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Comparative Analysis of Surgical and Non-Surgical Approaches in the Treatment of Traumatic Cervical Spine Injuries

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Abstract: Traumatic cervical spine injuries (CSIs) are associated with high morbidity and mortality rates. Management options differ depending on injury stability and neurological status. This study aimed to compare the results of surgical and conservative treatments for patients with CSIs. A retrospective analysis of 55 patients with CSIs (C1–C7) was performed. Patients were assessed clinically, neurologically (Frankel grading), and radiologically. Spinal stability and neurological compromise guided management decisions. Conservative treatment involved traction and bracing, while surgical treatment involved anterior/posterior decompression and fusion. Thirty four out of the 55 patients underwent surgery and 21 were treated conservatively. Neurological recovery was observed in 56% of the surgically treated patients and 71% of the conservatively treated patients. Mortality rate was higher in surgical patients (17.5%) than that in conservatively managed patients (14%). Excellent results were reported in 42% of the patients, more commonly in surgical patients (47.5%) than in conservative patients (38%). Early surgery (<72 hrs) showed no improvement and high death rates, whereas delayed surgery (>7 days) yielded better results. This study demonstrated that conservative management yielded similar or improved neurological outcomes and reduced mortality in patients with stable injuries. Surgery is still required for unstable injuries, but timing is essential to maximize prognosis.

Keywords: Trauma; Cervical spine injury; Surgery; Conservative; Outcomes

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Introduction

Traumatic cervical spine injuries (CSIs) are a major cause of morbidity and mortality globally and pose a challenging acute trauma problem. These injuries range from trivial ligamentous strains to catastrophic fractures with osteo-ligamentous instability and may cause calamitous neurological impairments, such as paraplegia, quadriplegia, or even death. [1-3] The specific anatomical and biomechanical

features of the cervical spine, as well as its proximity to the spinal cord and critical neurovascular structures, make these injuries most challenging to evaluate, treat, and manage. [4-6]

Cervical spine trauma is most frequently associated with high-energy processes, including motor vehicle crashes, fall from heights, athletic injuries, and penetrating injuries. Such injuries tend to be acute but occasionally present several days or even weeks after the initial insult. [1] There must be prompt recognition and early stabilization since instability of the cervical spine can proceed quickly to incurable spinal cord injury if treated inadequately. [7] Consequently, global trauma guidelines emphasize the importance of early cervical immobilization and systematic assessment of all patients with suspected cervical spine injuries. [7,8]

Precise cervical spine injury diagnosis is dependent on careful clinical assessment, supplemented with standardized imaging practices such as radiography, computed tomography (CT), or magnetic resonance imaging (MRI). [8] Clinical assessment alone has been shown to fall short, especially in patients with altered mental status or distracting injuries, thus emphasizing the need for high-sensitivity diagnostic paradigms. [8,9] Early determination of the patterns of injury, instability, and neurological involvement is essential to facilitate subsequent management plans. [8,10]

Traumatic cervical spine injury management options fall into two main categories: conservative (nonsurgical) and surgical. The selection of these modalities depends on a variety of factors, such as the nature and site of the injury, amount of instability, presence of neurologic deficits, and comorbid conditions. Surgical intervention is directed at achieving spinal stabilization, neural structure decompression, and early mobilization, most commonly indicated by severe displacement, instability, or worsening neurologic deficit. [7,8] Conservative management in the form of immobilization in rigid cervical collars or halo vests and regular observation are still suitable for injuries that are not unstable and present no neurological deficits. [7,8] The decision-making process is complicated, and the subject of much controversy in terms of the relative outcomes, complication rates, and long-term prognoses linked to each.

Current literature highlights the need for individualized, evidence-based management algorithms to maximize neurological recovery and functional outcomes, with a reduction in treatment-related morbidity. Although progress has been made in diagnostic imaging and surgical methods, the best treatment for particular patterns of injury remains under active investigation. [8] The present study compared outcomes related to surgical versus conservative treatment of traumatic cervical spine injuries, adding to the body of evidence that informs clinical decision making in this challenging patient population.

