

SPINE SURGERY

Adherence to a standard operating procedure for patients with acute cervical spine dislocations: review of a tertiary, referral, academic hospital in South Africa

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Abstract

Background

To analyse the impact that the adoption of our institutional standard operating procedure (SOP) for cervical spine dislocations had on the timing of closed reduction at our hospital.

Methods

The study was a retrospective review of patients who presented to our institution with cervical dislocation injuries and who were managed with closed reduction. The patient records of acute cervical spine dislocations from 2015 to 2018, data from the Acute Spinal Cord Injury database along with patient's demographic information were gathered and compared. Participants within the study time frame were diagnosed with a cervical facet dislocation based on clinical examination findings and radiological confirmation. Patients who had reduction performed at other referring hospitals were excluded from the study.

Results

The practice within all tertiary hospitals in the Western Cape is to perform closed reduction of cervical fracture dislocations as soon as possible after injury. In this study the time between injury and closed reduction before introducing the SOP was 13 h 13 min and after introducing the SOP, the time increased to an average of 14 h 28 min. The main cause of delay was the transfer time from the site of injury to the emergency ward. Other reasons for the delay include missed diagnosis, orthopaedic registrar unavailability and incomplete reduction bed.

Conclusion

This study found that the time taken for orthopaedic management of cervical dislocations increased by an hour after introduction of the SOP. Additionally, the overall time to reduction also increased. This was due to delays in transfer to the emergency ward and referral to Orthopaedics. We recommend that, in our setting, reduction could be initiated within an hour of patient arrival, if emergency ward doctors rapidly identified the problem and commenced cervical traction when the orthopaedic team was not immediately available. Our impression was that there was poor adherence to the new SOP guidelines on time management by the trauma team, and possibly transport delays prior to hospital admission. A further study to investigate the bottlenecks of the referral system is advisable.

Level of evidence: Level 3

Keywords: acute outcomes, cervical spine, dislocation injuries

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Introduction

Cervical dislocations are acute, high-risk injuries associated with a range of potentially catastrophic long-term disabilities. Regional hospital data has shown that up to 60% of spinal trauma, which accounts for 3–6% of all trauma admissions, involve injury to the cervical region.¹ The most common mechanism of injury results from motor vehicle accidents (MVAs), violent assault or falls, with the typical patient being a male under the age of 30 years.^{2,3}

These injuries have the potential to cause a profound change in lifestyle, with the resulting neurological deficit affecting the motor, sensory and autonomic nervous system.⁴ Patients require lifelong supportive care, impacting patients' quality of life, independence and psychological wellbeing.^{5,6} Additionally, given the aetiology of the injury, a large proportion of those affected are earning an income with dependants reliant on them. As such, cervical spine injuries tend to have a profound effect on not only the individual patient but also on their direct family members and society. Unless there are any contraindications, the best management for patients with cervical dislocations is early reduction, with skeletal traction to realign the vertebrae.⁷ The objective of early reduction is to align the vertebral column and alleviate external pressure on the spinal cord. Successful early reduction may potentially reduce subsequent neurological deficits.⁷ A key variable in this treatment method was found to be the time between the offending injury and the intervention being performed.⁸ A retrospective review of rugby players with cervical dislocations found a 63% difference in reported neurological improvement if closed reduction was performed within four hours of the injury – a larger quantified effect on patient recovery than surgical intervention.⁹

All Western Cape hospitals strive to perform closed reduction of cervical dislocations within four hours of the injury,¹⁰ partly to comply with a 2015 Constitutional Court ruling but also to adhere to best medical practice.¹¹ This is, however, particularly challenging as the mean transport time between sustaining a spinal injury and receiving medical care was previously found to be three hours, which leaves little room to comply with the four-hour ruling.¹⁰ Therefore, a new management protocol was introduced in June 2016 – the 'early reduction protocol' – requiring all closed reductions to be performed within one hour of admission.

This study aims to assess adherence and the effect of the 'early reduction SOP or protocol' on the timing of the reduction of cervical dislocations and its influence on the neurological outcomes of patients managed at our institution during the time period of the study.

