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Assessing The Effectiveness and Complications of Lateral Mass Screw Fixation in Cervical Spine Trauma: A Clinical Review

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Abstract: ***Background**: This study reviews a clinical series of 30 patients operated by lateral mass fixation with poly axial screws and rods for cervical instability due to posterior element injury with good long-term results and very less morbidity. **Methods**: A retrospective review of total 172 lateral mass screws were placed in 30 patients of ages 16 - 55 out of which males predominated accounting 87% and females comprised 13%. All cases were performed with a polyaxial screw - rod construct and screws were placed using Anderson - Sekhon trajectory.12 - 14 mm polyaxial screws of 3.5 mm diameter were used in most patients to get a good bony purchase. The depth of the screw was around 11+/ - 5 and mean trajectory was 30 degree lateral and superiorly directed in order to prevent nerve injury, facet joint violation and injury to the vertebral artery. Screw location was assessed by post - operative plain x - ray and computed tomography scan (CT). **Results**: None of the patients experienced neural or vascular injury as a result of screw position. There were no biomechanical complications post operatively in the form of screw pull outs or breakage of screws within the period of follow up. Good fusion was achieved in almost all the cases at the end of 6 months. **Conclusion**: Decompressive cervical spine laminectomy with lateral mass screw stabilization using Anderson - Sekhon trajectory is safe and effective in maintaining alignment in patients with cervical trauma associated with cord changes. Early surgical decompression in acute cervical spinal cord trauma is associated with improvement in neurological status, thereby improving quality of life.*

Keywords: Cervical trauma, lateral mass fixation, spine surgery complications, cervical spine alignment and poly axial screws

1. Introduction

Posterior plating utilizing lateral mass screw fixation has been widely accepted for treating the unstable cervical spine caused by trauma, neoplasms, significant degenerative conditions and failed anterior fusions [1 - 6]. Clinical studies have shown that posterior cervical plating results in a high rate of fusion [2 - 4, 7]. The major advantage of this procedure is that it provides equal and great biomechanical stability when compared to anterior plating or traditional interspinous wiring techniques [8 - 11]. It is also a superior method for patients who have had extensive, multiple - level laminectomies and for those whose spinous processes, laminae and facets are injured or deficient. Injury to the adjacent nerve roots associated with lateral mass screw insertion and screw fixation failure is the main potential complication [7 - 12]. A solid anatomic and radiographic knowledge will avoid or minimize anatomic complications during lateral mass screw insertion.

In 1964 in France, Roy - Camille [3] was the first to insert screws into the lateral mass of the cervical spine to stabilize the unstable spine. Those to follow included Louis [4] in France and

Magerl [3] in Switzerland. The senior author [1] introduced the Roy - Camille technique in the United States for treating fractures and dislocations and dislocations of the lower cervical spine.

Several techniques of lateral screw placement have been developed. Each has its unique entrance point for screw insertion and screw trajectory. Roy - Camille [13] advocated that the entrance point for screw insertion should be located at the top of the lateral hill of the lateral mass, exactly at its midpoint.

The entrance point is then drilled with a 2 - mm bit, perpendicular to the vertebral plane and 10 degrees lateral to the sagittal plane. The drill hole is further tapped with a 3.5 mm tap, and a contoured Roy - Camille cervical plate of appropriate length is secured with cortical screws of 3 - 5 mm diameter. Louis [4] developed another technique in which the starting point for screw insertion is situated at the intersection of a vertical line 5 mm medial to the lateral margin of the inferior facet and a horizontal line 3 mm below the inferior margin of the inferior facet. The screw hole is drilled with a 2.8 - mm bit, and the drill bit is directed strictly parallel to both sagittal and axial planes of the vertebra. The screw should not penetrate the ventral cortex, otherwise the nerve roots directly anterior to the superior facet may be at increased risk. Magerl [3] recommended that the screw entrance point be slightly medial and cranial to the posterior center of the lateral mass and the orientation of the screw be 20 - 30 degrees lateral and parallel to the adjacent facet. Anderson et al. [2] modified Magerl's technique. They recommended that the starting point for screw insertion be 1 mm medial to the center of the four boundaries to the lateral mass and screw direction be 30 - 40 degrees cephalad (parallel to the facet joint) and 10 degrees lateral. The screw hole tapping should be limited to the dorsal cortex to achieve sound bicortical bony purchase. An et al. [14] recommended that the ideal screw direction should be approximately 30 degrees lateral and 15 degrees cephalad starting 1 mm medial to the center of the lateral mass for C3C6. For C7 special care should be taken during screw placement because the anteroposterior diameter of the lateral mass is thin.