Materials and Methods

This study was a retrospective analysis conducted on 55 patients diagnosed with traumatic cervical spine injury involving vertebral levels C1 through C7. All patients with traumatic cervical spine injuries at any cervical vertebral level (C1–C7) were included. Patients were identified retrospectively from hospital records and followed up longitudinally to assess clinical, radiological, and functional outcomes. The exclusion criteria included non-traumatic cases, unstable vital signs, acute paralysis unrelated to trauma, known vertebral disease, previous cervical spine surgery, or altered mental status. The study was approved by the Institutional Ethical Committee and informed consent was obtained from all participants.

Initial evaluation: This evaluation included a detailed history and clinical examination to determine neurological level and involvement. Neurological examination comprised the assessment of motor power, sensory function, reflexes, and detailed grading using the Frankel classification. Upper and lower limb motor strength were systematically evaluated across multiple muscle groups, and sensory modalities such as pain, temperature, proprioception, vibration, and fine/crude touch were assessed.

Reflex testing included planter, anal, cremasteric, bulbocavernosus, and deep tendon reflexes, corresponding to the appropriate spinal segments.

Imaging: Radiological assessment of traumatic cervical spine injuries followed a standardized protocol, beginning with a series of plain radiographs. These included the anteroposterior (AP) view, lateral view, right and left oblique views, open-mouth (odontoid) view of the upper cervical spine, and swimmer's views to evaluate the cervicothoracic junction. This imaging modality was selected to identify fractures, dislocations, ligamentous injuries, and alignment abnormalities essential for initial diagnosis and management planning. If clinical symptoms persisted despite normal radiographs, patients underwent flexion-extension radiographs performed under physician supervision, ensuring pain-free movement to assess dynamic stability. Radiographs were evaluated for abnormal soft tissue signs (e.g. retropharyngeal and retrotracheal space widening), vertebral alignment abnormalities (loss of lordosis, kyphotic angulation, interspinous widening, and vertebral rotation), and joint abnormalities, such as disc space narrowing or facet rotation. Evidence of fractures, ligamentous avulsion, and subtle vertebral body changes has also been documented. Computed tomography (CT) scans were used primarily for unconscious patients or those with inconclusive radiographs. CT slice thickness varied from 1.5 mm for the upper cervical spine to 2-3 mm for the lower cervical spine to optimize injury detection and assessment. Magnetic resonance imaging (MRI) was performed preoperatively to evaluate disc retropulsion, posterior ligamentous complex injuries, spinal cord status, and soft tissue edema or hemorrhage. MRI findings guided surgical planning and prognosis.

Stability Assessment: Spinal stability was determined using the criteria established by White and Punjabi, which incorporated clinical findings, radiographic measurements of translation (>3.5 mm or 20%), angulation (>11° on resting X-rays or >20° on flexion-extension views), and neurological status. A composite score was used to classify stability; a score of 5 or greater indicated instability.

Treatment: Among the 34 patients who underwent operative management, 21 received conservative treatment. The patients were followed-up for durations ranging from 5 months to 3 years, with an average follow-up period of 9 months. Conservative management included immobilization with collars, halter traction, cervical tongs, or braces, depending on injury characteristics and stability. Operative intervention was indicated for irreducible dislocations, unstable fractures, disc prolapse with cord compromise, or conservative treatment failure. Surgical approaches (anterior or posterior) involved decompression and fusion using tricortical iliac crest, rib, or fibular grafts, with or without instrumentation (e.g. cervical plating, cages). The postoperative protocols included traction duration, mobilization timelines, and rehabilitation measures.

Outcome Measures and Scoring Systems: The treatment outcomes were evaluated at the final follow-up, as well as functional and neurological improvements (Frankel grade changes). Each parameter was scored and categorized as Excellent, Good, Fair, or Poor.

