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Evaluation of the results of sub axial cervical spine injury with incomplete neurology treated by posterior lateral mass fixation with screws and rod and fusion by bone graft

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ABSTRACT

Background: The cervical spine is a highly mobile segment of the spinal column, liable to a variety of diseases and susceptible to trauma. Lateral mass screw fixation has become the method of choice in stabilizing subaxial cervical spine among other posterior cervical fixation techniques. This study aimed to assess the radiological efficacy of the cervical lateral mass screw insertion and rod fixation by Yoon's method.
Methods: This was a prospective observational study conducted in the Department of Orthopedics, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, over a period of two years from July 2014 to June 2016. We included 100 patients who will be admitted with a diagnosis of unstable cervical spine injury during period of study.
Results: The mean age of the patients was (36.87±7.45) years. Majority of the patients were male (80%). Bearing load on the head was the most common (40%) cause. Most commonly involved level of injury was C5/C6 (30%) and type of injury was Fracture Subluxation (35%). Hemorrhage (15%) was the most common per operative complication followed by neck pain (12%), superficial infection (10%), screw pull out (10%), and post-operative khyphotic deformity (10%). Evaluation of final outcome revealed 67% and 33% patients had satisfactory & unsatisfactory results respectively.
Conclusions: The lateral mass screw insertion and rod fixation is a safe and reliable technique with low rate of complication related to instruments. This method enhances neurological recovery, reduce pain and improve working status with early rehabilitation.

Keywords: Bone graft, Fusion, Posterior lateral mass fixation, Screws, Sub axial cervical spine

INTRODUCTION

The cervical spine is a very dynamic part of the spinal column that is prone to damage and a number of disorders. It is a complicated area with a lot of important structures near together. Lateral mass screw fixation has become the method of choice in stabilizing subaxial cervical spine among other posterior cervical fixation techniques whenever the posterior elements are absent or compromised.[1] The injury can be caused by any trauma to the cervical spine that can result from motor vehicle accidents, fall, sports injuries (particularly diving into shallow water), gunshot- wounds, assaults and others. A seemingly minor injury can cause spinal cord trauma if the spine is weakened (e.g., from rheumatoid arthritis or osteoporosis). Cervical spinal injury occurs most frequently in the young male patient with an average age of 35 years.[2] A significant cervical spine injury affects 5-10% of unconscious individuals who arrive at the emergency department following a car crash or fall. The majority of cervical spine fractures mostly happen at two levels. Half of injuries happen at the level of C6 or C7, and one-third happen at the level of C2.3 Cervical spinal cord injury may be complete resulting in quadriplegia and incomplete resulting in anterior cord syndrome, central cord syndrome, Brown-Sequard syndrome, and specific nerve root injury.[4] Spinal concussion can also occur consisting of complete or incomplete spinal cord dysfunction that is transient and generally resolving within 1 or 2 days. Approximately 40% of cervical spinal cord injury patients present with complete spinal cord injuries and 20% with either no cord or only root lesions.[4] Estimated global SCI incidence is 40 to 80 new cases per million populations per year, based on quality country-level incidence studies of spinal cord injury from all causes. This means that every year, between 250,000 and 500,000 people become spinal cord injured.[5] The preferred method for treating lower cervical spine instability following substantial multiple-level cervical laminectomies with reversed lordosis is lateral mass cervical fixation. It is safe and reliable, but it is difficult to be used in patients with abnormal cervical anatomy as it may lead to injury of the spinal nerves or the vertebral arteries during the insertion of lateral mass screws. Roy-Camille was the first to insert screws into the lateral mass of the cervical spine in 1964 in France followed by Louis and Magerl in Switzerland.[6]

