

## **Canadian c-spine criteria and nexus in the spinal trauma: comparison at a tertiary referral hospital in Turkey.**

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### **Abstract**

**Objective:** Spinal trauma and the ensuing neurological problems transform a person's social life and result in significant economic and non-economic burden. We compared the diagnostic performances of the National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) with the Canadian C-Spine Rule (CCSR) criteria in identifying lesions.

**Methods:** This retrospective study was conducted on 724 patients after obtaining approval from the ethical board of the hospital. The demographic characteristics of the patients (age, gender), their medical histories, season, trauma occurrence mechanism, hospital arrival time following the development of spinal trauma, their Glasgow Coma Score at the time of admission, their complaints at the time of admission (such as pain, paresthesia, and loss of muscle strength), their spinal trauma lesion levels, and compatibility of the applied viewing methods with the NEXUS and CCSR criteria were collected from the patients' files.

**Results:** A total of 2,442 cases were diagnosed with spinal trauma. For patients with a spinal fracture, the sensitivity and specificity of CCSR were 99.7% and 17.9%, respectively, while the sensitivity and specificity of NEXUS were 97.6% and 27.2%, respectively. Positive predictive value (PPV) and negative predictive value (NPV) of CCSR were, respectively, 16.3% and 99.7%, while the PPV and NPV of NEXUS were 17.7% and 98.6%, respectively.

**Conclusions:** This study showed that the CCSR criteria are more sensitive than the Nexus criteria.

**Keywords:** Spinal injury, Emergency, NEXUS.

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### **Introduction**

Spinal trauma and the ensuing neurological problems transform a person's social life and result in significant economic and non-economic burden [1].

The incidence of spinal trauma in developing countries was reported to be 25.5 per million in 2013. Spinal traumas are frequently observed in young people aged 15-25 years, with a male:female ratio is 4:1. The most common reasons for spinal traumas are motor vehicle accidents (50%), falls and occupational accidents (30%), violent crimes (11%), and sports injuries (9%) [2-5]. Magnetic resonance imaging plays an important role in the management of spinal trauma [6].

In this study, we aimed to compare the diagnostic performances of the National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) with the The Canadian C-Spine Rule (CCSR) criteria in identifying lesions.

### **Material and Methods**

This was a retrospective study conducted in Sisli Etfal Training and Research Hospital involving 724 patients after obtaining approval from the ethical board of the hospital. Sisli Etfal Training and Research Hospital is a tertiary training hospital located in the European side of Istanbul. We examined a total of 2,442 patients who were admitted to the emergency service due to spinal trauma and vertebral pathology between July 1, 2013, and June 30, 2014. The demographic characteristics of the patients (age, gender), their medical histories, season, trauma occurrence mechanism, hospital arrival time following the development of spinal trauma, their Glasgow Coma Score (GCS) at the time of admission, their complaints at the time of admission (such as pain, paraesthesia, and loss of muscle strength), their spinal trauma lesion levels, and compatibility of the applied viewing methods with the NEXUS and CCSR criteria were collected from the patients' files.

Statistical analysis was performed using the *Statistical Package* for the Social Sciences (SPSS version 17.0; SPSS,

Inc., Chicago, IL). Patients with a positive traumatic spinal fracture based on computerized tomography (CT) results were categorized as Group 1, and those who with a negative spinal fracture were categorized as Group 2. Results were expressed as number and percentage. Chi-square test was performed to compare categorical data. Receiver operating characteristic (ROC) curve analysis was performed to determine the effectiveness of detecting spinal injury using both decision rules. The sensitivity, specificity, and predictive values with 95% confidence intervals (CIs) were determined for assessing the performance of each decision rule for radiological assessment. P values<0.05 were considered to be statistically significant.

**Results**

A total of 957,803 patients were admitted to our emergency department throughout the period during which we conducted our study. Among the total admissions, 5,276 were due to trauma and 2,442 cases were diagnosed with spinal trauma. The frequency of spinal traumas among all the admissions was determined to be 25.4%, while the frequency among trauma admissions was determined to be 46.2%. Details of 20 patients with spinal traumas (1%) were complete, whereas details of the remaining 2,422 patients (99%) were incomplete.

Of the patients admitted to the emergency department due to spinal trauma, 1,566 of them (64%) were males and 876 (36%) were females, constituting a male:female ratio of 1.78. Regarding the age groups of the patients, 162 (7%) were aged 0-9 years, 283 (12%) were aged 10-19 years, 577 (24%) were of 20-29 years of age, 443 (18%) were aged 30-39 years, 333 (14%) were aged 40-49 years, 226 (9%) were aged 50-64, and 418 (17%) were aged ≥ 65 years. Spinal trauma was frequently observed in the young adult group of patients aged 20-29 years (24%) (p<0.05).

