The Egyptian Journal of Hospital Medicine (October 2019) Vol. 77 (5), Page 5570-5578

Outcome of Pedicular Fixation of Unstable Dorsolumbar Fractures

Mohammad Salah Eldein Abd Elhafez, Mohammad Ibrahim Abulsoud, Mahmoud Moursy Saleem Moursy
Department of Orthopedics and Traumatology, Faculty of Medicine – Al-Azhar University

ABSTRACT

Background: The spine is made of 33 individual bones stacked one on top of the other. This spinal column provides the main support for your body, allowing you to stand upright, bend, and twist as well as protecting the spinal cord from injury.

Objective: The aim of this study was to evaluate the post-operative clinical outcome of transpedicular screw and rod fixation in unstable thoracolumbar fractures by using Mc Nab's criteria in patients collected from Sohag General Hospital and Sohag University Hospital.

Patients and methods: A prospective study included patients admitted to Orthopedic and Traumatology Department of Sohag General Hospital suffering from unstable fracture of thoracolumbar area. The study was conducted on twenty patients suffering from thoracolumbar fractures attending to Department of Orthopedics and Traumatology, Sohag University Hospitals, Sohag General Hospital and Al-Azhar University Hospitals from June 2018 till December 2018.

Results: In comparison between cases, which conserved and those operated as regard vertebral height loss, angle of kyphosis, oswestry disability index and visual analogue score, we found that p value was not significant in these parameters and its value was 0.15, 0.46, 0.15, and 0.88 respectively. Which means that decision making correlated to patient score. As regards type of operative fixation done, there were non-significant comparison between type of fixation done and the mentioned parameters. All changes in the parameters explain that these parameters correlate with TLICS and prove the validity of this classification.

Conclusion: Posterior short segment pedicle screw fixation is good and enough for treatment of thoracolumber fractures (burst fracture) when neurological condition of the patients is intact.

Keywords: Pedicular fixation of unstable dorsolumbar fractures, transpedicular screw.

INTRODUCTION

The vertebral column is composed of alternating vertebrae and intervertebral (IV) discs supported by robust spinal ligaments and muscles. All of these elements, bony, cartilaginous, ligamentus and muscular are essential to the structural integrity of the spine [(1)]. The spine serves three vital functions including protection of the spinal cord and spinal nerves, transmitting the weight of the body, and providing a flexible axis for movements of the head and the trunk. The vertebral column is capable of extension, flexion, lateral flexion (side to side), and rotation. However, the degree to which the spine is capable of these movements varies by region. These regions, including the cervical, the thoracic, the lumbar, and the sacro coccygeal spine that form four curvatures [(2)].

The thoracic and the sacro-coccygeal curvatures are established in fetal development, while the cervical and the thoracic curvatures develop during infancy. The cervical curvature arises in response to holding the head upright, while lumbar curvature develops as an infant begins to sit upright and walk [(3)].

AIM OF THE WORK

The aim of this study was to evaluate the post-operative clinical outcome of transpedicular screw and rod fixation in unstable thoracolumbar fractures by using Mc Nab's criteria in patients collected from Sohag General Hospital and Sohag University Hospital.

PATIENTS AND METHODS

This was a prospective study conducted in Orthopedic and Traumatology Department of Sohag General Hospital suffering from unstable fracture of thoracolumbar area. Twenty patients suffering from thoracolumbar fractures attending at Department of Orthopedics and Traumatology of Sohag university hospitals, Sohag General Hospital and Al-Azhar university hospital from June 2018 till December 2018. Some cases were obtained retrospectively from the data base of the department.

Ethical approval and written informed consent:
An approval of the study was obtained from Al-Azhar University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation.

Type of interventions:

1. Posterior pedicle screws fixation to one level above the fractured vertebra and one level below it.
2. Decompression of neural canal was done in cases with neurological affection.
3. Vertebral fusion was done with decompression by using autogenous bone grafting to prevent metal failure, instability and progression of kyphosis.

Received:7/08/2019
Accepted:7/09/2019

Data collection:
After the patients with thoracolumbar t fracture were admitted to our hospital, all the necessary clinical details were recorded in proforma prepared for this study including:

1- Age
2- Sex
3- Mode of trauma
4- Level of fractured vertebra
5- Associated injury

After the completion of the hospital treatment patients were discharged and Follow up of cases at 2 weeks postoperative, 1, 2, 4 & 6 months by:

- Clinical and neurological evaluation of each patient and Modified Oswestry Low Back Pain Disability scoring system Top of Form
- Radiological evaluation at (1, 2, 4 & 6 months) to assess
  - Angle of kyphosis by measuring of cobb angle
  - Metal failure in the form of backing out of screws or rod migration
  - Vertebral height loss

1. Age distribution: Most of patients in present study were from age group of 2nd to 6th decade of life. Youngest of them was 18 years old and the oldest was 58 years old. Mean age in our study was 31years.

