North American Spine Society Journal (NASSJ) 1 (2020) 100009

Contents lists available at ScienceDirect

North American Spine Society Journal (NASSJ)

journal homepage: www.elsevier.com/locate/xnsj

Clinical Studies

Osteoporotic burst fracture-clinical, radiological and functional outcome of three-column reconstruction using single posterior approach (Instrumentation, Corpectomy, Arthroscope Assisted Transpedicular Decompression and Mesh Cage) ☆

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A R T I C L E I N F O

Keywords:
Osteoporotic fracture
three-column reconstruction
Posterior approach
Arthroscope Assisted Transpedicular decompression
Mesh CageIntroduction

A B S T R A C T

Purpose: To evaluate a novel effective procedure utilizing three-column reconstruction via a posterior approach with a technique that utilizes an arthroscope to visualize the anterior surface of the dura during decompression.

Methods: A Prospective Study. 80 Osteoporotic vertebral burst fracture patients with similar demographic data managed by three-column reconstruction through single posterior approach surgery: Pedicle screw fixation, Corpectomy, Arthroscope Assisted Transpedicular Decompression (AATD) and Fusion (Mesh Cage + Bone grafting). Preoperative and postoperative clinical parameters (Visual Analog Score VAS, swestry Disability Index ODI, neurlogy, radiological parameters and surgical variables were recorded analysed.

Results: No significant differences in demographic data. Significant improvement was noted in VAS (pre-operative, 7.90 ±0.60; final follow-up 2.90 ± 0.54) and ODI (preoperative, 77.10 ± 6.96; final follow-up 21.30 ± 6.70). Neurological improvement was noted in 74 patients (Frankel grade E) while six patients remained non-ambulatory (Frankel grade C). Significant improvement was noted in local kyphosis angle (preoperative, 22.14 ± 2.60; postoperative, 10.40 ± 1.40) with a 10% loss of correction (2.5 ± 0.90) at final follow-up. Implant failure in two patients and proximal junctional failure in two patients managed with revision surgery. No iatrogenic dural or nerve injury.

Conclusions: Osteoporotic Burst fracture can be managed with single posterior surgery, three-column reconstruction with mesh cage. It provides a significant improvement in clinical, radiological and functional outcomes. The arthroscope can improve a surgeon's operative field and magnification thereby ensuring complete decompression without injuring the dura or spinal cord.

Introduction

The incidence of wedge fractures in the osteoporotic spine is gradually increasing with increasing life expectancy [1,2]. Most osteoporotic fractures are well managed conservatively [3]. Osteonecrosis of fractured vertebrae can lead to non-union and delayed collapse, that can result in progressive kyphosis with the possibility of delayed neurological deficit [4–6]. These cases require decompression-fixation surgeries. There is a controversy regarding the ideal surgical procedure [7,8]. The efficacy of various approaches is well documented in the literature. Anterior approach has high morbidity and mortality in these fragile patients [9,11]. In osteoporotic bone, sufficient implant purchase power is very low and it may lead to implant loosening and adjacent segment kyphosis [12–14]. Pedicle screw with cement augmentation is an option but it has cement associated complication so not recommended in these fragile patients [9,15]. Transpedicular decompression has become a standard surgery to achieve anterior spinal cord decompression. Transpedicular approach including its extensile variants has a blind spot where the surgeon has to work to remove ventral compression of the spinal cord. One of its main disadvantages is the inadequate visualization of the anterior surface of the dura. A retropulsed bony fragment can cause anterior spinal cord compression, so surgeons often must rely upon palpation to judge the adequacy of spinal cord decompression. Therefore, surgeons often resect both pedicles, which further damages the intact posterior column and adds to

☆ Financial support and sponsorship: Nil.
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https://doi.org/10.1016/j.xnsj.2020.100009
Received 9 April 2020; Received in revised form 8 May 2020; Accepted 20 May 2020
Available online 29 May 2020
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the invasiveness of the procedure. One potential solution to this clinical problem is to use a conventional 30-degree arthroscope to visualize the ventral dura during the decompression. The aim of this study was to evaluate a novel, effective procedure utilizing three-column reconstruction via a posterior approach with a technique that utilizes an arthroscope to visualize the anterior surface of the dura during decompression.

