Original article

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An Analysis of Predicting Factors for Surgical Outcomes in Traumatic Cervical Spine Subluxation Operated with Cages and Plates

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Abstract:

Background: Accidents, falls, assaults, and sports all contribute to the prevalence of cervical subluxation. **Purpose:** Predictive indicators and the extent to which patients recover from surgery for severe cervical subluxation- are explored. Study design: This is a retrospective series. **Patient and methods:** Between March 2019 and August 2021, data on 41 patients with cervical subluxation were gathered, including demographics, presentation, imaging results, surgery details, and the ASIA scale. **Results:** Age, sex, related injuries, degree, and level of subluxation were not significant in a study of 41 individuals with traumatic subluxations. The ASIA scale was demonstrated to be an important predictor of surgical success, and improvements in patient measurement on the other two criteria, also, accounted for the remaining significant p-value. The second aspect is the signal strength of cord edema, which allows for valuable assessment and prediction of the result; for example, in 15 patients, G2 had a high significant p-value 0.001, indicating an improvement of at least one grade in the ASIA scale. Seventeen patients (p-value 0.001) underwent surgery within three days, suggesting that is a substantial and favorable prognostic factor. **Conclusion:** The factors that determine whether or not a patient will heal from a cervical subluxation are identified in our research. Only the moment of operation was under anyone's control; the other two variables (pre-ASIA status and cord edema signal severity) were not. It has been proven that a greater degree of improvement and recovery may be expected after surgery if the procedure is scheduled optimally.

Keywords: cervical, subluxation, traumatic, cord edema.

Introduction

As a result of its flexibility, the cervical spine often sustains fractures and dislocations. There are two main categories of cervical trauma: occipito-cervical (C1-C2) and subaxial (C3-C7) [1, 2]. Accidents, falls, attacks, and sports where contact is made are common causes of subaxial subluxation of the cervical spine. A sudden impact and/or twisting of the neck during trauma may cause damage to the ligaments in the neck. Patients with cervical fractures may have a broad variety of physical manifestations. The fracture site at the back of the patient's neck is clearly swollen and bruised. The patient may have a "step-off" symptom if the dislocation is severe. Cervical spine subluxation fractures and spinal cord injuries are associated with neurologic breathing regulation disruption and sensory and motor affection [3 -5]. External devices, such as cervical collars or a cervical halo, may be used for non-operative stabilization of patients with subaxial spine injury. Treatment of patients without the need for invasive surgery. Non-operative therapy is the gold standard if the cervical spine is not significantly unstable or the patient is not a surgical candidate [6].

Mechanical stress on the spinal cord causes the first phase of injury, and the many vascular abnormalities in the first few days after trauma cause the second phase of injury, which includes symptoms including edema, necrosis, and ischemia [7, 8]. When biochemical signalling cascades are set in motion, other pathogenic processes are set in motion. Since avoiding harm during the primary phase is impossible, efforts instead focus on lessening the impact of harm during the secondary phase. Animal studies suggest that spinal decompression surgery may lessen the risk of further damage and improve motor function [9]. Although decompressing the spinal cord has been found to have a neuroprotective effect and improve clinical outcomes in a number of trials, there is still some disagreement over when this should be done [10, 11]. Many researches have focused on elucidating the importance of the timing of surgical intervention in terms of neurological outcomes.

Surgical fixation may be performed using either an anterior or posterior approach, or through a combination of the two (360° fixation). When there is instability, misalignment, or compression of the spinal cord or cervical nerve roots, open surgical stabilization of cervical fractures is necessary. Comorbidities, surgical risks, and expected long-term outcomes after surgical and/or external fixation - are all crucial factors to consider when making a choice [12- 14].

Patients and methods:

This is a retrospective series. From March 2019 to August 2021, 41 patients with traumatic cervical subluxation were treated in the neurosurgery department at Benha University Hospital, where they were prepared for anterior cervical discectomy utilizing cages and plates, with 6-month follow-up. Our IRB has provided its stamp of approval to this study {M.D.9.5.2023}. A formal informed consent form was submitted and signed by all patients.