2. Sex distribution: Most of patients from present study were males. There was a male preponderance in our patient. Amongst them majority were in 3rd-4th decade of life. The ratio of males to female was nearly 3:1. This clearly reflected the preference and better acceptance of surgery by males and higher incidence of thoracolumbar fractures in male population due to their more active lifestyles.

3. Mode of Injury: High energy trauma like falling from height (13 cases) or motor car accident (6 cases) and only one case is subjected to direct trauma to the spine.

4. Level of fracture: Most of our cases had fracture L1 about (8 cases), 6 cases with fracture L2, 5 cases with fracure Th 12 and only one case with fracture Th12 and L1.

5. Associated Injures: In present study series, eight patients had associated injuries. Three cases had fracture calcaneus, three cases had fractures in the upper limb, one case had fracture scapula and one case had pylon fracture.

Methods:

Management of patients:

1. As soon as the patients with suspected fracture spine were seen in Causality Unit, initial attention and care was directed to life threatening conditions (ABCs) Airway, breathing and circulation. Immobilization and cervical collar is necessary.
2. Examination of body system searching for head trauma, cardiothoracic injuries and visceral injuries.
3. After that we move to musculoskeletal system examination searching for other fractures in upper limbs, lower limbs, pelvis and acetabulum.
4. Then neurological examination is performed as soon as the patients were hemodynamically stable.

Radiological

1- X-rays: AP and lateral views on thoracolumbar junction to see vertebral alignments, pedicles, vertebral heights, disc space relations and to measure kyphotic angle (Fig. 1), which is the angle between two lines drawn perpendicular to another two line representing the superior endplate of the upper adjacent vertebra and the inferior endplate of the lower adjacent vertebrae by the Cobb method

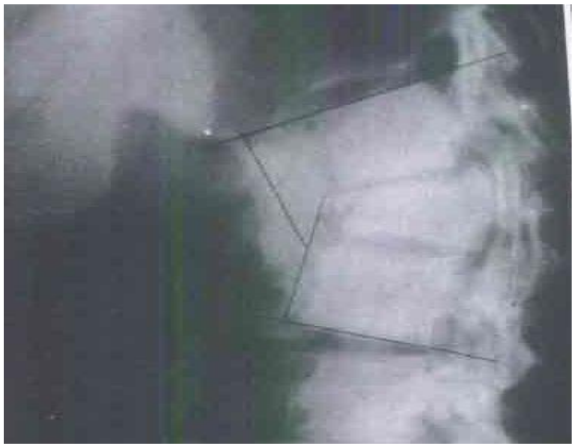


Figure (1): Cobb angle.

2- C T scan: We do it routinely in patients with thoracolumbar fractures to show fracture morphology, lamina, pedicles, and canal compression.

3-MRI: we do it if there is nerve injury.

Pre-operative planning:

1. Complete surgical fitness was done to the patients to decide whether the patients were candidate for surgery or not.
2. All the patients were evaluated for associated medical problems and were referred to respective departments and necessary treatment was given.
3. Associated injuries were evaluated and treated simultaneously. All the patients were operated in Emergency Unit after overcoming the avoidable anesthetic risks.
4. 1 gm 1st generation cephalosporines was given to all patients 30 minutes before surgery.
5. For all patients admitted with urine retention catheterization was done.

Operative Technique of pedicle screw fixation

Anesthesia:

- General anesthesia was used in these cases.

Patient positioning:-

- The patient was placed in prone position on a radiolucent spine table over spinal frame supporting chest and pelvis so that the anterior abdominal wall clears the table, this allows emptying of the non valvular vertebral venous plexus into the vena cava, reducing operative bleeding and this help to extend the spine aiming at opening up the affected segment anteriorly to allow for indirect reduction using principle of ligamantotaxis. Fluoroscopy was used throughout the procedure.

Incision:

- Straight mid line incision was done over the affected vertebra and one level above and one level below. We used C arm to locate the fractured vertebra.

Superficial and deep surgical dissection:

- Palpate the individual spinous processes continue dissecting down to the middle of spinous processes and move the muscle origins to either side of the surface by using cobb elevator.
- Remove the Para spinal muscles from the spinous processes and partially from the laminae by sub periosteal dissection, then keep the dissection open by using self–retaining retractors (Fig. 2).
- Now, still using cobb elevator to remove the short rotators from the base of spinous processes to leading edge of the laminae. Then strip the muscles from the rest of the laminae till transverse processes.