This article presents a brief review of the status of posterior lateral mass fixation, including anatomic and radiographic considerations, which will help to decrease the complications associated with this technique.

2. Statistical Methods

The software used was GraphPad Prism version 5 (San Diego, California: GraphPad Software Inc., 2007) for data processing and analysis. The subject variables were described using frequency distribution for categorical variables and mean along with standard deviation was used for continuous variables. P value less than or equal to 0.005 is considered not significant.

Clinical Materials and Methods

This study was approved by the Institutional ethics committee of B. I. N & I. P. G. M. E. R, Kolkata. The study group consisted of 30 patients treated for traumatic cervical spine disease between June 2014 to August 2016. Decompressive cervical laminectomy with a total of 172 lateral mass screws were applied in different cervical spine levels to deal with traumatic cervical myelopathy. Exclusion criteria included: cervical degenerative disease with myelopathy, radiculopathy and abnormal EMG/NCV, patients unfit for GA including severe cardio - pulmonary disease and other gross comorbidities which could affect the study result. The severity of cervical myelopathy was assessed by using Nurick's scale. The patient demographics were reviewed and analyzed in a retrospective manner.

Surgical Technique

All patients were operated in prone position with head in neutral position maintaining slight flexion with skull traction in situ. Vertical midline skin incision was given and dissection deepened by retracting the paraspinal muscles exposing the cervical lamina and the whole extent of the lateral mass laterally. For locked facets which could not be reduced pre operatively, the facets were manipulated to achieve the reduction under vision. Once reduction was achieved, the neutral position of the head was maintained and lateral masses were prepared for screw placement. The entry point into the lateral mass was 1 mm medial to the center of the lateral mass.

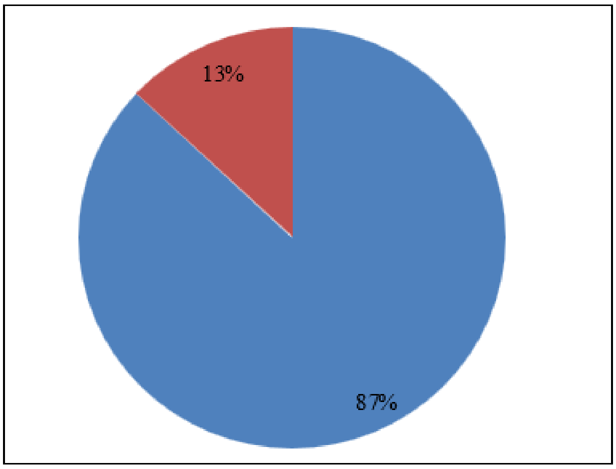
The bone was drilled from the entry point vertically and perpendicular to the surface of the lateral mass for about 2 - 3 mm and the drill was then redirected superiorly and laterally at an angle of 15 - 20 degrees till the opposite cortex was penetrated. This technique avoided the breakage of the cortex at the entry point. The superolateral trajectory was achieved by resting the drill against the lower spinous process which was immediately below. Once drilling was done, the track was tapped and screws were threaded into the track. Each screw position was assessed separately by imaging guidance before the final placement. Once all the screws were placed in position, the facet joint was opened and the articular surfaces were thoroughly decorticated. For biological fusion, chips of auto graft bone from the posterior elements were placed over the decorticated lateral masses and into the appropriate facet joints. Finally, the rods were tightened in neutral position maintaining the reduction. Fluoroscopic check was used at the end of the procedure to look for the alignment of screws and whether or not reduction was achieved. Postoperatively, all patients were immobilized in a hard cervical collar and plain Xray was done on the first post - operative day. Neurological examination was routinely performed in the immediate post - op period to check for any neurological deterioration. Follow - up examination and X - rays were taken at discharge, at 3 months, 6 months and 1 year to access the standard of bony fusion achieved and for any hardware failure.

3. Results

The demographics of 172 lateral mass screws per 30 patients are shown in table 1. The majority of patients were males, with an average age of 16 - 55. Most of the patients included in the study are patients with road traffic accident, fall from height and labors carrying axial load on their head.