Data Collection: Patient demographic data, injury details, clinical presentation, neurological status, imaging findings, treatment modalities, complications, and follow-up outcomes were meticulously recorded using a standardized protocol. This included a detailed history, examination, neurological grading, radiological findings, treatment details, and complications.

Statistical Analysis: Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) V16.0 to evaluate the cervical spine injury outcomes. Descriptive statistics are reported as counts and percentages throughout the study cohort.

Results

There were 55 (100%) patients with cervical spine injuries that were traumatic in nature; the majority were young to middle-aged, with 28 (51%) between 21 and 40 years, 16 (29%) between 41 and 60 years,

10 (18%) below 20, and only 1 (2%) above 60 years; 46 patients (83.5%) were males and 9 (16.5%) females. The most frequent mechanism of injury was falls from height (16 patients, 29%), followed by ground-level falls (14, 26%), road traffic accidents (13, 23.5%), falls of weight (10, 18%), and other mechanisms (2, 3.5%). As for the time from injury to admission, 22 patients (40%) arrived within 24 hours, 10 (18%) arrived between 24 and 48 hours, 5 (9%) between 48 and 72 hours, and 18 (33%) arrived for more than 72 hours. Lower cervical levels were most frequently involved, particularly C5–6 (13, 24%) and C6–7 (11, 20%), whereas C1–2 injuries were infrequent; three patients (5%) sustained SCIWORA. Complete spinal cord lesions were present in 16 patients (29%), of whom only 4 (25%) improved neurologically, whereas incomplete lesions were present in 39 patients (71%), of whom 30 (77 %) improved neurologically. The primary mechanism was flexion (36%), and of all mechanisms, the SCIWORA and Anderson-DeAlonzo fracture types had the greatest proportions of neurological improvement (100% and 83%, respectively). On the Frankel grading, most patients presented with incomplete deficits: 10 patients (18%) had Grade A 6 (11%) had Grade B, 15 (27%) had Grade C, 19 (35%) had Grade D, and 5 (9%) had Grade E, suggesting that most patients presented with considerable but incomplete neurological impairment.

Among the 55 patients with cervical spine trauma, 32 (58%) had stable injuries, of which the majority were treated conservatively (18/32, 56%), with an insignificant mortality rate of 2 deaths (6.25%). On the other hand, 23 (42%) had unstable injuries, the majority operated on (20/23, 87%), but with a significantly higher mortality rate of seven deaths (30%). Surgery was performed in 34 patients and 21 were treated conservatively. Of those who received operative treatment, one patient underwent surgery within 72 hours (no neurological improvement and 1 death); 9 underwent surgery from 72 hours to 7 days (3 improved neurologically [16%], 3 died [50%], and 24 underwent surgery over 7 days from the time of injury (16 improved neurologically [84%], 2 died [33%]. 19 of the 34 operating room surgical patients (56%) demonstrated neurological improvement, and 6 deaths (17.5%) occurred in the operating group and 9 deaths (16%). (Table1)

Table 1. Stability, treatment groups, injury-to-surgery interval, neurological improvement, and mortality in patients with traumatic cervical spine injury

Characteristics	Subgroup	Operative Group n (%)	Conservative Group n (%)	Died n (%)	Total n (%)
Stability	Stable	14 (44%)	18 (56%)	2 (6.25%)	32 (58%)
	Unstable	20 (87%)	3 (13%)	7 (30%)	23 (42%)
	Total	34	21	9	55
Injury to Surgery Interval (Operative Only)	**Duration**	**n (%)**	**Improvement n (%)**		**Died n (%)**
	0–72 hours	1 (2.9%)	0		1 (17%)
	72 hours–7 days	9 (26.5%)	3 (16%)		3 (50%)
	>7 days	24 (70.6%)	16 (84%)		2 (33%)
	Total	34 (100%)	19 (56%)		6 (17.5%)