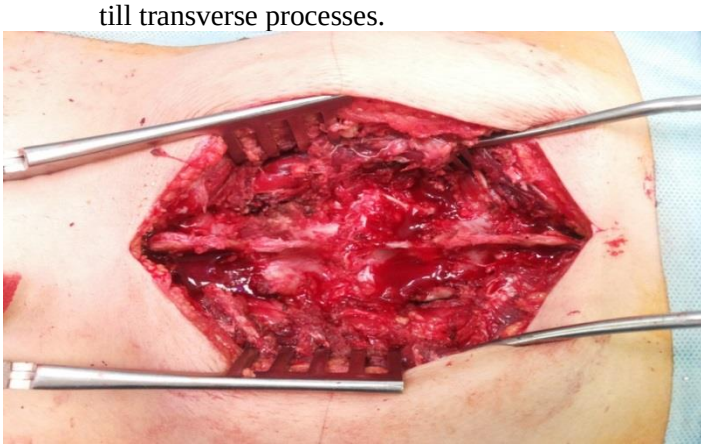


Figure (2): Surgical dissection

Insertion of pedicle screws:-

In the lumbar vertebrae:

The superior and inferior boundaries of the transverse processes on each side of the vertebrae are identified. The point of entry to the pedicles is considered to be at the point of intersection of a line bisecting the transverse process with the lateral margin of the facet joint complex.

In the thoracic vertebrae:

The point of entry to the pedicles is considered to be at the point of intersection of lateral margin of the facet joint complex with the upper border of the rib. This area was roughened by using small bone nibbler and then we used the Awl to start the tract in the pedicle, after that we used pedicle probe to insure the proper passage within the boundaries of the pedicle. Tapping of the resultant tract was done and screw of appropriate length and diameter was inserted. This procedure is repeated in the other pedicles (Fig 3).

Figure (3): Insertion of screws

We used C arm to be sure that we are in the pedicles of the vertebrae and the appropriate length and diameter of the screws (Figure 4).

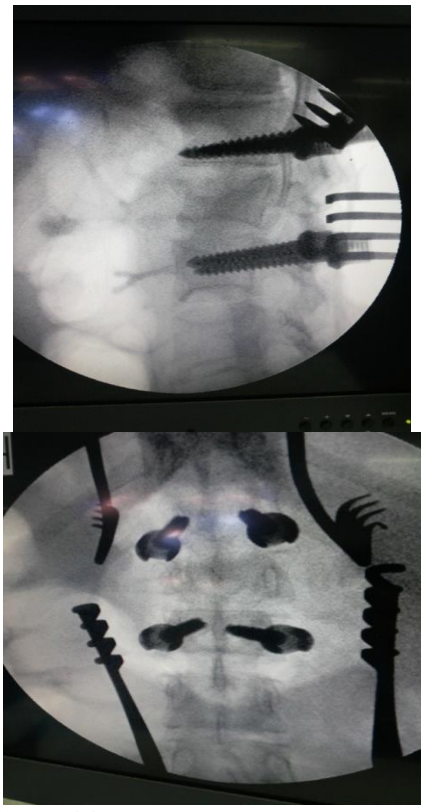


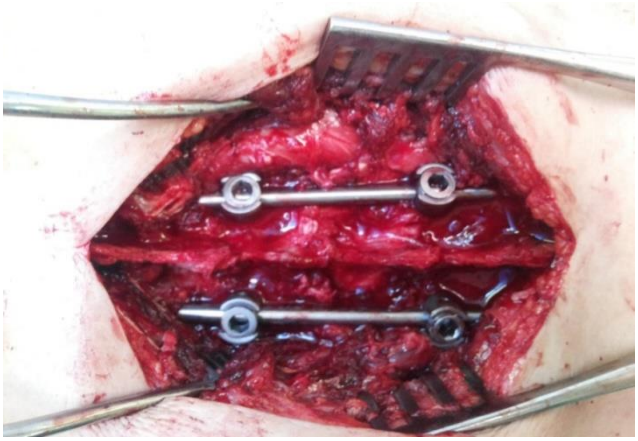
Figure (4): C arm views intraoperative.

After insertion of the pedicle screws, the connecting rods are placed. Distraction of the levels above and below the fracture is used to create tension on the posterior longitudinal ligament, to reduce the fracture of

the vertebra by ligamantotaxis and restore vertebral height (fig 5).

Decompression of neural canal is done in cases with neurological affection by doing laminectomy, retraction of the cord and forward pushing of any displaced fragments from within the canal.

Vertebral fusion is done either posteriorly by Decortication of exposed bone elements in neurologically intact patients or postrolateral by using autogenous bone grafting when
decompression is done.



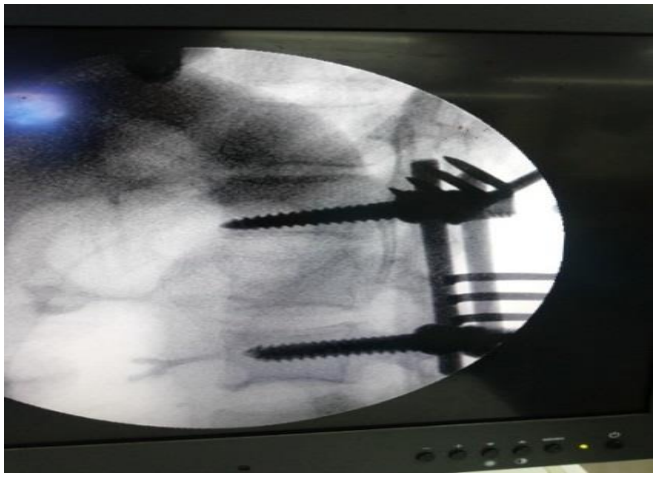


Figure (5): Reduction of fracture by ligamantotaxis.