Table 1 shows the demographic characteristics of the patients, the trauma mechanisms, the NEXUS vs. CCSR criteria, and the GCS of the patients according to the groups.

**Table 1.** Demographic characteristics, trauma mechanisms, NEXUS vs. CCSR criterias, and GCS of the patients according to the groups.

| Variable                 | Group 1 (n) | Group 2 (n) | p      |
|--------------------------|-------------|-------------|--------|
| Gender (Male/<br>Female) | 207/121     | 1359/755    | 0.71   |
| Trauma mechanism         |             |             |        |
| Motor vehicle            | 34          | 278         | <0.001 |
| Fall                     | 206         | 1026        |        |
| Assault                  | 12          | 161         |        |
| Pedestrian               | 56          | 489         |        |
| Other                    | 20          | 160         |        |
| Criteria                 |             |             | <0.001 |
| NEXUS ±                  | 321/7       | 1541/573    |        |

|   |       |          |        |
|---|-------|----------|--------|
| CCSR ±  | 327/1 | 1738/376 | <0.001 |
| GCS   |       |          |        |
| 14-15   | 279   | 1987     |        |
| 9-13  | 36    | 93       | <0.001 |
| <9  | 13    | 34       |        |
| NEXUS: National Emergency X-Radiography; Utilization Study, CCSR: Canadian C-Spine Rule Criteria; GCS: Glasgow Coma Scale |       |          |        |

Evaluation of the complaints related to spinal trauma revealed that the most common complaint was pain due to which 993 patients (41%) were admitted to the emergency service, followed by 858 patients (35%) due to pain and paresthesia, 451 patients (18%) due to paresthesia and fatication, 51 patients (2%) due to loss of muscle strength, and 47 patients (2%) due to paresthesia and loss of muscle strength.

Among the diagnoses of the patients with spinal trauma following their examination, the most common diagnosis was found to be compression fracture (178 patients (7.3%).

Regarding the distribution of cases according to the spinal trauma levels, it was found that the cervical region was the most common site of injury observed in 1,000 patients (41%), followed by 421 patients (17%) with injury in all spinal levels, 318 patients (13%) in the lumbar region, 289 patients (12%) in the cervical and lumbar regions, 168 patients (7%) in the cervical and thoracic regions, 127 patients (5%) in the thoracic and lumbar regions, 62 patients (3%) in the lumbar and sacral regions, 51 patients (2%) in the thoracic region, 3 patients (0%) in the cervical and sacral regions, and 3 patients (0%) in the thoracic and sacral regions.

Evaluation of the distribution of neurological deficits among the patients at the time of admission revealed that most of them (1,935 patients (79%) had no neurological deficit, whereas monoparesis was the common neurological deficit observed in 287 patients (12%), followed by 107 patients (4%) with upper extremity paresis, 42 patients (2%) with paraparesis, 36 patients (1%) with quadriplegia, 25 patients (1%) with paraplegia, and 10 patients (0%) with quadriparesis.

Examination of the CT results of the patients in terms of their compatibility with the NEXUS and CCSR criteria showed that 1,862 patients (76%) met the NEXUS criteria, whereas 580 (24%) did not meet the NEXUS criteria. A total of 2,065 patients (85%) met the CCSR criteria, whereas 377 (15%) did not meet the CCSR criteria. These results indicate that CT results of the patients with spinal trauma were highly compatible with the NEXUS (76%) and CCSR (85%) criteria.

Regarding the diagnoses of the cases following the radiological examination conducted according to the NEXUS criteria, it was found that 1,532 (82%) of the 1,862 patients who met the NEXUS criteria were not diagnosed due to spinal trauma, whereas compression fracture was identified in 174 (9%) patients, rupture fracture in 92 patients (5%), compression and rupture fracture in 26 patients (1%), burst fracture in 12 patients (1%), compression and burst fracture in 10 patients

(1%), compression and dislocation in 7 patients (0%), dislocation in 6 patients (0%), rupture and dislocation in 2 patients (0%), and rupture and burst fracture in 1 patient (0%). Among the 580 patients who did not meet the NEXUS criteria, 572 (99%) were not diagnosed due to spinal trauma, whereas compression fracture was identified in 4 patients (1%) and rupture fracture in 4 patients (1%).

