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Results of 'Two Above- One Below Approach' with Intermediate Screws at the Fracture Site in the Surgical Treatment of Thoracolumbar Burst Fractures

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ABSTRACT

The aim of this retrospective clinical study was to evaluate and compare the results of the technique so called 'two above one below approach' with intermediate screws at the fracture site with long-segment posterior fusion in the surgical treatment of thoracolumbar burst fractures. For this purpose neurologically intact 27 patients having isolated one level thoracolumbar burst fracture underwent posterior instrumentation and fusion in our clinic via 'two above-one below approach' with intermediate screws at the fracture site. A control group consisting of 15 patients having one level thoracolumbar burst fracture treated with long segment posterior spinal fusion in our institute was formed. At the preoperative, postoperative and final follow up period, anterior body height loss, local kyphosis and sagittal index values of both groups were noted. At the final follow up Visual Analogue Pain Scale and Oswestry disability scores were noted. Retrospective data from both groups underwent statistical analysis. In both groups anterior body height loss, local kyphosis and sagittal index measurements improved at the final follow-up, but there was no significance between two groups in terms of radiological and clinical follow-up data. The loss of correction in local kyphosis of short-segment group in the interval between postoperative and follow-up period was also significant. No implant failure was noted. As a conclusion 'two above one below approach' with intermediate screws at the fracture site is associated with loss of correction radiographically, but favorable clinical outcomes in the presence of any implant failure can be achieved in the treatment of thoracolumbar burst fractures.

INTRODUCTION

Ideal fixation method in the surgical treatment of thoracolumbar burst fractures remains controversial. (1-5) As a simple and commonly used technique, short-segment pedicle instrumentation of thoracolumbar burst fractures seems to have a high rate of implant failure and correction loss of the reduction. (1,3,6-10) Insertion of pedicle screws at the fracture site or transpedicular intracorporeal grafting were used in the past in order to prevent the early failure and increase the biomechanical stability of the construct. (1,4,5,6,7,11,12)

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Objective of this retrospective study was to evaluate and compare the clinical and radiological results of the technique so called ‘two above-one below approach’ with additional intermediate screws at the fracture site versus long-segment posterior fusion in the treatment of thoracolumbar burst fractures.

MATERIALS AND METHODS

Between 2004 and 2008, 96 patients having thoracolumbar fractures were treated surgically in our institute. Among this group neurologically intact 42 patients having isolated one level burst fracture who received the inclusion criteria consisting of; >%50 anterior body height loss (ABHL), >%50 canal comprimise or sagittal index>15^{o} were included in the study. Of 42 patients, 27 of them were treated with the technique so called ‘two above-one below approach’ with additional intermediate screws at the fracture site (Group I).

Table I (a). Demographics of the patients (Group 1)

number	gender	age	level of fracture	type of fracture	follow-up (months)
1	female	34	L1	A	14
2	male	51	L4	B	23
3	male	71	L2	A	20
4	female	18	L3	A	32
5	male	58	T12	B	28
6	female	34	L4	A	29
7	male	76	L1	A	36
8	female	21	L2	A	19
9	male	48	T10	B	24
10	male	50	L2	B	24
11	male	31	T9	B	25
12	male	39	L1	B	19
13	male	35	T12	A	20
14	male	21	L1	A	13
15	female	28	L1	B	15
16	female	43	L1	A	51
17	male	35	L1	A	51
18	female	55	L3	A	35
19	male	43	L2	B	24
20	male	37	L1	A	59
21	male	38	L1	A	57
22	female	37	L2	B	31
23	male	33	T12	B	31
24	male	45	L2	B	20
25	female	20	L1	B	20
26	male	28	T12	A	18
27	male	23	L3	A	29

The remaining 15 patients were treated with long-segment posterior instrumentation and fusion (Group II). Of 27 patients in Group I, 18 were men and 9 were women. Mean age of the patients at the operation time was 39.3±16.65. The most frequent etiology of the injury was a fall from a height in 20 patients followed by motor vehicle accidents in 7 patients. There were 10 L-1 fractures, 6 L-2 fractures, 4 T-12 fractures, 1 T-9 fracture, 1 T-10 fracture, 3 L-3 fracture and 2 L-4 fractures. Fractures were classified according to Denis classification system for burst fractures and there were 15 type A and 12 type B fractures respectively. [13] Patient demographics are given in Table I(a).

