



# Incidence and Demographics of Cervical Spine Fractures over a 10 Year Period at a Level I Trauma Center

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## ABSTRACT

**Background:** In an effort to capture all cervical fractures in the trauma setting, many institutions have implemented protocols for urgent cervical computed tomographic (CT) imaging for any patient with traumatic neck pain. This has led to a high frequency of negative imaging studies.

**Objectives:** The objective is to characterize a consecutive series of cervical spine fractures diagnosed at a single Level I trauma center over a 10-year period. It is expected that a greater awareness of the associations between age, injury mechanism, and fracture type may facilitate the diagnosis and management of patients with cervical spine trauma.

**Methods:** In this study, every cervical CT scan ordered in the Emergency Department (ED) at our institution was reviewed and evaluated for fractures. The relevant demographic data and mechanism of injury for patients with fractures were recorded.

**Results:** Of 763,099 ED visits, 13,896 cervical CT scans were ordered (1.8% of visits) and 492 scans (3.5% of scans, 0.06% of visits) were found to have cervical fractures resulting from blunt trauma. There was a bimodal distribution of fractures with respect to age, with peaks at 20 to 24 and >85 years of age. These age ranges were also found to have higher incidence of fracture than would be predicted by population alone. Fractures in younger patients resulted from high-energy trauma and fractures in older patients resulted primarily from falls.

**Conclusion:** This elucidation of epidemiology and mechanism of cervical fractures can be used to improve the rapidity of diagnosis and management of these potentially devastating injuries.

**Keywords:** Cervical spine, Cervical spine fracture, Computed tomography, Level I Trauma, Trauma.

Blizzard DJ, Miller CP, Blizzard ST, Grauer JN. Incidence and Demographics of Cervical Spine Fractures over a 10 Year Period at a Level I Trauma Center. *The Duke Orthop J* 2016;6(1):21-25.

**Source of support:** Nil.

**Conflict of interest:** None.

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## INTRODUCTION

It has previously been reported that only 2 to 3% of patients experiencing blunt trauma will sustain injuries to their cervical spine,<sup>1,2</sup> yet fractures or dislocations affecting this region may bring about a number of potentially devastating consequences including neurologic compromise, permanent disability, or death.<sup>3-5</sup> It is clear that prompt and accurate diagnosis of these injuries is essential such that the optimal treatment may be initiated as quickly as possible. As a result, there continues to be significant interest in understanding the incidence and pattern of these injuries as they occur in the general population.

The clinical presentation of cervical spine fractures is variable and is influenced by several factors such as patient age and the mechanism of injury.<sup>7</sup> Young, healthy people are more likely to have been subjected to high-energy trauma from motor vehicle collisions or sports-related accidents while in the geriatric population, these injuries frequently arise from ground-level falls.<sup>8,9</sup> It is expected that a greater awareness of the underlying associations that exist between age, injury mechanism, and fracture type may facilitate the diagnosis and management of patients with cervical spine trauma.

Various groups have attempted to characterize the incidence and age distribution of cervical spine injuries; however, most of these studies focused solely on specific fracture patterns or were otherwise limited by small sample size or utilization of plain films alone without computed tomographic (CT) imaging.<sup>10,11</sup>

In an effort to overcome these inadequacies, other authors have used data derived from public trauma registries. In their analyses, the NEXUS study group considered a large cohort of patients with a history of blunt trauma that was assembled from 21 different institutions.<sup>12-14</sup> However, even among these 33,922 subjects, there were only 818 confirmed injuries involving the cervical spine. Despite their relatively larger numbers, these studies are limited in their generalizability due to the lack of an incidence calculation normalized to the hospital reference populations. Furthermore, the studies are limited by reliance upon radiology reports.

The purpose of this study was to characterize a consecutive series of cervical spine fractures and dislocations

that were treated at a single Level I trauma center over a 10-year period and relate them with other variables, such as patient age and mechanism of injury.

## MATERIALS AND METHODS

### Identifying Injuries and Demographic Information

Human Investigation Committee approval was acquired prior to the commencement of this study. Every cervical CT scan (partial or complete) that was ordered in the Emergency Department (ED) of our Level I academic medical center during a 10-year period (between November 27, 1997, and April 14, 2008) was identified by searching a database maintained by the Department of Radiology.