Materials and methods

This was a retrospective analysis of records for patients managed at our institution from 2015 to 2018. The study compared the management of patients with low and high velocity injuries treated before the introduction of the early reduction standard operating procedure (SOP) in June 2016 against those treated after. Low velocity injuries were classified as injuries sustained during sport activities or fall from low heights where the patients sustain purely ligamentous dislocation. High velocity injuries were classified as MVA and violent assaults where the patients sustain fracture dislocations. From the Acute Spinal Cord Injury database, records and notes of patients who presented to our institution from 2015 to 2018 with acute cervical dislocation and received subsequent closed reduction management were reviewed by the principal author (the researcher). The SOP requirement for cervical reduction was set to be within one hour after patients arriving at the primary emergency ward (ER). Variables such as the American Spinal Injury Association (ASIA) score, time to reduction, duration of hospital stay, along with patient mortality and morbidity, were retrieved. Data collected included age, sex, date, mechanism of injury, neurological examination findings and radiological diagnoses. A

qualitative interview was conducted with the emergency room personnel at Groote Schuur Hospital (GSH) to complement our quantitative analysis findings.

Patients who presented to our institution in a conscious state with cervical injuries within the given time frame of the study and were diagnosed with a cervical facet dislocation based on clinical examination findings with radiological confirmation (X-rays or CT scan) were included in the study. All patients who were managed outside our institution with closed reduction were excluded from the study as were patients with other injuries such as open head injuries, an obtunded state or decreased level of consciousness.

Qualitative assessment

The qualitative assessment was conducted by the principal author between August and September 2018 on emergency personnel (ER nurses, ER doctors and orthopaedic registrars) at GSH. The participants were individually interviewed in person and asked to complete the 'yes/no' answers in *Table I* based on their area of speciality.

Statistical analysis

Data was summarised using descriptive statistics. Continuous variables were summarised using means and standard deviations, whereas categorical or nominal variables were summarised using percentages. Matched t-tests were used to test for significance between continuous variables, while chi-squared tests were used for categorical or nominal variables. Graphical analysis was used to display the distribution of variable(s) and to illustrate findings visually.

Results

The study comprised 19 participants, of whom 79% were male and 21% female. The median (IQR) age of participants was 48 years (26.0–55.0); range from 20 to 80 years (*Figure 1*). There was a pre-hospital delay between injury and arrival at the primary emergency ward (ER) of seven hours. The mean time between injury and closed reduction before introducing the new SOP was 13 h 13 min (*Table II*). After introducing the new SOP, the time to closed reduction increased significantly ($p < 0.0001$) to a mean of 14 h 28 min (*Table II*).

Other associated injuries were cervical fractures (63.1%) and pelvic fractures in 26%. Furthermore, most common cervical fractures were bilateral lamina fractures in 21% and vertebral body fracture in 11% (*Figures 2a and 2b*).

The main time delays (*Figure 3*) were between injury and arrival at the ER (7 h 43 min after the new SOP). There was minimal change between pre- and post-introduction of the new SOP, with only a 6% decrease in time taken between injury and arrival at the ER.

A matched t-test was used to compare pre- and post-mean changes on the ASIA scale, pre-reduction and post-reduction (*Table III*), and no significant changes were found (pre- versus post $p = 0.331$). Similarly, there were no significant changes between admission versus discharge for: ASIA motor score, $p = 0.078$; ASIA light touch, $p = 0.454$; ASIA pinprick, $p = 0.662$.

Table IV presents the time delays in the referral system at GSH. The median time delay from injury to the ER was increased by 55% (07 h 13 min), whereas the median time from the ER to the orthopaedic registrar on call was increased by 12% (01 h 36 min).

Times from start to completion of reduction by the orthopaedic registrar were increased by a median of 8% (01 h 00 min) and 6% (00 h 45 min), respectively.

In this study, there were equal rates of reduction success before the new SOP and after the new SOP ($p=50\%$) (*Figure 4*).

The common injuries were sustained from MVAs (37%) and falling (37%). The most common pattern of injury was C5/C6 bifacet dislocation (32%). Common neurological deficits were C4 motor complete sensory complete (MCSC) (26%) and C5 MCSC (21%). Most patients had a pre-reduction ASIA-A, 63% and the most common post-reduction score was ASIA A, 63% (*Table IV, please correct this*).

Qualitative findings

Additional in-depth qualitative interviews were used to complement evidence gathered quantitatively. *Table VI* summarises themes that emerged from in-depth interviews with five ER nurses, five ER doctors and five orthopaedic registrars. The red colour coding highlights answers indicating poor understanding of the management of cervical dislocations while answers in green demonstrates a better knowledge of cervical dislocation management. There was no awareness of the SOP for rapid reduction among ER nurses 0% ($n=5$) and ER doctors 0% ($n=5$); the exception was the orthopaedic registrars who had 100% ($n=5$) level of awareness. In addition, orthopaedic registrars had 100% ($n=5$) level of awareness on the 'four-hour ruling under the Constitutional Court', while ER nurses had 0% ($n=5$) and ER doctors had 20% ($n=1$). Only two out five (40%) ER nurses knew 'where the reduction bed and equipment were kept'; this shows a knowledge gap since ER nurses attend most cases during admissions. Surprisingly, only one out of five (20%) orthopaedic registrars 'knew where the reduction bed and equipment are kept'.