Materials and methods

This prospective study was conducted from June 2016 to July 2018 after approval from the institutional ethics committee. One hundred consecutive patients with osteoporotic burst fractures surgically managed by three-column reconstruction using a posterior approach with pedicle screw instrumentation, AATD and mesh cage fusion were included in the study as per inclusion and exclusion criteria. Informed consent was obtained from all patients included in the study.

Inclusion criteria

1. Age 60–80 years
2. DEXA scan T score <−2.5
3. Single level burst fracture - Magerl Type A with >50% collapse of the vertebral body
4. Neurological deficit (Frankel Grade C, D)
5. Minimum 18 months follow-up.

Exclusion criteria

1. Other pathological fractures
2. Previously operated spine patients
3. Neurology Frankal Grade A, B and E

Twenty patients were lost to follow-up, eighty patients were included in the study analysis.

Pre-Operative Workup and assessment

Detailed clinical, radiological and functional assessment was performed to confirm the diagnosis, all secondary causes of vertebral collapse like infection, metastasis and significant trauma were ruled out.

1. Clinical and Functional Assessment:
   a. Demographic data: Age, Sex, Mode of injury, Duration of injury to clinical presentation, Duration of neurological deficit, Bone Density
   b. Pain score - Visual Analog Score [VAS]
   c. Oswestry Disability Index [ODI]
   d. Neurological - Frankel Grade
2. Laboratory assessment: Complete blood counts, Erythrocyte sedimentation rate (ESR), CRP, Serum Vitamin D level, Vitamin B12, Total protein Albumin, Liver Function Test and Renal Function Test and Thyroid Profile
3. Radiological assessment: Radiographs, Whole Spine Scanogram, Magnetic Resonance Imaging and computed tomograms (CT) scan of every patient [Fig. 2].

Radiological parameters–kyphosis angle was noted and recorded preoperatively and at each follow-up. Sagittal local kyphosis was measured from the superior endplate of immediate, intact cephalic vertebrae, and the inferior endplate of intact caudal vertebrae [9].

Surgical procedure

A standard midline posterior approach was used. All pedicle screws were inserted in two vertebral levels above and two vertebral levels below fracture and one side connected with a connecting rod. After connecting rods and screw, bilateral hemilaminectomy at fracture level, with care to preserve medial one-third facetectomy was performed. A subtotal corpectomy of the fractured vertebral body was performed with an osteotome and curettes, leaving the lateral and anterior vertebral body wall in place. In order to evaluate for ventral spinal cord compression secondary to a retropulsed bony fragment, a 30° arthroscope was utilized. If a retropulsed bone fragment was recognized, it was pushed anteriorly with the use of a reverse-angled curette, with great care taken to avoid retraction of the dura or conus [Fig. 1]. By gently distracting the spinal nerve on the more severely injured side, the decompression was reconfirmed with the help of an arthroscope. A 2 cm incision was placed over the posterior superior iliac spine (PSIS) to harvest cancellous iliac crest autograft. A titanium mesh cage was inserted into the intervertebral space, which was of 80–100% length of fractured segmental height and filled with bone graft. The cage was then longitudinally aligned and set parallel to the axis of the spinal column using an impactor. The cage was placed in the center of the fractured body with the assistance of biplanar fluoroscopy. Compression was then applied across the fractured level to create a press-fit for the cage. The nerve root was rechecked for any compression before placing the other rod and final tightening set caps. A crosslink was inserted in the standard fashion. Gelfoam was placed over the exposed dura. Posterolateral fusion with facet fusion with morselized cancellous autograft was performed in all patients [16]. A surgical drain was inserted in all patients. Multilayer closure was performed [Fig. 3].

Postoperative protocol

Patients received three days of IV antibiotics followed by 5 days of oral antibiotics. Patients were encouraged to sit up in bed 24 h after surgery and mobilized out of bed on the second postoperative day using a thoracolumbar orthosis(TLSO). All patients were protected using TLSO for approximately three months after surgery. All patients were started on standard anti-osteoporotic medications as per endocrinologist advice. Surgical parameters including operative time, intraoperative blood loss and intraoperative complications were noted. Patients were followed up for 18 months with regular sequential follow-up at 1,3,6,12 and 18 months after surgery, and then annually. Neurological improvement, ambulatory status, and complications during this course were documented. Focal kyphosis correction was assessed using standing AP and lateral thoracolumbar spine radiographs. Fusion status was assessed by thoracolumbar radiographs and dedicated CT scan of the surgical area after six months of the surgery. Implant failure, pull out and adjacent level fractures were noted during the follow-up. Statistical analysis was performed using SPSS software version 20.0 (SPSS Inc., Chicago, IL, USA) and paired Student's t-test.