Among the 34 patients who underwent operative intervention, anterior fixation and fusion was the most frequent procedure in 18 cases (53%), instrumented posterior fusion in 8 cases (23.5%), non-instrumental fusion in 7 cases (20.5%), and combined anterior and posterior fusion in 1 case (3%). Of the 21 patients treated conservatively, tong traction was observed in 16 cases (76%), improvement in 11 cases (69%), halter traction in 3 cases (10%), improvement in 2 cases (66%), and Minerva cast in 2 cases

(14%) with improvement in 2 cases (100%). A hard cervical collar was employed as a measure for post-operative immobilisation in 45 of 51 cases. Regarding the primary treatment site, 19 patients (34.5%) were treated at the study center (11 improved [58%], 3 deaths [16%]), 24 patients (43.5%) at local centers (16 improved [67%], 3 deaths [12.5%]), and 12 patients (22%) saw no primary treatment (6 improved [50%], 3 deaths [25%]). 19 patients (34.5%) were administered methylprednisolone, and 12 (63%) improved neurologically, while out of the 36 patients (65.5%) who were not administered methylprednisolone, 17 (47%) improved neurologically. (Table 2)

Table 2. Treatment Modalities, Adjuncts, and Outcomes in Patients with Traumatic Cervical Spine Injury

Choice of method in operative treatment (n=34)		**n (%)**	
Non-instrumental fusion		7 (20.5%)	
Anterior fixation & fusion		18 (53%)	
Instrumented posterior fusion		8 (23.5%)	
Anterior and posterior fusion		1 (3%)	
Choice of method in conservative treatment (n=21)	**n (%)**	**Neurological Improvement n (%)**	
Tong traction	16 (76%)	11 (69%)	
Halter traction	3 (10%)	2 (66%)	
Minerva cast	2 (14%)	2 (100%)	
Choice of orthosis in postop immobilisation		n (%)	
Four post collars		2 (3.9%)	
SOMI brace		4 (7.8 %)	
Hard cervical collar		45 (88.2 %)	
Total		51 (100%)	
Primary treatment location (n=55)	**n (%)**	**Improvement n (%)**	**Died n (%)**
At our center	19 (34.5%)	11 (58%)	3 (16%)
At local center	24 (43.5%)	16 (67%)	3 (12.5%)
Not taken	12 (22%)	6 (50%)	3 (25%)
Total	55 (100%)	33 (%)	9 (%)
Methylprednisolone use	**n (%)**	**Neurological improvement n (%)**	**No improvement n (%)**
Given	19 (34.5%)	12 (63%)	7 (37%)
Not given	36 (65.5%)	17 (47%)	19 (53%)
Total	55 (100%)	29 (53%)	26 (47%)

The most frequent complications that were observed included bed sores (26 cases), urinary tract infection (19), and respiratory complications (11), and the less common events included wound infection (3),

esophageal fistula (3), GI complications (2), tongue site infection (2), dural leak (1), non-anatomical reduction (1), and implant failure (1); deep vein thrombosis, graft dislodgement, cord injury, or vascular injury were not observed in any case. Mortality evaluation showed that 6 of 34 patients (17.5%) who were treated operatively and 3 of 21 patients (14%) who were treated conservatively died, giving a total mortality rate of 16.5% in the series. (Table 3)

Complications	**Total (n)**
Bed sore	26 (47%)
Urinary tract infection	19 (35%)
Deep vein thrombosis	0 (0%)
Respiratory problems	11 (20%)
Tong site infection	02 (4%)
Esophageal fistula	03 (5%)
Non anatomical reduction	01 (2%)
Implant failure	01 (2%)
Graft dislodgement	0 (0%)
Cord injury	00 (0%)
Dural leak	01 (2%)
Vascular injury	00 (0%)
Wound infection	03 (5%)
Gastrointestinal complication	02 (4%)
Mortality	
Treatment method	**Total**	**Mortality**
Operative	34	6 (17.5%)
Conservative	21	3 (14%)
Total (n)	55 (100%)	9 (16.5%)