Discussion

Cervical dislocations are serious injuries associated with a range of potentially catastrophic long-term disabilities. Previous regional hospital data has shown that up to 60% of spinal trauma, which accounts for 3–6% of all trauma admissions, is caused by injury to the cervical region.¹ The most common mechanism of injury is the result of an MVA, violent assault or fall – with the typical patient being a male under the age of 30 years.^{2,3} In this study MVA and falls were the most common causes of injury: MVA 37% and falls 37%.

Previously, it had been recommended that the time between injury and closed reduction should be within four hours in order to have favourable neurological outcomes.^{9,12} In this study, the mean time between injury and closed reduction before introducing the new SOP was 13 h 13 min, with median time of 9 h 19 min. After introducing the new SOP, the mean time significantly increased to 14 h 28 min and median time of 13 h 15 min. Based on the study findings, the intended potential benefits of the SOP were not achieved. There was no significant improvement in reduction times from initial injury. The main delay was from injury to arrival at the ER. In-depth study reflected the challenges of low awareness of the SOP for rapid reduction; lack of knowledge of where the reduction bed and equipment are kept; and inconsistency on preparations before surgery. Reduction beds and equipment might not be maintained and not always prepared, all of which point to low availability of adequate resources. These gaps

explain why there was no significant improvement on several continuous outcomes and increased time delays along the referral chain before actual reduction. It took 1 h 21 min to 1 h 51 min from assessment to initiating reduction, with a variety of factors causing delays including doctors needing to look for equipment. The SOP failed to improve on this time to initiate reduction. Although recent data showed that the average transport time between sustaining a spinal injury and receiving medical care was three hours, in this study the average time was 13 h 56 min after a new management protocol was introduced as of June 2016 whereby all closed reductions should be performed within one hour of admission. This indicates a discrepancy in terms of policy availability and/or SOP adherence and implementation of guidelines regarding this issue.

The SOP was an effort to improve reduction times; however, our review found that the overall time from injury to reduction had not appreciably improved. Furthermore, the time taken for ER doctors to assess the patient and refer to Orthopaedics had increased from 1 h 56 min to 2 h 56 min. The possible reasons for this were difficulties in locating required equipment, lack of equipment, policy unavailability and very low SOP adherence. We recommend that, in our setting, reduction could be done within an hour of patient arrival if other ER doctors activate the early reduction protocol, even in the absence of an orthopaedic registrar. Furthermore, we recommend pre-hospital diagnosis by paramedics be done at the scene of the accident and in-hospital activation of the SOP by the ER staff which would then result in time-saving.

In the qualitative assessment of staff, results showed only orthopaedic doctors were aware of the new SOP for cervical dislocation injuries and had knowledge of the four-hour constitutional rule for performing early reduction of cervical dislocation injuries. Based on these findings, we recommend that all ER staff must be educated and made aware of the SOP and the four-hour rule. The SOP should be available on large posters in the ER.

Limitations of the study are that the new SOP did not include the transport time (it addresses the time from arrival in the ER to reduction). Secondly, most of the study patients had high energy mechanisms of injury thus other associated injuries resulted in their exclusion from having acute reduction performed. Thirdly, due to the retrospective aspect of the study, selection bias and mis-classification or information bias might have been introduced.

Conclusions

In this study, motor vehicle accidents and falls were the most common causes of injury. The time taken from the site of injury to an assessment and complete reduction was significantly increased after introduction of the new SOP. There were no significant changes in ASIA scales post-introduction of the new SOP. The main message is that there is very poor adherence to the new SOP guidelines on time management along the emergency health referral system by healthcare workers (nurses and general doctors). Future study is needed to examine the role of patient assessment at a primary care level prior to transfer to a tertiary hospital for patients with suspected spinal injury.