The radiology reports of these studies were scrutinized for any mention of acute traumatic fractures and/or dislocations of the cervical vertebrae or occipital condyles; for these scans, the diagnosis was confirmed by reviewing the actual images using digital radiography software (Synapse V3.0, FujiFilm, USA). Any report that did not explicitly state the absence of a fracture and/or dislocation was also directly reviewed. Exclusion criteria included pathologic fractures and penetrating trauma (e.g., gunshot wounds). Finally, relevant demographic information including medical record number, age, gender, and date of the study was also recorded in each case.

The population statistics for the state in which the study was conducted (i.e., Connecticut) were obtained from the US Census Bureau ([www.census.gov](http://www.census.gov)) which published its most recent figures in 2000 – concurrent with the time of the study. The total number of patient visits to the ED of this institution was provided by the billing office of the Radiology Department.

### Fracture Mechanisms

The circumstances under which each of these fractures had occurred were established by reviewing the patient’s medical record and the various mechanisms of injuries were segregated into several broad categories. Automobile and motorcycle collisions were both classified as motor vehicle accidents (MVAs). All falls were grouped together, whether they were from a standing position or greater heights. Any additional etiologies, such as diving injuries, pedestrians struck by vehicles, assaults, and blows to the head were combined into “other.”

### Statistical Considerations

A one-sided student’s t test was used to compare the number of fractures per person (individual risk of fracture) in each age group to the mean number of fractures per person (mean individual risk of fracture) for the total population of the state of Connecticut. The relative risk of sustaining a fracture in each age group was

calculated by comparing the risk of sustaining a fracture in a given age group relative to the risk of sustaining a fracture in the remaining population group. Student’s t tests were used to compare the rate of positive scans relative to total scans obtained as a function of age.

## RESULTS

### Identification of Study Population and Demographic Data

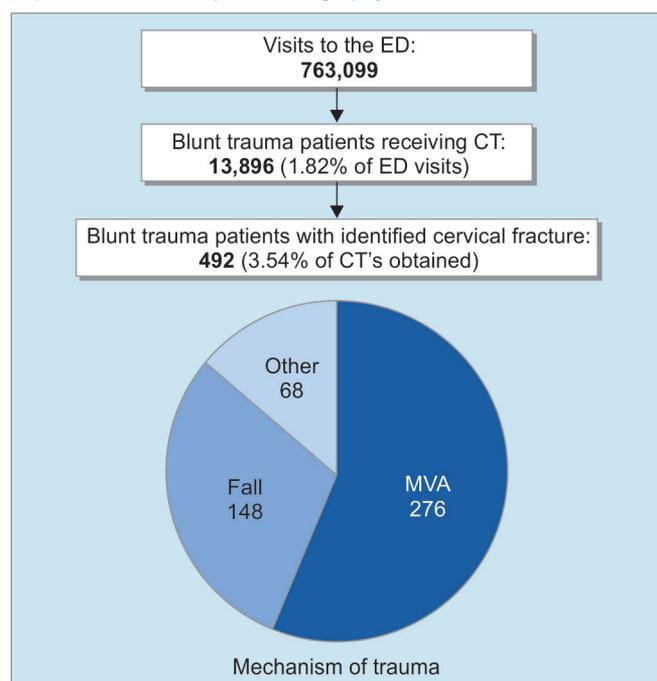
Between November 17, 1997, and April 14, 2008, there were 763,099 visits to the ED at our institution. From these visits, 13,896 cervical spine CT scans were obtained in the ED, with 604 (4.4%) noted to have reports that were either positive or equivocal for acute fractures or dislocations. Following careful review, 97 were excluded from the analysis because they did not reveal any injuries, and an additional 15 scans were omitted because they either involved pathologic fractures (8) or penetrating trauma (7). The elimination of these studies gave rise to a final study cohort of 492 (3.5%) of subjects who had blunt trauma-related cervical fractures after presenting to the ED (Flow Chart 1).