Abumi et al, first reported the results of pedicle screw fixation for traumatic lesion of the middle and lower cervical spine in 1994. Thereafter, they expanded indications for cervical pedicle screw fixation to lesions other than spinal trauma. Their clinical results showed that the cervical pedicle screw fixation procedure is one of the potential procedures for posterior reconstruction of the cervical spine in various kinds of disorders. This technique was particularly valuable for simultaneous posterior decompression and reconstruction in the cervical spine.[7] According to Barry et al, the Roy-Camille approach would result in a low incidence of nerve root injury since the screw would be driven toward the midway between the nerve bundles.[8,9] A screw aimed anterolaterally may injure the spinal nerve root because the spinal nerve, with its ventral and dorsal ramus, located anterior, superior, and lateral to the posterior center of the lateral mass. According to Heller et al., the Mager approach has a higher rate of nerve root injury than the Roy-Camille technique.[10] However, the risk of nerve root injury for the Anderson and a technique is not known.[11] Since Roy-Camille first inserted screws into the cervical spine's lateral masses in 1964 to stabilize the unstable spine, posterior plate-screw fixation, with or without supplementary bone grafting, has been utilized to treat an unstable cervical spine brought on by a variety of illnesses. When compared to anterior plating or the more conventional interspinous wiring method, posterior plating with lateral mass screws offers biomechanical stability that is on par with or better.[12] Many surgeons performed lateral mass screw fixation after laminectomies, and it is also applicable in extension to the occiput or the thoracic spines, and in multilevel placement with biomechanical superiority. Various authors such as Magerl, Roy- Camille, Anderson, Louis, and an have developed different methods of placing screws into the lateral mass.[13] The Roy-Camille and Magerl's techniques were the most often used methods for inserting lateral mass screws. These methods served as the foundation for the modification of new insertion angle procedures for deep screw insertion, the results of which have already been published in terms of clinical and radiological safety. But, Yoon's method, one of the modified Magerl's technique, was not precisely studied in long-term follow-up yet, although it was reported safe method.[14]Thus, with a minimum of two years of follow-up, our goal in this study was to evaluate the radiological efficacy of the cervical lateral mass screw insertion and rod fixation using Yoon's method.

METHODS

This was a prospective observational study and was conducted in the Department of Orthopedics, National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka, over a period of two years from July 2014 to June 2016. In our study, we included 100 patients who will be admitted with a diagnosis of unstable cervical spine injury during period of study. These are criteria to be eligible for enrollment as our study participants: a) Patients aged more than 15 years and less than 60 years old; b) Patients with unstable cervical spine injury; c) Traumatic patients with or without fracture; d) Patients without neurological deficiency or incomplete cord injury; e) Patients with cervical spine C3-C7; f) Patients who were willing to participate were included in the study And a) Patients with open spine injury; b) Patients with complete cord lesion; c) Patients with associated head injury; d) Patients with poly trauma; e) Patients with tumor causing incomplete neurological deficit; f) Patients with cervical spine C1-C2 level; g) Patients with any history of acute illness (e.g., renal or pancreatic diseases, ischemic heart disease, asthma, COPD etc.) were excluded from our study.

Surgical technique

The surgery was performed in a steady fashion. Fiberoptic Intubation was used as indicated. All cases were performed with digital fluoroscopic guidance. The lateral masses were initially drilled and tapped prior to laminectomy. Placement of screws was performed after cervical decompression. The entry point was about 1 mm medial to the midpoint of the lateral mass. The screws were angulated about 250 laterally and superiorly to achieve the best position of the lateral mass and to minimize the risk of neural or vascular violation, (modified Anderson and Sekhon techniques). At C7 level, when its lateral mass is included in the fixation a more angulation was affected in comparison with other trajectories. Intraoperatively, each screw position was assessed separately by imaging guidance before the final placement. For biological fusion; chips of auto-graft bone from the posterior elements or artificial bone were placed over the decorticated lateral masses and into the appropriate facet joints after screw insertion. Postoperatively all patient were placed into a hard neck collar and plain x-ray done on the first post operative day. Any intraoperative or postoperative clinical or radiological evidence of nerve root or vertebral artery violation were also evaluated immediately by considering a thin-slice CT scan to evaluate all lateral mass screws position, encroachment into the foramen transversarium or into the neural foram Postoperatively patients were evaluatedmclinically and radiologically at 4 weeks, 2 months, 6 months, 12 months, 24 months and 36 months. Follow-ups, in this study, ranged from 2 months to 3 years. All myelopathic patients discharged for rehabilitation programmed Scoliosis.[15]

Screw insertion techniques

Several techniques of lateral screw placement have been developed. Each has its unique entrance point for screw insertion and screw trajectory. Roy-Camille 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 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 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 to 30 degrees lateral and parallel to the adjacent facet. Anderson et al. modified Magerl's technique.[16] They recommended that the starting point for screw insertion be 1 mm medial to the center of the four boundaries of the lateral mass and screw direction be 30 to 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. 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 C3-C6.[17] For C7 special care should be taken during screw placement because the anteroposterior diameter of the lateral mass is thin. After surgery the patients started using wheel chair and walking aid or without support (if conditions permit) according to their clinical status and degree of fracture and transposition. After discharge each patient was followed up at OPD initially monthly-twice, then after three monthly for one year. On each visit the wound status, motion, presence of any infection, pain at the fracture site, work status or other complications were assessed. Radiographs were taken a teach visit to follow the fracture healing, position of screw & status of fusion. Neurological status was assessed by ASIA impairment scale system. During each visit counseling of the patient about his further job, role of physiotherapy, psychological support and rehabilitation. Patient worn cervical collar for 3 months then discarded it. Patients were allowed to resume normal activities and employment at 3 months or later according to his job or when clinical examination and plain radiographic assessment revealed complete healing of all fractures and a stable fusion. Our study patients were measured by these following scales.

