Clearing the Cervical Spine in Patients with Distracting Injuries:

An AAST Multi-Institutional Trial

Abid D Khan MD¹,², Sean C Liebscher MD¹, Hannah C Reiser MD¹,

Thomas J Schroeppe MD², Michael J Anstadt MD¹, Patrick L Bosarge MD³,
Shannon L Carroll MD³, Jacob A Quick MD⁴, Stephen L Barnes MD⁴, Justin Sobrino MD⁵,
Jason Murry MD⁶, Nicholas Morin MD⁷, Mario Gomez MD⁷, Heitor Consani MD⁸,
Richard P Gonzalez MD¹

¹Loyola University Medical Center, Department of Surgery, Division of Trauma and Acute Care Surgery, Maywood, IL
²University of Colorado Health-Memorial Hospital, Department of Trauma and Acute Care Surgery, Colorado Springs, CO
³University of Alabama at Birmingham, Division of Acute Care Surgery, Birmingham, AL
⁴University of Missouri, Division of Acute Care Care Surgery, Columbia, MO
⁵University of South Alabama Medical Center, Department of Surgery, Mobile, AL
⁶University of Texas Health-Tyler, Tyler, TX
⁷New York University Langone Hospital-Brooklyn, Department of Surgery, New York, NY
⁸Conjunto Hospitalar de Sorocaba, Sorocaba, Brazil

To be presented as a podium presentation at the 77st Annual Meeting of the American Association for the Surgery of Trauma and Clinical Congress of Acute Care Surgery, September 26-29, 2018 in San Diego, CA
Conflicts of Interest and Financial Disclosures: None of the authors has anything to disclose

adkhan@gmail.com
hcreiser@gmail.com
manstadt@lumc.edu
shannoncarroll@uabmc.edu
barnesste@health.missouri.edu
jason.murry@gmail.com
mfgomez129@gmail.com

slibscl@gmail.com
thomas.schroeppel@uchealth.org
pbosarge@uabmc.edu
quickja@health.missouri.edu
jasobrino@cmh.edu
nicholas.morin@nyumc.org
hconsani@icloud.com

Corresponding Author:

Richard Gonzalez MD

2160 S. First Ave, Maywood IL 60153

Office: 708-327-2072; Fax: 708-327-3474

Email: richard.gonzalez@lumc.edu
**Background:** Single institution studies have shown that clinical examination of the cervical spine (c-spine) is sensitive for clearance of the c-spine in blunt trauma patients with distracting injuries. Despite an unclear definition, most trauma centers still adhere to the notion that distracting injuries adversely affect the sensitivity of c-spine clinical examination. A prospective AAST multi-institutional trial was performed to assess the sensitivity of clinical examination screening of the c-spine in awake and alert blunt trauma patients with distracting injuries.

**Methods:** During the 42-month study period, blunt trauma patients 18 years and older were prospectively evaluated with a standard c-spine examination protocol at 8 Level 1 trauma centers. Clinical examination was performed regardless of the presence of distracting injuries. Patients without complaints of neck pain, tenderness or pain on range of motion were considered to have a negative c-spine clinical examination. All patients with positive or negative c-spine clinical examination underwent computed tomography (CT) scan of the entire c-spine. Clinical examination findings were documented prior to the CT scan.

**Results:** During the study period, 2929 patients were entered. At least one distracting injury was diagnosed in 70% of the patients. A c-spine injury was found on CT scan in 7.6% of the patients. There was no difference in the rate of missed injury when comparing patients with a distracting injury to those without a distracting injury (10.4% vs 12.6%, \( p=0.601 \)). Only one injury missed by clinical examination underwent surgical intervention and none had a neurological complication.

**Conclusions:** Negative clinical exam may be sufficient to clear the cervical spine in awake and alert blunt trauma patients, even in the presence of a distracting injury. These findings suggest a potential source for improvement in resource utilization.

