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Outcome of posterior decompression by L1 laminectomy, transpedicular fixation, posterolateral fusion in burst fracture L1 with incomplete spinal cord injury

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ABSTRACT

Introduction: Burst fractures are more severe than compression fractures as the bones spread out in all directions and may damage the spinal cord, leading to paralysis or nerve injury. This study aims to find the surgical outcomes of Posterior Decompression by L1 Laminectomy in terms of burst fracture with incomplete spinal cord injury.
Methods: 48 adult patients with burst fractures with incomplete spinal injury came to NITR from June 2023 to May 2024. In this non-randomized clinical trial, the outcomes of decompression by L1 laminectomy were analysed by using the canal encroachment ratio, while deformity correction was assessed using the sagittal Cobb angle and the percentage of anterior vertebral height for the treatment of L1 burst fracture with incomplete spinal cord injury.
Results: The patients were followed up for an average of 12 months. The mean operation time was 154.53 minutes, mean intraoperative blood loss of 48.84 mL, and the mean incision length was 7.78 cm. The canal encroachment ratio decreased significantly, as well as the sagittal Cobb angle, and anterior vertebral percentage height increased. Oswestry Disability Index, and American Spinal Injury Association impairment scale classification were significant.
Conclusions: Posterior decompression combined with Transpedicular Fixation and Posterolateral Fusion in the treatment of Burst Fracture L1 with Incomplete Spinal Cord Injury is safe and effective.

Keywords: Laminectomy, Posterior decompression, Transpedicular fixation, Posterolateral fusion, Burst fracture, Spinal cord injury

INTRODUCTION

Thoracolumbar burst fractures (TLBFs) are categorized as type A3 and A4 by Arbeit gemeinschaft für osteosynthesefragen spine (AOSpine). In these types of fractures, the spinal canal is often invaded by fracture fragments, which can lead to neurological deficits.[1,2] When neurological deficits occur, surgical intervention is usually necessary. The surgery aims to decompress the nerve, restore the sagittal plane sequence, and stabilize the spine.[3] Common surgical approaches for these fractures include the anterior approach, posterior approach, and a

combination of anterior and posterior approaches.[4] However, open surgeries have drawbacks such as significant blood loss, high infection risk, chronic postoperative pain, and slow postoperative functional recovery.[3-5] To address these drawbacks, various minimally invasive procedures, such as tubular retractors or microscope-assisted decompression combined with percutaneous pedicle screw fixation (PPSF), have been developed.[6-9] The thoracolumbar junction (TLJ) has unique characteristics from both mechanical and anatomical perspectives, setting its injuries apart from other types of spinal column injuries. The transition from lumbar lordosis to thoracic kyphosis, the shift from thoracic to lumbar vertebrae, and the gradual increase in range of motion from a stiff thoracic spine to a fully mobile lumbar spine present challenge in TLJF (thoracolumbar junction) surgery. Additionally, the protective anterior rib cage in the thoracic spine and the stress placed on TLJ stability by the abdomen adds complexity to this area.

Moreover, due to the proximity of the conus medullaris and cauda equina to the thoracolumbar junction, there is a critical need for neural decompression and stabilization in this area.[37] Endoscopic spinal surgery (ESS) is a minimally invasive form of spinal surgery that was initially designed for lumbar discectomy. With advancements in instruments and surgical techniques, ESS can now remove the lamina, facet joints, and other bone tissues.

It is widely used in the surgical treatment of cervical, thoracic, and lumbar degenerative spine diseases. Evidence suggests that ESS has clinical outcomes comparable to other types of minimally invasive techniques, such as microsurgery and tubular retractor techniques. These advances and advantages also provide new possibilities for minimally invasive treatment for nerve damage patients with TLBFs.[10-18]

The Thoracolumbar Injury Classification and Severity Scale (TLICS) and The AO thoracolumbar system are currently the most utilized scoring systems to help clinicians make decisions between surgical and conservative treatment for TLJF. Each scoring system has its advantages and pitfalls, but they have acceptable validity, reproducibility, and generalizability.[3,4] Studies recommend that unstable TLJF lesions benefit from surgical fixation/fusion, while more stable lesions can be treated conservatively.[5] There are extensive controversies regarding the selection of the optimal surgical approach for TLJF stabilization.