Of 15 patients in Group II, 10 were men and 5 were women. Mean age of the patients at the operation time was 39.3±15.51.

The most frequent etiology of the injury was a fall from a height in 12 patients followed by motor vehicle accidents in 3 patients. There were 4 L-2 fractures, 3 L-3 fractures, 4 L-1 fractures, 1 T-9 fracture, 1 T-10 fracture, 1 T-12 fracture and 1 L-4 fracture. According to Denis classification system for burst fractures; there were 7 type A and 8 type B fractures respectively. Patient demographics are given in Table I(b).

Table I (b). Demographics of the patients (Group 2)

number	gender	age	level of fracture	type of fracture	follow-up (months)
1	male	73	L2	A	28
2	female	20	L3	A	40
3	female	23	L2	A	12
4	female	36	L3	A	37
5	male	26	L1	B	17
6	male	50	L2	B	11
7	male	50	T10	B	31
8	male	52	L1	B	31
9	male	33	T9	B	33
10	female	54	L1	B	17
11	male	37	L2	A	28
12	male	25	L4	B	45
13	male	23	L1	A	20
14	male	33	T12	B	31
15	female	55	L3	A	35

All of the patients were operated at the same institute under general anesthesia using a standard posterior midline incision in prone position. The patients in Group I underwent posterior instrumentation and fusion via ‘two above-one below approach’ with intermediate screws at the fracture site. (Figure 1(a,b))

Figure 1 (a). Lateral radiograph of L-1 burst fracture.

Figure 1 (b). Lateral view of two above-one below instrumentation with intermediate screws at the fracture level.

In Group I; two levels above and one level below the fractured vertebra were fixed by pedicle screws bilaterally. At the same time we used pedicle screws at the fractured levels after confirming that the entry points with the mass of the pedicles were intact by axial computerized tomography (ct) scans. (Figure 2(a)) We were able to use intermediate screws at the fractured levels in 20 patients bilaterally where 7 patients had unilateral intermediate screws due to the fractured pedicles at the burst levels. We used 6.5 mm-diameter multiaxial screws at lumbar and T-12 levels. Upper levels were instrumented by 5.5 mm-diameter multiaxial screws. Intermediate screws were one size smaller in width due to aviod screw related injuries at the fractured level. (Figure 2(b)) In Group II; a minimum of two levels above and below the fractured vertebra were instrumented using posterior transpedicular segmental instrumentation without intermediate screws. Indirect reduction by contouring the rods was achieved through all the patients. Two cross-links were used routinely to augment torsional rigidity. Autografts derived from the spinous process were used for posterolateral short level fusion in all patients in both groups.

Figure 2 (a). Axial ct view of a burst fracture with intact pedicles.

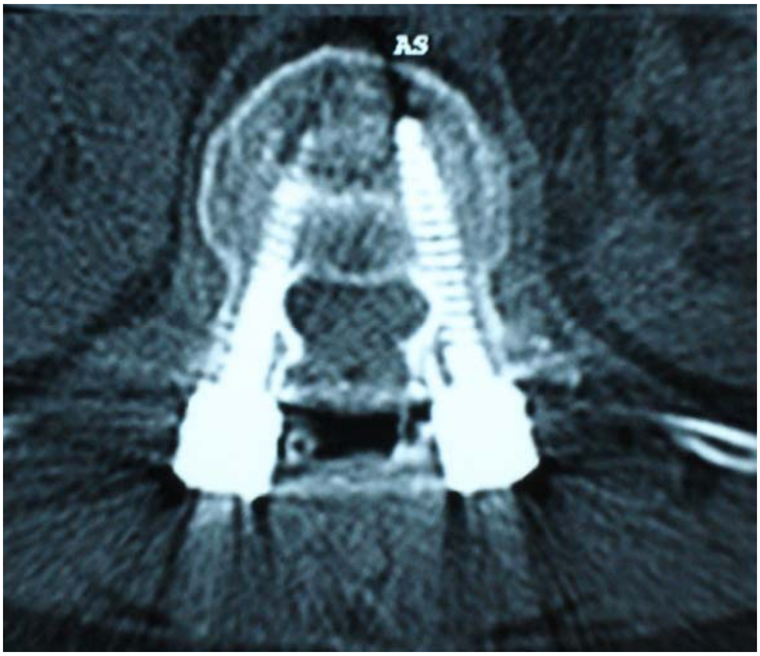

Figure 2 (b). Follow-up axial ct view of the intermediate screws at the level of the fracture.