**Level of Evidence:** Level 3, Diagnostic Test

**Keywords:** Cervical spine injury, distracting injury, Blunt trauma, CT scan in trauma
Background

Cervical spine (c-spine) clearance after blunt traumatic injury poses an ongoing dilemma for trauma surgeons. Most trauma centers have a regimented protocol for evaluation of the c-spine, however, specific algorithms vary widely from center to center. These protocols often involve the liberal use of radiographic tests, the vast majority of which are negative for injury.\(^1\) Adding to the variability is the emergence of data that have called into question some long-held beliefs about the method by which the c-spine can be safely cleared. The recent trend has been toward the more judicious use of radiography, but a consensus on which patients require radiographic evaluation has not been reached. Limiting radiographic testing can lead to improvements in resource utilization, but missed injuries can have catastrophic ramifications.

Screening for c-spine injuries traditionally utilizes a combination of physical exam and radiographic testing.\(^2,3\) Plain film radiography is unreliable as a screening tool and computed tomography (CT) scan has taken over as the radiographic test of choice for c-spine injury clearance.\(^4,5\) Some trauma centers mandate the use of a c-spine CT scan in any patient with a mechanism concerning for possible c-spine injury.\(^6-9\) However, several studies have suggested that physical exam alone is adequate for c-spine screening in properly selected patients.\(^4, 10-16\) Current Eastern Association for the Surgery of Trauma (EAST) guidelines recommend the use of physical exam with the selective use of CT scanning for a patient who suffers blunt trauma and does not have altered mental status, a neurologic deficit, nor a distracting injury.\(^17\) Patients that meet these criteria without neck pain or tenderness on physical exam do not require further radiographic evaluation, according to the guidelines.
The concept that a distracting injury (DI) precludes the use of physical exam to screen for c-spine injury has very little evidence to support it. The EAST guidelines, Advanced Trauma Life Support (ATLS) teaching, and several studies, including the widely cited National Emergency X-Radiography Study (NEXUS), refer to DI as a reason to obtain radiographic studies, regardless of physical exam findings.\textsuperscript{1,3,4,8,17,18} Despite these recommendations, the definition of what constitutes a DI remains elusive. It is left to the clinician to determine which type of injuries classify as distracting, leading to a variety of definitions and practice patterns across trauma centers.

Recent single center trials suggest that a negative physical exam may be sufficient to clear the c-spine in awake and alert blunt trauma patients, even in the setting of DI.\textsuperscript{19-21} The purpose of this study is to perform a multicenter assessment of the sensitivity of utilizing clinical exam to screen for c-spine injury in the presence of DI.

**Methods**

During the 42-month study period from July 2014 to December 2017, data was collected prospectively at 8 Level 1 trauma centers in an American Association for the Surgery of Trauma Multi-Institutional Trial. The primary study was designed to evaluate the effect of DI on the sensitivity of physical exam in clearing the c-spine. The participating centers were Loyola University Medical Center, Maywood, IL, University of Colorado Health-Memorial Hospital, Colorado Springs, CO, University of Alabama at Birmingham, Birmingham, AL, University of Missouri, Columbia, MO, University of South Alabama Medical Center, Mobile, AL, University of Texas Health-Tyler, Tyler, TX, New York University Langone Hospital-Brooklyn, New York,
NY, and Conjunto Hospitalar de Sorocaba, Sorocaba, Brazil. All patients 18 years and older who sustained a trauma via a blunt mechanism and had a GCS $\geq$ 14 were enrolled in the study. There were no additional exclusion criteria. All participating institutions utilized multislice CT scanners with a minimum of 32-slice capability to evaluate patients for this study.

Institutional Review Board approval was obtained at each of the individual institutions. Information regarding the demographics, mechanism of injury, and clinical findings was collected prospectively and documented on the study data form prior to the completion of CT scan evaluation.