The ethics committee in charge of reviewing medical studies provided its approval for this one. Forty-one patients diagnosed with post-traumatic cervical subluxation on cervical CT and treated with open fixation surgery between March 2019 and August 2021- were included in our study. Patients with compressive or burst fractures necessitating corpectomy or multi-segment fixation, those whose fracture was found to be connected to neoplastic or infectious origin (pathologic fracture), patients with ankylosing spondylitis, patients with no neurological deficits, and patients who refuse consent approval were excluded (Fig 1). Information on patient demographics, previous diseases, mechanism of injury, time of neurosurgical assessment after injury, and length of hospital stay- were collected from paper medical records. The timing of the first injury, the length of time spent in the intensive care unit (ICU), and the results of the cervical MRI- all went unrecorded.

Illustrative cases:

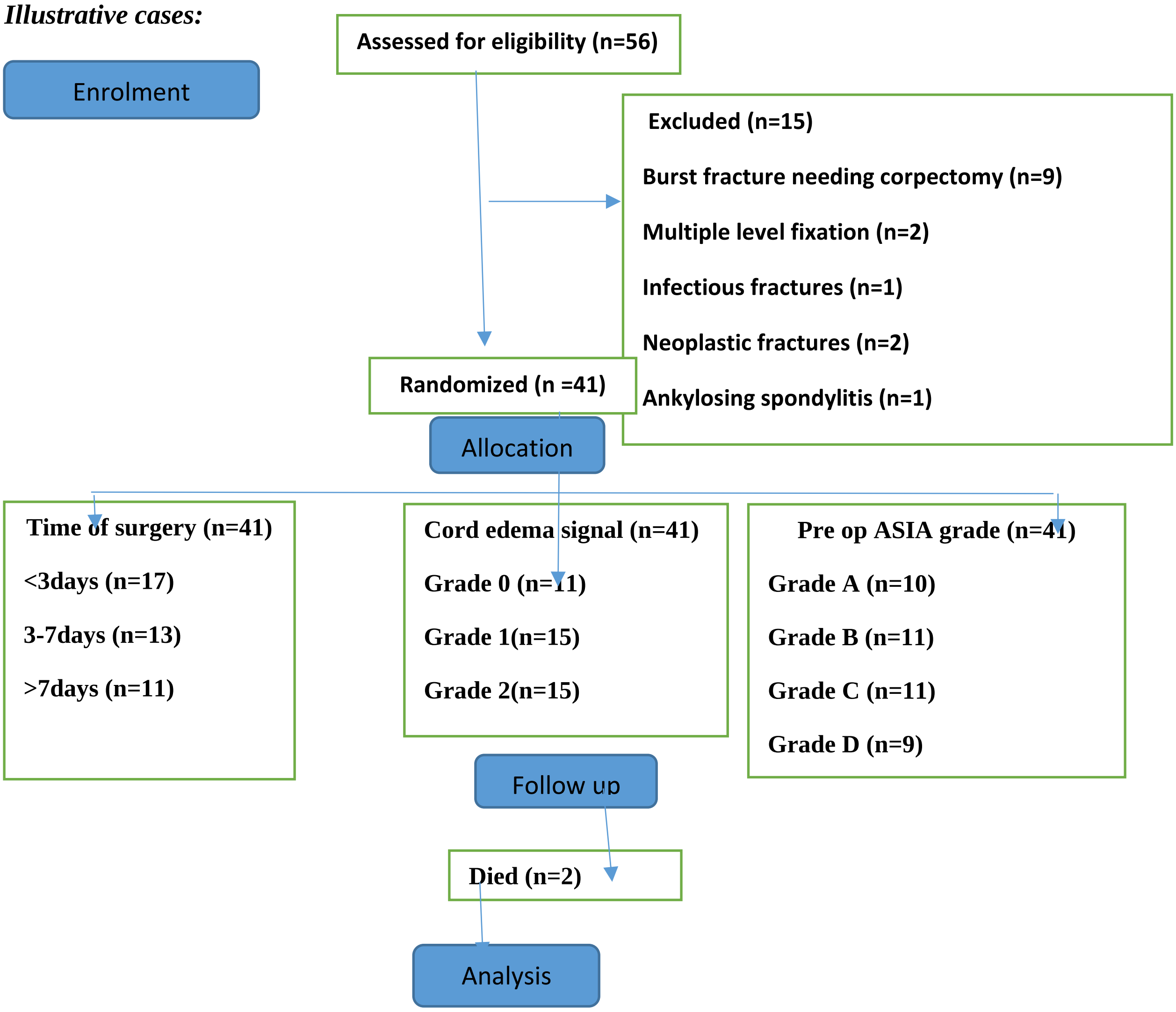

Fig 1: Consolidated Standards of Reporting Trials (CONSORT) Flow Diagram for Study selection