Age (years)	Number of patients	%
16 - 25	8	26.70%
26 - 35	12	40%
36 - 45	6	20%
46 - 55	4	13.30%

The mean age in the lateral mass fusion group was 32.1 +/ - 9.5 years



Graph 1: Sex Distribution

There was significant difference in sex distribution among study groups. Males (87%) predominance was noted in this study.

Table 2: Timing of Surgery

Duration of symptoms	Frequency	%
Upto 15 days	16 patients	53.30%
Upto 30 days	4 patients	13.30%
Upto 45 days	6 patients	20.00%
Upto 3 months	4 patients	13.30%
Upto 6 months	None	0.00%

Most of the patients underwent early surgery in the form of lateral mass fixation within 7 days of admission.

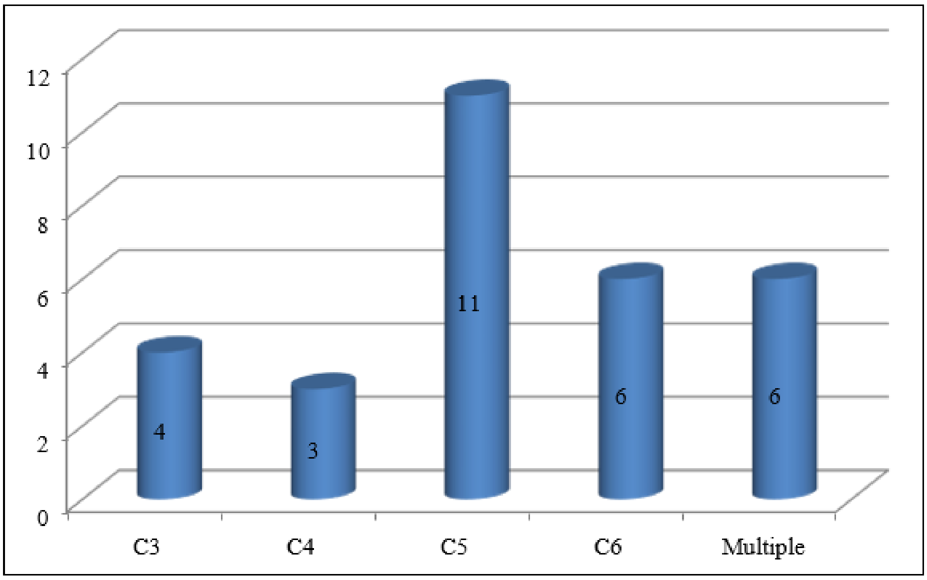
Duration of symptoms (interval between onset symptoms and surgery) – 15 days to 3 months (mean=25.6 + 26.45)
Median duration of symptoms – 13.5 days

Pre - operative Nurick's grade: 2 to 5
11 patients were of grade 2 - 3/5 (11/30= 36.6 %)
12 quadriplegia grade 5 (12/30=40%)
07 having intact power grade 1 (7/30=23.3%)

Table 3: Cause and Frequency of Cervical Spine Injury

Causes	Frequency	%
Road traffic accident	16	53.35%
Fall from height	8	26.70%
Falling of object	4	13.40%
Assault	2	6.60%
Total	30	100

Out of 30 patients included in the study, most common cause for cervical cord injury was road traffic accident (53.3%), followed by fall from height (26.6%). Fall of object and fall while carrying heavy load comprised 13.3 % and secondary to assault were 0.6%.



Graph 2: Vertebral Level of Injury

Majority of the injuries were at the fifth cervical vertebra (C5), and the two adjacent vertebrae fourth (C4) and sixth (C6).11 patients had injury at C5, 06 (21%) had injury at C6, 04 (13.3%) had injury at level C3, 03 (10%) had injury at C4.6 patients had injuries at multiple levels.

Table 4: Type of Cervical Spine Injury with Imaging Correlation

Imaging feature	No of patients	%
Hematomyelia	30	100%
Stenosis	22	73.30%
Subluxation	16	53.30%
Lamina fracture	12	40%
Loss of lordosis	12	40%
Locked facet	12	40%
PIVD	2	6%
Others	2	6%

All 30 patients showed cord contusion.16 out of 30 patients presented with subluxation, the lesions were at C4 - C5 (9/16) and C5 - C6 (7/16) vertebral levels. The degree of subluxation in all the cases was below 25% of the vertebral width.

