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Comparative Diagnostic Accuracy of the NEXUS Criteria and the Canadian C-Spine Rule in Cervical Spine Trauma

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Abstract

Background & Objectives: Road traffic injuries are the fourth most common cause of death globally, according to surveys. The Canadian Cervical-Spine Rule (CCR) and the National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) are decision rules to guide the use of cervical-spine radiography in patients with trauma. In this study we aim to evaluate and compare the sensitivity and specificity of these rules in trauma patients for suspected C-spine injury.

Materials & Methods: 500 patients were prospectively enrolled, in the event of them meeting the criteria. They were subjected to radiologic studies (X-ray or CT) of the cervical spine if they met NEXUS criteria or the CCR.

Results: Of the 500 patients, 44.5% were subjected to radiography based on the NEXUS score and 58.8% based on the Canadian CCR. When the CCR was applied, the test was found to be 95.2% sensitive, 54.2% specific, 65% accurate, and with 42.6% positive predictive value and 97% negative predictive value. When NEXUS criteria were applied, sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 100%, 75.3%, 59%, 100%, and 81.8%, respectively.

Conclusion: When the NEXUS score was applied, the diagnostic accuracy was better. With the CCR, a greater number of patients were subjected to radiological evaluation. Either of the two criteria may be applied for emergency care in the Indian population to avoid unnecessary investigations. CCR followed by NEXUS criteria is recommended, and the utilization of the same is to be studied in a larger population.

Keywords: Cervical Spine Trauma, Diagnosis, NEXUS Criteria, Canadian C-Spine Rule

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Introduction

Approximately 5-10% of unconscious patients who present to the ED after a motor vehicle accident (MVA) or fall have a major injury to the cervical spine. Cervical spine fractures have been reported to occur most commonly at two levels: at the level of C2 and at the level of C6 or C7. Most fatal cervical spine injuries occur in upper cervical levels, either at the cranio-cervical junction C1 or C2 (1).

Road Traffic Injuries (RTI) are the fourth most common cause of death globally, according to surveys. Every year around 1.3 million people die on the roads, and 20–50 million people have non-fatal injuries, which may or may not lead to life-altering disability (2, 3). According to the

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latest global status report by the World Health Organization (WHO), there were 1.19 million deaths in 2023 due to RTI (4). A recent estimate in 2022 showed RTA deaths in India to be around 1.5 lakhs (5). Very few of these patients have cervical spine fractures, and the current pattern of use of radiography is not efficient. There is considerable variation in published guidelines and also among physicians with respect to the use of radiography. Cervical spine radiography is a low-cost procedure that adds substantially to healthcare costs because of the high volume of its use (6).

The Canadian Cervical-Spine Rule (CCR) and the National Emergency X-Radiography Utilization Study (NEXUS) Low-Risk Criteria (NLC) are decision rules to guide the use of cervical-spine radiography in patients with trauma. NEXUS Low-Risk Criteria was first introduced in 1992 when research indicated that cervical spine radiography may not be necessary to rule out C-spine injury in patients who displayed no cervical spine tenderness, signs of intoxication, altered mental status, or significant and painful distracting injuries. A fifth element (absence of focal neurological deficits) was subsequently added to produce what stands as the current NEXUS Low-Risk Criteria (6). A study of 34,069 participants with cervical spine injury showed that the NLC had a specificity of 12.9% and a sensitivity of 99.6%. This rule has thereby been recommended for use by emergency department physicians (7-10).

More recently another group developed the CCR for use with alert patients in stable condition. The CCR first evaluates suitable patients for any of the three criteria that are classified as high risk. The first is age: any patient who is at or above 65 years of age is at high risk. The second factor is the mechanism of injury: a fall from more than 3 feet in height, a high-speed motor vehicle collision, a bike/motorized vehicle accident, or a direct axial load with a higher risk for C-spine injury. The third high-risk factor is paresthesia in any or all extremities. If a patient fits into any of the three high-risk factors, radiography is mandatory according to CCR. In the absence of any high-risk factor, CCR evaluation is done to detect any low-risk factors, which include ambulatory patients, absence of midline cervical pain or delayed onset of pain, and simple rear-end motor vehicle collisions. If none of these low-risk factors applies to the patient, the CCR mandates radiography. If, however, the patient has no high-risk factor and does have at least one low-risk factor, the ability to rotate their neck actively (both left and right, at a 45° angle) with or without pain is assessed. In case the exercise cannot be performed by the patient, radiography is indicated. If this exercise can be performed, according to CCR, radiography is not necessary for ruling out CSI.