All six patients were under the age of 20, with four men and two women in that age range. There are a total of 20 patients, including 9 males and 11 women, between the ages of 20 and 40. There were five male patients, all in their forties and fifties. Ten patients, five women and five men, all aged 60 and above- were treated. Based on how soon after an accident surgery was conducted, patients were divided into three groups. This study's distribution fell outside the usual range of 8 hours to 7 days following surgery because of the existence of many factors that decrease the likelihood of surgery in the early days, such as related injuries with additional risks, and anesthetic concerns, and an inaccessible MRI. Group A consisted of 17 participants who all had their operations within a span of 3 days (9 males and 8 females). Thirteen patients in Group B (short-term surgery, 3-7 days) (7 males and 6 females). Eleven patients in Group C had surgery; all of them had sustained

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injuries more than 7 days before the procedure (7 males and 4 females). T2-weighted magnetic resonance scans at the most proximal level (15) were used to assign one of three grades depending on the signal intensity (SI) of the spinal cord (grades 0, 1, or 2). Grade 0 SI was assigned to 9 people whose T2-weighted MR scans indicated no evidence of intramedullary SI. There were a total of nine people present (4 men and 5 girls). Fifteen people were given a grade 1 if a blurry line could be made out between them and the next grade (9 males and 6 females). Grade 2 was assigned to 17 people based on the presence or absence of a very sharp and distinct border (10 males and 7 females).

All patients have had pre- and post-operative clinical examinations using the ASIA impairment scale (Table 1). The patient was neurologically evaluated every 6 hours in the first 24 hours following arrival and wore the neck collar until surgery. In all instances, closed reduction was attempted first before surgery; 7 of these attempts were unsuccessful, and surgery was performed within 3 days. The patient had both anterior cervical discectomy and internal cervical fixation.

Statistical analysis:

A special document, the "Investigation report form," was used to document all that had happened. In order to tabulate, analyze, and analyze this data, we turned to SPSS (Statistical Package for the Social Sciences) version 26 (SPSS Inc., PASW Statistics for Windows version 26. (Chicago, Illinois, USA)). Descriptive statistics like mean and standard deviation (SD)- were calculated. Data were analyzed statistically using tests like the paired t-test and analysis of variance to see whether there was a significant difference between the groups (analysis of variance) The Mann-Whitney U-test was used to compare two groups utilizing continuous, non-parametric data, with a significance level of P 0.05.

Results:

The main causes of cervical subluxations were 8 patients due to assaults, 10 due to falling, 15 motor vehicle accidents, 5 due to sports activities, and 3 heavy objects subjected to the neck.

Table 1: ASIA Impairment scale.

Grade	*Description*
A	***Complete injury***. *No motor or sensory function is preserved in the sacral segments S4 or S5.*
B	***Sensory incomplete***. *Sensory but not motor function is preserved below the level of injury, including the sacral segments*
C	***Motor incomplete***. *Motor function is preserved below the level of injury, and more than half of muscles tested below the level of injury have a muscle grade of less than 3 (see muscle strength scores table).*
D	***Motor incomplete***. *Motor function is preserved below the level of injury and at least half of the key muscles below the neurological level have a muscle grade of 3 or more.*
E	***Normal***. *No motor or sensory deficits, but deficits existed in the past.*

Table 2: Post-operative ASIA regarding age and sex in studied cases.

Age	**post op ASIA**		**p-value**
	Mean	**S.D**	
<20y (n=6)	2.50	0.55	0.5
20y -40y (n=20)	3.00	1.30	
40Y-60Y (n=5)	2.20	1.48	
>60y (n=10)	2.90	0.99	
Sex	post op ASIA		p-value
	Mean	S.D	
Male (n=23)	2.74	1.32	0.8
Female (n=18)	2.89	0.96	

Table 3: Post-operative ASIA regarding associated injuries in studied cases

Associated injuries	**post op ASIA**		**p-value**
	Mean	**S.D**	
Head and chest injuries (n=16)	2.69	1.01	0.6
Head and orthopedic injuries (n=13)	3.08	1.38	
Chest and orthopedic injuries (n=12)	2.67	1.15	

no significance in the surgical outcome after 6 months of follow-up**,** but long stay in ICU and hospital stay.