Locked facet was present in 12 patients out of which unifacet dislocation was present in 8 patients and bilateral in 4 patients. 12 patients had fractures of spine and lamina at multiple levels.06 patients at C4 level had burst fracture and 04 C5 level fractures out of which 02 were tear drop, while the other 02 were fractures of the spinous process. One C3 fracture was an anterior wedge collapse.

The fractures on C5, C6 level were varying degrees of vertebral body compression, ranging from mild lipping to wedge collapse in which one had a fracture of the left lamina of C6.

03 patients had injuries at multiple levels.

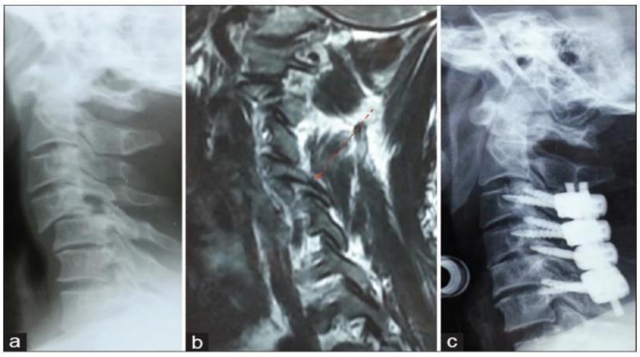


Figure 1

35 year old male patient with a) C4 - 5 grade 2 listhesis b) MRI images with cord contusion c) post op X - ray

Table 6: Treatment Offered for Cervical Spine Injury

Type of treatment	Frequency	%
Cervical collar	30	100%
Traction	16	53.30%
Surgery	30	100%

All patients were put on Philadelphia cervical collars as an initial management, of which 16 (53.3%) patients were put on traction, patients who had subluxation and locket facet, traction for 6 weeks.

Figure 2: Image showing Philadelphia collar before shifting the patient for surgery

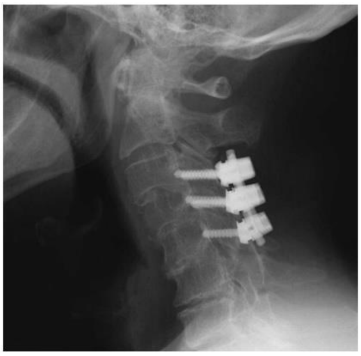


Figure 3: Immediate post - op image

Table 7: Presenting Signs and Symptoms

Signs and symptoms		No of patients	%
Weakness	Grade 23/5	11	36.60%
	Grade 0/5	12	40%
Spasticity		22	73.30%
Numbness		12	40%
Pain		30	100%
Bladder and bowel		6	20%
Others		8	26.60%

The most common presenting symptom was weakness (except pain which was present in all patients) affecting all limbs with difficulty getting up from squatting position, difficulty in walking fast, climbing stairs, loss of dexterity and grip weakness.

Some had radicular symptoms such as weakness of one or both arms, difficulty in raising arm, bending elbow. Numbness and paraesthesia were also frequently reported as tingling sensation over limbs with loss of sensation.

Pain was most commonly nuchal in location aggravating on flexion and extension, affecting range of motion in almost all patients with trauma. Sphincter involvement was present in 06 patients (among the 12 patients who are quadriplegic), in the form of hesitancy, increased frequency of micturition. Sexual dysfunction was noted in some patients.

The median duration of symptoms is 13.5 days.

Table 7: Total Number of Screws Placed according to Cervical Level

Cervical level	No of screws
C3	38
C4	40
C5	52
C6	42

Total 172 screws were placed in 30 patients among which 3 level screw placement was done in 22 patients, 2 level screw placement in 6 patients and 4 level screw placements from C3C6 in 2 patients. We have also put a pedicle screw in 4 level fixations in C7, however due to study limit, C7 is not tabulated in the column.

Table 8: Level of Fixation

Two level fixation	C3 - 4	2
	C4 - 5	1
	C5 - 6	3
Three level	C3+4+5	7
	C4 - 5+6	12
	C5+6	3
Four level	C3+4+5+6	2
	Total	30

Most common level of fixation was C5 as radiography C5 was more frequently involved in traumatic cases.
In multiple level involvement, all the four levels of fixation was done in two patients.
In all cases, screw - plate fixation was done (peri operative confirmation done by C - ARM).