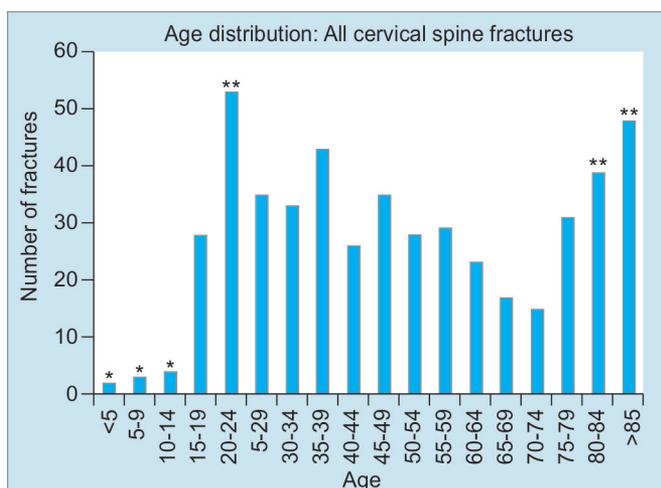
### Incidence of Cervical Fractures

Overall, these injuries clearly exhibited a predilection for males (63.2%, n=311) with only approximately one-third occurring in females (36.7%, n=181). Males comprised a greater proportion (61.8%, n=8,593) of patients undergoing a cervical CT scan relative to females (38.2%, n=5,303).

When correlating the incidence of fractures with patient age, there was a bimodal distribution of cervical

**Flow Chart 1:** Patient population in the study (ED: Emergency department; CT: Computed tomography; MVA: Motor vehicle accident)





**Graph 1:** Age distribution of all cervical spine fractures. The \* denotes a statistically significant lower incidence of cervical fracture than would be predicted by population alone. Conversely, the \*\* denotes a statistically significant higher incidence of cervical fracture that would be predicted by population alone. Population data for the state of Connecticut was taken from the US Census 2000 (p < 0.05)

fractures, with one peak centered at 20 to 24 years of age range and another at >85 years of age (Graph 1). These fractures are further subdivided based upon the mechanism of fracture (i.e., MVAs, falls, and other) in Graph 2.

Table 1 shows the breakdown of positive scans relative to all scans obtained as a function of age and gender. The rates of positive scans are compared for statistical significance showing a statistically lower rate of positive scans for patients less than 15 years old and statistically higher rate of positive scans for patients 55 to 84 years old.

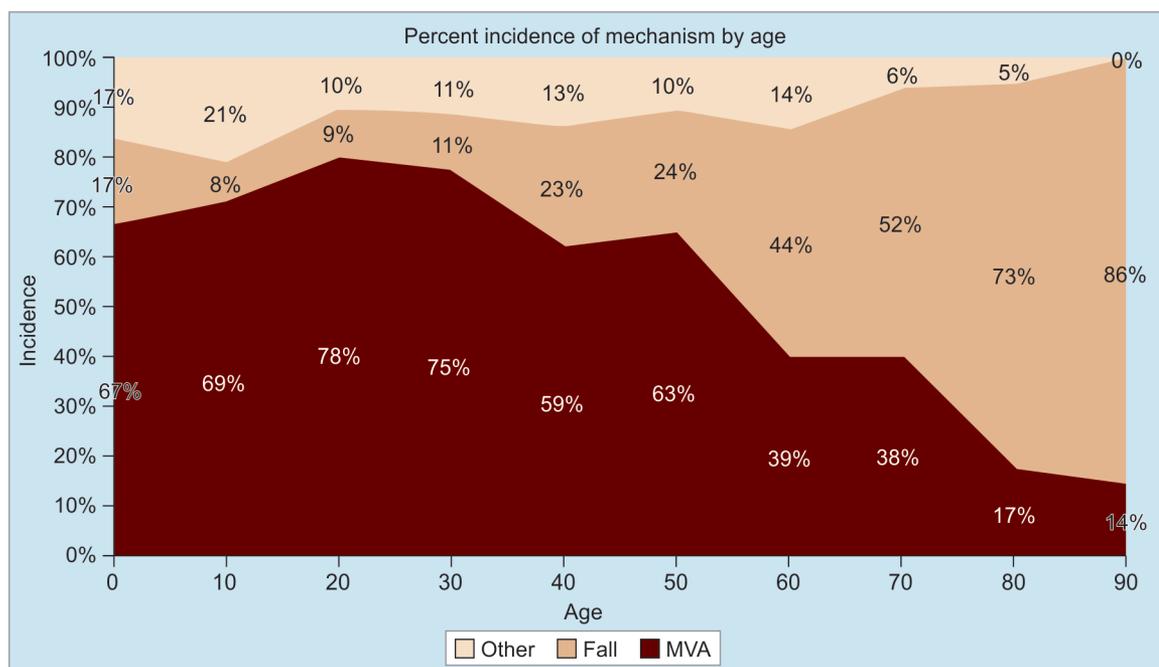
**Table 1:** Comparison of total computed tomographic scans and computed tomographic scans with identified fractures (positive scan) by age group