Table 4: Post-operative ASIA regarding subluxation level and type of facet subluxation in studied cases

Subluxation level	**post op ASIA**		**p-value**
	Mean	**S.D**	
C3-4 (n=8)	3.50	.93	0.3
C4-5 (n=11)	2.36	1.50	
C5-6 (n=14)	2.64	1.01	
C6-7 (n=6)	3.17	0.98	
C7-D1 (n=2)	2.50	0.71	
Type of facet subluxation	post op ASIA		p-value
	Mean	**S.D**	
Unilateral (n=14)	3.21	0.80	0.1
Bilateral (n=27)	2.59	1.28	

With no significant *p–value*. Facet subluxations were unilateral in 14 patients and bilateral in 27 patients with no significance in surgical outcome.

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Table 5: Preoperative and post-operative ASIA in studied cases.

		Pre-op ASIA				Total	p-value
		A	**B**	**C**	**D**		
post op ASIA	A	2	0	0	0	2	<0.001*
	B	2	0	0	0	2	
	C	5	6	1	0	12	
	D	0	4	7	2	13	
	E	0	0	3	7	10	
	Death	1	1	0	0	2	
Total		10	11	11	9	41	

With a significant impact in predicting surgical outcomes with better results in patients with high grades in ASIA with a significant *p-value <0.001*

Table 6: Pre- and post-operative ASIA regarding cord edema signal and timing of surgery in studied cases with a p-value.

cord edema signal	**Pre-op ASIA**		**post op ASIA**		**p-value**
	Mean	**S.D**	**Mean**	**S.D**	
G0	2.45	0.82	3.45	0.82	0.005*
G1	1.80	0.68	3.20	0.78	0.002*
G2	0.40	0.63	1.93	1.22	<0.001*
	<0.001*		<0.001*		
timing of surgery	Pre-op ASIA		post op ASIA		p-value
	Mean	**S.D**	**Mean**	**S.D**	
<3 days	0.76	0.66	2.53	1.28	<0.001*
3-7days	2.00	0.82	3.08	0.64	0.002*
>7days	1.91	1.38	2.91	1.45	0.005*
	0.003*		0.25		

Table (6): Cervical MRIs were done after trauma with missed data about MRI timing after surgery as there were multiple reasons for the delay of investigations as ICU admission, referred lately, comatose patients with associated injuries. Signal intensity was divided into 3 grades with G 0 (n= 11), G 1(n=15), and G 2 (n=15), with a significant p-value**.** According to the time of surgery, 17 patients had surgery within 3 days, 13 patients had surgery between 3 and 7 days, and 11 patients had surgery after 7 days. The surgical outcome was better in patients operated on <3 days then 3-7days, and least in >7days. This controllable factor should be considered to achieve the best chance for patients.

Case (1) this male patient sustained C7-D1 subluxation in a vehicle accident and presented with pre-operative ASIA grade D and preserved sphincters. The MRI of the cervical spine showed no medullary signal at Grade 0 and the CT scan showed a C7-D12 subluxation with bilateral locked facet joints. The patient had an anterior discectomy, reduction of subluxation, unlocking of the facet, cage insertion, plate, and screws for three to seven days (Fig 2 A, B, C). Following surgery, the patient's ASIA improved to grade E.