Ethics statement

This study was approved by the University of Cape Town Human Ethics Committee (2018/137). Verbal consent was obtained from doctors and nurses that participated in the study. There was no direct involvement of patients, thus no need for verbal or oral consent. The study comprised patient notes and records, with each patient identified by their hospital number only. All study data storage was password protected.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed written consent was not obtained from all patients for being included in the study.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

Ayik GDD: Primary author; study design, data collection, data analysis

Mukabeta TDM: Data collection and analysis

Nyandoro G: Information technology and data analysis

Osborne C: Data collection and analysis

Kruger NA: Conceptualisation, study design, manuscript revision and supervision

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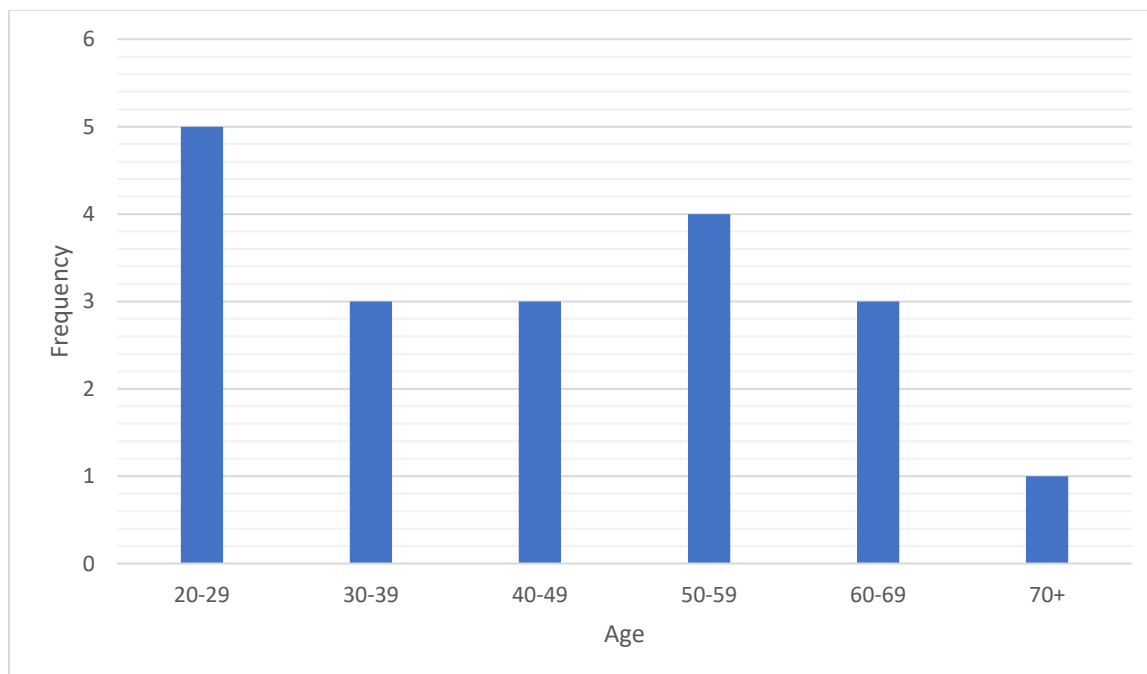


Figure 1. Distribution of patients' age (in years) in the study

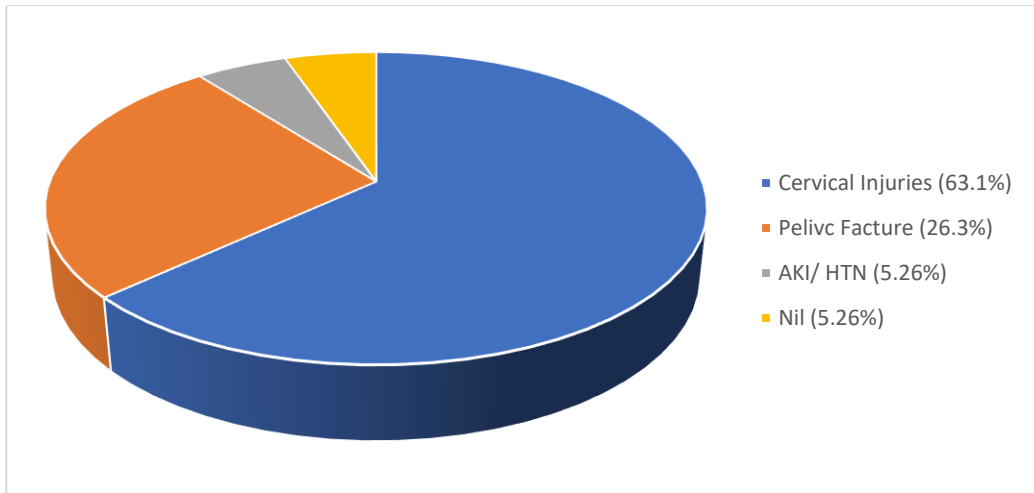


Figure 2a. Injuries and medical conditions sustained by patients in the study

Cervical injuries (63%)