Closure: After the fixation was over, lavage is given using normal saline. Incision closed in layers. Sterile dressing is applied over the wounds.

After surgery:

1. Postoperatively thoracolumbar brace was used by the patients for 2-3 months.
2. X ray AP and lateral views were done, antibiotics were continued, I.V for 3 days and oral antibiotics for 2 week. Analgesics were given when indicated.
3. The patients were allowed to sit in the bed, walk at home and go to W.Cs the next day after surgery. Leaning forward not allowed for 1 month at least
4. Sutures were removed on 14th day postoperatively.

Discharge: Patients were discharged from the hospital 2-5 days postoperatively.

Follow up:

All patients were followed up at

- 2 weeks to remove stitches.
- 4 weeks
- 2 months
- 4 months
- 6 months

At every visit patients were examined using x-ray AP and lateral views to assess vertebral fusion, vertebral height loss and metal failure in the form of rods migration or backing out of screws. Clinical and neurological examination was evaluated also. In the last visit Modified Oswestry Low Back Pain Disability scoring system was used and measurement of cobb angle was measured at 6 months using Adobe Photoshop program.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:
- Probability (P-value)
  - P-value <0.05 was considered significant.
  - P-value <0.001 was considered as highly significant.
  - P-value >0.05 was considered insignificant.

RESULTS

The present study included 20 patients having thoracolumbar fracture type A3, according to AO/magerl classification, surgically treated by posterior pedicle screws fixation from June 2018 till December 2018 in the Department of Orthopedics and Trauma Surgery at Sohag University Hospital, Sohag General Hospital and Al-Azhar University Hospital. The patients had been followed up at (1, 2, 4, 6 months). Results were evaluated at 6 months post-operative from the date of discharge.

Table (1): Age distribution of cases.

Age group	No. of Patients	Cumulative percent
<20	1	5 %
20-30	10	50%
30-40	5	25 %
40-60	4	20 %
Total	20	100 %

In our series, majority of the cases i.e.10 were seen in the age group of 20-30 years, the youngest patient in our study was 16 years old while the oldest was 58 years old. With mean age was 31 years old (Table 1).

Sex distribution of cases

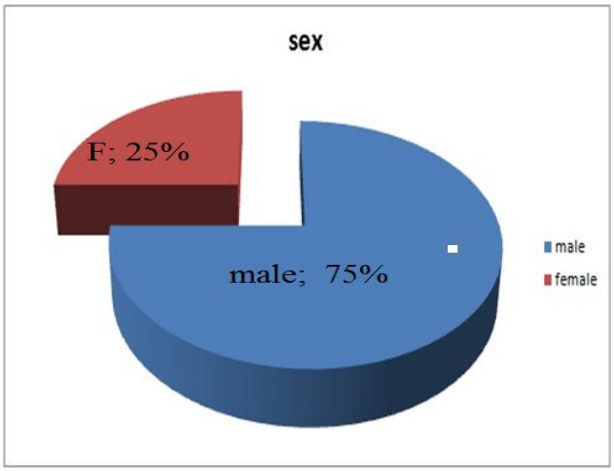


Figure (6): Chart represents sex distribution of cases

Most of patients in the present study were males. There was a male preponderance in our patient. Amongst them majority were in 3rd-4th decade of life. The ratio of males to female was nearly 3:1 (Figure 6). This clearly reflected the preference and better acceptance of surgery by males and higher incidence of thoracolumbar fractures in male population due to their more active lifestyles. The majority of the patients in the series were male as they were more outgoing and engaged in activities like agriculture, buildings, driving of motor vehicles, praying outside home and are more likely to be involved or prone to accidents and falls. Females play a more dormant role and are involved more in household activities.

Table (2): Mode of trauma

	No. of Patients	Cumulative percent
Falling from height	13	65%
Motor car accident	6	30%
Direct trauma	1	5 %
Total	20	100 %

In our study, 13 cases had fracture at thoracolumbar area as a result of falling from height, most of them were males due to daily activities and hard works in buildings (table 2). 6 cases had motor car accident. And only one case had a direct trauma to his back.

Table (3): Level of fractured vertebra

Level	Sex		
	No. males	No. females	Total
Th 12	4	1	5
L 1	6	2	8
L 2	4	2	6
Th12&L1	1		1
Total	15	5	20

In our study, only one case had thoracolumbar fracture at two levels, and the rest of cases had single level injury. About 40% of the cases were at L1, 30% at L2 and 25% at Th 12.

Time before operation.