Clinical evaluation of the c-spine in patients meeting inclusion criteria was performed in a standardized fashion across all 8 centers using the following algorithm: patients were assessed for neurologic deficits through the use of subjective questioning and physical examination. If no neurologic deficit was identified, the patient’s cervical collar was removed and manual in-line stabilization of the neck was initiated. The patient was then interrogated for the presence of neck pain. If no pain was present, the posterior neck was then palpated for midline and lateral tenderness. In the absence of tenderness, the patient was then asked to flex and extend the neck and to rotate their neck 90 degrees side to side, with 45 degrees of rotation in each direction. If these range of motion maneuvers did not elicit pain, the physical exam was considered negative. At this point, the cervical collar could either be removed or replaced, based on each institution’s protocols. If any aspect of the exam was positive, the exam was terminated, the cervical collar was replaced, and the physical exam was considered positive. All patients, regardless of the results of the physical exam, had a CT scan of the c-spine. Plain radiographs or MRI were not performed unless otherwise indicated, based on the clinical judgement of the individual provider. (Figure 1)
Physical exam was performed by an attending trauma surgeon, trauma surgery resident, or trauma surgery advanced practice provider, based on each institution’s protocols. No limitation was placed on the level of resident performing the exam. Providers did not undergo any special training or instruction in order to participate in the study. CT scans were evaluated for injury by attending radiologists at each institution. Only finalized, attending radiologist interpretation of CT scan results was used for data collection.

Data regarding the patient’s individual injuries were collected after the completion of the full trauma evaluation, including primary, secondary, and tertiary survey. The following injuries were considered “distracting”: Skull fracture, >2 facial bone fractures, mandible fracture, intracranial hemorrhage (including subdural hematoma, epidural hematoma, subarachnoid hemorrhage, intraventricular hemorrhage, intraparenchymal hematoma), > 2 rib fractures, clavicle fracture, sternal fracture, pelvic fracture, thoracolumbar spine fracture, intra-abdominal injury (including solid organ injury, hollow viscus injury, or diaphragmatic injury), femur fracture, tibia/fibula fracture, humerus fracture, radius/ulna fracture, and hip or shoulder dislocation.

Patients with a DI were compared to those without a DI. Categorical variables were compared with Chi-square or Fisher’s exact test where appropriate. Continuous variables were compared with Student’s t-test or Wilcoxon Rank Sum test based on the distribution. Multi-variable analysis was not performed due to the limited number of events. The primary outcome variable was clinical missed injury, defined as an injury that was missed by physical exam but subsequently detected by CT scan. A p value less than 0.05 was considered significant.
Results

During the study period, 2929 blunt trauma patients with a GCS ≥14 were enrolled in the study. The mean age was 46.7 (±20.7) and approximately ⅔ were male (65.3%). Two thousand and fifty eight patients (70.3%) had at least one DI. C-spine injuries were found on CT scan in 222 (7.6%) patients. When examining the entire population, clinical missed injuries were found in 25 (0.8%) of patients and there was no difference in the rate of clinical missed injury between those with and without DI (0.7% vs 1.3%, \(p=0.117\)). Patients with DI were less likely to have c-spine injuries than patients without DI in this series (6.6% vs 10.0%, \(p=0.0016\)). Additionally, patients with DI were less likely to have positive findings on clinical exam (16.4% vs 28.4%, \(p<0.0001\)), and to undergo operative intervention for a c-spine injury (1.4% vs 2.6%, \(p=0.016\)). (Table1)

Motor vehicle collision (MVC) was the most common mechanism of injury (45.1 %) followed by falls (26.1%), motorcycle collisions (8.5%), pedestrian struck by motor vehicle (7.2%), assaults (4.9%), ATV collisions (2.8%), bicycle crashes (2.4%), crush injuries (2.1%), found down (0.4%), explosions (0.2%), and boat collisions (0.2%). There were no significant differences between these groups.

The mean age of patients that had a c-spine injury on CT scan was 53.2 (±21.2) and 65.3% of those with c-spine injuries were male. One hundred and thirty five patients (60.8%) with a documented c-spine injury also had at least one DI. Clinical missed injuries were identified in 11.3% of patients who had a c-spine injury. There was no difference in the rate of clinical missed injury when comparing patients with a DI to those without a DI (10.4% vs 12.6%, \(p=0.601\)). There was no difference in the rate of operative intervention for c-spine injury
between those with and without DI (26.4% vs 19.3%, \( p=0.208 \)). (Table 2) Only 1 of the 25 patients with a clinical missed injury required operative intervention for their c-spine injury and no patient had a complication from a clinical missed injury. (Table 3)

The sensitivity of physical exam in detecting c-spine injury was 89.6% in patients with DI and 87.4%. The specificity of physical exam was 88.7% in patients with DI and 78.0% in patients without DI. The negative predictive value of a negative physical exam was 99.2% in patients with DI and 98.2% in patients without DI. The positive predictive value of a positive c-spine exam was 35.8% and 30.8% in patients with and without DI, respectively. No significant differences were found between these groups.