Results

A total of eighty osteoporotic burst fracture patients (72-females, 8-males) with a mean age 66.19 years were in the final study population. Demographic data is given in Table 1. The most common mechanism of injury was a history of fall ($N = 36$) followed by outdoor slips ($N = 36$) and weight lifting ($N = 4$). The cause of injury was unknown in 4 patients (N=4). The mean duration of delay in the presentation (time from injury to surgery) was 14.31 ± 2.90 weeks (12–24 weeks). All patients underwent DEXA scan preoperatively, and mean T score was −3.89 ± −1.12 (−2.6 to– 5.4). Radiographs of spine demonstrated fracture with the following frequency: T10 $N = 8$, T11 $N = 20$, T12 $N = 28$, L1 $N = 17$ and L2 $N = 7$ [Table 1].

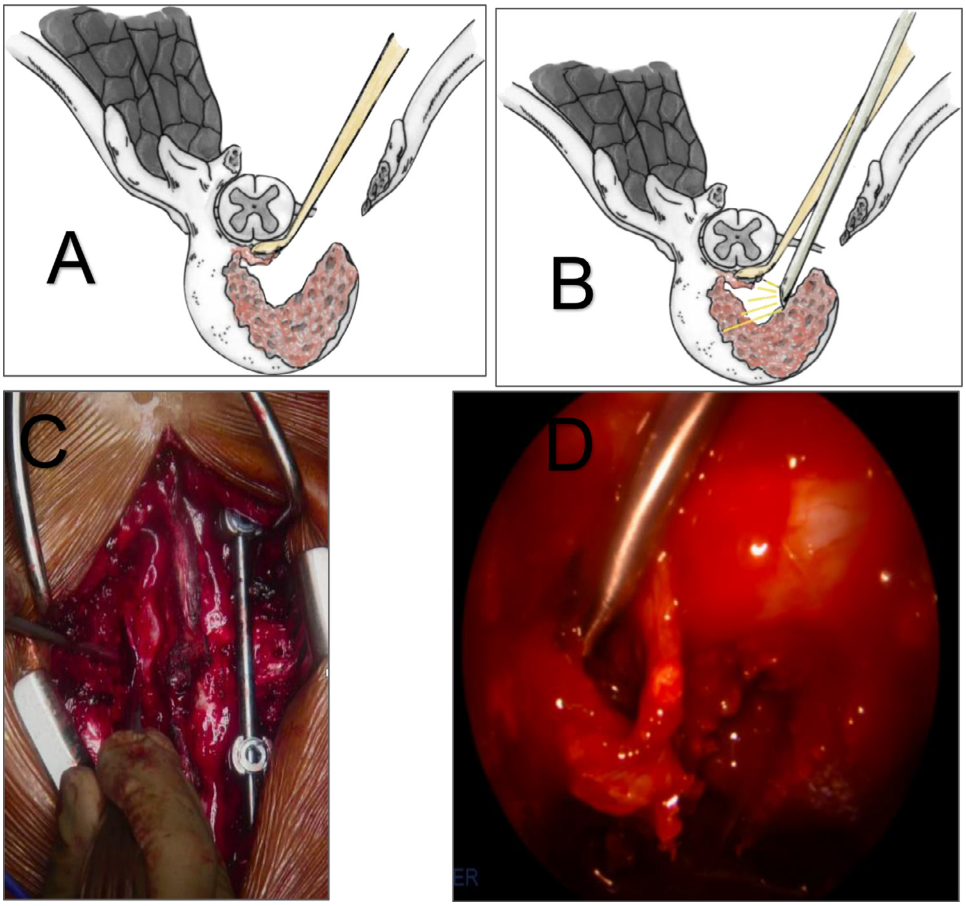

Fig. 1. A. The surgeon usually relies on a tactile feedback to find a plane between the pathology and the dura and tries to push the compressive structure into the cavity created anteriorly. B. Us of a conventional 30 degree arthroscope assists with visualization of the ventral dura during decompression. C. Posterior Approach with arthroscope assisted Decompression D. Arthroscopic view of ventral dura

Table 1
Patient demographic data (n = 80).

Variables	Value
Age	66.19 (60-80)
Male: Female Ratio	8:72
Delay in presentation (weeks)	14.31 (12-24)
Dexa scan T score	Mean −3.89 (−2.6to−5.4)
Fracture level	
T10	8
T11	20
T12	28
L1	17
L2	7

Table 2
Pre- and post-operative neurological status using Frankel grading.