Factors such as construct length, open versus percutaneous techniques, neural decompression approaches, type of graft usage, laminectomy versus ligamentotaxis, necessity of spinal column reconstruction, intervertebral prosthesis application, screw properties, and the role of steroid therapy are among the most important surgical determinants during TLJF surgery.[6,7]

Nevertheless, multiple questions remain unclear, requiring further high-quality studies.[5] This study aims to assess the clinical efficacy and safety of posterior decompression by L1 laminectomy in the treatment of patients with TLBFs and with incomplete spinal cord injury. Ethical clearance was ensured. The objectives of the study were.

General objective

The objective of this research is to study the effectiveness of posterior decompression in the management of burst fracture L1.

Specific objective

This study aims to evaluate the efficacy of posterior decompression by L1 laminectomy in terms of burst fracture with incomplete spinal cord injury.

METHODS

Study place

This non-randomized clinical trial study was conducted at National Institute of Traumatology and Orthopedic Rehabilitation, Dhaka, Bangladesh.

Study duration

The study duration was from June 2022 to May 2022. Within these 12 months, 68 patients were admitted to this hospital with the injury levels T12, L1, L2 and L3. Among these, only 48 adult patients were selected for this study.

Inclusion criteria

Patients who were more than 18 years of age, came with incomplete injury, partial retention of sensation below the injury plane, complete loss of movement, incomplete injury, the muscle strength of more than half of the key muscles below the injury plane is less than grade 3, and the leg cannot leave the bed surface, incomplete injury, more than half of the key muscle strength below the injury plane is greater than or equal to grade 3, who underwent surgery within 48 hours of admission, and patients who completed follow-up evaluation were included.

Exclusion criteria

Patients who have evident osteoporosis or metastatic tumour, severe mental disorders, end-stage diseases, severe multiple organ injury or cardiopulmonary dysfunction, which may interfere with surgical treatment, and the key clinical data are incomplete were excluded from the study.

The patient's basic medical records, including neurological and other system examinations, lab results, CT scan, and MRI results were all documented. These records were reviewed by the anesthesiologist and trauma team,

consisting of orthopedic and general surgeons, to assess for any possible concurrent traumatic lesions.

Special care was taken to minimize dissection and spare the PLC ligaments as much as possible. A monopolar was strictly used to clean the lamina and bony elements from soft tissues. The data includes demographic information, on-admission symptoms, physical examination findings, spine injury features, concurrent non-CNS injuries, comorbidities, lab results, imaging findings, details of the neurospine surgery, specifications of fusion constructs (rods, screws, bone grafts, supplementary procedures), complications, ODI, spinal biometrics, and follow-up clinical data.

Statistical analysis

IBM SPSS statistics for windows, version 26.0. Armonk, NY: IBM Corp was used for statistical analysis. The chi-square test for nominal by nominal and, ANOVA, and Pearson correlation for nominal-numeric and numeric-numeric correlations were used. The significant level was p value<0.05. The ethical review committee of the Hospital has approved the study. A well-informed written consent paper was signed.

RESULTS

A total of 48 patients were enrolled in this study. The patients underwent minimal-invasive surgery and were followed up for a year (Table 1). CER was significantly higher after the surgery compared to prior to the surgery, and the decompression effect be substantial (p<0.05). Both CA and AVH were improved at different evaluation time points after the surgery compared to before the surgery, with well-corrected deformity (p<0.05) (Table 2). Visual analogue scale and Oswestry disability index scores were statistically significant at various postoperative evaluation time points, p<0.05 higher than before surgery (Table 3). According to the ASIA, 3 (3.1%) patients received a three-grade recovery, 12 (25%) had a two-grade recovery, and 27 (56.2%) had a one-grade recovery, while 9 (15.6%) did not recover. Grade A and grade E scores were 5 points and one point, respectively, showing that the neurological function at the last follow-up was significantly improved compared to before surgery (p<0.05) (Table 4).

Table 1: Demographics of the study patients.