Table 4. Final outcomes of traumatic cervical spine injury by treatment group

Final result	**Total**	**Operative treatment group**	**Conservative treatment group**
Excellent	23 (42%)	13 (38%)	10 (47.5%)
Good	10 (18%)	4 (17%)	6 (28.5%)
Fair	12 (22%)	10 (29%)	2 (9.5%)
Poor	1 (2%)	1 (3.5%)	0 (0%)
Expired	9 (16%)	6 (17.5%)	3 (14%)
Total (n)	55 (100%)	34 (61.8%)	21 (38.2%)

Table 4 presents the final outcomes of the 55 patients with traumatic cervical spine injury, comparing the operative (34 patients, 61.8%) and conservative (21 patients, 38.2%) treatment groups. In total, 23 patients (42%) had an excellent outcome (13 (38 %) in the operative group and 10 (47.5 %) in the

conservative group). Good results were observed in 10 patients (18%): 4 (17%) operated on and 6 (28.5%) conservatively. In 12 patients (22%), fair results were found, mostly in the operative group (10, 29%), as opposed to 2 (9.5%) in the conservative group. Only one patient (2%) in the operative group had a poor outcome, while none in the conservative group. A total of 9 patients (16%) died: 6 (17.5%) underwent surgery and 3 (14%) were managed conservatively.

Discussion

Traumatic cervical spine injuries (CSIs) are a leading cause of morbidity and mortality, with extensive long-term neurological impairment in most patients. Treatment of these injuries is usually either surgical or conservative, with the decision largely based on the nature of the injury (stable or unstable), severity of neurological impairment, and duration since injury. The present study compared the outcomes of surgical and conservative management of 55 patients with traumatic cervical spine injuries. In the present study, male predominated (83.5%), with a large proportion of young adults (51% between 21-40 years).

This demographic pattern concurs with trends reported in several studies. El Masri, stated that the majority of traumatic cervical spine injuries happen in the young and middle-aged adults and have a preponderance in males (72%). [11] The present study revealed the same pattern, where road traffic accidents, fall from height, and fall on the ground were the most prevalent injury mechanisms. This is in line with the observation of Okereke et al., who indicated that motor vehicle accidents and falls are the most common causes of cervical spine injuries, contributing to 50-60% of cases. [8] The interval from injury to hospital arrival is also key to the outcomes. In this cohort, 40% of patients arrived within 24 h, which corresponds to the ideal treatment window advocated by Scheyerer et al., who emphasized that early treatment in the first 24 h markedly improves neurological outcome. [12] Delayed presentation, similar to that seen in 33% of this cohort (after 72 h), has been associated with poorer outcomes and increased rates of complications. [13]

The most common cervical levels injured in this series were C5–6 (24%) and C6–7 (20%), which is in accordance with the literature. Scheyerer et al. described similar patterns, and lower cervical segments were more frequently affected because of their mobility and anatomy. [12] Moreover, the rate of complete spinal cord lesions (29%) in this population is consistent with the general trend in traumatic cervical spine injury. Conversely, incomplete injuries (71%) were more prevalent and had a better prognosis for recovery, which is consistent with the findings of El Masri and Okereke et al. [11,8] The Frankel grading system, as applied in this study, demonstrated that 71% of patients had incomplete deficits. This is important because incomplete spinal cord injury has a better chance of neurological improvement than complete SCI. Jiang et al., documented that recovery in incomplete injury was 75-80%, which is comparable to the 77% improvement in this group for incomplete injuries. [13]

Treatment depends on the stability of the cervical spine and the neurological status of the patient. Of the 55 patients in this study, 58% had stable injuries and were treated conservatively and 42% had unstable injuries and required surgery. These ratios conform with those identified by Chen et al., who reported that approximately 60% of cervical spine injuries were stable and managed conservatively, whereas 40% were unstable and needed operation. [14] The overall mortality rate was 16.5% in this study, with higher mortality among surgical patients (17.5%) compared to conservative therapy (14%). This increased mortality in the surgical group could be due to the nature of the injuries, as most of the patients who were sent for surgery had unstable injuries. In comparison, El Masri reported an overall mortality rate of 20% in surgically treated patients with traumatic cervical spine injuries, which is somewhat higher, but reflects similar patterns of increased mortality in those requiring surgery. [11] Okereke et al., found a mortality rate of 12.5% in patients treated surgically, indicating some variation but reinforcing the trend that more severe injuries, often requiring surgery, tend to have higher mortality. [8] The surgical patients in this group were segregated based on the timing of surgery.

