shown that when there is loss of >50% of the vertebral body height [20, 22] or angulation of the thoracolumbar junction of more than 20° [20], acute spinal instability results, and the spinal segment will eventually fail with weight-bearing. Biomechanical studies have also shown that spinal instability results when there is a failure of at least two of Denis' three columns [11].

The aim of this study was to evaluate the outcome of patients with thoracolumbar fractures who were treated by short segment posterior fixation device.

Materials and methods

Patients

Fifty patients with unstable thoracolumbar spinal fractures, admitted between 1–7 days after injury (average: 2.8 days), were treated by posterior short segment spinal system (Steffee VSP) between July 2000 and December 2001. The average age of the patients was 33.6 years (range: 20–50 years), and there were 36 male and 14 female patients. The length of the follow-up period averaged 59 months (range: 49–68). A fall from a height, usually a tree, was the most common cause of injury.

The bulk of the fractures (88%) was in the thoracolumbar junction (T11–L2). Following a routine examination and X-ray of the spine, computed tomography (CT) scan of the involved vertebra and adjacent vertebrae was carried out. McAfee's [17] system was used to classify the fractures. There were 26 unstable burst fractures, 13 translational injuries and nine flexion-distraction injuries.

There were associated injuries in 13 patients: two head injuries, three haemo- and/or pneumothoraces, two extremity fractures, five patients with rib, clavicle or facial bone fracture and one patient with intra-abdominal injury requiring laparotomy.

Frankel's [8] grade system was used for assessment of neurological deficit on admission and subsequently in the follow-up. Thirty two patients (64%) had neurological deficit on admission.

Indication for surgical stabilisation

Patients with one of the following were considered to have an indication for surgical stabilisation of the spine:

– presence of neurological involvement caused by the fracture;

– all neurologically stable patients with instability criteria (kyphotic deformity of more than 20° and vertebral body height loss of more than 50%).

Operative procedure

Operations were done between 5 and 16 days (average: 5.9 days) after the initial trauma, and the Steffee VSP [25] system was used for stabilisation of the spine, with one screw above and one below the injured vertebra.

The operative technique involved posterior exposure of the spine up to the tips of the transverse process. The pedicle entry points were located by the Roy-Camille technique [24], and the area was marked with a pointed awl which was used to penetrate the pedicle at the junction of the transverse process and superior facet and to develop a tract through the pedicle into the vertebral body. The awl was also used to feel for any violation of the pedicle wall. If no defect was found, the hole was tapped and the pedicle screw placed in position. The whole procedure was carried out under C-arm control in the lateral plane. When all of the screws were in position, bilateral fusion was achieved by placing the harvested iliac bone over the transverse process. Plates of the proper length were placed bilaterally after contouring to the spinal curvature. Umbrella and locking nuts were then tightened into position. Excess screw was cut off, and the wound was closed. Patients were encouraged to sit by the second post-operative day and to use a dorso lumbar sacral orthesis (DLSO) for 3 months. Parenteral antibiotics were administered for 3 days, and patients were discharged after 5 days.

Results

Table 1 presents a master chart on the patients and their treatment, including patient parameters, mode of trauma, level of injury, type of fracture, injury admission interval, kyphotic angles (pre-op, post-op, loss of kyphosis), neurological status, complications and pain and functional evaluations.

The average pre-operative kyphotic angle was 21.48° which improved to 12.86° in the immediate post-operative period. The average pre-operative vertebral height was 44.7%, which improved to 72% in the immediate post-operative period. The loss of body height averaged 3.0% at the final follow-up, and the loss of kyphotic correction averaged 3.46°.

Neurological recovery of one or more Frankel grade was seen in 24 patients. Of the 17 patients with partial neurological deficit, two grades of improvement were observed in seven patients and one grade of improvement was found in ten patients. Of the 15 patients with complete paraplegia on admission, one- and two-grade improvements were observed in five and two patients, respectively.

Table 2 Complications which appeared in some of the patients who underwent surgical treatment

Complications	Number (%)
Hardware failure	20 (40)
Screw loosening	8 (16)
Bent screws,	7 (14)
Broken screws	5 (10)
Graft site infection	3 (6)
Superficial wound infection	2 (4)
Deep wound infection	1 (2)
Urinary tract infection	7 (14)

More than 50% of our patients had one or more complication (Table 2). There were 18 cases of hardware failures involving 20 pedicle screws: eight loose, seven bent and five broken screws. Only two patients agreed to revision surgery in which four screw failures were involved. No neurological complication due to instrumentation was observed in any patient. Seven patients with pre-operative neurological deficit had urinary tract infections and required prophylactic antibiotics. Two patients with superficial wound infections responded to antibiotics and antiseptic dressings. One patient had a deep wound infection due to *Pseudomonas aeurogenosa*; this infection responded to parenteral ceftizidime and the wound healed with granulation. One patient with decubitus ulcer required plastic surgery. There were three cases of graft site infection.

