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ARTICLE

Clinical outcome of closed reduction of cervical spine injuries in a cohort of Nigerians

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Abstract

Study design A prospective observational study.

Objectives To evaluate the effectiveness of closed reduction of cervical spine injuries (CSIs) using cervical traction and identify probable complications.

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Methods Consecutive CSIs managed by closed reduction using Gardener–Well's Tongs traction were prospectively analysed. The data included imaging and neurological examinations findings, Frankel grading, and extent of reduction. Reduction of 95% or more was deemed satisfactory. The primary outcome measures were extent/degree of reduction and neurologic status classified as improved, same, or worse. Other complications were taken as secondary outcome measures.

Result Seventy-four patients, 49 males, mean age 35.2 years (SD 9.7) were included. In all, 78.4% presented within 72 hours of injury. In total, 85.1% had road traffic crashes. Anterior subluxation was seen in 86.5%. The degree of displacement was <25% in 36/74 (48.6%), 25–50% in 19/74 (25.7%), 50–75% in 8/74 (10.8%), and >75% in 11/74 (14.9%). Traction reduction was done after 7 days of injury in 52.7% and same day of injury in 1.4%. Reduction weight ranged from 2 kg to 60 kg. Reduction was satisfactory in 67.6% and failed in 32.4%. In all, 81.1% of patients remained neurologically the same, while 18.9% improved. Causes of failed reduction were facet lock (15), old injury (8), new-onset/worsening pain (3), and over-distraction (2). Complications of closed reduction were over-distraction (5), tong pull-out (2), new-onset/worsening pain (2), and skull perforation (1).

Conclusions Satisfactory closed reduction is feasible in patients with CSI and significant malalignment. The method is associated with few complications.

Introduction

The cervical spine is the most vulnerable and most frequently injured portion of the vertebral column because of its high degree of mobility [1–3]. Injuries follow high velocity trauma in road traffic collisions, falls, sports and diving accidents, while disruption of spinal alignment arises from hyperflexion, hyperextension, and axial loading forces with or without accompanying rotation [1, 2, 4]. The malalignment can be due to subluxations and distractions of the various cervical joints or/and fractures involving the cervical bones. The neurologic injuries may be complete or incomplete with potential for recovery based upon degree of injury.

In order to prevent further neurologic injury from instability and continuous neuronal compression, it is

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pertinent to reduce or realign the cervical spine [5, 6]. This provides the optimal condition for healing and recovery of neurologic functions. The most effective means of initial reduction and management of cervical spine injuries (CSIs) is controversial [7]. Many studies favour early and rapid aggressive reduction while others disagree especially in complete injuries. Current guidelines indicate that early reduction improves neurologic outcome by restoring anatomic alignment and canal diameter, and decompressing the cervical spinal cord [4, 5, 8].

Reduction may be by open (operative) or closed (non-operative) means. Both may be applied in some instances. Surgery for injuries with neurological deficits is promoted as the standard of choice, but this is debated by some clinicians who query the scientific basis for the decision, the proof of clinical benefit, and the role of expanding technical possibilities and approval of implant usage by regulatory bodies [9]. The arguments against surgical decompression and/or fixation include the risks of secondary trauma during surgery, risks of early mobilisation, delays in reaching a trauma centre where an experienced surgeon is available, and the unclear decision between long segment and short segment/minimally invasive procedures [9]. These arguments have projected the excellent neurologic outcomes that follow conservative management (including traction use), which require simultaneous attention to the injured spine and other body systems in a recumbent position for up to 4–6 weeks post trauma [10]. No evidence suggests that surgical realignment and stabilisation or deformity correction or decompression achieves equal or superior outcomes to conservative care, and the opinion that surgery gives better neurological outcomes in incomplete injuries do not consider that neurological recovery may be better if no surgical intervention is carried out [10].

Non-operative or closed reduction is simple, efficient, quick, cheap, reliable, and safe [6, 11–14]. It was first described by Walton in 1893, and expounded by Crutchfield who introduced special tongs for in-line traction in 1933 while Evans and Kleyn popularised reduction under anaesthesia [5, 11, 15]. Closed reduction using continuous axial traction is advocated in the conscious patient before stabilisation through operative fixation [5, 16]. The methods of closed reduction in current use include manipulation under anaesthesia (MUA), Halter traction, Halo traction and Skull tong (Crutchfield or Gardener–Wells tongs (GWTs)) traction [1, 2, 4, 5, 7, 11–16]. Skull tongs are cheap and provide a firm grip on the skull; and skull tong traction is commonly used in low-income settings like Nigeria.