**Discussion**

In today’s medical landscape, increasing emphasis is being placed on resource utilization. Decreasing the number of radiographic studies utilized in c-spine clearance can have obvious cost benefits, but a missed injury can lead to devastating consequences for the patient, physician, and hospital. Deciding which patients truly require radiographic evaluation of the c-spine and which patients can be cleared without radiographic testing is a difficult but important task.

Removal of hard cervical collars as soon as is safely possible is in a patient’s best interest. A longer time in a cervical collar has been associated with a prolonged ICU and overall hospital length of stays and with more ventilator days.\(^{22}\) Multiple studies have found an increase in decubitus ulcers with extended time in a cervical collar.\(^{23-25}\) Studies have also shown a decrease in ICP in head injured patients after cervical collar removal.\(^{26-28}\) There are clearly
advantages to removing cervical collars as soon as clinically significant injuries have been excluded, but the question remains: when is it safe to remove the collar? The answer to this question has been evolving over the past several years.

Historically, evaluation of the c-spine involved a combination of exam and plain radiography. Plain film radiography was found to have an unacceptably high rate of missed injury with sensitivities as low as 35% for all radiographs and as low as 63% for plain radiographs deemed “adequate”. CT scan has supplanted plain film as the radiographic test of choice for c-spine evaluation in blunt trauma. The sensitivity of CT scan for detecting c-spine injury is >99% in most recent series. Although CT has proven to be very sensitive, there has been a steady trend toward less radiographic testing in a variety of patient populations prior to cervical collar removal. Several studies have proven the safety of physical exam alone as a method of clearing the c-spine in the awake and alert patient. A variety of publications, including an EAST practice management guideline, recommend the removal of cervical collars in obtunded patients based on negative CT scan results without subsequent MRI. A 2017 WTA multi-institutional trial suggested that intoxication is no longer an indication pursue further workup after a negative c-spine CT and a negative exam. A recent single center trial suggested that MRI is unnecessary if a patient has a negative CT scan and no focal neurological findings, even with pain or tenderness on exam.

The idea that a DI limits the sensitivity of physical exam is a principle that has been long held by trauma surgeons. The EAST guidelines, ATLS teaching, the NEXUS study, and multiple other studies claim that a painful DI precludes the safe use of physical exam as a screening tool for c-spine injury and that radiographic evaluation is required in these patients. Among the problems with this recommendation is that none of these
publications defines specifically what qualifies as a DI. This has left the individual clinician to
determine which injuries qualify as “distracting”, resulting in a wide range of practice patterns
across the trauma landscape.

The confusion surrounding the definition of a DI is compounded by the lack of evidence
that a painful injury actually limits the sensitivity of clinical c-spine examination. The majority
of literature assessing the role that DI plays in the reliability of physical exam findings would
suggest that clearance based on negative physical exam findings alone is safe. Rose et al.
performed a single center prospective study that suggested that DI did not interfere with the
sensitivity of physical exam as a screening tool. DI was identified in 464 patients, 86 of which
were also found to have a c-spine injury. Of those 86 patients with both a DI and a c-spine
injury, 85 had a positive physical exam. The single patient with a clinical missed injury did not
suffer a neurologic complication and did not require surgical intervention. The authors
concluded that a negative physical exam was sufficient to clear the c-spine in patients with DI.
Similarly, Konstantinidis et al. found that patients with a DI, other than those to the upper chest,
did not require c-spine imaging if physical exam did not illicit concern for a c-spine injury. They found that 4% of patients found to have c-spine injuries did not have pain or tenderness on exam. All of these patients with clinical missed injury had bruising and pain to their upper anterior chest. None of the patients with clinical missed injury had complications or required surgery. Velmahos et al. studied 549 patients that were able to follow complex commands, 409 of whom suffered at least one DI. They found that DI did not affect the reliability of their exam. Stiell et al., in developing the Canadian C-spine Rule, found that physical exam had a 100% sensitivity in the setting of DI.
Most practitioners would agree that if the concept of a DI is relevant, then major long bone or pelvic fractures would qualify as such. However, studies looking at particular injury patterns have found that femur or pelvic fractures do not negatively impact the sensitivity of physical exam findings in clearing the c-spine.\textsuperscript{39,40}