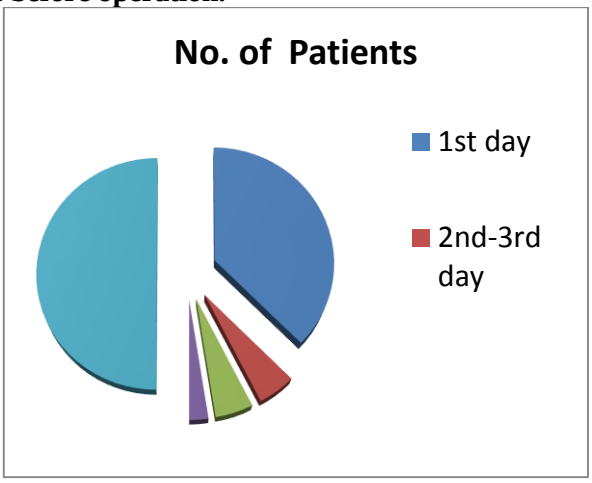


Figure (7): Chart represents time before operation.

Majority of patients in present study series were operated within the 1st day of admission in hospital (15/20). But in some patients (5/20) operative procedure was delayed either due to medical problem or due to financial constraints (fig. 7). Two cases were operated in the 3rd day of admission. Another two cases were operated in the 5th day of admission. Only one case was operated after 10 days of admission.

Table (4): Type of operation

	No. of Patients	Cumulative percent
T P F only	13	65 %
T P F& Decompression With postrolateral fusion	7	35 %
Total	20	100 %

Majority of patients in present study series were operated by posterior pedicle screws fixation only without decompression (13/20) representing about 65%. Decompression was needed in other cases (7/20) because they were suffering from neurological insult (Table 4).

Vertebral height loss in % (Table 5)
In present study series, there was marked improvement in vertebral height loss. Average preoperative percentage of vertebral body height loss was 36.8%, which improved to 17.6% at final follow-up.

Table (5): Vertebral height loss in %

	No. of patients preoperatively	No. of patients 6months postoperatively
Less than 10%	0	6
10-20 %	1	9
20-30 %	5	3
30-40 %	7	0
More than40 %	7	2
Total	20	20

Pre-and post-operative morbidity:

In our study series, eight patients had associated injuries; fracture calcaneus, fractures in the upper limbs, fracture scapula and pylon fracture.

While, two patients were found to have chest infection, as they were chronic smokers and strong antibiotics and nebulizer were used. Four patients were found to have diabetes mellitus and their blood glucose was controlled preoperatively by using crystalline insulin, one case of them had diabetic ketoacidosis postoperatively and admitted in the department of internal medicine to control blood glucose level. Three patients suffered from ischemic heart disease for which they had anti-ischemic measures for 4 days preoperatively (table 6).

Wound Complications:
Superficial would infection was seen in one case. She was a female patient, diabetic and was fatty. The infection was noticed one week postoperatively and IV antibiotics were given and this superficial wound infection was completely cured. No recorded cases of deep wound infection or wound hematoma.

Mortality: No recorded cases died in our study series.

Table (6): Pre and post-operative morbidity

Pre and post-operative morbidity	No. of Patients
Chest infection	2
Diabetes mellitus	4
Ischemic heart disease	3
Superficial wound infection	1
Deep wound infection	0

Intra operative and post-operative complications
In our study, two cases had dural tear (fig. 8). Both of them were Frankle C and needeed transpedicular fixation and decompression was done and both of them improved to Frankle D & E. They received strong antibiotics, slept in bed in prone position and improved later on.
Two cases had metal failure in the form of knot migration and backing out of the rods. One of them was Frankle B and deteriorated to Frankle A. removal of the implant occur after 3months. The other case was female patient with Frankle D and improved to Frankle E postoperatively and she didn't remove the implant. One case had deep infection in his leg because she had pylon fracture, debridement and removal of the implant was done.