Pelvic fracture (26%)

AKI/HTN (5%)

Nil (5%)

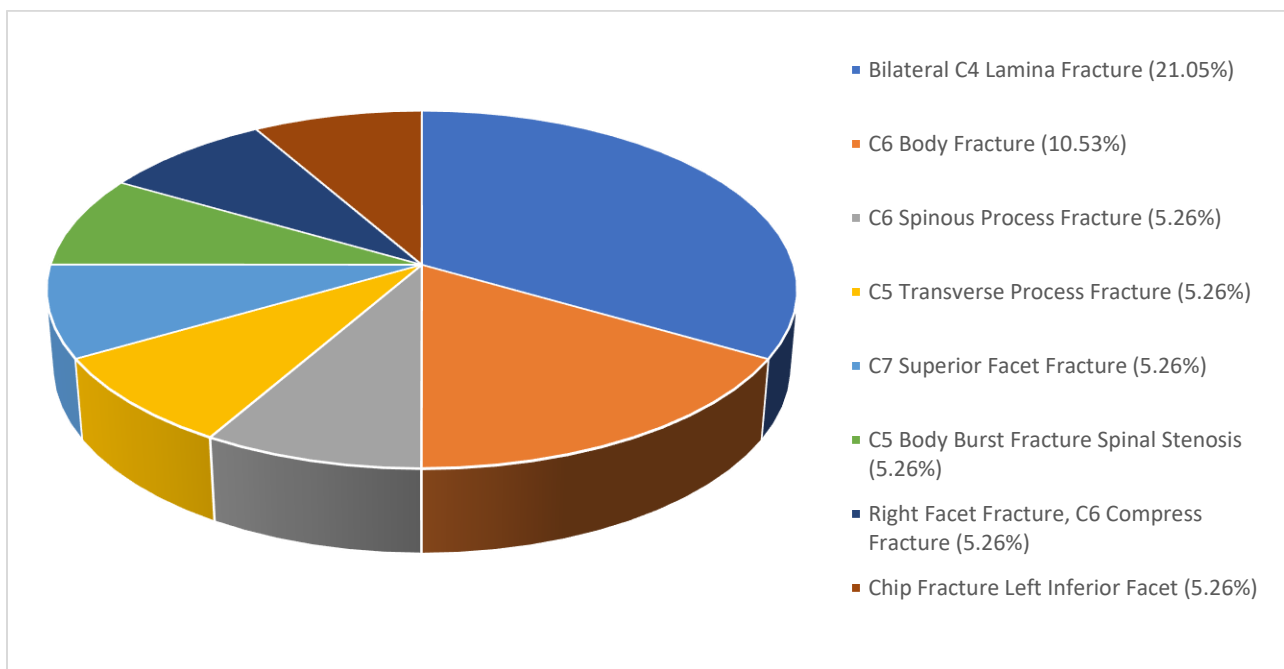


Figure 2b. Cervical Injuries sustained by patients in the study

- Bilateral C4 lamina fracture (21%)
- C6 body fracture (11%)
- C6 spinous process fracture (5%)
- C5 transverse process fracture (5%)
- C7 superior facet fracture (5%)
- C5 body burst fracture spinal stenosis (5%)
- Right facet fracture, C6 compression fracture (5%)
- Chip fracture left interior facet (5%)