Closed traction reduction is usually monitored using bedside fluoroscopy, magnetic resonance imaging (MRI), or simple X-ray guidance [4, 5, 13]. No consensus exists on the initial reduction weight, maximal reduction weight, and maintenance weight [7, 12]. Some authors begin with a 3-pound (1.4 kg) weight per level of cervical injury and increase by 5–10 pounds (2.3–4.5 kg) every 5–15 min [2, 4, 5]. Various maximal weights, up to 80% of the patient's body weight have been reported [2, 4, 5, 11–13]. In one study, the maximal weight used was 150 pounds (68 kg) [12].

Despite its numerous advantages, the use of skull tongs must be performed with caution as the surgeon has little or no control over the cervical vertebrae at the moment of disengagement. Thus, the potential disadvantages are over-distraction, tong pull-out, increasing pain and worsened neurologic deficits [2, 4, 5, 7]. Other potential complications during the patient's in-hospital course while in traction are skull penetration, tong-site sepsis, osteomyelitis, and penetrating brain injury with extradural, subdural, or intracerebral haematoma [1, 2, 4, 5, 7, 16, 17]. Appropriate techniques in inserting the GWT may mitigate these complications. The complications of prolonged immobilisation, such as pressure sores, orthostatic pneumonia, autonomic dysfunction, deep vein thrombosis, urinary tract infection, etc, could also occur in patients on cervical traction. Thus, patients with CSI require a holistic approach to their management and rehabilitation. While we practice a holistic model of care in our centre, and some other centres in Nigeria, post-hospitalisation rehabilitation is often problematic as there are no dedicated spinal injury rehabilitation centres in the country.

The use of closed traction reduction of CSIs has been reported in various parts of Africa, with differing reported outcomes and effectiveness [18–23]. In our neurological surgery service, established in 1962, CSIs are managed mainly by closed reduction using Crutchfield's calipers (before 1988) and GWT (after 1988) traction. The patients may be maintained on traction for long periods (6–10 weeks) or have operative stabilisation if they can afford surgery. In the absence of regular fluoroscopy service, our closed traction reductions are routinely done under X-ray film guidance. The effectiveness, outcome, and complications of the technique, as practiced in our centre for decades, have not been previously documented. This study was, thus, designed to determine the outcome of closed reduction of CSIs using GWT traction under X-ray film guidance in our patients.

Methods

We prospectively reviewed all consecutive CSI managed with closed reduction using the Gardener-Wells traction over a 3-year period (February 2012 to February 2015). Ethical approval was obtained from the institution's ethical committee. Patients with CSI managed conservatively or operatively without GWT insertion and traction were excluded from the study. Patients were enrolled on admission. The data collected for this study included their demography, presenting symptoms and duration, aetiology, diagnosis, X-ray findings (pre-, intra-, and post-traction reduction), bony and neurologic level of injury (pre- and post-traction reduction), Frankel grading (pre- and post-traction reduction), interval between injury and traction, weight to achieve maximal reduction, complications of closed reduction and of traction use. The degree of displacement on X-ray or computed tomography scan was graded as <25%, 25–50%, 50–75%, and 75–100%.

Intervention technique

The technique of GWT insertion was uniform. Previously sterilised tongs were inserted under strict aseptic technique at the bedside using 2% Lignocaine local anaesthesia. The tongs were inserted in neutral position on either side about 4 cm or two finger breaths above the pinna. Slight variations in position about 2 cm anterior or posterior to the neutral site were accepted, for suspected flexion and extension injuries, respectively. The maintenance traction weight was 1–2 kg per level of cervical injury. Closed traction reduction was done in the central X-ray suite under close supervision by a doctor not below the rank of Junior Resident. Serial X-ray images were obtained with incremental traction weights of 5 kg, which was left for about 10–20 min before the spine was imaged. This allowed adequate traction and relaxation of the muscles and ligaments. Reduction was discontinued if there was satisfactory vertebral realignment, worsening pain or neurologic deficits, or new-onset pain or neurologic deficits. Following satisfactory reduction (deemed as reduction up to 95% or more), the weight was reduced to the maintenance range, the lower value being preferred. The radiographic assessment pre and post traction were done by a neuro-radiologist.