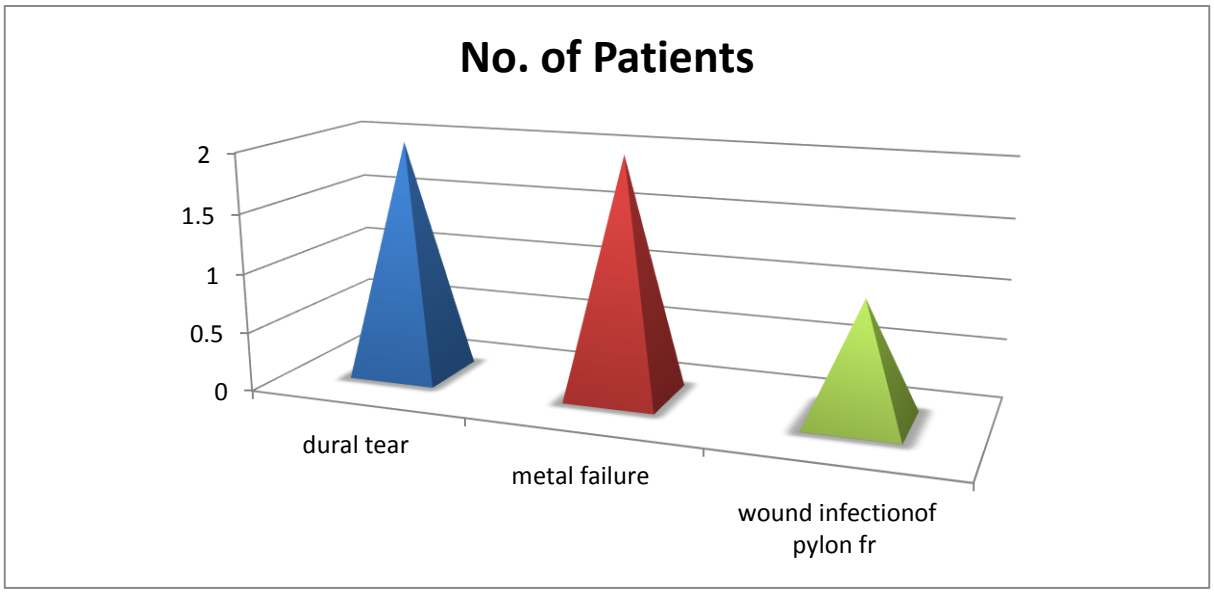


Figure (8): Chart represents complications

Follow up period

In our study, mean follow up period was 8.55 ± 3.38 ranging (6-20 ms) (fig. 9).

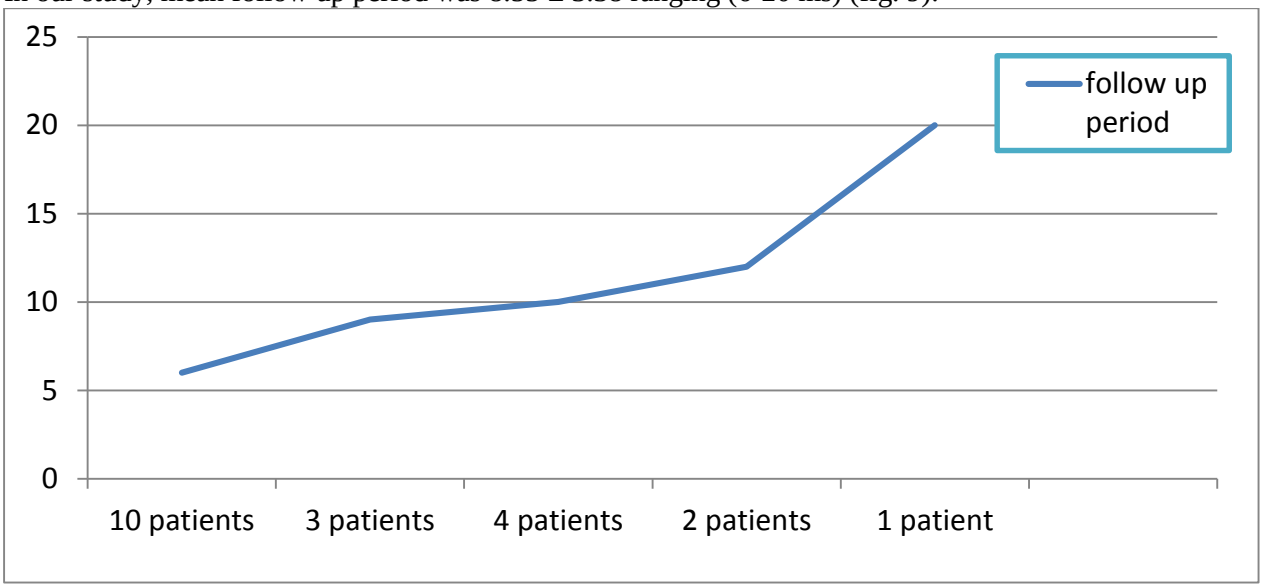


Figure (9): Chart represent follow up period

DISCUSSION

Thoracolumbar fractures are commonly seen at thoracolumbar junction, because it is transition zone from a relatively rigid thoracic kyphosis to a more mobile lumbar lordosis and the facet joints of the thoracic region are oriented in the coronal (frontal) plane [(4)]. Many classifications are present to classify the thoracolumbar fractures including Denis, AO Magrel classifications and thoracolumbar injury and severity score (TLICS) [(5 & 6)].

In this study, an attempt was made to evaluate the use of TLICS and validate its efficacy in orthopaedic emergency at Sohag university hospitals. The study was conducted on thirty patients attending at our Department of Orthopedics and Traumatology, Sohag University Hospitals, from October 2016 till October 2017. In the study, we followed the patients up for functional and neurological improvement.

This study demonstrated that the TLICS accurately matches decision making in 28 of 30 (93.33%) patients. The TLICS score also accurately reflected the severity of the injury, with 87.5% of patients with a TLICS score > 6 demonstrated some degree of neurologic injury. Burst fractures without neurologic deficit and no injury to the PLC remain a controversial issue.