Motor 1 - Power
Proportion of patients with motor weakness at baseline value - 23 (76.6%)
Proportion of patients with motor weakness at the end of the study - 4 (13.3%)

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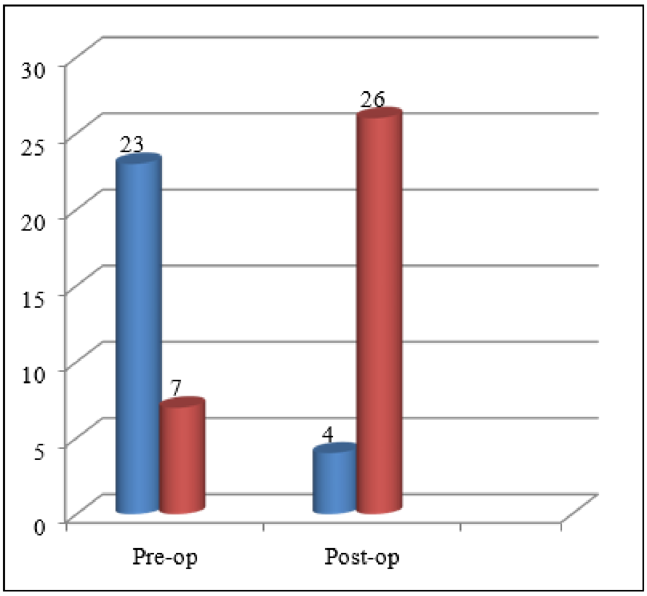


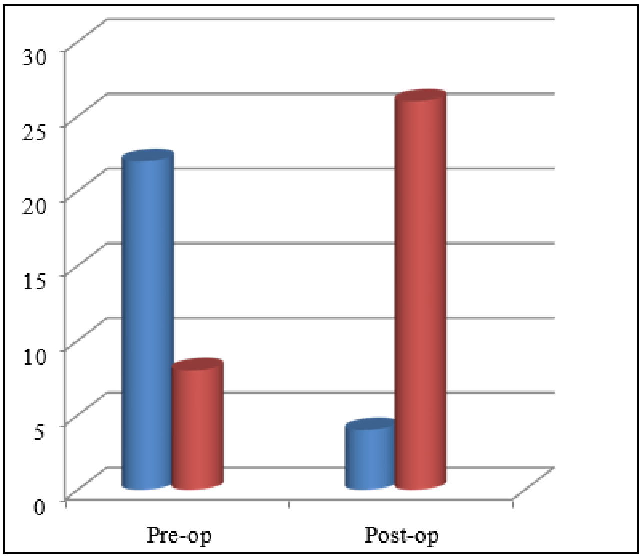
Graph 4: Motor Power Pre - OP and post - OP

In our study group preoperatively, weakness was present in 23 patients of which grade 2 - 3/5 power was present in 11 patients and quadriplegia in 12 patients. Post operatively 19/23 (82.6%) had improved and 07 /07 (100%) who are neurologically intact remained same, with no case of worsening in any of the 07 cases noted.

2 - Spasticity

Proportion of patients with spasticity at baseline value - 22 (73.3%)

Proportion of patients with spasticity at the end of the study - 4 (13.3%)



Graph 5: Spasticity Pre - OP and post - OP

In the lateral mass fusion group 22/30 (73.3%) the patients had spasticity preoperatively, of which 18 (81.8%) improved and 4 (18.2%) remained the same.

Autonomic Function Bladder

Proportion with bladder at baseline value - 6 (20%)

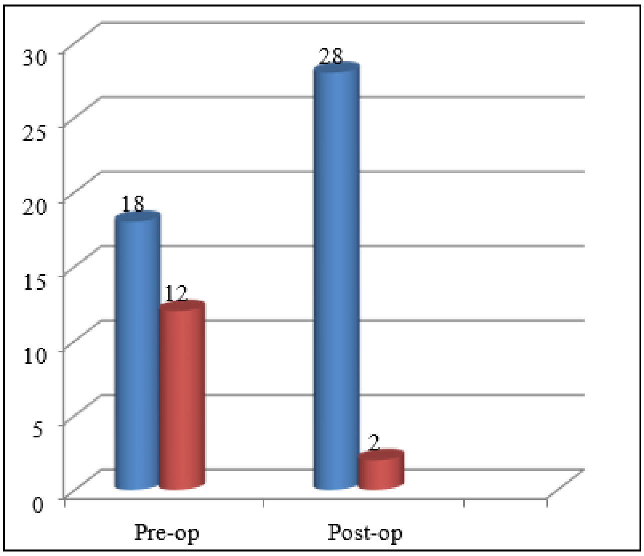
Proportion with bladder at the end of the study - 2 (6%)

In our study, bladder function was affected preoperatively in 6 out of 12 patients who are quadriplegic (50.5%) patients and among them 4 (66.7%) improved after surgery. It was absent in 24/30 (80%) patients who remained the same after surgery.