Evaluation of the diagnoses of the cases following the radiological examination conducted according to the CCSR criteria showed that the 1,728 patients (84%) of the 2,065 patients who met the CCSR criteria were not diagnosed due to spinal trauma, whereas compression fracture was identified in 178 (9%) patients, rupture fracture in 95 patients (5%), compression and rupture fracture in 26 patients (1%), burst fracture in 12 patients (1%), compression and burst fracture in 10 patients (0%), compression and dislocation in 7 patients (0%), dislocation in 6 patients (0%), rupture and dislocation in 2 patients (0%), and rupture and burst fracture in 1 patient (0%). Of the 377 patients who did not meet the CCSR criteria, 376 (100%) were not diagnosed due to spinal trauma, but rupture fracture was identified in 1 patient (0%). Table 2 summarizes the distribution of patients as per the radiological diagnosis according to the NEXUS and CCSR criteria. Results of the statistical analyses showed that the post radiological examination diagnostic ratio of the patients who individually met the NEXUS and CCSR criteria was significantly higher ( $p < 0.05$ ) than the diagnostic ratio of patients who did not meet the criteria.

**Table 2.** Radiological diagnosis of the patients according to NEXUS and CCSR criteria.

| Diagnosis | NEXUS positive | NEXUS negative | CCSR positive | CCSR negative |
|-----------|----------------|----------------|---------------|---------------|
|-----------|----------------|----------------|---------------|---------------|

**Table 3.** Neurological deficits of the patients according to NEXUS and CCSR criteria

| Deficit                 | NEXUS positive | NEXUS negative | CCSR positive | CCSR negative |
|-------------------------|----------------|----------------|---------------|---------------|
| Monoparesis             | 262            | 25             | 284           | 3             |
| Upper extremity paresis | 103            | 4              | 105           | 2             |
| Paraparesis             | 41             | 1              | 42            | 0             |
| Quadriparesis           | 10             | 0              | 10            | 0             |
| Paraplegia              | 25             | 0              | 25            | 0             |
| Quadriplegia            | 36             | 0              | 36            | 0             |

NEXUS: National Emergency X-Radiography Utilization Study; CCSR: Canadian C-Spine Rule criteria

## Discussion

In this study, we compared the performances of the CCSR and NEXUS diagnostic criteria in identifying spinal trauma. We found that the CCSR criteria were more sensitive in predicting spinal trauma and their NPV values were higher. Stiell et al. [7] reported a sensitivity of 99.7% for the CCSR criteria. Dickson et al. [8] reported that the NEXUS criteria have less sensitivity. While most of the studies reported in the literature examined

|                         |     |   |     |   |
|-------------------------|-----|---|-----|---|
| Compression fracture    | 174 | 4 | 178 |   |
| Rupture fracture        | 92  | 4 | 95  | 1 |
| Compression+rupture     | 26  |   | 26  |   |
| Burst                   | 12  |   | 12  |   |
| Compression+burst       | 10  |   | 10  |   |
| Compression+dislocation | 7   |   | 7   |   |
| Dislocation             | 6   |   | 6   |   |
| Rupture+dislocation     | 2   |   | 2   |   |
| Rupture+burst           | 1   |   | 1   |   |

NEXUS: National Emergency X-Radiography Utilization Study; CCSR: Canadian C-Spine Rule criteria

For patients with a spinal fracture, the sensitivity and specificity of CCSR were 99.7% and 17.9%, respectively, whereas the sensitivity and specificity of NEXUS were 97.6% and 27.2%, respectively. Positive predictive value (PPV) and negative predictive value (NPV) of CCSR were 16.3% and 99.7%, respectively, whereas the PPV and NPV of NEXUS were 17.7% and 98.6%, respectively.

Among the patients who met the NEXUS criteria, 477 (25.6%) had neurological deficits, while 502 patients (24%) who met the CCSR criteria had neurological deficits. However, only 30 patients (5%) who did not meet the NEXUS criteria had neurological deficits and only 5 patients (1%) who did not meet the CCSR criteria had neurological deficits (Table 3). Statistical analysis showed that the ratio of neurological deficits in the group that met the NEXUS or CCSR criteria was significantly higher than the ratio in the group that did not meet the NEXUS or CCSR criteria ( $p < 0.05$ ).

the CCSR and NEXUS criteria on a separate basis in terms of their relationship with cervical trauma, the study conducted by Stiell et al. [7] compared both the criteria directly and found that the NEXUS criteria had a sensitivity of 91% and a specificity of 37%, while the CCSR criteria had a sensitivity of 99% and a specificity of 45%. The authors concluded that the CCSR produced a better overall diagnostic accuracy and

reduced the radiological examination ratio by 44%, whereas the NEXUS reduced it by 36% [7].

In the systematic review by Michaleff et al. [9], the sensitivity for NEXUS was found to be 0.83-1.00, whereas it was 0.9-1.00 for CCSR. The specificity for NEXUS was 0.02-0.46, whereas it was 0.01-0.77 for CCSR. This systematic review thus showed that the CCSR was diagnostically superior to the NEXUS [9].

Collins et al. detected significant cervical trauma in three geriatric patients who did not require imaging, based on the NEXUS criteria [10].