However, data is lacking with regard to the clinical use and decision-making outcomes of both these criteria in populous countries like India, where the incidence of road traffic accidents is also the highest in the world. About 4% of trauma patients present with injuries to the cervical spine. Failure to detect cervical spine injury in an efficient and timely manner in the acute clinical setting can result in catastrophic consequences involving permanent neurologic sequelae or even death. Currently, uncertainty exists about the optimal diagnostic approach. The radiologist plays a crucial role in the diagnosis of spinal injury and is vulnerable to inter-observer variability and accidental overlooking of key findings. A crucial correlation of clinical presentation, examination findings, and radiological findings is ideal for a more accurate diagnosis. There arises the need for a study to compare the accuracy and reliability of CCR and NLC in stable and alert patients as an important initial step in patient care (11-15).

Radiography is not recommended if a patient meets the following criteria:

1. Absence of tenderness at the posterior midline of the C-spine

2. Absence of a focal neurological deficit
3. Normal level of alertness
4. No evidence of intoxication
5. Absence of distracting pain

In case these criteria are not fulfilled, radiographic imaging is indicated and ought to be done as early as possible. According to international guidelines, use of computerized tomography (CT) has been advised as the first imaging of choice. ATLS spine and spinal cord trauma guidelines and the Western Australian Department of Health's Diagnostic Imaging Pathways for Cervical Spine Injury suggest the use of plain radiography in low-risk injuries. But the possibility of missing out on significant findings is high due to the increased chance of missing out on findings by the reporting physician (16). Poor quality of the radiographic images obtained and inadequate viewing of the field of interest (17). In addition to ruling out severe spine trauma, initial assessment of pain is also helpful in the prediction of long-term pain and slow recovery (18). This will also aid in early initiation of assisted treatment, including physiotherapy and anti-inflammatory medications, for faster recovery and reduced impact on daily activities. Prompt identification of the primary injury and proper immobilization are important, as failure to do so may result in a secondary injury.

In developing countries like India, most of the patients are from middle-class families and might be the primary earning member of the family. It is a need of the hour that the burden on the patients be reduced and investigations be kept to the bare minimum, and investigations should be done only if absolutely required. The specificity has been found to be more for the CCR when compared to NEXUS criteria (19), but current imaging guidelines or clinical guidelines do not reflect these findings, and a well-established guideline that is tailored to the Indian population is necessary. The goal of the current study was to compare the reliability, accuracy, and clinical acceptability of CCR and the NLC in stable and alert patients with cervical spine injury. To evaluate and compare the sensitivity and specificity of the CCR and NEXUS criteria in trauma patients undergoing radiographic evaluation for suspected C-spine injury.

Materials and Methods

This is an observational hospital-based study to know the clinical accessibility and diagnostic accuracy of both criteria. Of all the trauma patients presenting to the institution's Emergency Medicine Department, 500 patients were prospectively enrolled. During the study period, a total of 724 patients were brought in following road traffic accidents, and out of these, 569 patients were brought in with cervical injury. The participants were enrolled by convenience sampling, and patients were provided with a detailed consent form, and consent was obtained for participating in the study. All patients requiring radio imaging according to either NEXUS or the CCR were a part of the study after receiving formal consent. Patients who refused either investigation were not considered in this study. The sensitivity and specificity of the criteria were analyzed, keeping multidetector computerized tomography (MDCT) as the gold standard. Other imaging tests done included X-ray of the cervical spine—anteroposterior (AP) view, lateral view (from the skull base to the upper limit of the vertebral body of T1), and an open-mouth odontoid view.

Study Population

All trauma patients with suspected C-spine injury attending the Emergency Medicine Department during the period of 6 months (1st September 2024–31st February 2025) were included in the study. An annual incidence of around 1400–1600 cases of trauma with C-spine injury has been observed in the Emergency Department. Considering the sensitivity and specificity for C-spine radiology (for X-ray

and CT) and assuming 5% precision and a 95% confidence interval, a sample size of 500 was considered adequate. Statistical analysis, including calculation of sensitivity, specificity, and accuracy, was carried out using SPSS software version 22.0.