Outcome measures

The primary outcome measures were extent/degree of reduction (based on percentage linear/translational motion of adjacent vertebrae) and neurologic status following closed reduction (using the motor and sensory levels of injury). The Frankel grading (pre- and post-reduction) were also quantified, and were classified as improved, same, or worse. Secondary outcome measures were the complications of closed reduction and GWT traction use. The reasons for failed reduction were noted.

Limitations of our study

Our study was conducted in a tertiary hospital with limited bed spaces reserved for spinal injuries. Many patients with these injuries could not be admitted and managed, and were referred to other centres. In addition, we utilised the Frankel grading rather than the International Standard for the Neurologic Classification of Spinal Cord Injuries (ISNCSCI) because we lack the resources needed to perform the ISNCSCI in our centre.

Results

Seventy-four patients with CSI underwent GWTs traction reduction over the study period. The mean age of the patients was 35.2 (standard deviation 9.7) years and 66.2% (49) of them were males (Table 1). Aetiology was primarily motor vehicular accidents (74.3%) and most (48.6%) of these were passengers (Table 2).

Most patients complained of neck pain (94.6%). Many (78.4%) presented within 3 days of injury, with only 31.1% presenting within 24 h of injury. The majority of patients had anterior subluxation (86.5%). Of the patients, 48.6%

Table 1 Age and gender distribution

Variable	Total, $N = 74$ (n/N, %)
Age group (years)	
≤20	4 (5.4)
21–30	24 (32.4)
31–40	28 (37.8)
41–50	14 (18.9)
>50	4 (5.4)
Gender	
Male	49 (66.2)
Female	25 (33.8)

Table 2 Aetiology of CSI

Aetiology	Number of patients	Percentage (%)
Motor vehicular accident	55	74.3
Driver	11	14.9
Passenger	36	48.6
Pedestrian	3	4.1
Status not stated	5	6.8
Motorcycle accident	8	10.8
Driver/rider	3	4.0
Passenger	4	5.4
Pedestrian	0	0
Status not stated	1	1.4
Falls	8	10.8
Others	3	4.1
Total	74	100

Table 3 Bony level of injury and interval to reduction

Variable	*n/N* (%)
Bony level of injury	
C1	2 (3%)
C2	1 (1%)
C3	3 (4%)
C4	19 (26%)
C5	20 (27%)
C6	21 (28%)
C7	8 (11%)
Total	74 (100.0)
Interval to reduction	
<24 h	1 (1.4)
1–3 days	14 (18.9)
4–7 days	20 (27.0)
>7 days	39 (52.7)
Total	74 (100.0)

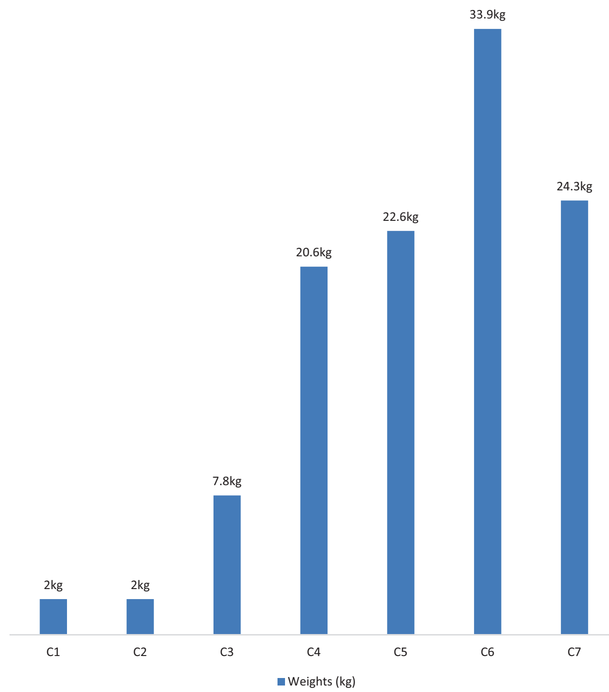

Fig. 1 Average weight for each bony level of traction reduction

had less than 25% displacement, 25.7% had 25–50% displacement, 10.8% had 50–75% displacement, and 14.9% had more than 75% displacement.