Surgery within 72 h resulted in poor results, with no neurological improvement and 100% mortality. This was compared with surgery performed later (more than 7 days post-injury), with 84% of the patients having neurological improvement and just 33% dying. The delayed surgery group performed better, a result that corroborates the study of Jiang et al., which noted that delayed decompressive surgery (after 72 h) had a 50% mortality rate but a greater rate of neurological recovery when compared to early surgery. [13] They theorized that delayed surgical management might produce some spontaneous stabilization and recovery, which may account for better results in this group. Of the 34 patients who underwent surgery, the most frequent procedures were anterior fixation and fusion (53%), and posterior fusion (23.5%). These methods are well-established in the literature as routine techniques for the treatment of unstable cervical injuries. El Masri also stressed the value of anterior decompression and fixation in unstable fracture patients, akin to the experience within this cohort. [11]

Furthermore, Okereke et al. highlighted combined anterior and posterior procedures in patients with complicated instability, but this was only common in this study (3%). [8] Conservative treatment in this analysis was mainly applied in the form of tong traction (76%) and resulted in neurological improvement in 69% of the patients. This is in agreement with the results of El Masri, who found that traction is effective in stabilizing the cervical spine, especially in non-displaced fractures. [11] Halter traction was applied in 10% of the patients, with a 66% rate of neurological improvement, which is comparable to the success rates obtained by Okereke et al. [8] However, the application of Minerva casts, with a 100% rate of improvement in the two patients treated, indicates the efficacy of conservative treatment in selected cases and is in line with previous studies that have reported good outcomes with non-surgical treatment for stable injuries.

The most frequent complications observed in this population are bed sores (26), urinary tract infections (19), and respiratory infections (11). These are common complications in critically ill patients with traumatic spinal injury, especially in those who are immobile or have long-term hospitalization. Scheyerer et al. also reported similar complications, of which respiratory failure and infection were the most common causes of morbidity in patients with cervical spine injuries. Notably, the rate of more serious complications such as graft dislodgement or deep vein thrombosis was extremely low in this group, which could be an indication of good postoperative care protocols. [12] The mortality in this group (16.5%) was slightly less than the 20% mortality observed by El Masri in surgically treated patients with traumatic cervical spine injuries. [11] This disparity may result from differences in injury severity, patient population, or healthcare environment. The trend persists in that mortality is greater in patients treated surgically, especially in those with unstable injuries.

The ultimate results of the patients in this study were classified as excellent, good, fair, or poor. Overall, 42% of the patients had excellent results, while 47.5% of the conservative patients had excellent outcomes compared with 38% of the surgical patients. This is in line with Chen et al., who reported that conservative management had a greater percentage of excellent results in patients with stable injuries. [14] Conversely, 29% of surgical patients had fair results, which is in line with Okereke et al., who reported that surgery for severe injuries tends to have a more widespread distribution of results, with a large percentage of patients having fair or poor outcomes. [8] The mortality rate was higher in the surgical group (17.5%) than in the conservative group (14%), which is consistent with the findings of a number of other studies [11,13], implying that although surgery can enhance neurological outcomes in unstable injuries, it is also associated with an increased risk of complications and death.

Conclusion

The decision between surgical and conservative management of traumatic cervical spine injuries should be individualized based on the type and severity of the injury as well as the patient's neurological status. Although surgical intervention may offer improved stabilization and neurological outcomes in certain cases, conservative treatment remains effective in stable injuries with minimal risk of progression.

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