Age distribution:

Thoracolumbar fractures are more frequent in men than in women and peak between the ages of 20 and 40 years [(7, 8, and 9)].

In our study, there was a male predominance. Male to female ratio was 2:1 and majority of them were in 2nd -3rd decade of life. The majority of the patients in this series were male as they were more outgoing and engaged in activities like agriculture, driving of motor vehicles and are more likely to be involved or prone to accidents/ fall. Females play a more dormant role and are involved more in household activities. The mean age was (34 years) and this goes with mean age of patients that reported in other studies.

Mode of Injury

Falling from height and motor car accidents are the most common cause. In our study, 76.6% of the cases had thoracolumbar fractures as a result of falling from height and 20% due to motor car accident.

Level of fractured vertebra

Most of our cases had single level injury, about 30% had fracture at L1, about 10% had fracture at L2 and 20% had fracture at Th12. In a study by **Magerl and Engelhard** [(10)] on 1446 thoracolumbar fractures most injuries concerned the first lumbar vertebra, i.e., (28%), followed by T12 (17%) and L2 (14%). The epidemiologic multicenter study on fractures of the thoracolumbar transition (T10–L2) by the German Trauma Society studied 682 patients and revealed (50%) L1 fractures, (25%) T12 fractures and (21%) L2 fractures [(7 and 11)].

TLICS scoring results:

In our study, there were 9 cases (30%) with TLICS score < 4 (two of them with score 2 with morphological affection burst type and 7 cases with

score 1 with morphological affection compression type with intact neurological and PLC) and all of them treated conservatively, 8 cases (26.67%) with TLICS score = 4 (2 cases treated conservatively with morphological affection burst type and PLC of suspected injury and 6 cases were operated ,all of them with morphological affection burst type and also PLC suspected injury) and 13 cases (43.33%) with TLICS score > 4 (with morphological affection burst type and neurological affection in form of incomplete and complete spinal cord injury and PLC status was injured in 8 cases and suspected in 5 cases) all were operated. **Joaquim *et al.* [12],** reported that a total of 65 patients were treated. In 37 patients, TLICS was 3 and the patients were treated non-surgically (group 1).The remaining 28 patients with TLICS of 4 or more underwent surgical treatment (group 2). In group 1, 28 patients were neurologically intact with compression or burst fractures (TLICS of 1 or 2, median 2). In group 2, TLICS ranged from 4 to 10 (median 7).

Vertebral height loss:

In our study, vertebral height loss at time of arrival and after 6 months has been changed with statistically significant difference with P value < 0.0001. When the vertebral height loss was <10% there were 8 (26.67%) patients preoperative became 15 patients (50 %) at the final follow up. When vertebral height loss 10-19% , there were 8 patients (26.67%) preoperatively became 7 patients (23.33%) at the final follow up. Also, when the vertebral height loss were 20 -29%, there were also 9 patients (30%) at preoperative time became 5 patients (16.67%) at the final follow up. In addition, when the vertebral height loss were 30-40% there were 3 patients (10%) at preoperative time became 3(10%) patients at the final follow up. Finally, when the vertebral height loss was > 40%, there were 2 patients (6.67%) became zero at the final follow up.

Angle of kyphosis:

In our study, there was improvement in kyphotic angle. Mean kyphotic angle preoperative was 13.50 and post-operative mean angle was 9.150 with statistically significant P value that was 0.008. **Sapkas *et al.* [13],** out of 40 patients with unstable thoracolumbar fractures, 20 patients treated by short segment fixation and the others treated by long segment screws fixation. There was no statistically significant difference noted between the short segment and long segment instrumentation group. These results suggest that LS and SS stabilization are equivalently able in reducing the segmental kyphosis and the vertebral body deformation.

Disability scoring system:

According to our study, at the final follow up , there were 13 cases with minimal disability about (43.33%), they can cope with most living activities. 17 cases (56.67%) with moderate disability and the back condition can usually be managed by conservative means. No cases with sever disability. **Sapkas *et al.* [13],** concluded that at the long term follow up, the long segment stabilization was associated with better results. Concerning the patients' satisfaction about (80%) were with minimal disability in cases treated with long segment but in cases treated with short segment about 45% only were with minimal disability. Some studies demonstrated that clinical long-term results are favorable in patients who underwent short segment pedicle instrumentation **[14, 15].**

Visual analogue score:

VAS has statistically significant changed in the study with P value < 0.0001 before and after treatment.

In our study, the result of those with TLICS score, cases conservatively managed with the following parameters:

For VAS: p value at admission was 0.08 and become 0.049 at the final follow up.

For Height loss: p value at admission was <0.0001 and become 0.04 at follow up.