Brehaut et al. showed that the CCSR was a hard rule in terms of learning, remembering, and using in practice [11]. The NEXUS criteria consist of only five questions and it comes as an easy criterion for emergency physicians' usage. Based on this, we believe that caution is needed in clinical practice to not miss a diagnosis, especially in geriatric patients, and to use both criteria if possible.

Rahimi-Movaghar et al. reported the frequency of spinal trauma cases in developing countries to be 22.5 per million a year (range 2.1-130.7 per million/year) [12]. Although epidemiological data regarding spinal trauma in Turkey are fairly limited, Karacan et al. [13] found that the incidence of spinal trauma was 12.7 per million a year, and Karamehmetoglu et al. reported incidence rates of 16.9 per million a year in Southeastern Turkey and 21 per million a year in Istanbul [14]. In the present study, we found that the incidence of spinal trauma cases among the total patients admitted to the emergency service was 25.4 permillion a year and that the incidence among the total trauma patients was 46.2 per million a year. These findings were highly consistent with the results of other studies conducted in Turkey.

Regarding the male:female ratio, Ackery et al. [15] reported a ratio of 3-4:1, whereas Ning et al. [16] reported a ratio of 5.63:1. In the Turkish context, Dryden et al. [17] reported a male:female ratio of 2.5:1, Gur et al. [18] reported 3.38:1, Karacan et al. [13] reported 2.5:1, and Karamehmetoglu et al. [14] reported ratios of 5.8:1 and 3:1 in Southeastern Turkey and Istanbul, respectively. In the present study, the male:female ratio was 1.78 which was found to be consistent with the studies conducted in our country, but not with those conducted outside Turkey.

Regarding the incomplete and complete ratios of patients admitted due to spinal trauma reported in the literature, it was observed that the ratios were 74.8% and 25.2%, respectively, as reported by Ning et al. [16], whereas in the Turkish context, Ones et al. [19] reported ratios of 36.65% and 63.35%, respectively, and Dincer et al. [20] reported ratios of 10.04% and 89.96%, respectively. In the present study, the complete and incomplete ratios were 1% and 99%, respectively, which do not appear to be consistent with the aforementioned figures in the literature. We believe that the reasons for this contrasting finding lie with the fact that the present study also included patients with spinal trauma who had no neurological deficits as opposed to the other studies reported in the literature and that

the present study mostly included traumas of low kinetic energy due to the location of the hospital being in the city center and thus the majority of the complete cases were excluded before they were even admitted to the hospital.

Regarding the age groups of the patients with spinal trauma, Kraus et al. [21] reported that spinal trauma is observed in patients aged between 0 and 24 years, whereas Karamehmetoglu et al. [14] reported this in patients aged between 20 and 29 years in Istanbul. The present study finding is consistent other studies reported in the literature, in that the majority of spinal trauma cases are observed in the young adult age group. Our study also found that the number of males in the complete and incomplete injury groups was higher than that of females. However, no statistically significant difference ( $p>0.05$ ) was found between both groups in terms of gender and age.

Hagen et al. [22] reported that 45% of the spinal trauma cases resulted from falls and 35% from motor vehicle accidents. Feng et al. [23] reported that 51.9% of the cases resulted from a combination of trip and falls and fall from heights (16.7% trip and falls, 35.2% fall from heights), 36.4% from motor vehicle accidents, and 5.4% from falling objects. In the USA, Devivo et al. [24] found that 50% of the cases resulted from traffic accidents. In the Turkish context, however, Karamehmetoglu et al. [14] reported that 37.3% of the cases resulted from falls, 29.3% from firearm injuries, 25.3% from motor vehicle accidents, and 1.3% from stab wounds in Southeastern Turkey, while their study in Istanbul found that falls and motor vehicle accidents were, respectively, the most common factors leading to spinal trauma cases. The data we obtained were, to a large extent, consistent with the literature.

## Conclusion

Spinal trauma cases have a significant position in our emergency service due to their incidence frequency, and thus patients with spinal trauma should be managed in a quick and correct manner. By adopting the NEXUS and CCSR criteria used in deciding whether to view cervical trauma injuries, in the entire spinal level, we observed that unnecessary labor, cost, and radiation exposure can be minimized, thanks to the application of such criteria. Both criteria can be used for the purpose; however, we found that the CCSR criteria are more sensitive than the Nexus criteria.

## Limitations

The most important limitations of study are retrospective cross-sectional study.

## Authors' Contributions

CC, DO and EA designed the study and wrote the manuscript. AEK and CK were involved in acquisition of data. CK and NY were involved in statistical analysis and interpretation of the data. MS, HG and CC participated in the coordination and helped to draft the manuscript. EA and CK were involved in

the final corrections. All authors read and approved the final manuscript.

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