Table 1: Types of grading scales used in our study.

	Grade definition
MRC grading	
Grade 0	No contraction
Grade 1	Flicker of muscle contraction
Grade 3	Contracts with motion but not against gravity
Grade 4	Reduced motor power
Grade 5	Normal motor power.
ASIA impairment scale	
ASIA A	Complete: No motor or sensory function is preserved in the sacral segments S4-S5

Continued.

	Grade definition
ASIA B	Incomplete: Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
ASIA C	Incomplete: Motor function is preserved below the neurological level and more than half of the key muscles below the neurological level have a muscle grade less than 3.
ASIA D	Incomplete: Motor function is preserved below the neurological level and at least half of the key muscles below the neurological level have a muscle grade 3 or more.
ASIA E	Normal: Motor and sensory functions are normal
Fusion grades	
l	Fused with remodeling and trabeculae
ll	Graft intact, not fully remodeled and incorporated, no luciencies
lll	Graft intact with definite lucency at the top or the bottom of the graft
lV	Graft definitely not fused with graft resorption and collapse
Work status	**Criteria**
W1	Return to previous employment (heavy labor) or physically demanding activities
W2	Able to return to previous employment (sedentary) or return to heavy labor with lifting restrictions
W3	Unable to return to previous employment but working full-time at a new job
W4	Unable to return to full-time work
W5	No work, completely disabled
Result	**Criteria**
Excellent	No pain, no restriction of mobility, return to work and level of activity.
Good	Occasional non-radiated pain, relief of presenting symptoms, able to return to modified work.
Fair	Some improved functional capacity, still handicapped and unemployed.
Poor	Continued objective symptoms of root involvement, additional operative intervention needs at the index level irrespective of length of post-operative follow-up.

Statistical analysis

All data were recorded systematically in preformed data collection form. Quantitative data was expressed as mean and standard deviation and qualitative data was expressed as frequency distribution and percentage. Statistical analysis was performed by using SPSS (Statistical Package for Social Sciences). The study was approved by the Ethical Review Committee of National Institute of Traumatology and Orthpaedic Rehabilitation (NITOR), Dhaka, Bangladesh.

RESULTS

Table 2 shows that out of 100 patients 5 patients (30%) were aged below 31 years, 40 (40%) aged 31-40 years and the rest 2 (13.33%) aged >40 years. Mean age was (36.87±7.45) years with range from 28 to 41 years.

Table 2: Age distribution of the study subjects (n=100).

Age (years)	Frequency	Percentage
21-30	30	30
31-40	40	40
41-50	20	20
51-60	10	10
Mean±SD	36.87±7.45	100

Figure 1 shows that out of 100 patients, 80 (80%) patients were male and only 20 (20%) patients were female.

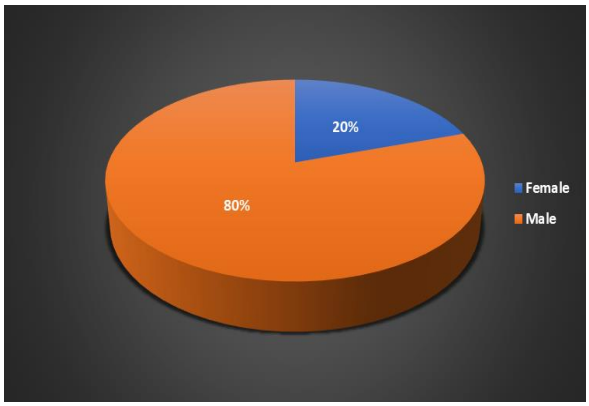

Figure 1: Sex distribution of our study patients.

Table 3 shows in this series the most common cause of injury was carrying heavy weight on head. Out of 100 patients, 40 (40%) patients were in this group. History of History of fall from height was second common cause which was 30%. According to findings of imaging on admission, fracture Subluxation (35%) was the most common type of injury. Then second most common type of injury was fracture dislocation (30%). Only 15%

patients had associated injuries like fracture shaft to tibia and calcaneal fracture. The most common level of injury C5/C6 which was 30 (30%), second most common level of injury was C6/C7 which was 20 (20%).

Thus, percentage of operable growths in our study was less as compared to other series indicating advanced stage disease due to illiteracy, social bindings, less diagnostic tools available, lack of surveillance etc. More than half of colorectal adenocarcinomas are still diagnosed only when the disease involves regional or distant structures.[13] Patients with Dukes

Table 3: Distribution of our study patients by cause, type, and level of injury (n=100).