Age (years)	Total CT scans	CT scans with identified fractures	% CT scans with identified fractures
<5	301	2	0.66*
5-9	155	3	1.94*
10-14	256	4	1.56*
15-19	1,019	28	2.75
20-24	1,620	53	3.27
25-35	2,188	68	3.11
35-44	2,154	69	3.20
45-54	1,861	63	3.39
55-59	600	29	4.83*
60-64	498	23	4.62*
65-74	756	32	4.23*
75-84	1,197	70	5.85*
>85	1,291	48	3.72

The overall average rate of a positive scan is 3.54%. The fractional percent of positive scans for patients less than 15 years old was statistically significantly lower than mean fractional percent for all ages. Conversely, patients 55 to 84 years old had a statistically significantly higher rate of scans with positive findings (\*signifies statistically significant difference from mean of all age groups: p < 0.05; CT: computed tomography)

**Regional Incidence**

In Table 2, the age distribution of fractures is compared with population statistics for the state of Connecticut in 2000. Patients aged less than 15 exhibited a lower statistically significant lower rate of cervical fractures than would be predicted by population statistics alone. Conversely, patients 20 to 24 and patients over 75 years of age exhibited an incidence of cervical fracture that



**Graph 2:** The age distribution of the various mechanisms of fracture (expressed as a percentage of total injuries for each age group); MVA: Motor vehicle accident

**Table 2:** Normalized demographic and fracture data

Age (years)	% population	% fractures	Relative risk	p-value
<5	6.6	0.4	0.059	↓0.0010
5–9	7.2	0.8	0.107	↓0.0014
10–14	7.1	1.2	0.163	↓0.0020
15–19	6.4	6.8	1.071	0.2959
20–24	5.5	10.7	2.051	↑0.0171
25–35	13.3	14.4	1.098	0.3171
35–44	17.1	14.6	0.830	0.1157
45–54	14.1	12.3	0.855	0.1268
55–59	5.2	5.7	1.113	0.3438
60–64	3.9	3.9	1.010	0.2369
65–74	6.8	7.0	1.029	0.2546
75–84	5.1	15.2	3.321	↑<0.0001
>85	1.9	7.0	3.902	↑<0.0001

Population is reported as the percent of the total Connecticut population comprised by each respective age group range. Fracture incidence is reported as the percent of total cervical fractures comprised by each respective age group range. Down arrows indicate a statistically significant lower incidence of cervical fractures than would be predicted by population alone. Up arrows indicate a statistically significant higher incidence of cervical fractures than would be predicted by population alone. p values were calculated using a one-sided t test comparing the number of fractures per person in each age group to the mean number of fractures per person for entire population. Relative risk was calculated for each age group relative to the remainder of the population

is higher than the rate that would be predicted by population statistics alone.

## DISCUSSION

Cervical spine fractures and dislocations are potentially devastating injuries that must be quickly identified and properly managed in order to optimize patient outcomes. While previous investigations have reported the demographic information associated with specific cervical fractures,<sup>10-13,16,19-22</sup> nearly all of these studies focused on a single type of injury and failed to provide a comprehensive survey of the spectrum of cervical trauma. A clear understanding of the age distribution and mechanisms of these injuries would not only serve to increase clinicians' awareness of individuals who are at high risk for cervical fractures, but also allow for the rapid initiation of appropriate treatment strategies.