All patients were mobilized the day after surgery and no braces were applied to any of them.

At the preoperative, postoperative and final follow up period radiological assesment of the patients were achieved on lateral standing good quality x-rays in the outpatient clinics of the same institute. ABHL was calculated using the formula adopted by Mumford et al. [(1)] Local kyphosis was measured by the Cobb method and sagittal index was measured as described by Farcy et al. [(14)]

At the final follow up, patients were asked to assess the severity of pain using 10-cm Visual Analogue Pain Scale(VAS) and Oswestry disability scores (a measure of long-standing chronic spinal disability) and the results were noted. [(15)] In the interpretation of the Oswestry disability score, 0-20 suggests minimal disability, 20-40 moderate disability and 40-60 severe disability respectively.

The retrospective data of both groups were analyzed using SPSS for Windows 11.5.0 software package (6 Sep. 2002, LEAD Technologies Inc.). For the comparison of; age, follow-up period, VAS and Oswestry scores Mann Whitney U test was used. Gender was analyzed via Pearson Chi-Square test. For the comparison of; preoperative-postoperative-follow-up ABHL, local kyphosis, and sagittal index Pillai's Trace test was used via general linear models in repeated measures method. *p* values smaller than 0.05 were accepted as being statistically significant.

RESULTS

In Group 1; the mean follow-up period was 28.41±12.7 months (range 13-59 months). The mean preoperative ABHL was 0.51. Than it improved to 0.80 postoperatively (p:0.001) and decreased to 0.65 (p:0.263) at the final follow up with an amount of %17,28 correction loss rate. (p:0.001)

The mean preoperative local kyphosis was measured 9.96° according to Cobb method. Than it improved to -1.74 (lordosis) postoperatively (p:0.001) and decreased to 1.96° at the final follow up (p:0.013) with an average amount of 3.7º loss of reduction. (p:0.001)

The average preoperative sagittal index was 18.15º. Than it improved to 6.52º postoperatively (p:0.001) and increased to 8.30º at the final follow up (p:0.420) with a correction loss of 1.78º. (p:0.001)

The mean VAS score was 2.3 and the mean Oswestry score was 10 at the final follow-up. (Table II(a))

In Group 2; the mean follow-up period was 27.73±10.23 months (range 11-45 months). The mean preoperative ABHL was 0.52. Than it improved to 0.78 postoperatively (p:0.001) and decreased to 0.69 (p:0.98) at the final follow up with an amount of %11,5 correction loss rate. (p:0.003)

The mean preoperative local kyphosis was measured 9.86° according to Cobb method. Than it improved to -0.66° (lordosis) postoperatively (p:0.001) and decreased to 3.13° at the final follow up (p:0.244) with an average amount of 3.79º loss of reduction. (p:0.037)

The average preoperative sagittal index was 20.46º. Than it improved to 9.26º postoperatively (p:0.001) and increased to 9.6º at the final follow up (p:1) with a correction loss of 0.34º. (p:0.001)

The mean VAS score was 2.13 and the mean Oswestry score was 11 at the final follow-up. (Table II(b))

According to the statistical analysis; two groups were similar in terms of age (p:0.99), gender (p:1), follow-up period (p:0.772), VAS (p:0.686) and Oswestry scores (p:0.560). Radiographical parameters including ABHL, local kyphosis and sagittal index in the preoperative-postoperative and follow-up period did not have a significant difference between each other. (p:0.621, p:0.907, p:0.716)

Table II (a). Radiographic and clinical outcome data (Group 1)
(Pre-op.: preoperative, post-op.: postoperative, n: number, AVBHL: anterior body height loss, COBB: local kyphosis, SI: sagittal index, VAS: visual analogue scale, OSW: oswestry)