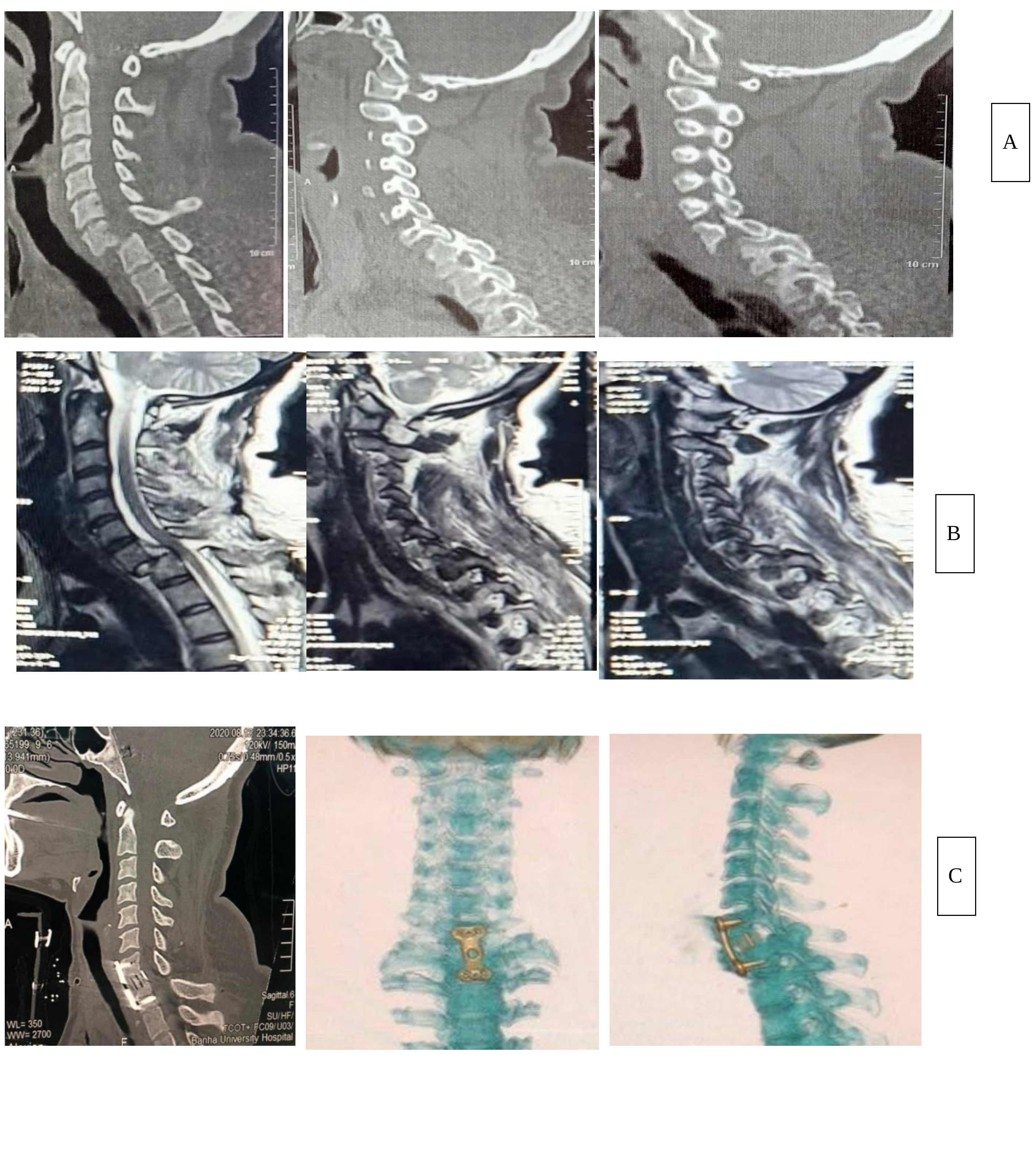

Fig 2: A: CT cervical spine with post-traumatic C7-D1 subluxation with bilateral locked facet (B): MRI T2 cervical spine with post-traumatic C7-D1 subluxation with the bilateral locked facet with G0 signal intensity. (C): post-operative CT cervical spine with discectomy, cage insertion with plate and screws with facet unlocking

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Case (2) Female patient with a preoperative ASIA grade of A and compromised sphincters owing to a C4-5 subluxation sustained in a sports-related injury. The MRI of the cervical spine revealed a medullary signal of Grade 2, and CT imaging of the spine revealed C4-5subluxation with bilateral locked facet joints. Within 3 days, the patient had surgery that included an anterior discectomy, a reduction of subluxation, facet unlocking, and the insertion of a cage, plate, and screws (Figs 3 A, B, C). Improved to Grade C ASIA after surgery.