The interval to reduction from time of accident was >7 days for about half of the patients (52.7%) (Table 3). The reduction weight ranged from 2 kg to 60 kg, with the highest average weight used being 33.9 kg (at C6 bony level) and the lowest being 2 kg (at both C1 and C2 bony levels) as shown in Fig. 1. The majority of patients (67.6%) had a satisfactory extent of reduction (Fig. 2). Moreover, there were no patients with neurological deterioration post-traction and 14 patients (18.9%) had improved neurological status post-traction (Table 4). More than half of the patients (62.2%) had complete realignment. The majority of patients (85%) had no complications while one patient had skull perforation.

The extent of reduction was not significantly associated with age, gender, neck pain, motor deficits, sphincter dysfunction, duration of symptoms, nature of injury, degree of displacement at presentation, and interval to reduction (Table 5). The only variable that was significantly associated with outcome post-traction was traction reduction weight. Weights ≤20 kg resulted in improved neurological status post-traction as compared with weights >20 kg ($p = 0.022$) (Table 6).

Variables, which were associated with extent of traction reduction at 10% level of significance, were further analysed by logistic regression. The weight with the most satisfactory traction reduction was between 11 kg and 30 kg ($p = 0.004$). Reduction weights between 11 kg and 30 kg were approximately nine times more likely to have satisfactory reduction than weights >30 kg [odds ratio 8.99 (confidence interval 2.04–39.50)]. Patients who reported no sensory deficit had more satisfactory traction reduction than those who reported sensory deficit ($p = 0.05$).

Discussion

This study examines the effectiveness of closed traction reduction of CSI using the GWT traction in the current era in a Nigerian tertiary hospital. Successful traction was noted using the extent of reduction and the post-traction neurologic status.

The mean age and the male preponderance in this series are similar to other studies on CSI [4, 12, 20, 22, 23]. One of such studies found an average age of 42 years and males accounted for 76.8% of the patients [4]. In another study, the average age was 44 years and men were twice affected than women [24]. Other studies from Nigeria found average ages of 32.6 (±1.9 years) to 40.1 (±1.1 years) [20, 22, 23]. Young adult males are more likely to be involved in road traffic accidents (sustaining various injuries including CSI) because they are more mobile, adventurous, and more likely to be involved in sporting activities. The aetiology in this study is similar to previous studies though injuries from motorcycle accidents and passenger injuries were higher compared with prior studies. In similar studies, motor vehicular accidents accounted for 50–64.7% of the patients among which passengers accounted for 22–23.5% [4, 13, 24].