Pre-operative	No of patients	Post-operative				
		A	B	C	D	E
C	42			4		38
D	38			2		36

Preoperative neurological status was assessed using Frankel grade (Grade C=42, Grade D=36 patients). Postoperatively, 74 patients showed complete neurological recovery. Two patient deteriorated neurologically from Grade D to Grade C and Four patients remained Frankel Grade C did not show improvement in neurology [Table 2].

The mean preoperative local kyphotic angle of 22.14° ± 2.60° improved to 10.4° ± 1.40° immediately post-operatively and 12.90° ± 1.90° at 2 years follow-up ($p < 0.01$). The average total correction was 7.9 ± 0.70°[Table 3].

Table 3
Kyphosis.

Variables	Value (Mean)	SD
Pre-Operative	22.14°	2.60°
Immediate postoperative	10.40°	1.40°
Final follow-up	12.90°	1.90°
Correction	7.90°	0.70°
Loss of correction	2.50°	0.50°

Table 4
Surgical Data.

Variables	Value (Mean)	SD
Duration of Surgery (min)	150.7	21.1
Intraoperative blood loss(ml)	399.6	30.4
Hospital stay (Days)	9	4

All patients showed healing of fractures by 6–9 months follow-up as demonstrated on radiographs and CT scans [Fig. 4]. The mean surgical duration was 150.7 min (SD 21.10, range 120–190 min) and mean intra-operative blood loss was 399.6 ml (SD 30.4, range 35–420 ml). Mean hospital stay was 9 days (SD 4, range 5–13 days) [Table 4].

Following surgery four patients developed a superficial infection that resolved with IV antibiotics. Two patient developed urinary tract infection, both of which resolved with a course of oral antibiotics. No patient developed an intra-operative dural injury or nerve root injury. Two patient developed proximal junctional failure after 12 months of fixation and presented with increasing back pain and kyphosis which required revision surgery in the form of extension of the level of fixation. Two patients showed radiographic evidence of hardware failure but were asymptomatic and did not receive revision operative intervention. One