Sensory

Proportion with numbness at baseline value - 12 (40%)

Proportion with numbness at the end of the study - 02 (6%)



Graph 6: Sensory Power Pre - OP And Post - OP

In the lateral mass fusion group sensory involvement was present in 12 of 30 patients in the form of numbness as pain is excluded from this chart which was present in all 30 patients. Out of which 10/12 (83.3%) patients improved and 2 (16.7%) remained the same, the improvement reaching statistical significance.

Sensory involvement was absent in 18 patients.

Pain

Patients were asked to self - assess their neck pain in the follow up period.

Table 9: Pain

Pain present	Pain absent
3-30	27/30

Pain at the time of presentation was present in 30 of 30 patients in the cervical trauma patients, all patients underwent laminectomy followed by lateral mass fusion.

In the lateral mass fusion group 27/30 (90%) patients responded to the feedback request.

Radiographic Outcome at the end of 3 Months

Duration	N	Fusion at 3 months	No fusion at 3 months
Short	20	18 (90%)	2 (10%)
Long	10	0	10 (33.3%)

n - number of patients (total=30)

Out of 30 patients, 20 (66.7%) patients with short duration of symptoms showed signs of fusion in early group of patients who were operated early (18/20=90%) and (23.3%) patients at the end of 6 months and 3 (10%) at the end of 1 year.

Thus, odds ratio with $P < 0.001$ showed success of early surgery with fusion rate of 69.9 (3.4 to 145.1) according to

Fischer exact test Ztack of p value which is a significant value.

Figure 4

CT image of C3C4C5 lateral mass fixation at the end of 3 months.

Table 10: Long Term Follow Up And Outcomes

Mean follow - up (mo)	20
Range of follow - up (mo)	3-36
Instrumentation failure	0
Adjacent segment disease	0
Late vascular or neural damage	0
Related to instrumentation	0

There were no long - term complications up to 36 months.

4. Statistical Analysis

In this study, the patients were mostly in the age group from 25 - 35 years, with the mean age of the patient being 32 years. Males predominated accounting 87% and females comprised of 13%. All our patients underwent pre - operative imaging workup with dynamic X - rays, CT scan and MRI. Most patients had loss of lordosis (100%), PIVD (95.1%), canal stenosis (98.8%). The presence or absence of these features did not seem to affect the outcome of patients in any of the groups. CSF leak was encountered in two cases of badly traumatized cord injury during the procedure. This was conservatively managed in the post - op period. The lateral mass was completely exposed by dissecting the muscles which resulted in no facet joint injury in any cases.5 out of 30 (1.6%) patients had complications in the immediate post - operative period - 1 case of wound gaping not requiring resuturing, 2 had seromas and 2 had dural tears which were managed conservatively. However, no hardware related complications were noted post - operatively. Good fusion was achieved in almost all cases at the end of 6 months. Neurological improvement was seen in 26 (86.6%) cases of trauma at the end of 3 - 6 months to the extent of self-ambulation and the rest four did not show any improvement and remained quadriplegic at the end of one year follow up. Power improved in 85.7% of patients, sensory deficits improved in 68.2 % of patients, bladder function improved in 87.5% of patients, and spasticity improved in 68.2% of patients. In a 2 year follow up course, none of the post - operative radiographs showed implant dislocation or reduction in body size. There was no evidence of neurovascular injury either during the procedure or immediately following the surgery.

This study documents that early decompressive cervical laminectomy and lateral mass fixation can be utilized for variable cervical spine pathologies with safety and efficiency. The Anderson - Sekhon trajectory can be used as a reliable method to provide adequate fixation with less violation to the adjacent structures.