These studies all suggest that clearing the c-spine in the setting of DI is safe. The suggestion that the c-spine can be safely cleared in the presence of a DI is further augmented by the results of the current study, which found no difference in the rates of clinical missed injury when DI was present versus when no DI was present. When looking at the overall study cohort, the rate of patients with a clinical missed injury who had operative fixation was a minuscule 0.03%.

Eleven percent of patients that had a c-spine injury had an injury that was missed on clinical exam. Although there was no difference in the frequency of clinical missed injury in patients with and without a DI, the overall rate is higher than has been found in previous investigations.\textsuperscript{4,10-17} This highlights the importance of a good physical exam when evaluating the c-spine for traumatic injury. Institutions participating in this study were given the freedom to develop their own protocols regarding whether to remove cervical collars after a negative physical exam or to replace them. Some institutions adopted a policy of replacing the collars. Since all patients had a subsequent CT scan, the risk of incomplete assessment of the c-spine was low and may have contributed to the high rate of clinical missed injury. Additionally, any member of the trauma team was permitted to perform the physical exam, according to the study protocol. No restriction was placed on residents or advanced practice providers conducting the exam. Less experienced providers performing initial assessment may have led to a higher rate of clinical missed injury than was seen in other studies.
Despite a higher rate of clinical missed injury than in previous studies, the rate was similar in patients with and without DI. The negative predictive value of a normal physical exam of the c-spine was high, at 99.2% for patients with DI and 98.2% for patients without DI. Even when a clinical missed injury was present, these injuries appeared to be of limited clinical significance, as only 1 of the 222 (0.4%) patients with c-spine fractures had a clinical missed injury that subsequently underwent operative fixation. The remaining patients with injuries not detected by physical exam were treated either with a cervical collar or not at all.

Patients without a DI were more likely to have positive physical exam findings than those with a DI. While at first glance this may suggest that physical exam was more sensitive in patients without DI, this is not actually the case. Patients without DI had a significantly higher rate of c-spine injury which accounts for the higher rate of positive physical exam findings. As already stated, the rate of clinical missed injury was the same in patients with and without DI.

Some previous studies evaluating c-spine injuries, including the NEXUS study and the Canadian c-spine rule, exclude patients 65 years of age and older. Older patients were included in the analysis of the current study. A subgroup analysis was performed on patients 65+ and they were not found to have a higher rate of clinical missed injury.

There are some limitations to this study. The definition of DI was chosen to be consistent with previous studies assessing the role of DI in c-spine evaluation. The intent was to include only injuries that most practitioners would see as distracting. Since there is no consensus definition of DI, it is likely that some practitioners would consider additional injuries as a DI, while others would not consider all of the included injuries to be a DI. Defining DI based on the presence of specific injuries is consistent with previous studies evaluating DI, but does not account for the subjective difference in pain perception between patients.
As this study is a multi-center trial, intra-institutional differences in protocols, policies, and biases could have led to inconsistency in exam technique, reporting of results, and patient enrollment. Additionally, patients were not followed long term, so there is the possibility that some clinical missed injuries presented at a different institution after discharge. Finally, since no a priori power analysis was performed and the true effect size is unclear, it is possible this study is underpowered. A more adequately powered study may have yielded different results.