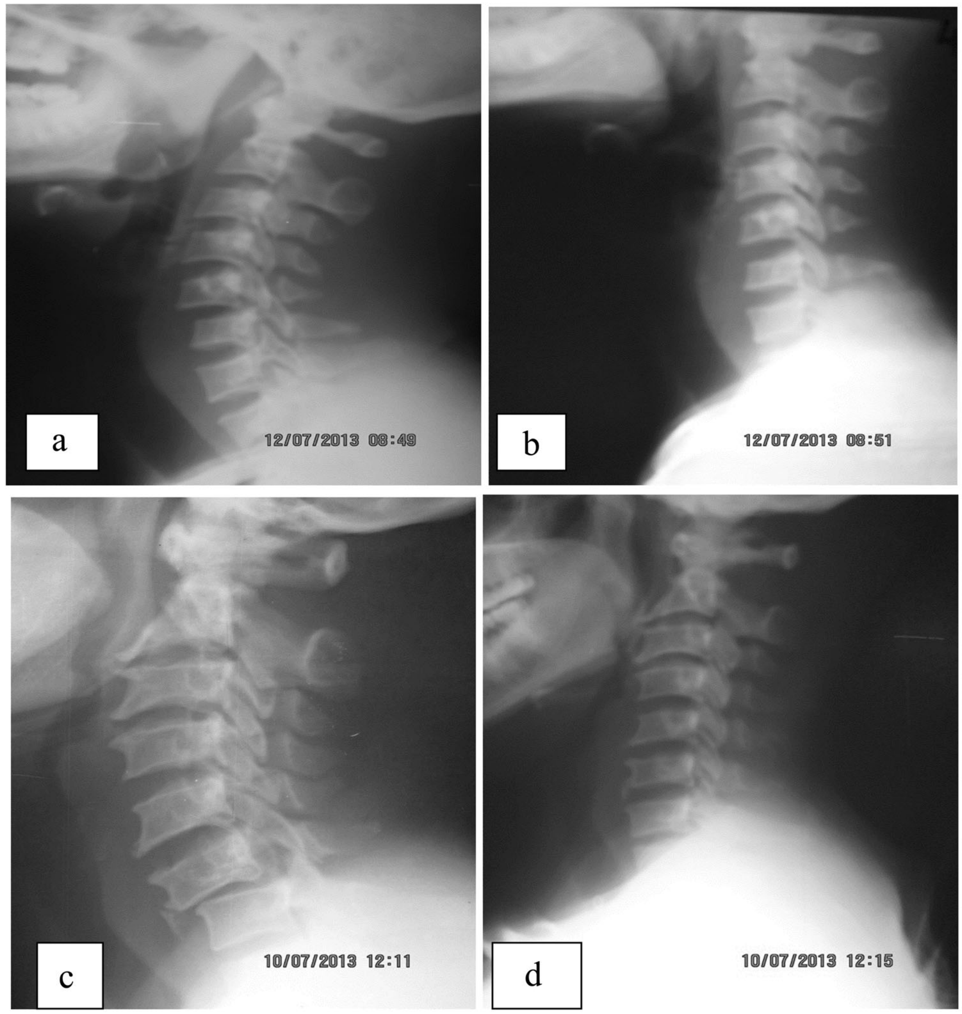

Fig. 2 a, b Cervical spine X-rays showing 25% C5 on C6 subluxation with satisfactory reduction on closed traction. **c, d** Cervical spine X-rays showing 20% C6 on C7 subluxation and angulation with satisfactory reduction on closed traction

Table 4 Neurological status pre and post-traction

Pre-traction neurological status (Frankel grading)	Post-traction neurological status (Frankel grading)					
	A	B	C	D	E	Total
A	38		1			39
B		5	2	2		9
C			3	1		4
D				4	8	12
E					10	10
Total	38	5	6	7	18	74

Neck pain was the most common complaint among the patients (94.6%). Most (78.4%) of the patients presented within 72 h of injury, with 31.1% presenting within 24 h. In other studies, the majority (76.5%) presented within 24 h of injury [13]. The possible reasons for late presentation by the patients include lack of organised emergency rescue and ambulance services, poor road network, and few neurosurgical/spinal services. Poverty and ignorance are rampant among many patients and their care-givers, causing them to seek the services of traditional or alternative care providers at the initial instance.

The nature of injury has been variously classified by different authors [3, 4, 7, 13]. Lower CSIs are reportedly more prevalent than upper cervical injuries. Thus, a higher proportion of our patients had the bony level of their injuries at C6 (28%), C5 (27%), and C4 (26%) (Table 3). This is similar to another study where the main injury bony levels were C5–6 (35%), and C6–7 (35%) [13]. In the series by Hofmeister et al., lower CSIs were more prevalent (65.98%) being more at C6/7 (24.4%) and C5/6 (19.24%) [24].

There is no consensus on the exact average weight to be used for initial traction reduction or maintenance traction [12]. The reduction weight in our series ranged from 2 kg to 60 kg, with the highest average weight (used at C6 bony level) being 33.9 kg and the lowest average weight (used at C1 and C2 bony levels) being 2 kg. Some researchers begin

