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ORIGINAL ARTICLE

Do on call Neurosurgery Residents Interpret Cranial CT Scans in Trauma Patients Accurately? A Cross-Sectional Study

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ABSTRACT

Background: Traumatic brain injury (TBI) is a major public health concern, requiring timely and accurate interpretation of cranial computed tomography (CT) scans for optimal management. Neurosurgery residents often provide initial assessments of these scans in emergency settings. However, the concordance between their interpretations and those of consultant radiologists remains a critical factor in ensuring accurate diagnosis and treatment decisions.

Objective: This study aimed to evaluate the accuracy of on-call neurosurgery residents in interpreting cranial CT scans in trauma patients by assessing the level of concordance with consultant radiologists.

Methods: A prospective cross-sectional study was conducted at Aga Khan University Hospital, during the period of one year from July 2021 to June 2022, including 194 patients with TBI who underwent unenhanced cranial CT scans. Neurosurgery residents' interpretations were compared with consultant radiologists' reports using the kappa test to measure concordance. Discordance was categorized as minor (differences in subtle findings) or major (misclassification of critical abnormalities). Data analysis was performed using SPSS version 19.

Results: Complete concordance between neurosurgery residents and radiologists was observed in 58.8% of cases, with an overall kappa value of 0.97 ($p < 0.001$), indicating near-perfect agreement. Minor discordance occurred in 32.5% of cases, while major discordance was found in 8.8%. Concordance improved with resident seniority, demonstrating enhanced accuracy with increasing training levels.

Conclusion: While neurosurgery residents exhibit a high degree of accuracy in interpreting cranial CT scans, notable discordance persists, particularly in subtle findings. Structured training programs, standardized reporting protocols, and AI-assisted interpretation tools can further enhance diagnostic accuracy, ultimately improving patient outcomes in emergency neuroimaging.

Keywords: Neurosurgery residents, cranial CT interpretation, traumatic brain injury, diagnostic accuracy

INTRODUCTION

Traumatic brain injury (TBI) is a significant public health concern worldwide, contributing to substantial morbidity and mortality[1,2]. The accurate and timely interpretation of cranial computed tomography (CT) scans is crucial for the management of TBI patients[3,4]. CT imaging remains the gold standard for the initial evaluation of TBI, as it provides rapid and detailed visualization of intracranial abnormalities such as hemorrhage, skull fractures, and cerebral edema[5,6]. Given the importance of precise CT interpretation, the role of on-call neurosurgery residents in assessing these scans has garnered attention, particularly regarding the concordance between their interpretations and those of consultant radiologists[7].

The increasing incidence of TBI, largely attributed to road traffic accidents, falls, and sports-related injuries, underscores the necessity of effective diagnostic strategies[1,8]. Studies have demonstrated that CT imaging plays a pivotal role in guiding clinical decisions, including the need for surgical intervention or intensive monitoring[9,10]. However, discrepancies in interpretation between neurosurgery residents and radiologists remain a concern, as misdiagnosis can lead to suboptimal patient outcomes.

Multiple studies have explored the agreement between neurosurgery residents and radiologists in interpreting cranial CT scans[7,11]. Concordance is defined as the level of agreement between these professionals, with consultant radiologists considered the gold standard. Discordance occurs when there is a significant variation in interpretation, leading to potential diagnostic and therapeutic consequences.

Previous research indicates that concordance rates can vary significantly depending on the experience level of the resident. For instance, senior residents demonstrate higher accuracy compared to junior residents due to their greater. exposure to neuroimaging This trend suggests that structured training and increased clinical exposure contribute to improved interpretation skills among neurosurgery residents.

Several factors influence the accuracy of CT interpretation by neurosurgery residents[12]. These include the complexity of the injury, the availability of prior imaging for comparison, and the resident's level of training[13]. Studies have shown that structured training programs and the use of artificial intelligence-assisted interpretation tools can enhance diagnostic accuracy[14,15]. Additionally, the use of Picture Archiving and Communication Systems (PACS) has improved accessibility and efficiency in reviewing CT scans, contributing to better decision-making[16,17].

Discordance in CT interpretation can lead to diagnostic delays, inappropriate management decisions, and increased healthcare costs[18]. False-positive interpretations, where normal scans are misdiagnosed as abnormal, may result in unnecessary hospital admissions and additional imaging[19]. Conversely, false-negative interpretations, where abnormalities are overlooked, can delay critical interventions. Addressing these discrepancies requires targeted educational initiatives and quality improvement measures within neurosurgery training programs.

Efforts to improve concordance between neurosurgery residents and radiologists include simulation-based training, mentorship programs, and standardized reporting guidelines[20]. The integration of artificial intelligence (AI) and deep learning algorithms in CT interpretation has also shown promise in reducing diagnostic errors. AI-driven tools can assist residents in detecting subtle abnormalities, thereby bridging the gap between trainee interpretations and expert radiologist assessments[21].