Conclusion

Negative clinical exam is sufficient to clear the c-spine in awake and alert, blunt trauma patients, even in the presence of a DI. The unproven concept that a DI precludes the use of physical exam as a screening tool is based on dogma alone and is not supported by evidence. Implementation of a policy of utilizing physical exam to clear the c-spine in blunt trauma patients with a DI has the potential to reduce the number of radiographic tests utilized and can improve resource utilization at an institution that adopts such a policy.

Author Contribution Statement:

Study Design: Gonzalez

Literature Search: Khan, Leibscher, Reiser, Gonzalez

Data Collection: Khan, Schroeppe1, Liebscher, Reiser, Anstadt, Bosarge, Carroll, Quick, Barnes, Sobrino, Murry, Morin, Gomez, Consani, Gonzalez

Data Analysis/Interpretation: Khan, Schroeppe1, Gonzalez

Drafting of Manuscript: Khan, Gonzalez
Critical Revision: Khan, Schroeppel, Liebscher, Reiser, Anstadt, Bosarge, Carroll, Quick, Barnes, Sobrino, Murry, Morin, Gomez, Consani, Gonzalez

Final Approval: Khan, Schroeppel, Liebscher, Reiser, Anstadt, Bosarge, Carroll, Quick, Barnes, Sobrino, Murry, Morin, Gomez, Consani, Gonzalez

Conflict of Interest and Source of Funding: No conflicts or sources of funding declared by any author.

Acknowledgments: The authors gratefully acknowledge Jermica Smith for database support, LaDonna Allen RN and Heather Finch RN for data collection support, Ashley Meagher MD for data collection and analysis support, and Greg Day MD for data collection and proofreading support.
References


Figure Legends

Figure 1: Algorithm for Cervical Spine Assessment
Patient GCS assessed to be $> 14$

Clinical Examination of the Neck

Assess patient for spinal cord neurologic deficits and question patient for spinal cord neurologic abnormalities

If no neurologic abnormalities

1) Remove cervical collar and manually stabilize neck
2) Assess patient for subjective complaints of neck pain
3) Assess neck for cervical tenderness (midline and lateral neck)
4) If no tenderness elicited and no complaint of neck pain: have patient voluntarily flex and extend neck
5) If no complaints of pain upon flexion and extension: have patient voluntarily rotate neck 90 degrees side to side

- At any point during clinical examination if a positive finding is elicited the examination is terminated and c-collar replaced
- If clinical examination is negative, remove c-collar

Document all clinical findings on data collection form

CT Scan all patients
Table 1: Demographics/Physical Findings – Total Study Population

<table>
<thead>
<tr>
<th></th>
<th>Total Study n = 2929</th>
<th>Distracting Injury n = 2058</th>
<th>No Distracting Injury n = 871</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>46.7 (±20.7)</td>
<td>48.3 (±20.7)</td>
<td>42.8 (±20.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Female (n=1016)</td>
<td>34.7%</td>
<td>32.9%</td>
<td>39.0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Presence of C Spine Injury (n=222)</td>
<td>7.6%</td>
<td>6.6%</td>
<td>10.0%</td>
<td>0.001</td>
</tr>
<tr>
<td>Clinical Missed Injury (n=25)</td>
<td>0.8%</td>
<td>0.7%</td>
<td>1.3%</td>
<td>0.117</td>
</tr>
<tr>
<td>Clinical Exam Finding (n=585)</td>
<td>20.0%</td>
<td>16.4%</td>
<td>28.4%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Neck Pain (n=497)</td>
<td>17.0%</td>
<td>13.5%</td>
<td>25.3%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Neck TTP (n=474)</td>
<td>16.2%</td>
<td>13.0%</td>
<td>23.8%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pain w/ Flex/Ex (n=284)</td>
<td>9.7%</td>
<td>8.0%</td>
<td>13.7%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pain w/ Rotation (n=267)</td>
<td>9.1%</td>
<td>7.6%</td>
<td>12.6%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Operative Treatment (n=51)</td>
<td>1.7%</td>
<td>1.4%</td>
<td>2.6%</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Continuous variables expressed as means (SD) and categorical variables expressed as percentages. C Spine: Cervical Spine; TTP: Tender to Palpation on exam; Flex/Ex: Flexion and Extension.
Table 2: Demographics/Physical Findings – Patients with Documented C-Spine Injuries