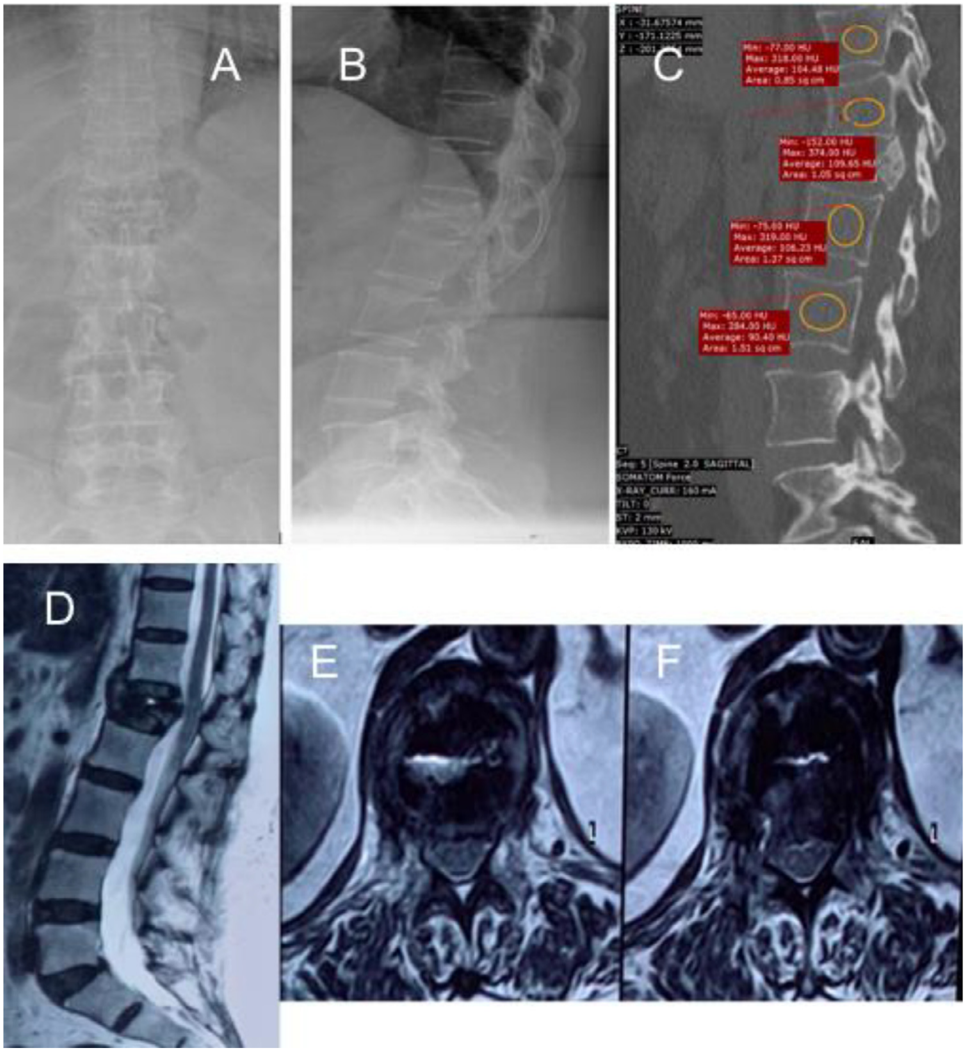

Fig. 2. A,B. 67-year-old female presented with Frankel Grade C neurology. Preoperative radiograph shows L1 osteoporotic fracture with local kyphosis; C. CT Scan Horos Image shows osteoporosis given in HU units. D,E,F. T2 image of Lumbar spines- L1 wedge fracture with cord compression.

Table 5
Complications.

Complications	Number	%
Superficial infection	2	2.5
Urinary tract infection	2	2.5
Proximal junctional failure	2	2.5
Pedicle screw breakage	1	1.25
Screw Pull Out	1	1.25

Table 6
Functional results of patients.

	Mean	SD	*p* value
VAS			
Preoperative	7.90	0.60	<0.05
Postoperative 1 month	4.00	0.54	
Final follow-up	2.90	0.54	
ODI			
Preoperative	77.10	6.90	<0.05
Postoperative 1 month	30.50	6.50	
Final follow-up	21.30	6.70	

VAS: Visual Analog Score; ODI: Oswestry Disability Index; SD: Standard deviation

of these patients developed screw pull out and the other patient had a single pedicle screw fracture. In the final follow-up, these patients were asymptomatic without any evidence of further implant failure [Table 5].

VAS was significantly improved from a mean value of 7.90 ± 0.60 preoperatively to 4.0 ± 0.54 at 1 month postoperatively and 2.90 ± 0.54 at final follow-up. ODI was significantly improved from a mean value of 77.10 ± 6.90 to preoperatively to 30.50 ± 6.50 at 1 month postoperatively and 21.30 ± 6.70 at final follow-up.[Table 6]

Discussion

Osteoporosis is a common condition that predisposes elderly adults to vertebral fractures. While most osteoporosis-related vertebral fractures are treated conservatively [1,2]–[3], in some cases, these fractures are associated with delayed collapse, kyphotic deformity and are a source of continuous back pain [4,5]–[6]. The definitive management of osteoporotic burst fracture with focal kyphosis is a source of controversy [7–10]. In this study, we managed these fractures with three-column reconstruction through posterior approach with pedicle screw fixation, AATD and anterior column reconstruction.

Instrumentation of vertebrae in osteoporotic patients has been associated with a significant risk of failure due to screw loosening, screw pull out and adjacent segment disease [12,13]–[14]. In osteoporosis, the vertebral body is affected more than the pedicles, so pedicle screws have greater pullout strength than anterior vertebral body screws. In