Table 5 Association between extent of reduction and other variables

Variable	Extent of reduction		*t*-test	*p*-Value	
	Satisfactory	Not satisfactory			
Mean age (years)	36.5 ± 9.9	32.5 ± 8.9	0.040	0.103	
Variables	Extent of reduction		Total, *N* (%)	χ^2	*p*-Value
	Satisfactory, *n* (%)	Not satisfactory, *n* (%)			
Gender					
Male	31 (63.3)	18 (36.7)	49 (100.0)		
Female	19 (76.0)	6 (24.0)	25 (100.0)	1.225	0.268
Neck pain					Fisher's exact = 0.097
Yes	49 (70.0)	21 (30.0)	70 (100.0)		
No	1 (25.0)	3 (75.0)	4 (100.0)	3.497	
Motor deficit					Fisher's exact = 0.527
Yes	39 (65.0)	21 (35.0)	60 (100.0)		
No	11 (78.6)	3 (21.4)	14 (100.0)	0.954	
Sensory deficit					
Yes	21 (56.8)	16 (43.2)	37 (100.0)		
No	29 (78.4)	8 (21.6)	37 (100.0)	3.947	0.047*
Sphincter dysfunction					
Yes	28 (63.6)	16 (36.4)	44 (100.0)		
No	22 (73.3)	8 (26.7)	30 (100.0)	0.765	0.382
Duration of symptoms					
≤24 h	15 (65.2)	8 (34.8)	23 (100.0)		
>24 h	35 (68.6)	16 (31.4)	51 (100.0)	0.084	0.793
Nature of injury					Fisher's exact = 0.484
Subluxation	42 (65.5)	22 (34.4)	64 (100.0)		
Retrolisthesis	8 (80.0)	2 (20.0)	10 (100.0)	0.816	
Degree of displacement					
≤50%	39 (70.9)	16 (29.1)	55 (100.0)		
>50%	11 (57.9)	8 (42.1)	19 (100.0)	1.091	0.296
Reduction weight					
≤10 kg	12 (75.0)	4 (25.0)	16 (100.0)		
11–30 kg	22 (81.5)	5 (18.5)	27 (100.0)		
>30 kg	6 (33.3)	12 (66.7)	19 (100.0)	11.944	0.003*
Interval to reduction					
≤7 days	27 (77.1)	8 (22.9)	35 (100.0)		
>7 days	23 (59.0)	16 (41.0)	39 (100.0)	2.779	0.136

*Statistically significant

traction with 3 pounds (1.4 kg) per level of cervical injury, increasing by 5–10 pounds (2.3–4.5 kg) every 5–15 min [2, 4, 5]. In one series, the maximum weight was 80% of the patient's body weight, whereas in another up to 150 pounds (68 kg) was used for a bilateral dislocation at C3/4 [4, 5, 12]. In all cases, the end point of traction was successful closed reduction and realignment of the cervical spine column or the development of complications like intractable pain, worsening neurologic status, over-distraction, or failed reduction [2, 4, 5, 12].

Because of the high prevalence of delayed hospital presentation in our patients, as well as socioeconomic difficulties in procuring funds for investigations and treatment, the time interval from injury to traction reduction was over 7 days in more than half (52.7%) (Table 3). In another study, the time interval ranged from 6 h to 8 weeks [13]. Other causes of delayed commencement of traction in our locality include incessant power outages, non-available or faulty equipment/facilities, and an overwhelming number of patients for an already over-stretched work force.

Table 6 Association between neurological status post-traction and other variables

Variable	Neurological status post-traction		*t*-test	*p*-Value	
	Improved *n* (%)	Same *n* (%)			
Mean age (years)	37.4 ± 13.0	34.8 ± 9.0	0.860	0.392	
Variables	Neurological status post-traction		Total, *N* (%)	χ^2	*p*-Value
	Improved, *n* (%)	Same, *n* (%)			
Gender					Fisher's exact = 0.525
Male	7 (14.3)	42 (85.7)	49 (100.0)		
Female	5 (20.0)	20 (80.0)	25 (100.0)	0.398	
Neck pain					Fisher's exact = 1.000
Yes	12 (17.1)	58 (82.9)	70 (100.0)		
No	0 (0.0)	4 (100.0)	4 (100.0)	0.818	
Motor deficit					Fisher's exact = 1.000
Yes	10 (16.7)	50 (83.3)	60 (100.0)		
No	2 (14.3)	12 (85.7)	14 (100.0)	0.047	
Sensory deficit					
Yes	5 (13.5)	32 (86.5)	37 (100.0)		
No	7 (18.9)	30 (81.1)	37 (100.0)	0.398	0.754
Sphincter dysfunction					Fisher's exact = 1.000
Yes	7 (15.9)	37 (84.1)	44 (100.0)		
No	5 (16.7)	25 (83.3)	30 (100.0)	0.008	
Duration of symptoms					Fisher's exact = 0.320
≤24 h	2 (8.7)	21 (91.3)	23 (100.0)		
>24 h	10 (19.6)	41 (80.4)	51 (100.0)	1.389	
Nature of injury					Fisher's exact = 1.000
Subluxation	11 (17.2)	53 (82.8)	64 (100.0)		
Retrolisthesis	1 (10.0)	9 (90.0)	10 (100.0)	0.329	
Degree of displacement					
≤50%	11 (20.0)	44 (80.0)	55 (100.0)		
>50%	1 (5.3)	18 (94.7)	19 (100.0)	2.257	0.169
Reduction weight					
≤20 kg	9 (30.0)	21 (70.0)	30 (100.0)		
>20 kg	2 (6.5)	29 (93.5)	31 (100.0)	5.720	0.022*
Interval to reduction					
≤7 days	4 (11.4)	31 (88.6)	35 (100.0)		
>7 days	8 (20.5)	31 (79.5)	39 (100.0)	1.120	0.290