	pre-op.			post-op.			follow-up				
n	**AVBHL**	**COBB**	**SI**	**AVBHL**	**COBB**	**SI**	**AVBHL**	**COBB**	**SI**	**VAS**	**OSW**
1	0,36	16	12	0,38	8	10	0,67	1	12	2	18
2	0,71	-16	18	0,79	-5	17	0,75	-7	17	2	2
3	0,33	1	11	0,4	-4	8	0,61	0	4	0	6
4	0,37	10	30	0,76	-10	12	0,8	2	12	2	6
5	0,67	22	9	0,73	4	8	0,39	10	1	0	9
6	0,33	-14	10	0,5	-22	-6	0,5	-20	-2	1	4
7	0,48	23	14	0,85	-5	-7	0,67	-4	2	2	8
8	0,65	10	22	0,88	-15	8	0,5	-10	16	4	16
9	0,33	30	22	2	22	11	0,57	30	15	0	4
10	0,44	1	17	0,76	-15	1	0,67	-12	9	7	20
11	0,5	18	12	0,67	13	9	0,71	16	11	2	8
12	0,55	10	14	0,81	-2	0	0,7	3	7	2	12
13	0,65	25	12	0,8	-2	0	0,72	5	4	4	23
14	0,75	0	9	0,8	-5	8	0,55	-7	1	2	4
15	0,61	11	25	0,94	-2	0	0,81	5	4	2	9
16	0,5	27	14	0,67	17	20	0,6	43	40	4	15
17	0,5	9	22	0,8	4	6	0,88	1	0	2	4
18	0,73	19	30	0,79	10	28	0,79	12	27	3	24
19	0,75	5	20	0,91	-8	12	0,77	2	3	2	3
20	0,62	8	17	0,94	-6	-6	0,89	0	0	2	4
21	0,50	9	22	0,80	4	6	0,88	1	0	2	4
22	0,46	17	22	0,90	5	13	0,80	7	14	2	11
23	0,62	18	20	0,86	5	10	0,82	6	12	2	9
24	0,66	0	23	0,90	-15	-10	0,90	-17	-12	1	5
25	0,71	10	13	0,80	-2	-2	0,78	0	0	2	4
26	0,33	30	20	0,77	2	5	0,71	4	7	5	23
27	0,41	-30	30	0,50	-23	15	0,50	-18	21	3	16

Table II (b). Radiographic and clinical outcome data (Group 2)
(Pre-op.: preoperative, post-op.: postoperative, n: number, ABHL: anterior body height loss, COBB: local kyphosis, SI: sagittal index, VAS: visual analogue scale, OSW: oswestry)

	pre-op.			**post-op.**			**follow-up**				
n	**ABHL**	**COBB**	**SI**	**ABHL**	**COBB**	**SI**	**ABHL**	**COBB**	**SI**	**WAS**	**OSW**
1	0.33	1	11	0.61	-4	8	0.4	0	4	0	6
2	0.37	10	30	0.8	0	12	0.76	-2	12	2	6
3	0.22	30	38	0.82	10	21	0.82	9	16	3	18
4	0.33	-14	10	0.5	-22	-6	0.5	-20	-2	1	4
5	0.64	5	16	0.85	3	1	0.83	5	2	2	11
6	0.62	2	12	0.73	-1	10	0.73	-3	11	0	6
7	0.33	30	22	0.67	22	11	0.57	30	15	0	4
8	0.44	1	17	0.76	-15	1	0.67	-12	9	7	20
9	0.5	18	12	0.71	13	9	0.67	16	11	2	8
10	0.64	15	18	0.9	2	-1	0.88	4	0	1	7
11	0.65	25	12	0.8	-2	0	0.72	5	4	4	23
12	0.62	-12	50	0.75	-26	27	0.68	4	21	3	15
13	0.75	0	9	0.8	-5	8	0.55	-7	1	2	4
14	0.62	18	20	0.86	5	10	0.82	6	12	2	9
15	0.73	19	30	0.79	10	28	0.79	12	28	3	24

All the patients in both groups were observed to union which was defined as either a fusion mass seen at the fractured level radiographically or a pain-free spine. No definite pseudoarthrosis was experienced in either of the groups during the final follow-up.

There were no cases of failure of instrumentation in terms of breakage,bending or loosening of the pedicle screws or the rods in either of the groups. There was no implant removal. There were no operative or perioperative deaths, neurologic deteriorations or thrombophlebitis.

There was one superficial wound infection in Group 1 which healed by antibiotic therapy. Debridement under general anesthesia was performed for two patients of Group 2 who had deep infections resistant to antibiotic therapy.