The mean pain score was 1.6 at the final follow-up.

The mean functional score was 2.8; in neurologically normal patients it was 1.6, whereas in grade A neurological deficit it was 5 (= patients were completely neurologically disabled). Most of the patients with partial neurological deficit (i.e. grade C and D) were unable to return to their previous activity.

Discussion

Fracture and fracture dislocations of the thoracolumbar spine are the most commonly occurring types of osseous spine injury. In developed countries such injuries mainly occur in association with motor vehicle accidents and falls [5, 9], while in the developing world they are primarily the result of a fall from a height [4, 19].The advantage of an operative procedure for treating these injuries is the immediate stabilisation of the injured spine and an indirect or direct decompression of the neural structures. Operative stablisation enables early mobilisation without a heavy and uncomfortable cast and clearly shortens the hospital stay [4, 5, 7, 9]. The indication for an operative stablisation in patients with unstable spine injuries and complete paraplegia is the prospect of early rehabilitation and a reduced burden to the care-giver.

At our hospital short segment fixation with fusion or without fusion (unpublished data) has replaced the earlier methods of fixation, such as Harrington instrumentation and Hartshill. Short segment fixation immobilises less motion segments, so the mobility of the spinal column is hardly affected. Operative stablisation of the patients reported in this study was based on the radiological criteria of more than 50% loss of vertebral height and kyphotic deformity of >20°, as has been adopted by many surgeons [4, 16].

We used McAfee's system to classify the fractures after radiological and CT evaluation. The most common fracture pattern in our study was unstable burst fracture, as revealed in the CT scan by subluxation of one or more facet joints, fracture of one or more neural arches or gross displacement of the neural elements [17]. The second most common pattern was translational injuries, usually involving the thoracolumbar junction. The CT reconstruction characteristically showed the malalignment. There were two vertebral body outlines at one level, referred to as the double margin sign [18]. Flexion distraction injury was another pattern of fracture which showed a characteristic, so-called naked facet sign on the CT scan [23]. Unstable burst fractures and, in particular, translational injuries were associated with severe neurological involvement. Nam-Hyun et al. [21] also reported a high degree of neurological involvement in patients with posterior element involvement – i.e. burst fractures and rotational injuries. Most of our patients with severe neurological involvement had a fall from tall trees while felling branches for firewood or collecting walnuts from tall walnut trees with slippery surfaces and relatively weak strength.

The improvements observed in the radiological parameters (vertebral body height, kyphotic deformity) measured in the immediate post-operative period and at the final follow-up are, with a few exceptions, comparable with those reported elsewhere [4, 5, 9]. After an initial substantial correction, there was a gradual partial loss of correction, leaving an overall loss of kyphosis of 3.46° at the final follow-up. The loss of initial correction after pedicle screw fixation has been reported by many authors. Although a good correction of kyphosis and restoration of vertebral body height is achieved by surgery, most is lost during the long-term follow-up period. This loss of correction and the failure of the implant are more common in spine fractures repaired with pedicle screws [2, 5] than in those in which anterior grafting and instrumentation are used [7, 13, 14], reportedly due to the failure of posterior instrumentation to support the anterior column.

Neurological recovery has been reported with early stablisation of thoracolumbar spinal fractures [9].The highest recovery rates have been reported for patients operated on within 8 h of the initial trauma, while high remission rates have been reported for patients operated on within 48 h of the initial trauma. After this time there is no significant difference in the neurological outcome with respect to the timing of operation after the trauma. The earliest we were able to stabilise a spine was 5 days after the initial trauma – primarily because of the non-availability of facilities for emergency stablisation of the spine in our hospital. The pattern of neurological recovery in our patients, however, is not discouraging despite this delay. Of the 17 patients with incomplete neurological deficit (i.e. Frankel grade B, C, D), two grades of improvement were observed in 40% (7/17) of the patients and one grade of improvement was observed in 60%. Even in the 15 patients with complete neurological lesion, one and two grades of improvement were seen in five and two patients, respectively.

As with all surgical implants, failure of the instrumentation with subsequent loss of reduction is of utmost concern. We had a significant number of implant failures in the form of loose, bent and broken screws. Almost all of the implant failures in our study occurred at the thoracolumbar junction. Krag [15] has suggested segmental pedicle fixation two levels above the kyphosis to avoid such implant failures. We believe that this technique should be used at the thoracolumbar junction where compression forces act more anteriorly. Another pedicle-related concern, which has been reported to occur in between 10 and 28.8% of cases [15], is screw misplacement. Twelve of our screws, as evident from post-operative radiographs, were misplaced, and all of these eventually failed.

Whereas early (within hours of the initial trauma) or immediate (within 48 h) stablisation and indirect or direct decompression is a distant dream in our surgical set-up (and, we believe, in most of the developing countries), even delayed stablisation of the unstable spine has benefits. However, the number of complications remains worrisome; this is particularly true with respect to hardware failure.

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