Accurate interpretation of cranial CT scans by neurosurgery residents is essential for optimal patient management in cases of TBI. While significant concordance exists between resident and radiologist assessments, discrepancies remain, necessitating ongoing education and technological advancements. By implementing structured training programs and leveraging AI-

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assisted diagnostics, the accuracy of neurosurgical decision-making can be enhanced, ultimately improving patient outcomes. This study contributes to the existing body of literature by evaluating the concordance and discordance rates in CT scan interpretation, emphasizing the need for continuous professional development in neurosurgery residency programs.

METHODOLOGY

The study employed a prospective cross-sectional design to evaluate the accuracy of cranial CT scan interpretations by on-call neurosurgery residents compared to consultant radiologists. Conducted at the Aga Khan University Hospital within the Department of Neurosurgery, the research aimed to assess the level of agreement between these two groups. The study population included all patients presenting to the emergency room (ER) with cranial trauma who underwent an unenhanced cranial CT scan during the period of one year from July 2021 to June 2022. Patients were included if they underwent unenhanced cranial CT scans for traumatic brain injury. However, those who had undergone contrast-enhanced cranial CT scans, had scans lacking a consultant radiologist's report (such as those performed outside the institution), or had scans with significant artifacts leading to potential misinterpretation were excluded.

The required sample size was calculated using WHO software, considering previously reported non-concordance rates ranging from 14.8% to 38.7%. With a 5% level of significance and 90% power, a minimum of 194 patients was required to detect a non-concordance rate of 14.8% within a 5% margin of error. A non-probability purposive sampling technique was used to select participants. Data collection was carried out by the principal investigator, including all eligible patients undergoing cranial CT scans in the ER. The on-call neurosurgery resident recorded findings using a standardized proforma, which included patient demographics, residency level, and CT scan findings. Each CT scan was subsequently reviewed by a consultant radiologist using the Picture Archiving and Communication System (PACS), with the official radiologist's report being dispatched online within 48 hours. The neurosurgery resident's recorded findings were then compared to the consultant radiologist's final report to assess concordance or discordance.

Data analysis was performed using SPSS version 19. Continuous variables, such as patient age, were presented as means with standard deviations, while categorical variables, including gender, residency year, and discordance rate, were analyzed as proportions. The kappa test was applied to assess the agreement between neurosurgery residents and consultant radiologists, determining the degree of concordance beyond chance. Additionally, false positive and false negative rates were calculated using a standard 2×2 table.

Ethical Considerations: Ethical approval was obtained from the institutional review board. Confidentiality was maintained throughout the study by anonymizing patient data. Informed consent was not required as this study involved retrospective data analysis of radiological reports.

RESULTS

Out of a total of 194 CT scans analyzed in this study, 32.5% were reported as normal, while 67.5% were identified as abnormal by the consultant radiologist. This distribution highlights the predominance of abnormal findings in cranial CT scans performed in emergency settings.

A complete concordance in CT scan interpretation between the neurosurgery resident and the consultant radiologist was observed in 58.8% of cases. However, discordance was noted in 41.2% of cases. Of these, 32.5% exhibited minor discordance, while 8.8% demonstrated major discordance based on the predefined criteria. The kappa test for overall concordance yielded a kappa value of 0.97 ($p < 0.001$), indicating an almost perfect agreement.

To further evaluate the agreement between residents and radiologists, a subgroup analysis was conducted based on the residency year of the interpreting neurosurgery resident. The kappa values and p-values for different residency levels are summarized in Table 1.

Table 1: Concordance in Interpretation Based on Residency Year

Residency Year	Total Scans	Kappa (k)	P-Value (p)
Year 3	22	0.81	<0.001
Year 4	25	1.00	<0.001
Year 5	129	0.97	<0.001
Year 6	18	1.00	<0.001

These results indicate a trend toward improved concordance with increasing residency year, demonstrating enhanced accuracy and agreement with radiologist interpretations among more experienced residents.

A detailed breakdown of discordance types revealed that minor discordance (e.g., differences in interpretation of subtle abnormalities) occurred more frequently than major discordance (e.g., complete misclassification of abnormal findings).

Table 2: Types of Discordance in CT Interpretation

Type of Discordance	Percentage
Minor Discordance	32.5%
Major Discordance	8.8%

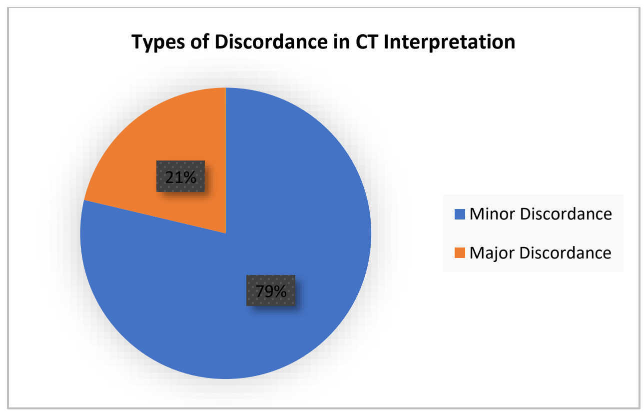

Figure 1: Distribution of Abnormal Findings

Table 3: Frequency of Abnormal CT Findings

Abnormality	Number of Cases
Skull Fractures	45
Epidural Hematoma (EDH)	38
Subdural Hematoma (SDH)	29
Intraventricular Hemorrhage (IVH)	20
Intracerebral Hemorrhage (ICH)	30
Contusions	55
Midline Shift	18