DISCUSSION

In this study, pedicle screws were inserted at the fractured vertebra in a two above-one below instrumented frame in order to prevent the early loss of reduction with an expectation of high rigidity of the construct and save more motion segments caudally to the instrumentation especially in the lumbar region which is crucial for establishment of well-balancing and active movement of the spine.

Translational forces acting on the fractured vertebra due to axial loading were supposed to be the major factor in the loss of correction as described McLain et al. before. [10]In the literature there are biomechanical studies aimed to determine the effect of adding pedicle screws at the level of a burst fracture. [6,7] Data obtained from those studies suggest that the use of intermediate screws provides the advantages of a stiffer construct, an increased biomechanical stability and the effect of 3-point fixation of the fractured segment leading to a beter pulled-out strength. Decreased flexibility of a short segment construct providing less motion at the fractured segment is supposed to be another advantage via intermediate screws. [7] Under the light of this data, one can assume that using intermediate screws in a two above-one below construct may transfer the central loads supposed to be most effective in the midpoint of the frame to a higher level above the fractured segment in order to decrease the implant failure. Scholl et al. confirmed this theory by their study reporting success with a compromise to short segment fixation using a two above-one below approach. [2]

Maintenance of postoperative fracture reduction for a satisfactory functional outcome is another point of view, [16] but no surgical method seems to maintain the corrected kyphosis angle according to a meta-analysis from 2004. [17] Longer constructs were advised for increased duration of the realignment where as planned construct shortening for the protection of valuable motion segments was also recommended. [8]

Implant failure after short segment posterior fixation is well-studied in the literature and there exists a number of reports associated with high rate of failure. [2,10,15,16] In the series of Kramer et al., 4 of the 11 patients who were terated with bilateral short segment transpedicular instrumentation had breakage or disengagement of the caudad screws. [16] Scholl et al. reported %40 instrumentation failure rate caused by implant bending or breakage not related to infection. [2] In the study of Mclain et al., 19 patients were managed with short segment pedicle instrumentation and 6 patients had a progressive kyphosis due to the bending of the screws. [10] Wood et al. reported two cases having instrumentation breakage through a group of 18 patients treated with posterior short segment fusion. [15] In the current study, we had no cases of failure of instrumentation in terms of breakage, bending or loosening of the pedicle screws or the rods respectively.

Transpedicular grafting in short segment fixation was also evaluated in terms of preventing correction loss and implant failure in the literature. [1,12] Average loss of correction was about 10° and grafting did not decrease the high rate of failure of the procedure. Although polymethyl methacrylate vertebroplasty [4] and calcium phosphate cement reinforcement in short-segment fixation [5] are associated with favorable results, long-term clinical and radiological outcomes are mandatory. As an alternative to fusion, nonfusion technique was also investigated by Wang et al. and elimination of donor site complications, saving more motion segments, reduction of blood loss and operative time at initial teatment were listed as the advantages of the technique. [18] In the study of Tezeren et al.[19], short-segment pedicle fixation was compared with long-segment instrumentation in posterior fixation of thoracolumbar burst fractures and it was concluded that; long-segment group had a better outcome in terms of the measurements of ABHL, local kyphosis and sagittal index. However there was no difference between the two groups according to Low Back Outcome Score.In our study, improvement in ABHL, local kyphosis and sagittal index after operations in both groups were significant at the final follow-up period, but the loss of correction in local kyphosis of Group I during the interval between postoperative and final follow-up period was also significant (p:0.013) meaning that a certain deterioration of radiographic correction was determined in an average follow-up period of 28 months in ‘two above one below approach’ group. There was no difference between two groups in terms of VAS and Oswestry Scores. (p:0.686, p:0.560)

In a recent prospective randomized study, the efficacy of fracture level screw combination in achieving and maintaining correction in the treatment of unstable thoracolumbar burst fractures was evaluated.[20] The authors of that study concluded that reinforcement with fracture level screw combination could help to provide better kyphosis correction and offered immediate spinal stability in patients with thoracolumbar burst fracture. Accordingly, our mid-term clinical results with the fracture level screw combination are concordant with the current literature, but the less number of patients and retrospective study design appear to be the weak points of our study.

On the basis of the results in the present study, we conclude that two above-one below approach with intermediate screws at the fracture site is associated with loss of correction radiographically, but favorable clinical outcomes in the presence of any implant failure can be achieved in the treatment of thoracolumbar burst fractures.

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