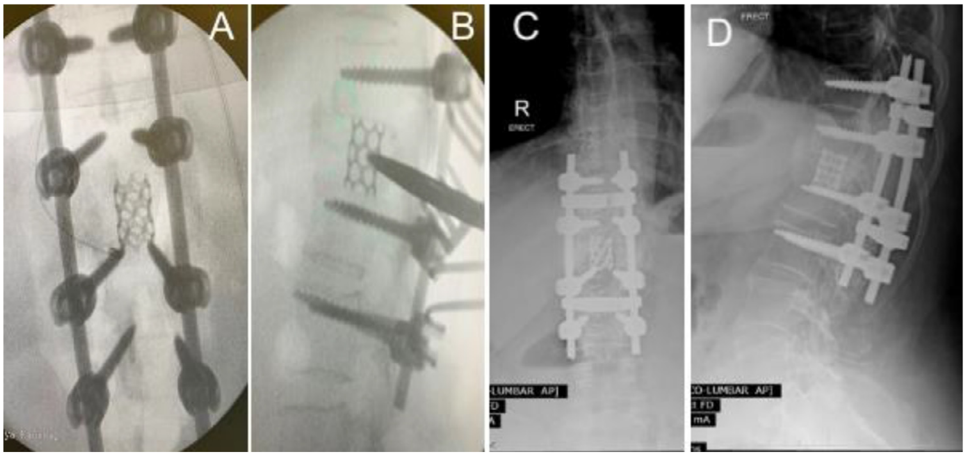

Fig. 3. A,B. Intraoperative images L1 wedge fracture instrumentation. C,D. Immediate post-operative radiograph for the surgery.

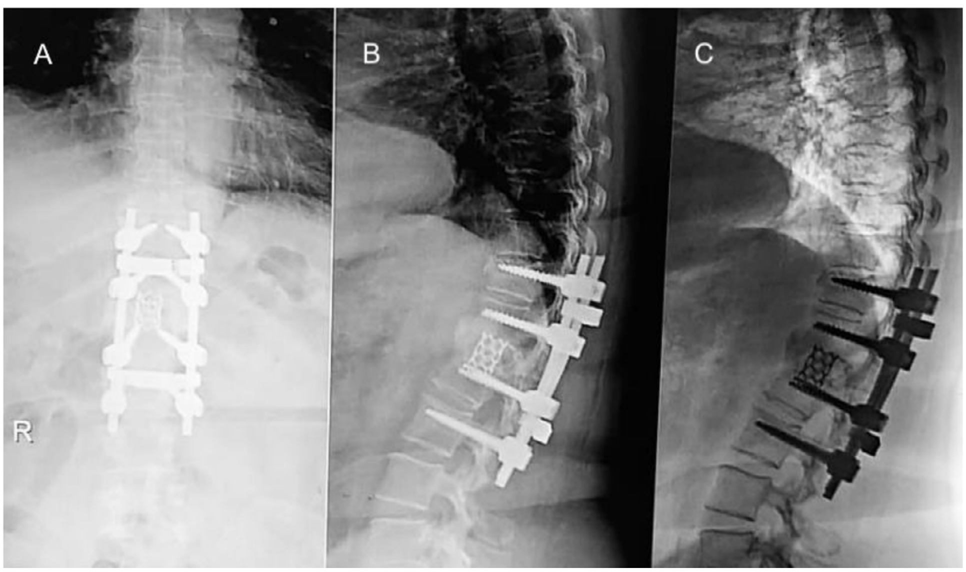

Fig. 4. A,B. 3 months post-operative radiograph with posterior fixation and instrumentation of fracture body with correction of local kyphosis C. Final follow-up lateral radiograph demonstrating healed fracture with minimal loss of correction.

addition, pedicle screws are less technically demanding and correction of the kyphotic deformity is feasible [19,22].

Weiser et al.[14], Choma et al.[15], Kim et al.[17] and Zhang et al [18] advocated cement augmentation of pedicle screws to increase the success rate of instrumentation. However, Hu et al note that there are significant dangers with the use of exothermic material in proximity to nerve roots [13]. Singh et al assessed the outcomes for surgery in patients with thoracolumbar stenosis secondary to osteoporotic burst fractures. These authors noted clinical improvement after the procedure with a 20% complication rate [20]. Blondel et al concluded that transpedicular decompression and corpectomy of fractures body was a safer option as compared to kyphoplasty or vertebroplasty [21].

Ayberk et al and Sasani et al have reported on thoracolumbar burst fractures treated with a combination of vertebral body reconstruction with non-expandable titanium mesh cage and pedicle screw fixation via a posterior approach and found that patients have had satisfactory clinical outcomes [23,24]. Pflugmacher et al assess the biomechanical properties of expandable and non-expandable cages and noted that both can withstand maximal thoracolumbar physiologic compressive load and reduce kyphotic deformity and restore height loss [25–27].

To be positioned satisfactorily, a mesh cage must be cut into a perfect size. If the cage is too large, it will not fit into the bony defect and if it is too small, it will be loose. We used a mesh cage slightly shorter than the segmental height so that the cage could be easily inserted into the anterior column. Compression was then applied through the pedicle screws in order to achieve a pressfit. Consequently, this manoeuvre did not affect the correction of kyphotic deformity and postoperative spinal stability at last follow-up. The shortening was from 0 to 5 mm is within the safe range [28]. This process of spinal shortening has two important advantages: it increases spinal stability of the anterior and posterior spinal columns and increases spinal cord blood flow, which is necessary for spinal cord recovery after injury [29].