Cause of injury	No. of patient	%
Carrying heavy weight on head	40	40
History of fall from height	30	30
Road traffic accident	10	10
Fall on the ground	20	20
Types of injury		
Fracture subluxation	35	35
Fracture-dislocation	30	30
Compression fracture	25	25
Associated other injuries	15	15
Level of injury		
C3/C4	10	10
C4/C5	10	10
C5/C6	30	30
C5	15	15
C6	15	15
C6/C7	20	20

Table 4: Neurological status at admission and discharge on the basis of ASIA Grade.

ASIA grade	Admission		Discharge	
	No. of patient	%	No. of patient	%
B	40	40	05	5
C	60	60	25	25
D	00	00	60	60
E	00	00	10	10
Total	100	100	100	100

Table 5 shows the distribution of patients according to per operative and post operative complications. Among all patients, 15 (15%) patients had haemorrhage, there was no per operative injury to dura mater. According to early post-operative complications 12 patients had neck pain (12%), 10 (10%) patients had superficial wound infection and 78 (78%) had no complications. Among all late post-operative khyphotic deformity and 65(65%) patients had no complications.

Table 5: Distribution of study patients by per operative and post operative complications (n=100).

Complications	Frequency	%
Haemorrhage	15	15
Damage to dura	0	00
Damage to spinal cord and nerve	0	00
Dural tear	0	00
Early post operative complications		
Neck pain	12	12
superficial wound infection	10	10
no complications.	78	78
Late post operative complications		
Neck pain	15	15
Screws pull out	10	10
Post operative khyphotic deformity	10	10
No complications	65	65

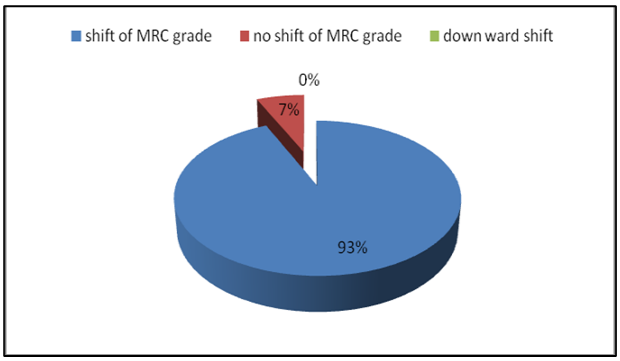

Figure 2: Shift of post-operative MRC grade.

Figure 2 shows the distribution of patients according to shift of post-operative MRC grade. In this study, shift of MRC grade was noted in 93(93%) patients, no shift of MRC grade was noted in 7(7%) patients, there was no (0%) down grade shift of MRC grade.

Table 6: Distribution of patients according to Bony fusion grade and Denis work scale.

Fusion grade	Frequency	%
I	80	80
II	20	20
III	0	00
IV	0	00
Denis work scale		
W1	13	13
W2	54	54
W3	0	00
W4	0	00
W5	33	33

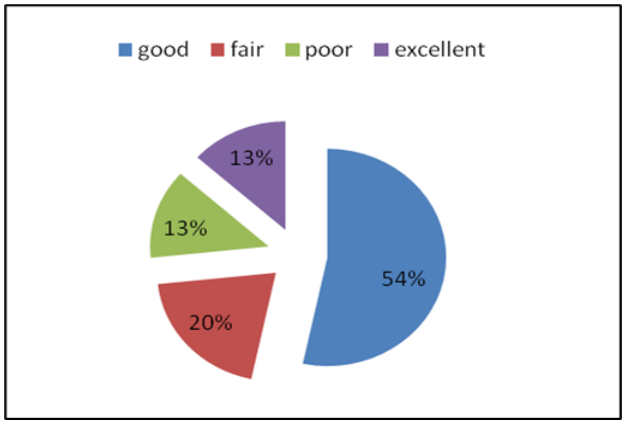

Figure 3: Overall results of our study participants (n=100).

Figure 3 shows the overall results of our study patients. In this study overall results were classified as excellent, good, fair and poor. Majority of patients showed good outcome (54%) followed by fair 20% and only 13% showed excellent outcome as well as poor outcome.