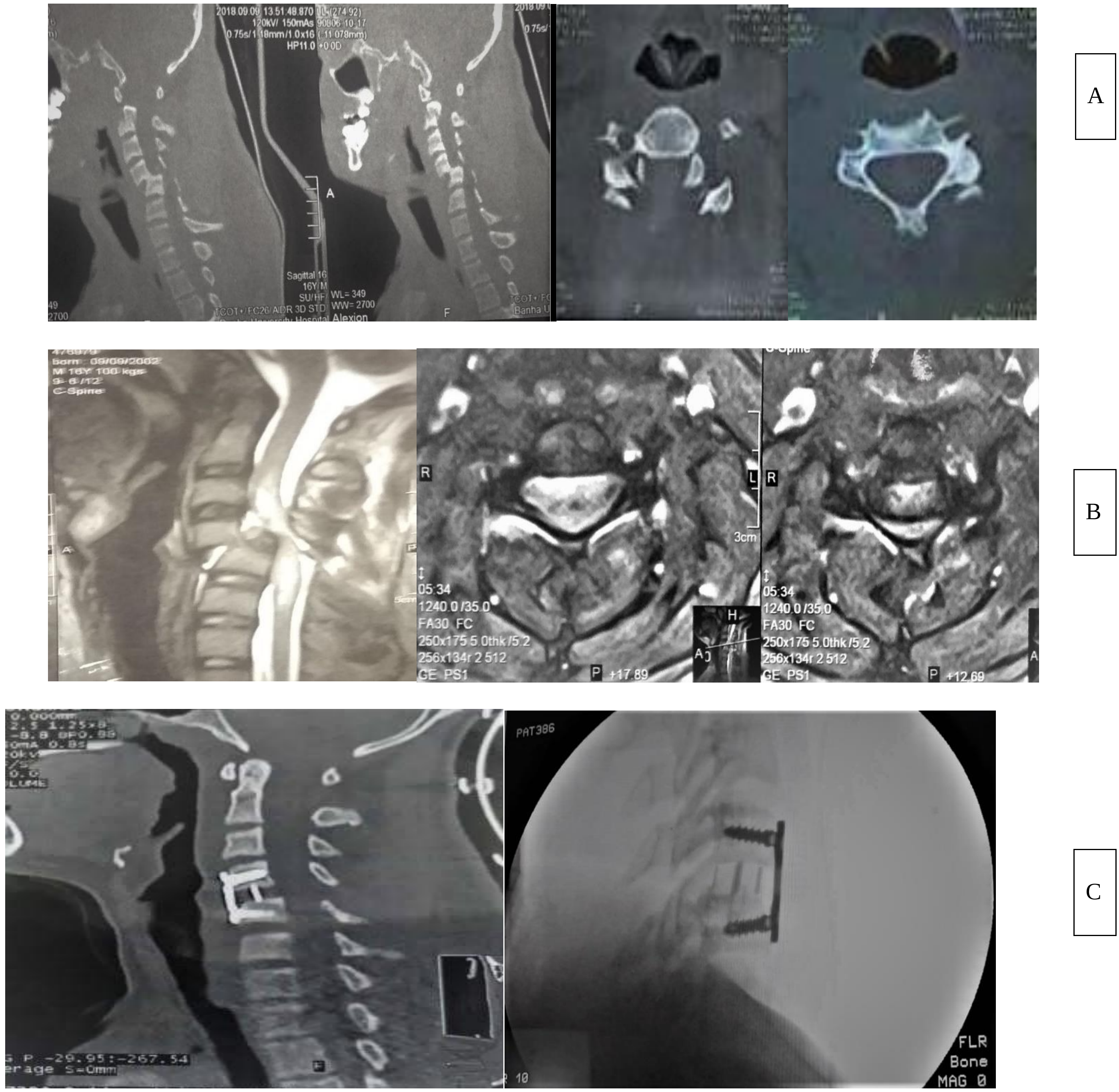

Fig 3 (A): CT cervical spine with C4-5 subluxation in sagittal views and bilateral locked facet in axial views. (B): MRI T2 (sagittal and axial views) cervical spine with C4-5 subluxation, with G2 signal intensity and cord compression. (C): CT cervical spine with C4-5 cage with plate and screws. C arm image intraoperative

Discussion:

Traumatic cervical subluxation is a common result of collisions, sports injuries, and physical violence. In every case, CT and MRI scans of the cervical spine led to the decision to do an open reduction, discectomy, cage insertion, and titanium mesh surgery. There was wide variation among 41 people in terms of radiological cord signal, ASIA status before surgery, ASIA status after surgery, and total surgical time.

One of the most common causes of long-term impairment is damage to the spinal cord [1, 4]. A spinal cord injury may have a severe effect on a person's autonomy if they lose control of physiological functions like urine and excrement [11, 15, 16].

The purpose of this study was to investigate the variables- that affect rehabilitation after traumatic cervical cord damage complicated by subluxation-. Sex, age, the presence of concomitant injuries, and the presence and severity of subluxation- were all criteria that were not statistically significant in determining surgical success. While it was proven that the severity of the cord edema signal and the pre-operative ASIA grade were factors beyond human control, the period between injury and the start of surgical decompression and stabilization was (time after injury). Bed rest, early corticosteroid medication, and closed reduction- may all improve outcomes despite these unavoidable factors. Depending on a variety of factors—including the severity of ASIA grade following subluxation, cord signal edema, and time for surgery—patients who exhibit post-operative improvements of one or more ASIA grades may enjoy better functioning.