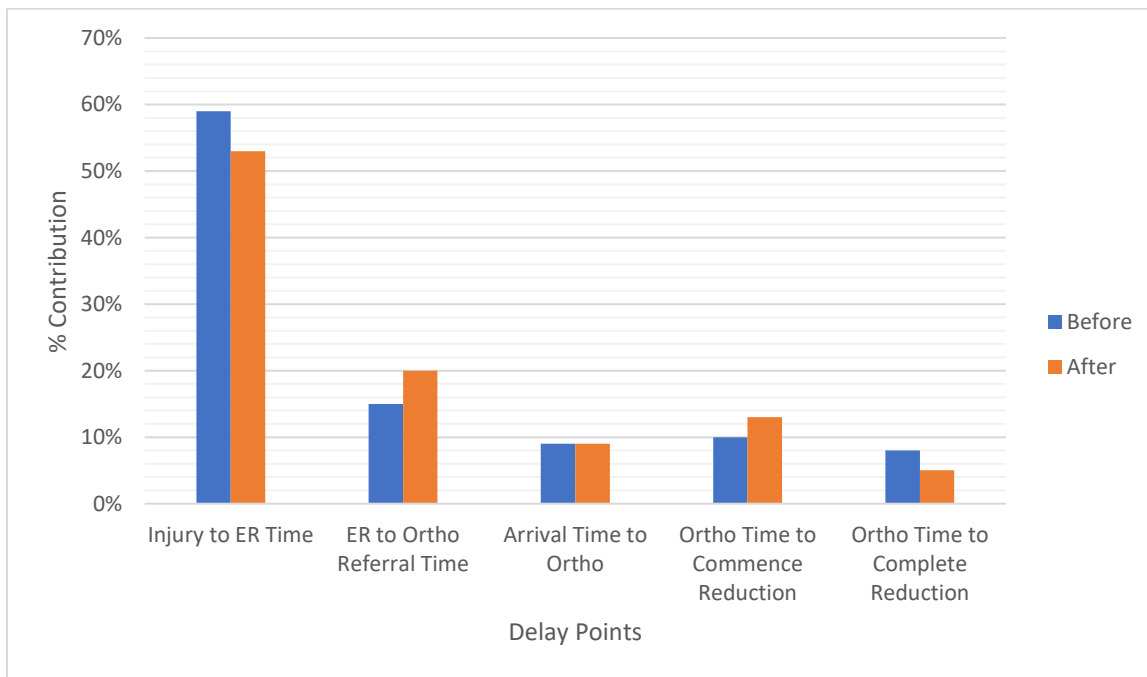


Figure 3. Change in time delays in the emergency referral system, before and after new SOPs

% Contribution
Delay points
Before

After

Injury to ER time

ER to ortho referral time

Arrival time to ortho

Ortho time to commence reduction

Ortho time to complete reduction

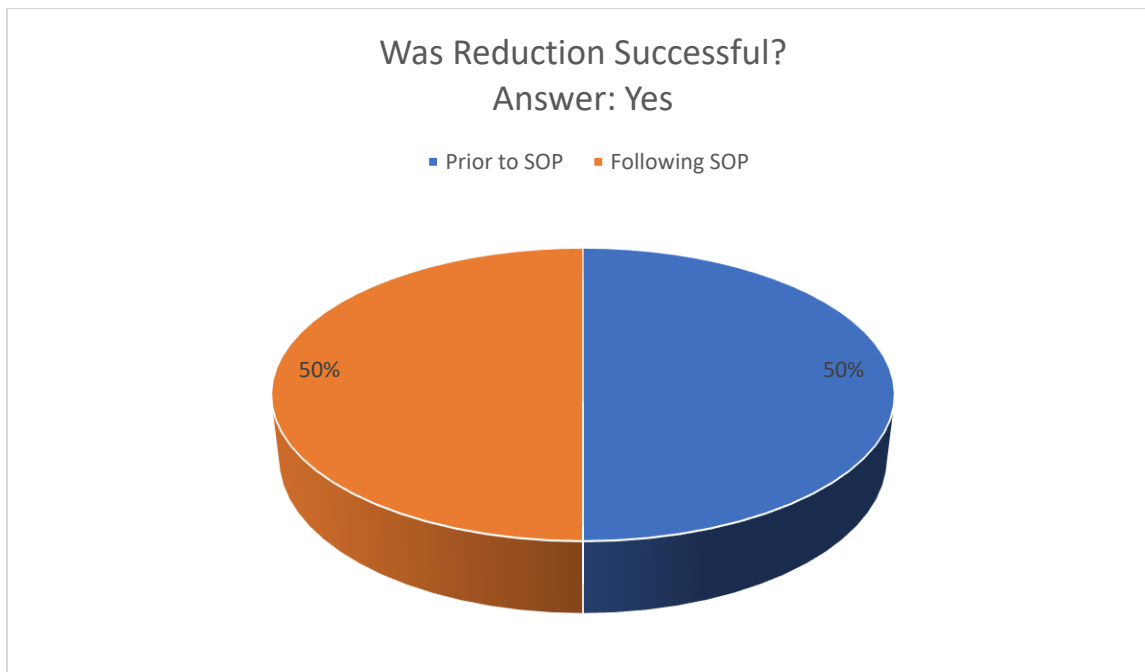


Figure 4: Percentage of successful reduction pre and post introduction of the SOP

Was reduction successful?