The classification of these fractures by age, as seen in Graph 1, reveals a bimodal distribution, with the first peak in incidence in the 20 to 24 year cohort (48 fractures, 10.7% of subjects). The incidence remains relatively high through the late 30 seconds, at which point it gradually decreases until a second peak begins in the 75 to 79 age group and peaks at the >85 group.

There were also clear differences between the mechanisms of fracture recorded among the various age groups. As shown in Graph 2, the most common etiology noted

for individuals younger than 60 years was high-energy trauma, such as MVAs and direct blunt force trauma (e.g., pedestrian struck by car, dive into shallow water, assault) that accounted for 72 to 90% of the fractures that occurred in these cohorts. However, the most frequent precipitating event for those older than 60 years of age was falls; this mechanism was responsible for between 52 and 86% of the cervical fractures that were incurred by this population.

The distribution of cervical spine fractures and population data from the state of Connecticut in 2000 is presented as a function of age in Table 2. This analysis suggests that children under the age of 15 years sustain significantly less cervical fractures than would be expected based on their demographics; the relative risks for cervical fracture for subjects under 5, 5 to 9, and 10 to 14 years were 0.059, 0.107, and 0.163 respectively. Conversely, individuals age 20 to 24 and those over 75 years suffer significantly more cervical spine fractures with relative risks of 2.051, 3.321, and 3.902 for the 20 to 24, 75 to 84, and greater than 85 year age groups respectively. These findings presumably reflect the propensity for young adults to be involved in high-energy accidents, whereas the elderly are more likely to incur injuries due to an increased proclivity for falling secondary to gait imbalance with concomitant osteoporosis, diminished mental status, and other medical comorbidities.

Finally, our data show that younger patients in this population are more likely than their older counterparts to have a scan that reveals no abnormality. This occurrence can be attributed to inherent difficulties obtaining a clear history from the patients, more liberal utilization of CT scans in cases of potential head injury, or a lower likelihood of the common injury patterns in this population to cause pathology. Conversely, the relatively higher rate of positive scans in the elderly population could suggest a higher threshold to order CT scans in this population or a greater propensity of falls (the most common injury pattern in this population) to cause identifiable trauma.

We acknowledge that this study is not without its limitations. First, it is possible that all cervical spine fractures were not identified in the initial survey. If the initial radiology report did not document a fracture that was subsequently confirmed upon further evaluation, it is conceivable that the patient may not have been included in this series. Additionally, patients were only included in the study if a CT scan was performed in our institution's ED – patients transferred to our hospital with radiographic studies completed at an outside facility may have been inadvertently omitted from this cohort. Nevertheless, given that the threshold for acquiring a CT scan of the cervical spine in the ED is very low for patients presenting with a history of trauma, we are confident that the vast majority of patients with cervical

spine injuries who were evaluated at this institution during this time period were successfully captured using this protocol and the number of fractures that may have been missed is small. Finally, this data only incorporate patient information from a single hospital system. Though it is likely representative of many Level I trauma centers, it may not be generalizable to a wider population. We also acknowledge this study lacks a prospective, detailed algorithm for stratifying severity of trauma and clinical suspicion of injury to determine which patients should undergo CT imaging. Although the type of trauma was recorded, there was no gradation to distinguish between severities (e.g., high-speed roll-over with ejection *vs* low-speed without airbag deployment). Additionally, this study does not account for symptoms upon presentation (e.g., mild neck soreness in the setting of poly-trauma *vs* primary complaint of severe unrelenting neck pain).

## CONCLUSION

This study characterizes a consecutive series of patients with cervical spine fractures who were treated in the ED of a Level I trauma center between December 1997 and April 2008. The results of this analysis indicate that cervical spine fractures appear to demonstrate a bimodal age distribution with peaks evident in the early 20 seconds as well as in those older than 85 years. The most common mechanisms of fracture were high-energy trauma, such as MVAs in the younger age groups and falls in the elderly population. Finally, relative to their population demographics, children under 15 were significantly less likely to injure their cervical spines, whereas patients in their early 20 seconds and those over 75 years sustained these types of fractures at a much higher rate than expected. Through elucidation of the epidemiology and mechanistic nature of traumatic insults to the cervical spine, it is our hope that the care of these individuals may be improved by facilitating the rapid diagnosis and proper management of these potentially devastating injuries.

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