For Kyphotic angle: p value at admission was 0.06 and become 0.37 at follow up

Difference shown due to decreased number of cases managed conservatively in the study. Our cases were treated and classified according to the TLICS. Thoracolumbar injuries scoring 4 were treated conservatively. Out of our study it was possible to be evaluated the conservative treatment inpatients scoring 4 and the results were satisfied **[16].**

In the relationship between the neurology of patients and their TLICS score, we found the P value is statistically significant (0.03) at the final follow up. Also, the relationship between vertebral height loss and the TLICS score was statistically significant (0.04). As regard kyphotic angle and TLICS, P value was not significant (0.37). Visual analogue score and TLICS, the P value was significant. Oswestry disability index relation with TLICS was statistically significant with P value (0.02).

In comparison between cases which conserved and those operated as regard vertebral height loss, angle of kyphosis, Oswestry disability index and

visual analogue score we found that p value not significant in these parameters and its value was 0.15, 0.46, 0.15, 0.88 respectively. Which means that decision making correlate to patient score.
As regard type of operative fixation done, there were non-significant comparison between type of fixation done and the mentioned parameters.
All changes in the parameters explain that these parameters correlate with TLICS and prove the validity of this classification.

CONCLUSION

Posterior short segment pedicle screw fixation is good and enough for treatment of thoracolumber fractures (burst fracture) when neurological condition of the patients is intact. But if the neurological condition of the patients is affected and decomoression of spinal canal is needed, it is better to do long segment fixation to achieve good stability and prevent metal failure, progressive kyphosis and vertebral collapse.

REFERENCES

1. **Hu R, Mustard CA, Burns C (1996):** Epidemiology of incident spinal fracture in a complete population. Spine, 21: 492.
2. **Tran NT, Watson NA, Tender AF *et al.* (1995):** Mechanism of the burst fracture inthoracolumbar spine. Spine, 20: 1984 -8.
3. **Bohlman HH (1985):** Treatment of fractures and dislocations of the thoracic and lumbar spine. J Bone Joint Surg Am., 67: 165-9.
4. **Dick W, Kluger P, Magerl F *et al.* (1985):** A new device for internal fixation of thoracolumbar and lumbar spine fractures: The 'fixateur interne'. Paraplegia, 23 (4): 225-32.
5. **Rihn JA, Anderson DT, Vaccaro A *et al.* (2008):** A review of the TLICS system: a novel, user friendly thoracolumbar trauma classification system. Acta Orthopaedica, 79 (4): 461-6.
6. **Schweitzer KM, Vaccaro AR, Lee JY *et al.* (2006):** Confusion regarding mechanisms of injury in the setting of thoracolumbar spinal trauma: a survey of The Spine Trauma Study Group (STSG). J Spinal Disord Tech., 19: 528 530.
7. **Knop C, Blauth M, Bühren V *et al.* (1999)**: Surgical treatment of injuries of the thoracolumbar transition. 1: Epidemiology. Unfallchirurg., 102: 924–35.
8. **Reid DC, Hu R, Davis LA *et al.* (1988)**: The nonoperativetreatment of burst fractures of the thoracolumbar junction. J Trauma, 28: 1188–94.
9. **Diaz JJ, Cullinane DC, Altman DT *et al.* (2007):** Practice management guidelines for the screening of thoracolumbar spine fracture. J Trauma, 63: 709–718.
10. **Magerl F, Engelhardt P (1994):** Brust- und Lendenwirbelsäule – Verlaufsformen. In:Witt AN, Rettig H, Schlegel KF (eds) Orthopädie in Praxis und Klinik, SpezielleOrthopädie (Wirbelsäule – Thorax – Becken). Thieme, Stuttgart New York, Pp. 3: 82–3.
11. **Knop C, Blauth M, Bühren V *et al.* (2000)**: Surgical treatment of injuries of the thoracolumbar transition. 2: Operation and roentgenologic findings. Unfallchirurg., 103: 1032–47.
12. **Joaquim AF, Daubs MD, Lawrence BD *et al.* (2013):** The spine journal, retrospective evaluation of the validity of thoracolumbar injury and severity score. Spine J., 13 (12): 1760-5.
13. **Sapkas G, Kateros K, Papadakis SA (2010):** Treatment of unstable thoracolumbar burst fractures by indirect reduction and posterior stabilization: short-segment versus long- segment stabilization. The Open Orthopaedics Journal, 4: 7-13.
14. **Muller U, Berlemann U, Sledge J *et al.* (1999):** Treatment of thoracolumbar burst fractures without neurologic deficit by indirect reduction and posterior instrumentation: bisegmental stabilization with monosegmental fusion. Eur Spine J., 8 (4): 284-9.
15. **Rommens PM, Weyns F, Van Calenbergh F *et al.* (1995):** Mechanical performance of the Dick internal fixator. A clinical study of 75 patients. Eur Spine J., 4 (2): 104-9.
16. **Pneumaticos SG, Karaminos PK (2016):** Evaluation of TLICS for thoracolumbar fractures. Eur spinr J., 25: 1123-1127.