Answer: Yes

Prior to SOP

Following SOP

Table I: The qualitative assessment questionnaire tailored to area of specialty

Questions	ER nurses	ER doctors	Orthopaedic registrars
1. Are you aware of the SOP for rapid reduction?	Yes/No	Yes/No	Yes/No
2. What is the four-hour rule under the Constitutional Court?	Yes/No	Yes/No	Yes/No
3. Do you know where the reduction bed and equipment are kept?	Yes/No	Yes/No	Yes/No
4. What patients require urgent neck X-rays?	Yes/No	Yes/No	-----
5. Which doctors can apply cervical traction in an emergency?	Yes/No	Yes/No	-----
6. Do you know who to refer to for neck dislocations?	-----	Yes/No	-----
7. With a cervical dislocation, do you request an MRI scan?	-----	Yes/No	-----
8. Is there always available radiography for rapid reductions?	-----	-----	Yes/No
9. List causes that delay initiating reductions.	-----	-----	Yes/No
10. If you are scrubbed in theatre and are referred a cervical dislocation, what action do you take?	-----	-----	Yes/No

Table II: Time delays summary

Period (time in hours:minutes)		Injury to ER	ER to ortho referral time	Ortho referral to assessment	Ortho time to start reduction	Ortho time to complete reduction	Injury to reduction total time	p-value	
Before new SOP	Mean (n=8)	7:45±8:33	1:56±1:14	1:08±0:41	1:21±0:44	1:01±0:17	13:13±9:07	<0.0001	
	Median (n=8)	03:17	01:40	00:57	01:07	00:54	09:19		
	Minimum	01:14	00:34	00:05	00:25	00:45	04:00		
	Maximum	24:00	04:00	02:00	02:44	01:30	05:30		
	Percentiles	25	01:30	00:51	00:40	01:00	00:46		06:50
		75	15:13	02:57	01:55	01:57	01:15		21:56
After new SOP	Mean (n=11)	07:43±04:39	02:50±03:24	01:14±01:10	01:51±02:48	00:47±00:34	14:28±08:53		
	Median (n=11)	08:30	01:36	01:00	00:30	00:36	13:15		
	Minimum	02:00	00:19	00:15	00:15	00:19	03:30		
	Maximum	13:56	10:15	04:19	09:00	02:20	07:15		
	Percentiles	25	02:19	00:20	00:30	00:15	00:30		04:35
		75	12:06	04:25	01:04	03:05	00:45	22:25	

Table III: Comparison of admission versus discharge for post-reduction clinical measurements

Paired t-test (two-tailed)		Mean	n	Std deviation	Std error mean	p-value
Pair 1	Pre-reduction ASIA scale	2.11	19	1.629	0.374	0.331
	Post-reduction ASIA scale	2.16	19	1.642	0.377	
Pair 2	Admission ASIA motor score	25.11	19	32.493	7.454	0.078
	Discharge ASIA Motor score	29.68	19	36.917	8.469	
Pair 3	Admission ASIA Light touch	39.53	19	40.622	9.319	0.454
	Discharge ASIA Light touch	41.95	19	44.244	10.150	
Pair 4	Admission ASIA Pinprick	40.47	19	40.171	9.216	0.662
	Discharge ASIA pinprick	41.84	19	44.276	10.158	

Table IV: Time delays in the referral system post-SOP

		Injury to ER	ER to ortho referral time	Ortho referral to assessment	Ortho time to start reduction	Ortho time to complete reduction	Injury to reduction total time
Mean (hours:minutes)		07:44 (56%)	02:27 (18%)	01:11 (8%)	01:39 (12%)	00:53 (6%)	13:56 (100%)
Median (hours:minutes)		07:13 (55%)	01:36 (12%)	01:00 (8%)	01:00 (8%)	00:45 (6%)	13:05 (100%)
Std deviation		06:21	02:41	00:58	02:09	00:28	08:45
Minimum		01:14	00:19	00:05	00:15	00:19	03:30
Maximum		00:00	10:15	04:19	09:00	02:20	07:15
Percentiles	25	02:00	00:34	00:40	00:25	00:34	06:45
	75	12:06	03:00	01:43	02:10	01:15	22:25