Patients were ineligible if they had penetrating neck trauma, acute paralysis, or known vertebral diseases; if they had been evaluated previously for the same injury; or if they were pregnant. All patients with suspected C-spine injury attending the Emergency Medicine Department were included in the study and were subjected to detailed history taking and examination. They were subjected to radiologic studies (X-ray or CT) of the cervical spine if they met NEXUS criteria or the CCR. All cases were subjected to X-ray study, and 79.2% of cases were subjected to CT imaging. CT imaging was opted for when X-ray findings were inconclusive and needed further evaluation for correlation with examination findings.

Results

This study was carried out in the Emergency Medicine Department of a tertiary care center for a period of 6 months, and these are the findings. Five hundred patients were included in the study, out of which the majority (48.4%) belonged to the 46–65 years age group, followed by patients in the age group of 26–45 years (19.4%). Only 15.4% of patients were in the age group of more than 65 years, and 16.8% of cases were in the age group of 16–25 years. An evaluation of the age distribution shows an increased incidence in middle-aged and elderly patients. This reflects the financial burden inflicted on patients following hospital admission for trauma, as most of them are earning members of the family.

Among the 500 patients enrolled in the study, 312 were males, constituting 62.4% of the study population. A total of 87.8% of patients sustained injury due to road traffic accidents, while the remaining patients had injuries due to falls. Patients were diagnosed with C-spine injury based on the presence of pain, alertness, intoxication, Glasgow Coma Scale (GCS), spine tenderness, ability to rotate the neck, and motor and sensory symptoms. They were subjected to radiological studies based on the NEXUS score and the CCR. Among these, 72% of patients were under the influence of alcohol.

Other clinical findings noted are as given below:

- Pain – 72.8% patients presented with pain
- Alertness – 84% of patients were alert when they presented to the casualty
- GCS score – 62% of patients had a GCS above 12 (12/15)
- Spine tenderness—Spine tenderness was seen in only 9.2% of patients.
- Ability to rotate neck – 84% of the patients were able to rotate their neck
- Paraesthesia – Only 10.8% of patients presented with paraesthesia (mainly of the extremities).
- Vitals – The majority (82.4%) of the patients were stable when they were brought to the Emergency Department.

When the NEXUS score was applied, 321 (64.2%) patients fulfilled the criteria and were subjected to radiological imaging according to this criterion. When the CCR was applied, 348 (69.6%) patients were recruited for radiological imaging, which means more patients were subjected to radiological imaging when this criterion was used. The predictive power of both rules was analyzed and depicted in Table 1.

NEXUS criteria showed a sensitivity of 100% and specificity of 75.3%, compared to the CCR that showed a significantly lower 94.2% and 54.2%, respectively. Although both criteria are effective in the evaluation of cervical trauma, the slight supremacy of the NEXUS criteria in terms of sensitivity may be due to the nature of the criteria, which enables easier understanding and an elaborate analysis of symptoms, with importance given to the mental status of the patient. The positive predictive value and

Table 1. Comparison of the predictive power of NEXUS criteria and Canadian C-spine rule among trauma patients with suspected C-spine injury.

	Nexus score	C spine rule	z-score	p-value
Sensitivity (%)	100.0	95.2	4.417**	<0.01
Specificity (%)	75.3	54.2	6.221**	<0.01
False Negative	0.0	4.8	4.417**	<0.01
False positive	24.7	45.8	6.221**	<0.01
Positive Predictive value (%)	59.0	42.6	4.649**	<0.01
Negative Predictive value (%)	100.0	97.0	3.508**	<0.01
Positive Likelihood ratio	4.0	2.1	1.609	0.110
Negative Likelihood ratio	0.0	0.1	0.593	0.555
Accuracy (%)	81.8	65.0	5.359**	<0.01

** Significant at 0.01 level

negative predictive value of NEXUS criteria were found to be significantly higher than that of the CCR, and the total accuracy was also higher in NEXUS criteria. When patients were subjected to radiological imaging using the NEXUS score or the CCR, C-spine injury was present in 82.4% of cases (412 patients). Eighty-eight patients (17.6%) were not having any C-spine injury.

Discussion

This study on the comparison of diagnostic accuracy and clinical acceptability of the NEXUS score and the CCR was carried out in the Emergency Medicine Department of a tertiary care center during a period of 6 months. Five hundred patients who satisfied the inclusion criteria were selected and included in the study after consent was obtained. Previous studies have shown an increased sensitivity of NEXUS criteria in comparison with the CCR (20, 21).