*Statistically significant

We achieved satisfactory extent of reduction in 67.6% of our patients, with 18.9% having improved neurologic status while none deteriorated. This is similar to other studies where the rate of successful closed traction was 58% to 97.6%, and neurologic improvement noted in 43.6% to 78% [2, 4, 12, 13, 15]. In these studies, the rate of neurologic deterioration was 1.3% to 11% [2, 4, 13]. The American Association of Neurological Surgeons (AANS) meta-analysis of closed traction reduction studies showed approximately 80% successful reductions, 2.4% transient neurologic injuries, and about 1% permanent neurologic injuries [5]. The significant rate of failed reduction in our series can be attributed to the delayed presentation and commencement of the closed traction reduction in a significant proportion of our patient population in this study. Up to 10.8% thus probably failed because their injury was so old (Fig. 3). Other causes of failed reduction were: facet lock (20.3%), worsening pain (4.1%), and over-distraction (2.7%). The reported causes of failed closed traction reduction in other studies include those already cited, as

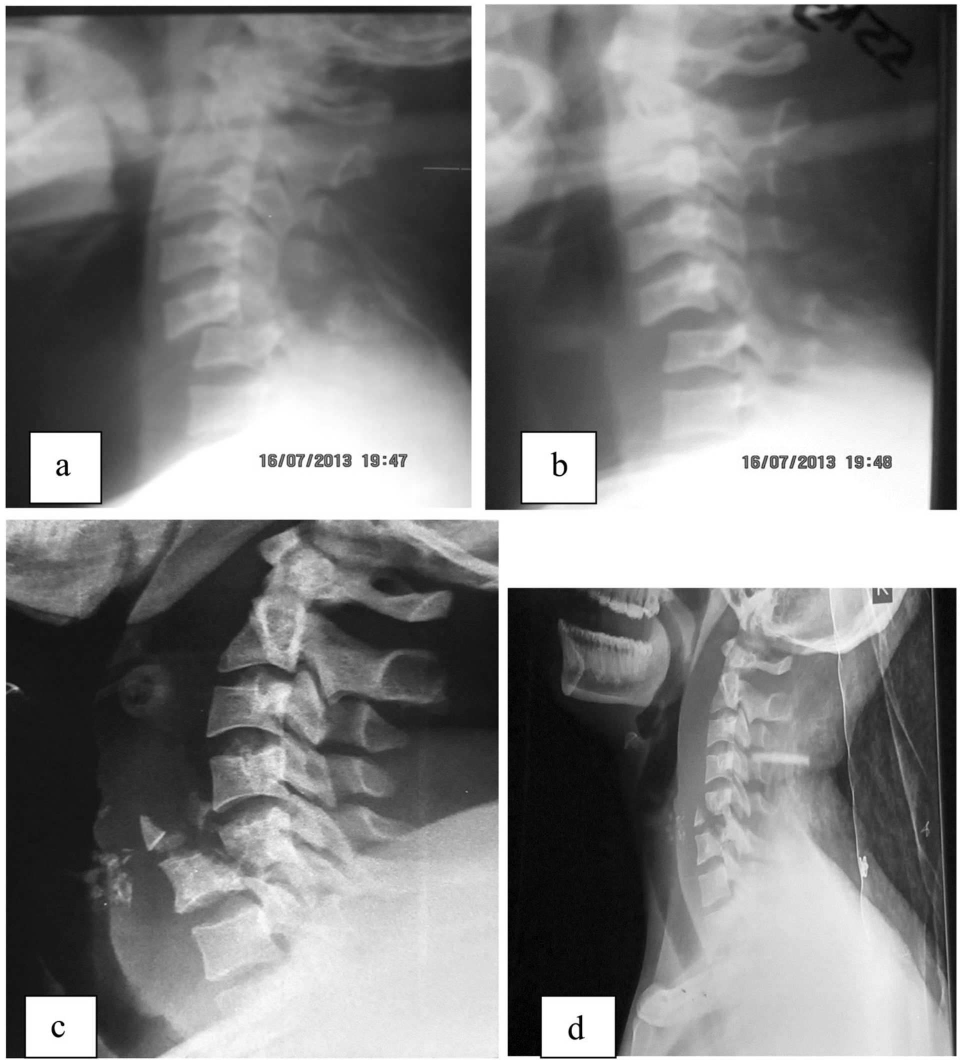

Fig. 3 **a**, **b** Cervical spine X-rays showing 50% C5 on C6 subluxation with angulation and bilateral facet lock, which failed on closed reduction. **c, d** Cervical spine X-rays showing 100% C5 on C6 retrolisthesis with C5 and C6 corporal fracture, which failed on closed reduction

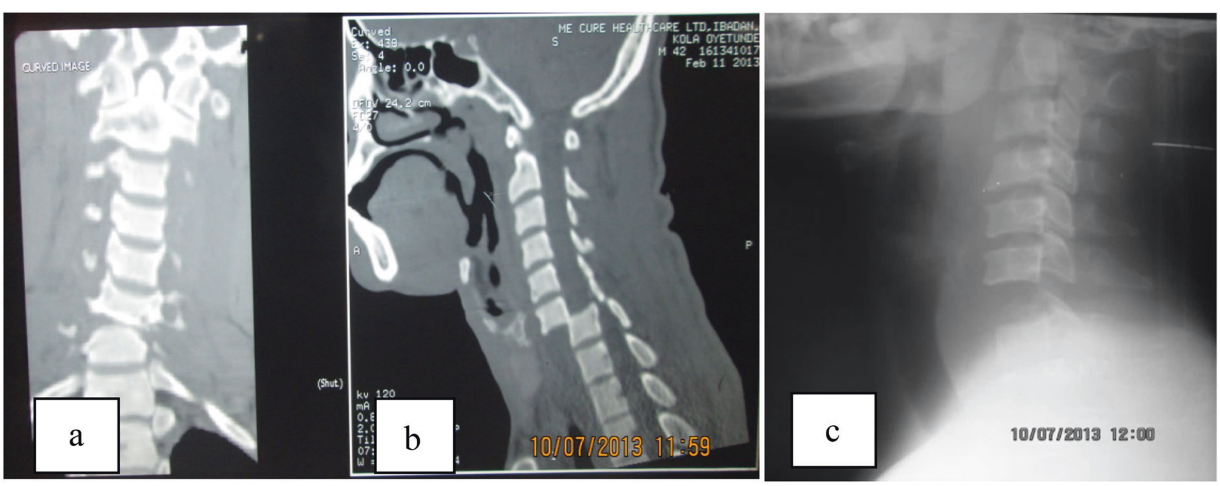

Fig. 4 **a**, **b** Cervical spine computed tomography scan showing 100% C6 on C7 subluxation. **c** Cervical spine X-ray of the patient in **a** and **b** showing complete reduction with over-distraction