Table V: Common description of patient notes

Variable	Categories	Frequencies	(%)
Cause of injury	Assault	1	5
	Diving accident	1	5
	Falling	7	37
	MVA	7	37
	PVA	1	5
	Surfing accident	1	5
	Train accident	1	5
Cervical level	C4/5BFD	1	5
	C4/5UFD	1	5
	C4/C5BFD	3	16
	C4/C5UFD	1	5
	C5/C6BFD	6	32
	C5/C6UFD	2	11
	C6/7UFD	1	5
	C6/C7BFD	2	11
	C6/C7UFD	2	11
Neurological deficit	C3–4MISI	1	5
	C3–5MCSC	1	5
	C4–C5MCSC	2	11
	C4MCSC	5	26
	C4MISI	1	5
	C5MCSC	4	21
	C5MCSI	1	5
	C5MISI	2	11
	Nil	2	11
Other injury or medical conditions	AKI, hypertension	1	5
	Bilateral C4 lamina fracture	4	21
	C5 body burst fracture		
	spinal stenosis	1	5
	C5 transverse process#Fracture	1	5
	C6 body fracture	2	11
	C6 spinous process fracture	1	5
	Nil	1	5
	Rt facet # Fracture,C6 compare # Fracture	1	5
	Scapula and pelvic fracture		
	C7 superior facet fracture	1	5

C7 transverse process

	Chip fracture left inferior facet	1	5
	Pelvic fracture	5	26
Pre-reduction ASIA scale	A	12	63
	B	1	5
	C	1	5
	D	2	11
	E	3	16
Post-reduction ASIA scale	A	12	63
	C	2	11
	D	2	11
	E	3	16

AKI, acute kidney injury; ASIA scale, American Spinal Injury Association scale; BFD, bifacet dislocation; MCSC, motor complete sensory complete; MISI, motor incomplete sensory incomplete; MVA, motor vehicle accident; PVA, pedestrian vehicle accident; UFD, unifacet dislocation

Table VI: In-depth interviews with ER nurses, ER doctors and orthopaedic registrars

ER nurses	1. Are you aware of the SOP for rapid reduction?	2. What is the four-hour rule under the Constitutional Court?	3. Do you know where the reduction bed and equipment are kept?	4. What patients require urgent neck X-rays?	5. Which doctors can apply cervical traction in an emergency?
1	No, I'm not aware	Observation of a patient	Yes	Patient with long bone fracture, poly trauma patient	Neurosurgeon
2	No, I'm not aware	I don't know	No	Spine injury, MVA, neck pain, fall from height	I don't know
3	No, I'm not aware	I don't know	Yes	Neck pain, fall from height, MVA	Orthopaedic doctor
4	No, I'm not aware	I don't know	No	MVA, fall from height,	Orthopaedic doctor, neurosurgeon

				gunshot, knife stab		
5	No, I'm not aware	I don't know	Yes	Neck pain	Orthopaedic doctor, ASCI	
ER doctors	1. Are you aware of the SOP for rapid reduction?	2. What is the four-hour rule under the Constitutional Court?	3. Do you know where the reduction bed and equipment are kept?	4. What patients require urgent neck X-rays?	5. Which doctors can apply cervical traction in an emergency?	6. Do you know who to refer to for neck dislocations?
1	No	Not sure	Yes	MVA, fall from height, neck pain	Orthopaedic, neurosurgeon, ASCI	Orthopaedic, ASCI
2	No	Not sure	Yes	Fall from height, MVA, gunshot, knife stab	Orthopaedic	Orthopaedic, neurosurgeon, ASCI
3	No	Not sure	Yes	Fall from height, MVA, gunshot, knife stab	Orthopaedic, ASCI, neurosurgeon	Orthopaedic, neurosurgeon
4	No	Not sure	Yes	Neck pain, significant tenderness, neurological fallout	Orthopaedic	Orthopaedic on call
5	No	Neck dislocation should be reduced within four hours	Yes	Low GCS, suspected C-spine injury, focal neurological deficit in polytrauma	Orthopaedic	Orthopaedic on call
Orthopaedic registrars	1. Are you aware of the SOP for rapid reduction?	2. What is the four-hour rule under the Constitutional Court?	3. Are the reduction bed and equipment maintained and always prepared?	4. Is there always available radiographer for rapid reduction?	5. List causes that delay initiating reduction?	6. If you are scrubbed in theatre and are referred a cervical reduction, what do you do?
1	Yes	C-spine dislocation must be	Not always	Yes	Late referral, late presentation	Will ask someone on call to do it

		reduced in four hours				
2	Yes	C-spine dislocation must be reduced in four hours	Not always	Yes	Late referral, late presentation	Will ask the senior trauma doctor to do it
3	Yes	C-spine dislocation must be reduced in four hours	Yes	Yes	Late referral, late presentation	Will ask someone on call
4	Yes	C-spine dislocation must be reduced in four hours	Not always	Yes	Late referral, late presentation	Will ask to call consultant
5	Yes	C-spine dislocation must be reduced in four hours	Not always	Yes	Late referral, late presentation	Ask someone in trauma to reduce it

GCS: Glasgow Coma Scale