Variables	Age (years)	Mean±SD (Range) or N (%)
		41.81±8.11 (22-57)
Sex	Male	33
	Female	15
Injured level	T12	7
	L1	48
	L2	10
	L3	3
Cause of injury	Falls from a height	12
	Traffic accidents	24
	Hit by a falling object	6
AOSpine thoracolumbar spine injury classification system	A3	12
	A4	15
	B2 with A3	9
	B2 with A4	9
	Thoracolumbar AOSpine injury score	6.91±1.23 (6-10)
	Duration of surgery (minute)	154.53±12.76 (111-187)
	Blood loss (ml)	48.64±7.59 (40-70)
	Length of incision (cm)	7.58±1.41 (7-11)
	Postoperative drainage volume (ml)	20.94±27.19 (10-90)
	Hospital stays (days)	16.28±1.09 (10-23)
	Follow-up (months)	17.03±1.88 (12-23)

Table 2: CA, AVH, and CER improvement.

Variables	Follow up	Mean±SD (Range)	P value
Sagittal Cobb angle (°)	Pre-operation	16.09±6.46 (7-34)	
	1 week after operation	4.59±3.25 (1-23)	<0.001
	1 year after operation	6.72±2.68 (2-21)	<0.001
Percentage of anterior vertebral height (%)	Pre-operation	52.72±9.99 (37-74)	
	1 week after operation	85.44±8.59 (71-97)	<0.001
	1 year after operation	73.22±18.21 (70-96)	<0.001

Continued.

Variables	Follow up	Mean±SD (Range)	P value
Canal encroachment ratio (%)	Pre-operation	55.91±12.27 (33-84)	
	1 week after operation	13.36±4.46 (6-26)	<0.001
	1 year after operation	12.54±3.81 (6-22)	<0.001

Table 3: VAS and ODI improvement.

Variables	Follow up	Mean±SD (range)	P value
VAS	Pre-operation	7.59±1.48 (5-9)	
	1 week after operation	2.57±0.88 (1-5)	<0.001
	1 year after operation	1.51±0.66 (0-3)	<0.001
ODI (%)	Pre-operation	85.50±9.36 (65-96)	
	1 week after operation	50.88±11.32 (33-79)	<0.001
	1 year after operation	12.53±9.73 (6-62)	<0.001

Table 4: American spinal injury association impairment scale.

ASIA	A	B	C	D	E	Mean±SD (range)	P value
Pre-operation	3	6	15	27		2.57±0.75 (2-5)	
Post-operation		3	6	9	48	1.51±0.66 (1-4)	<0.001

DISCUSSION

Surgery is the main treatment for TLBFs with neurological deficits. Common surgical methods include anterior, posterior, and combined anteroposterior approaches. There are no standard selection criteria for the surgical methods.[3,4,23-25] The anterior approach allows better reconstruction of the anterior column. Combined anterior and posterior surgery provides better stability while reconstructing the anterior column. However, the anterior approach involves greater surgical trauma. Studies have shown that a single posterior approach has no difference in neurological function and radiological outcomes compared with other surgical methods but is less invasive.[7,8,23-25] Therefore, in this study, posterior surgery without additional anterior reconstruction was chosen.

In traditional posterior surgery, open pedicle screw fixation is often used to restore spinal sequence and stability. It has been found that PPSF exerts similar mechanical strength and deformity correction ability as traditional open pedicle screw fixation while reducing surgical trauma.[5] Research suggests that short-level pedicle screw fixation may be enough to treat this condition and reduce the loss of motor function.[6,7,9,20]

Therefore, short-level PPSF was chosen for this study. Previous studies on PPSF in treating TLBFs (including AOSpine A3, A4, and B) demonstrated that the correction of CA was 7.85-12.9, while the correction of AVH was 29.16%-45%.[6-9] In this study, PPSF was used to restore spinal sequence and stability, resulting in a CA and AVH correction of 11.37% and 29.50% at the last follow-up. These findings were consistent with previous results. Posterior surgery for TLBFs is often combined with fusion to prevent kyphosis recurrence. However, in recent years, many prospective and retrospective studies have supported the use of nonfusion techniques in treating TLBFs.[20,26,27]

When comparing fusion and nonfusion reports, it was found that there was no difference in radiographic results, but nonfusion resulted in less injury and faster recovery of functions. These results support the basic principle of PPSF boneless fusion therapy for TLBFs. Studies evaluating treatment of TLBFs without fusion showed that CA loss ranged between 1.5 and 8.3.[20, 26-28] Fusion surgery was not performed in this cohort, yet the CA loss was 2.13 at the last follow-up. Previous studies also indicated that removal of internal fixation devices may not be necessary in patients without fusion.[29] Therefore, due to the trauma and financial cost of surgery, it is not recommending removal of the prosthesis unless requested by the patient. It was noted that one patient experienced a screw fracture during follow-up.