The existing literature shows that both anterior and posterior surgeries can be associated with postoperative loss of sagittal plane correction [9]. Uchida et al.[9] had a mean loss of kyphosis correction $4.60^\circ \pm 4.50^\circ$ after posterior surgery group and mean loss of $4.50^\circ \pm 5.90^\circ$ in the anterior surgery group, but at final follow-up kyphosis angle was not significantly different the between two groups. In our group, the mean kyphosis angle preoperatively was $22.14^\circ \pm 2.60^\circ$, immediately postoperatively was $10.40^\circ \pm 1.40^\circ$ and was $10.40^\circ \pm 1.40^\circ$ at final follow-up. There was a significant difference in preoperative and immediate postoperative kyphotic angle ($p < 0.05$) and preoperative and at final follow-up ($p < 0.05$). At final follow-up loss of correction was $2.50^\circ \pm 0.5^\circ$. We attribute the loss of only 10% sagittal plane correction to our surgical technique, in which three column fixation was performed with additional posterolateral fusion.

DeWald and Stanley [30] in their study documented 11% rate of pseudoarthrosis and 7% rate of implant breakage. In our study instrumentation failure was only in four (5%) patients, which was comparatively lower and can be accounted to lesser stress on implant due to three column support by bone graft after healing, added posterolateral fusion and not tried to attempt full correction of kyphotic deformity by any manoeuvre, thus reducing stress on implants.Our all patients were kept in TLSO for 3 months duration postoperatively and were started anti-osteoporotic therapy, which increased both bone quality, thus helps to prevent implant loosening.

Suk et al.[8] and Uchida et al.[9] did not find a significant difference in neurology improvement and pain scores between anterior and posterior surgery. In our study out of 80 patients 74 improved in neurology from Frankel Grade-C to Grade-E, two worsened from Grade-D to Grade-C, whereas four patients did not improve and remained Frankel Grade-C, 92.5% of patients demonstrated improvement in neurology which was statistically significant ($P < 0.05$). Verlaan et al demonstrated equivalent functional status and pain relief when comparing posterior surgery versus anterior surgery [10]. In our study, VAS score improved from 7.90 ± 0.60 to 4.00 ± 0.54 at four weeks postoperative and 2.90 ± 0.54 on final follow-up ($p < 0.05$). ODI functional scores also significantly improved ($p < 0.05$) from 77.10 ± 6.90 preoperative to 30.50 ± 6.50 1-month postoperative and final 21.30 ± 6.70.

In our study, we found that both 30° arthroscopes provide a good visualization of the anterior surface of the dura during decompression without manipulating the spinal cord. A complete decompression on the far lateral side could be visually confirmed despite using only a unilateral transpedicular approach.

Drawbacks of this study are the lack of a comparative study group, short follow-up and smaller data size. Our study did not provide real data points to evaluate the effect the arthroscope had on surgical safety or outcomes. Moreover, the AATD technique is associated with a significant learning curve and, therefore, future technical note with surgical video on AATD is required. Future prospective comparative studies with the larger patient number and longer follow-up are required for confirmation of our results.

Conclusions

Arthroscope-assisted decompressions can Improve the surgeon's operative field and magnification thereby ensuring complete decompression without Injuring the Dura or spinal cord. As most modern theatres will have an arthroscope, it is a useful trick in the armamentarium of an orthopaedic surgeon. Three-column reconstruction through a single posterior approach might be a safe and reliable surgical management for osteoporotic burst fracture, because of the following advances: Direct observing the spinal cord throughout the procedure even during anterior corpectomy and reconstruction

a. Circumferential spinal canal decompression
b. kyphosis correction and maintenance of correction
c. Decreased postoperative morbidity
d. Rigid enough biomechanical.

Compliance with ethical standards

All patients gave written informed consent prior to participation in the study, which was approved by the Institutional Ethics Committee.

Ethics approval

The study was conducted from June 2015 to March 2018 after approval from the institutional ethics committee.

Consent to participate

Informed patient consent was taken from all the patients.

Consent for publication

taken from all the patients

Declaration of Competing Interest

There are no conflicts of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2020.100009.

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