<table>
<thead>
<tr>
<th></th>
<th>Total Injuries n = 222</th>
<th>Distracting Injury n = 135</th>
<th>No Distracting Injury n = 87</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>53.2 (±21.2)</td>
<td>53.5 (±20.3)</td>
<td>52.6 (±22.6)</td>
<td>0.756</td>
</tr>
<tr>
<td><strong>Female (n=77)</strong></td>
<td>34.7%</td>
<td>31.9%</td>
<td>39.1%</td>
<td>0.269</td>
</tr>
<tr>
<td><strong>Clinical Missed Injury (n=25)</strong></td>
<td>11.3%</td>
<td>10.4%</td>
<td>12.6%</td>
<td>0.601</td>
</tr>
<tr>
<td><strong>Clinical Exam Finding (n=197)</strong></td>
<td>88.7%</td>
<td>89.6%</td>
<td>87.4%</td>
<td>0.601</td>
</tr>
<tr>
<td><strong>Neck Pain (n=169)</strong></td>
<td>76.1%</td>
<td>73.3%</td>
<td>80.4%</td>
<td>0.224</td>
</tr>
<tr>
<td><strong>Neck TTP (n=174)</strong></td>
<td>78.4%</td>
<td>75.5%</td>
<td>82.8%</td>
<td>0.203</td>
</tr>
<tr>
<td><strong>Pain w/ Flex/Ex (n=154)</strong></td>
<td>69.4%</td>
<td>69.6%</td>
<td>69.0%</td>
<td>0.917</td>
</tr>
<tr>
<td><strong>Pain w/ Rotation (n=144)</strong></td>
<td>64.9%</td>
<td>64.4%</td>
<td>65.5%</td>
<td>0.870</td>
</tr>
<tr>
<td><strong>Operative Treatment (n=49)</strong></td>
<td>22.1%</td>
<td>19.3%</td>
<td>26.4%</td>
<td>0.208</td>
</tr>
</tbody>
</table>

Continuous variables expressed as means (SD) and categorical variables expressed as percentages. TTP: Tender to Palpation on exam; Flex/Ex: Flexion and Extension.
<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Mechanism</th>
<th>GCS</th>
<th>DI</th>
<th>Level of Injury</th>
<th>Treatment</th>
<th>Type of DI</th>
<th>Type of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>M</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>64</td>
<td>F</td>
<td>Fall</td>
<td>14</td>
<td>Yes</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>26</td>
<td>M</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C6</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>74</td>
<td>F</td>
<td>Fall</td>
<td>15</td>
<td>No</td>
<td>C1</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>26</td>
<td>M</td>
<td>MCC</td>
<td>14</td>
<td>No</td>
<td>C5</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>31</td>
<td>F</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C2</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>58</td>
<td>F</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C4</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>22</td>
<td>F</td>
<td>MCC</td>
<td>15</td>
<td>No</td>
<td>C6</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>55</td>
<td>M</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>38</td>
<td>F</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C2</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>46</td>
<td>M</td>
<td>MVC</td>
<td>15</td>
<td>No</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>53</td>
<td>M</td>
<td>ATV</td>
<td>15</td>
<td>Yes</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>27</td>
<td>M</td>
<td>MVC</td>
<td>14</td>
<td>Yes</td>
<td>C6</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>38</td>
<td>M</td>
<td>MCC</td>
<td>15</td>
<td>No</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>53</td>
<td>M</td>
<td>ATV</td>
<td>15</td>
<td>Yes</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>26</td>
<td>M</td>
<td>MVC</td>
<td>15</td>
<td>Yes</td>
<td>C5</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>46</td>
<td>M</td>
<td>MCC</td>
<td>15</td>
<td>No</td>
<td>C7</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
<tr>
<td>27</td>
<td>M</td>
<td>MCC</td>
<td>14</td>
<td>Yes</td>
<td>C6</td>
<td>CTO - Collar</td>
<td>None</td>
<td>Transverse Process Frx</td>
</tr>
</tbody>
</table>

Table 3: Clinical Missed Injuries