In 2002, the State of Maine added the NEXUS criteria into their 2002 protocols, and it is different from the original NEXUS criteria in two ways. Firstly, the altered mental status criterion and the intoxication criterion were combined into a single criterion. This simplifies the rule and emphasizes the importance of the patient's mental status. This is one of the factors that might be the reason for the increased sensitivity of NEXUS criteria, as evidenced in this study and others too. The second difference is that the Maine protocols state that prehospital providers will initiate patient immobilization in all patients complaining of pain or tenderness anywhere along the posterior spine and is not limited to patients with cervical spine tenderness. This change works to increase the sensitivity of the rule as well as to decrease disagreement between providers.

The CCR is a clinical prediction rule based on physical examination, the role of which is to reduce the uncertainty in determining if a patient requires radiographic imaging of the cervical spine.

First published in 2001, the CCR assessed patients for a high-risk factor, a low-risk factor, and the ability to actively rotate their necks (15-20). Patients were only eligible for CCR evaluation if they were 16 years old or older, were alert and oriented (defined as scoring 15 on the Glasgow Coma Scale), had stable vital signs, and had sustained some trauma that can lead to C-spine injury. Additionally, patients were not eligible if they had any confounding factors such as paralysis, a history of vertebral injury or disease, or pregnancy. In the present study, when the CCR was applied and patients were subjected to radiography, the test was found to be 95.2% sensitive, 54.2% specific, 42.6% positive predictive value, 97% negative predictive value, and 65% accurate. In short, when this was applied, 95.2% of patients were having cervical spine injuries. When NEXUS criteria were applied and patients were subjected

to radiography, sensitivity was 100%, specificity was 75.3%, positive predictive value was 59%, negative predictive value was 100%, and accuracy was 81.8%.

When NEXUS criteria were applied, a lesser number of patients were included in the study, but the diagnosis was 100% accurate and sensitive. But when the CCR was applied, the diagnosis of cervical spine injury was only 65% accurate. While initial clinical assessment is generally conducted using one of the most commonly used evidence-based decision rules, the NEXUS criteria or the CCR, there is continuing debate about the optimal radiographic imaging protocol. When clinical clearance alone is done, it is not possible to rule out all injuries with confidence. This signifies the relevance of a specific radiographic imaging protocol and the need for such a study.

In order to directly compare the CCR and the NEXUS Low-Risk Criteria, Stiell et al. performed a comparison study in affiliation with nine Canadian emergency departments (15). Of the 8,283 trauma patients enrolled in the study, 169 (2%) were found to have significant C-spine injuries. The CCR was found to be 99.4% sensitive and 45.1% specific, while the NEXUS criteria were determined to have a sensitivity of 90.7% and a specificity of 36.8%. However, there are limitations to this study. The study was performed in Canada and may not be applicable to the US. As Canadian protocol does not mandate imaging of low-risk patients, all patients did not undergo imaging, and hence this required utilization of a phone survey and follow-up imaging (if needed) for assessment of the outcome. Interestingly, however, the study noted that physicians were both less comfortable and less accurate when applying the CCR as compared to the NEXUS criteria. In fact, physicians failed to perform the required range of motion assessment for 845 patients (10.2% of the enrolled population). Even though the radiography rate was high (98.8%), a higher incidence of injuries was not seen (0.8%). Although the reluctance to evaluate range of motion is understandable given the emphasis on complete spinal immobilization for patients with potential cervical trauma, one must question how useful the tool will be if physicians are reluctant to fully employ it. CCR also shows a more elaborate evaluation of the mechanism of trauma, which is less commonly documented in developing countries.

The present study shows an increased sensitivity, specificity, and accuracy of NEXUS criteria as compared to the CCR. The study conducted by Migilore et al. in 2011 showed a sensitivity of 100% for NEXUS criteria and a specificity of 23% (22). In the meantime, the study conducted by Coffey et al. in 2010 showed CCR to have a sensitivity of 100% and a specificity of 42% (23). Similarly, a study done in 2010 showed 100% sensitivity for CCR with 43.4% specificity (24). In 2012, a systematic review was done by Michaleff et al. to evaluate the accuracy of the two rules. Fifteen studies were analyzed and showed that both rules had a high sensitivity. Most of the studies were validation studies, but one direct comparison study recommended the use of CCR, as CCR had a higher sensitivity. They evaluated that imaging rates would have been reduced by 42.0% if CCR was utilized, while the use of NEXUS criteria would have reduced the radiography rates by 30.9% (19). In a study of 34,069 patients, the NEXUS researchers found the criteria to have a sensitivity of 99.6% and a specificity of 12.9% for significant cervical spine injuries (14). Although the original NEXUS research reported nearly 100% sensitivity for significant cervical spine injuries, subsequent studies have demonstrated slightly less sensitivity for the Low-Risk Criteria (20, 25).