DISCUSSION

In this study, out of 100 patients, 5 patients (30%) were aged below 31 years, 40 (40%) aged 31-40 years and the rest 2 (13.33%) aged >40 years. Mean age was (36.87±7.45) years with range from 28 to 41 years. Laus et al selected mean age 36 years (range 18-66 years).[18] Raja et al stated mean age 34 years (range 8-60 years).[19] Both the results correlate with the findings of this study. High incidence of young adult in the present series is due to working group people. In this study, we found 80 (80%) patients were male and only 20 (20%) patients were female. Singhal et al observed a male predominance (male-75.4% & female- 24.6%).[20] According to the series of Laus et al male was 18 (90.0%) and female were 2 (10.0%).[18]

In this series the most common cause of injury was carrying heavy weight on head. Out of 100 patients, 40 (40%) patients were in this group. History of fall from height was second common cause which was 30%. Laus et al found that common cause of injury was high energy trauma such as motor vehicle accidents (85%).[18] Raja et al found that fall is the most common mode of injury.[19] In this study, fracture Subluxation (35%) was the most common type of injury. Then second most common type of injury was fracture dislocation (30%). Among of our study patients, the most common level of injury C5/C6 which was 30 (30%), second most common level of injury was C6/C7 which was 20 (20%). In thirty-one patients, the spinal fracture levels were C6 in fourteen, C5 in eight, C7 in six, C4 in two, and C3 in one. One patient suffered from a superior articular process fracture of C4 in combination with inferior articular process fracture of C3.[21]

In our study, the distribution of patients' neurological status on admission, highest number of patients 60 (60%) were in ASIA Grade C and the next highest number of patients 40 (40%) were in ASIA Grade B, and during discharge highest number of patients 60 (60%) were in ASIA Grade D & lowest number of patients 05(5%) were in ASIA Grade B. In this study, according to per operative complications, 15 (15%) patients had haemorrhage, there was no per operative injury to dura mater. According to early post-operative complications 12 patients had neck pain (12%), 10 (10%) patients had superficial wound infection and 78 (78%) had no complications. Among all late post-operative complications, neck pain 15 (15%) was the highest among the patients, 10 (10%) patients had screws pull out, 10% had post operative khyphotic deformity and 65 (65%) patients had no complications. Intraoperative complications include fracture of lateral mass in 27 screws placement and nerve irritation in 3 bicortical screws. Early complications include hematoma formation in 2 cases and C5 root palsy in 5 cases after spinal canal decompression. Late complications include pseudarthrosis in 6 cases and screw pull-out in 3 cases.[22] In this study, shift of MRC grade was noted in 93(93%) patients, no shift of MRC grade was noted in 7(7%) patients, there was no (0%) down grade shift of MRC grade. Jeanneret et al reviewed 51 patients who had stabilization with posterior cervical hook plates and lateral mass screws as described by Magerl. At follow-up, fusion was achieved in all patients without loss of alignment. Neurovascular injury resulting from lateral mass screw placement did not occur.[23] In this study, the distribution of patient's according to fusion grades according to Bridewll et al. fusion grade I was noted in 80 patients (80%), grade II in 20(20%). Good bony fusion was observed in all patients except 1 (99.1%). The mean follow-up period was 14 months (4-35 months). 24 In this study, distribution of patients was done according to Denis work scale. The highest number 54 (54%) of patients were found in grade W-2, 13(13%) patients in W-1, and 33(33%) patients in W-5. In this study overall results were classified as excellent, good, fair and poor. Majority of patients showed good outcome (54%) followed by fair 20%. Results are classified according to Modified Macnab criteria for characterizing outcome after surgery.[25] Overall results were classified as excellent, good, fair and poor. Satisfactory (excellent + good) results were noted in 67 (67%) patients and unsatisfactory (fair + poor) results were noted in 33 (33%) patients. Koller et al (2009) in his study showed satisfactory outcome 80% (excellent 53 %, good 27%) and fair 22%. No patient deteriorated in any of the studies.[26]

Limitations

Our study was a single-center study. We took a small sample size due to our short study period. Period of reduction of the dislocation was longer because close radiological monitoring was not available. We could not assess the long-term outcome. After evaluating those patients, we only followed them up for 2 years and did not know other possible interference that may happen in the long term with these patients.

CONCLUSION

In our study, we found this method enhanced neurological recovery, reduce pain and improve working status with early rehabilitation. In spite of a learning procedure, our operative results have been encouraging. Average postoperative neurological recovery was better in operative patients, hospital stay was minimal, less complications and early return to activity after operation. We believe, on the basis of results in the present study, that posterior cervical decompression, stabilization by lateral mass fixation and fusion by bone graft, of the patients who have traumatic unstable cervical spinal injury with incomplete neurological lesion provides substantial benefit. So further study with a prospective and longitudinal study design including a larger sample size with a long term follow up needs to be done to stabilize the lateral mass fixation among patients having bilateral locked facets with posterior column fracture.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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