However, a detailed history of the patient showed that the patient underwent heavy physical labor 5 months after surgery, placing a significant burden on the spine. Early decompression is an important surgical procedure for TLBFs (thoracolumbar burst fractures) with neurological deficits, as it is closely related to the recovery of nerve function.[3] In this study, all cases underwent emergency surgery within 48 hours.

However, there is an ongoing debate about whether direct decompression is necessary. Some studies suggest that during sequence reconstruction, the spinal canal can be indirectly decompressed through ligamentotaxis, which may also occur spontaneously in later stages.[30] However, it has been observed that only 50% spinal decompression can be achieved through ligament chemotaxis, and for some fracture types, chemotactic decompression of the posterior longitudinal ligament is not possible.[32-33]

Therefore, direct decompression remains the preferred choice for many surgeons. In our study, endoscopic decompression was utilized rather than the traditional open surgery method for direct decompression.

Our data demonstrated that the length of the decompression incision was approximately 1 cm, and the average intraoperative blood loss was 48.84 ml, which was significantly lower than the 14.17 cm incision and 536.67 ml blood loss associated with traditional open surgery.[8] These advantages create favorable conditions for the rapid recovery of patients.[10-12] The optimal range of direct decompression for TLBFs with neurological deficits is also an interesting topic. While bilateral total laminectomy has traditionally been considered necessary, recent data have shown that a minimally invasive approach, such as partial laminectomy, may also lead to neurological improvement despite having a limited decompression scope.[6-9] Jaiswal et al, compared prospective randomized controlled data for indirect decompression by ligamentotaxis and direct decompression by total laminectomy and found no difference in neurological improvement. Although these studies challenge conventional findings, more high-quality evidence is needed.[6-9,31]

In this study, endoscopic decompression to completely remove the lamina was utilized. However, the range of direct decompression based on each individual's condition was determined using ligamentotaxis for indirect decompression. The data revealed a decrease in CER from 55.91% before surgery to 12.44% postoperatively, with significant improvements in ASIA scores at the final follow-up. Along with ensuring sufficient decompression, the stable structure of the spine was also preserved, including part of the facet joints.[34,35]

Few studies have focused on endoscopic decompression for TLBFs with neurological dysfunction. Prior minimally invasive treatment studies for similar conditions involved partial laminectomy decompression, tubular retractor-assisted decompression, or micro endoscopic-assisted decompression.[6-9] In comparison, endoscopic decompression was shown to be less invasive to the tissues, utilizing progressive channels to expand the soft tissue. Endoscopic surgery in a water medium can result in a reduced infection rate, provide a clearer surgical field, and cause less damage to the epidural blood supply.[10-12,17,18] Another advantage of endoscopic decompression is the ease of observation with the ability to adjust the direction and angle of the endoscope.[12,15,16]

Endoscopic decompression offers several advantages, but it also comes with some limitations. For example, while it can effectively remove the lamina, it is not as efficient or extensive as traditional open surgery. One way to address this challenge is by using endoscopes with large channel systems. Additionally, during endoscopic decompression, water pressure can potentially worsen nerve damage and lead to water accumulation in the third space. One study performed endoscopic surgery using a flush pressure of approximately 150 cm H2O, which is considered relatively safe.[36] Although there are few reports on this issue, more analysis is needed to ensure safety.[11,15,16] Furthermore, the presence of early inflammatory substances is crucial for bone healing, and the use of an endoscope under a water medium can lead to the loss of some of these substances, potentially affecting the healing of fractures.[38]

There are some potential limitations to this study. Due to the artefacts formed by metal implants, some cases have measurement errors.

CONCLUSION

The results of this study show that Posterior Decompression in combination with Transpedicular Fixation and Posterolateral Fusion is a new, minimally invasive, safe, and effective treatment for patients with TLBFs and neurological deficits. It's important to note that this is a small retrospective case series, and a larger case series with longer-term follow-up is needed.

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