A study conducted in 2023 in Bengaluru, India, showed that out of the 631 patients evaluated, 92.7% fulfilled NEXUS criteria and 98.6% of patients fulfilled CCR. Among these, spine X-rays were found to be normal in 87.8% of cases, and fractures were seen in 9.5% of cases.

A total of 2.7% of cases showed the presence of doubtful lesions, warranting the use of CT or MRI (26). NEXUS and CCR have not been utilized in patients less than 16 years old, and to avoid unnecessary exposure to radiation during radiographic evaluation, the PECARN (Pediatric Emergency Care Applied Research Network) prediction rule was established for children. CT evaluation may be done in children only if plain radiographs are inadequate, or there has been a concerning finding in the radiograph, or if there was a high-risk mechanism of injury. This rule lacks prospective validation, and there is a need for a larger study for the establishment of these criteria in the pediatric population (27). NEXUS criteria has also been shown to be less accurate for elderly patients, and the initial assessment with CCR followed by NEXUS criteria has been suggested (28).

Numerous studies have been done to evaluate the value of X-ray imaging in high-risk and/or low-risk patients (29, 30). In 35–72% of the patients, injuries are missed by X-ray imaging that are detected by CT scanning (31-35). CT scanning is superior in imaging osseous injuries. However, soft tissue injuries like ligamentous, intervertebral disc, and spinal cord injuries can be missed on a CT scan. Magnetic Resonance Imaging (MRI) is more effective in the analysis of such injuries. CT and MRI have replaced conventional radiography, and the radiographic findings are easily overlooked by clinicians (36). The need for a large population-based study is warranted to arrive at a conclusive diagnostic format, specially tailored for the Indian population. CT has been described as the gold standard, and a higher sensitivity of 90–100% when compared to plain radiographs has been explained in various studies (37, 38). Avoiding unnecessary exposure to radiation, reduction of inter-observer variability in radiologic reporting, and reduction of patient load referred for further investigations are the main benefits to be expected through the application of a screening criterion. The hesitancy of clinicians to utilize CCR and the preference for NEXUS criteria ought to be addressed, and a guideline has to be set as the standard at the primary point of care.

Conclusion

When patients with suspected cervical spine injury were subjected to examination and evaluation based on NEXUS criteria and the CCR, a lesser number of patients were flagged to have spinal injury by NEXUS criteria with good accuracy. Even though the utilization of the CCR subjected a greater number of cases to radiographic evaluation, the chance of missing out on a spinal injury was less. Both rules have been shown to be effective in ruling out cervical spine injury and in deciding the need for radiologic evaluation. This is particularly helpful in the Indian population, as this can help in reducing the financial burden on the patients as well as reduce the number of patients sent for radiologic evaluation. The utilization of these guidelines in the emergency room has to be ensured, and the recommendation of using CCR followed by NEXUS criteria has to be analyzed in a larger population-based study.

Study Highlights

We aim to evaluate and compare the sensitivity and specificity of NEXUS criteria and the CCR in trauma patients undergoing radiographic evaluation for suspected C-spine injury. The present study shows an increased sensitivity, specificity, and accuracy of NEXUS criteria as compared to the CCR.

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Conflict of Interest

There are no conflicts of interest

Ethical Considerations

The Institutional Ethics Committee, KMCT Medical College, has approved the research project with IECRef No: IECKMCT/92/2024. No ethical issues were found, and patient data was maintained with care and kept confidential. Patients were informed of the methodology, and prior consent was obtained, and the patients had the right to withdraw from the study if they wanted to.

Code of Ethics

IECKMCT/92/2024.

Authors' Contributions

Conceptualization: Dr. Mohammed Fabin and Dr. Aswin Abbas; Data curation: Dr. Mohammed Fabin, Dr. Aswin Abbas, Dr. Rameez Roshan, Dr. Bimal Govind; Formal analysis: Dr. Mohammed Fabin, Dr. Aswin Abbas, Dr. Swathy Shanker; Methodology: Dr. Mohammed Fabin, Dr. Aswin Abbas, Dr. Rameez Roshan, Dr. Swathy Shanker; Validation: Dr. Mohammed Fabin, Dr. Aswin Abbas, Dr. Rameez Roshan, Dr. Bimal Govind; Writing—original draft: All authors; Writing—review & editing: All authors.

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