well as non-contiguous vertebral fracture at a more rostral level, facet fracture at the level of subluxation, worsening neurologic deficits, cervical disc herniation, epidural haematoma, cord oedema, arm weakness, tong pull-out, inadequate immobilisation, and poor patient status (cardiac, respiratory, and haemodynamic instability) [2, 4, 5, 8, 12, 14, 15, 17, 18, 22, 25]. The complications of closed traction reduction seen in our series were over-distraction (7%) (Fig. 4), tong pull-out (3%), new-onset/worsening pain (3%), pin site infection (3%), and skull perforation (1%). These are known complications of skull tong use, and have been previously documented [4, 5, 18, 19].

Although, this study showed that satisfactory closed traction reduction was dependent on traction weights and absence of sensory deficits other studies have rather reported significant association between neurologic recovery and timing of reduction [2]. Early reduction/realignment/decompression within 8 h of injury is said to improve the likelihood of neurologic preservation [5]. Perhaps, this study might have found the same results but for the fact that very few patients had traction reduction within 24 h of injury compared with a larger number who had traction reduction after 24 h; this made the groups non-comparable in terms of determinants of satisfactory closed traction reduction.

Conclusion

Satisfactory closed traction reduction with limited complications is feasible with GWT traction in many patients with CSI and significant vertebral malalignment. Neurologic outcome post-traction may be significantly associated with appropriate traction weight and presence or absence of sensory deficits.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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