5. Discussion

Cervical spine is a place of many pathological lesions that could compromise its biomechanical stability. Restoration of stability may ultimately require fixation and placement of hard fixation devices. There are many studies which retrospectively compared the outcomes of various posterior approaches for cervical trauma patients. This study aimed to define the outcomes after the procedures in relation to the safety and stability of cervical spine in traumatic patients. There is debate among spine surgeons regarding the use of anterior, posterior or combined anterior - posterior cervical stabilization for patients whose traumatic injury is amenable to any one of these approaches. Brodke et al. [15] compared anterior versus posterior approach in cervical spinal cord injury and found no statistically significant differences in the rate of fusion, change in neurological status, alignment, or long - term complaints of pain in either group. Lateral mass fixation has world widely gained popularity among spine surgeons with low morbidity and satisfactory outcome. Sekhon L reported the largest series of subaxial lateral mass screw fixation with a total of 1024 screws and no related neurovascular injury observed [16, 17].

Many screw entry points and directions have been described since this technique was first introduced. Roy - Camille advocated the entry point of the screw is the midpoint of the lateral mass and the direction of the screw is to be perpendicular to the posterior aspect of the cervical spine and 10 degrees outward [13], while Magerl proposed starting point is 2 - 3 mm medial and superior to the midpoint of the lateral mass and angling 30 degrees superiorly and 25 degrees laterally [3]. Anderson recommended that the drilling point is 1 mm medial to the midpoint of the lateral mass and that the screw be angled 30 - 40 degrees up and 10 degrees lateral [2]. An et al suggested angling 15 - 18 degrees superiorly and 30 - 33 degrees laterally, with a starting point 1 mm medial to the center `of the lateral mass [14]. Pait et al divided the lateral mass into four quadrants with the upper outer quadrant is the intention for screw insertion in this way its high likely to evade neurovascular injury [18]. Finally, Sekhon recommended that by using Anderson's starting point and then angling 25 degrees laterally and superiorly; this way is safe and easily applied. In regards to the lateral mass of C7 it can be attained with a steeper course without need for C7 pedicle [17].

Frequent clinical and cadaver investigations have been done on lateral mass fixation. Focusing on various trajectories to achieve proper placement of the screw and to avoid neural and vascular damage. Ebraheim et al on his cadaver study revealed the foramen transvesarium is located in line with the midpoint of the lateral mass. So, the direction of the screw is to be laterally to avoid entry into the vertebral foramen [19, 20]. The work done by Xu et al concluded that this technique is likely to avoid neural damage compared to Magerl and Anderson techniques [21, 22]. However, the incidence of nerve root violation when Roy - Camille or Magerl, Sekhon trajectories used is around 3.6%; this is most likely because of the lengthy screw and more lateral trajectory [17, 23, 24].

In terms screw length, Roy - Camille et al recommended 14 - 17 mm [13]. An et al suggested a screw length of 11 mm is effective [14]. Sekhon suggested that a 14 - mm screw is safe and efficient based on the fact that the average vertical distance between the posterior midpoint of the lateral mass and the vertebral foramen from C3 to C6 is approximately 9 - 12 mm [17]. As a result, insertion of a 14 mm screw obliquely should cross the lateral mass smoothly. In addition to that, a 14 mm screw can be bicorticate which adds further stability to the screw in place and causes no violation to the adjacent foramen, the Cadaveric studies of Heller et al concluded that bicorticate fixation with large diameter and non - self tapping screws had the utmost resistance to pullout [17, 25 - 27].

In comparison with other fixation techniques such as cervical pedicle screws, lateral mass fixation is safer, has higher success rate and low co - morbidities. In early studies, the failure rate was higher patients who underwent screw/plate constructs compared with the newer polyaxial screw/rod systems. The former systems were semi constricted with no cross link; which augment the stability of the system. In general, the newer polyaxial screw/ rod systems are more constrained and essentially avoid screw pullout [27 - 29].

6. Conclusion

The procedure laminectomy with lateral mass fixation, is a reliable means of treatment for cervical spine trauma with good improvement in the outcome - motor power, spasticity, sphincter function and sensory symptoms. The risks of complications were low and fusion rates were high when lateral mass screw fixation was used in patients undergoing posterior cervical sub - axial fusion. Occurrence of nerve root injury attributed to screw placement is very less when a divergent angle for screw placement is used. Thus, we can conclude that lateral mass fixation is safe and effective in maintaining alignment in cervical trauma patients associated with cord changes.

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