Some research [13] on 103 patients with cervical spine injuries found no statistically significant differences in neurological outcomes between early-operated patients (after 24 hours) and late-operated patients (after >24 hours).

According to research by Mirza SK, [14], only 30 individuals showed better motor function following early surgery (within 3 days). But there is no improvement, according to Frankel's ratings. After 4 days of follow-up, there were no statistically significant changes between the early and late groups on the AISA or the Short Form Health Survey [5]. Previous research [6], analyzing data from 291 individuals did not provide conclusive results on the connection between surgery time and neurological recovery.

Even though some research has suggested that delaying surgery might have negative consequences. A meta-analysis showed that the neurological prognosis for patients who had surgery within the first 24 hours was better than those who underwent surgery later or received conservative therapy [12]. In a study with 27 patients [4], found that there were statistically significant improvements in AIS grades for both the early group (within 8 hours) and the late group (after 24 hours). According to research by Fehlings [7], two full AIS grades may be gained by early surgery. Eleven researchers analyzed data on 69 individuals with subaxial cervical spine injury. According to the authors, the reduced risk of complications, faster recovery time, and decreased risk of mortality associated with early surgery (within 48 hours) warrant serious consideration.

In a retrospective analysis of 103 SCI patients by Moinay, [17], found that initial AIS grade, damage degree, and time of surgery were the most important independent variables affecting prognosis. As opposed to the inflexible AIS grade and injury level, the timing of the operation is largely up to the discretion of the treating physician. The early group had a far larger increase in AIS grades than the late group. According to research by Ter Wengel, [18], surgical timing decisions are heavily influenced by the extent of the first

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neurological impairment. Partial traumatic spinal cord injury (tSCI) is handled differently than complete tSCI or traumatic central cord injury (TCCI). Patients with partial tSCI benefit most from early surgical intervention. In terms of neurologic recovery, a meta-analysis [19], indicated that surgical decompression performed within 8 hours post tSCI was more effective than delayed surgery.

It was difficult to draw conclusions from the studies since they used varying time frames (in hours and days) to define early and late surgery. Our study divided surgical procedures into three time intervals: <3 days, 3 days to 1 week, and 1 week or more.

Three factors were utilized to determine the patient's improvement in our research. Pre-operative ASIA severity is an important initial predictor since it is a constant that is proportional to the degree to which the patient is at risk. It was used to measure the degree of response to the first two factors.

The second important predictor is the intensity of the signal and the degree of edema in the spinal cord. Since understanding the scope of progress is vital, it was split into three parts. Significant p-values for groups G 0 (n=11), G 1 (n=15), and G 2 (n=15). When outcomes were evaluated using the ASIA scale, those with a G2 were more likely to have an ASIA (A, B) and have opportunity for improvement across more than one grade, whereas those with a G0 were more likely to have an ASIA (D) and have potential for improvement across just one grade.

The third factor to think about is the scheduling of surgery. Surgery was performed on 17 patients before 3 days, on 13 patients between 3 and 7 days, and on 11 patients beyond 7 days. Patients operated on within 3 days fared better than those operated on within 7 days and those operated on after 7 days. The greatest possible outcome for patients requires taking this modifiable element into account. Therefore, it is a reliable indicator of prognosis improvement.

This study had a few caveats, including a small sample size (due to exclusion of patients who required surgery for a corpectomy or multiple subluxations), a lack of complete data (due to factors such as delayed MRI scans following injury), and an evaluation of functional outcome based on the ASIA grading system.

Our study's ultimate goal is to help doctors anticipate how much their patients will improve after receiving treatment for severe cervical subluxations by identifying factors that affect recovery time. Two fixed parameters (pre-ASIA and cord edema signal intensity), were shown to be reliable predictors of the outcome, whereas, a third variable was found to be malleable (the timing of surgery). The best surgical results are often seen in patients who have the procedure as soon as it is medically feasible.

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Author contribution: Authors contributed equally in the study.

List of Abbreviations:

ASIA: American Spinal Injury Association Impairment Scale
IRB: Institutional Review Board
TCCI: Traumatic Central Cord Injury
tSCI: traumatic Spinal Cord Injury

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