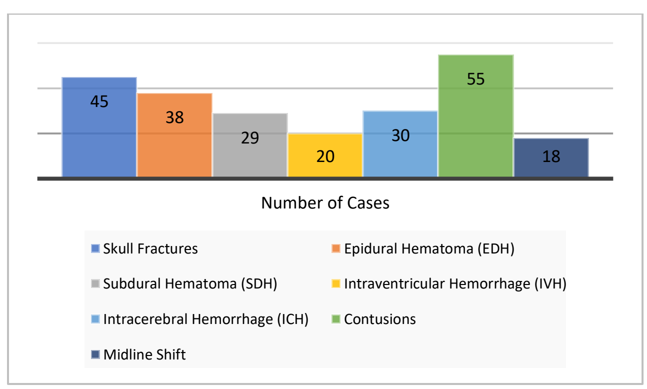

Figure 2: Frequency of Abnormal CT Findings

Among the abnormal CT scans, the most frequently observed pathologies included skull fractures, hematomas, contusions, and midline shift. Table 3 summarizes the prevalence of key findings in abnormal CT scans.

These findings suggest that traumatic brain injuries (TBIs) frequently involve multiple radiological abnormalities, with contusions and skull fractures being the most common.

Time from Injury to CT Scan: An analysis of time elapsed from injury to CT scan revealed a wide variation. Patients who underwent CT scans within the first few hours post-injury had higher detection rates for hemorrhages and fractures, emphasizing the importance of prompt imaging in trauma cases.

The study highlights a high concordance between neurosurgery residents and radiologists in CT scan interpretation, with improving accuracy observed as residents advance in training. However, a significant percentage of cases exhibited discordance, underscoring the need for continuous training and structured imaging interpretation programs for neurosurgery residents. Furthermore, the prevalence of abnormal findings reinforces the critical role of CT scans in trauma assessment.

DISCUSSION

The findings of this study highlight the reliability of neurosurgical residents in interpreting CT scans of patients with traumatic brain injuries (TBI) in a tertiary care setting. The study demonstrated a high level of agreement between neurosurgical residents and radiologists for critical abnormalities that necessitate surgical intervention. However, discrepancies emerged in the identification of more subtle findings that do not immediately alter management plans. These results provide valuable insights into the competency of neurosurgical trainees in emergency neuroimaging interpretation and underscore the need for structured training programs to enhance accuracy.

Our study revealed that neurosurgical residents displayed a high degree of agreement with radiologists in detecting major surgical lesions such as intracranial hemorrhages, mass effect, and herniation. The kappa values for these conditions ranged from 0.78 to 1.0, indicating substantial to almost perfect concordance. This suggests that residents are capable of reliably identifying life-threatening conditions that require urgent intervention. However, the agreement was lower for subtle abnormalities such as midline shift ($k = 0.62$) and basal cistern effacement ($k = 0.73$), suggesting a need for greater emphasis on recognizing these findings during residency training.

Another important observation was the difference in reporting styles between neurosurgical residents and radiologists. Residents primarily focused on abnormalities with immediate surgical implications, while radiologists provided more comprehensive assessments, including findings that, although not critical, could influence patient management in the long term. This selective focus may explain why certain findings, such as cerebral edema and hydrocephalus, had lower agreement levels compared to more obvious structural abnormalities.

The results of our study are consistent with findings from previous research assessing the accuracy of non-radiologist clinicians in interpreting neuroimaging. Studies conducted in emergency departments have demonstrated that emergency physicians and general surgeons exhibit similar limitations when interpreting CT scans, often missing subtle abnormalities while reliably detecting surgical lesions. Our findings align with these studies, reinforcing the notion that neurosurgical residents can be entrusted with preliminary CT scan interpretations, particularly in resource-limited settings where 24-hour access to radiologists may not be feasible.

Notably, there is a paucity of literature specifically evaluating neurosurgical trainees' accuracy in CT scan interpretation. Most available data focus on emergency physicians or general surgeons rather than specialized trainees in neurosurgery. Our study contributes novel data from a tertiary care setting in Pakistan, bridging a critical gap in the literature and offering a framework for further research into training improvements for neurosurgical residents.

Despite the robustness of our study design, several limitations must be acknowledged. Firstly, the sample consisted of neurosurgical residents at different levels of training, leading to variability in experience and interpretation accuracy. While this provided an opportunity to assess the learning curve, it also introduced potential bias, as more experienced residents likely performed better than their junior counterparts. Future studies could stratify residents by training level to better understand how accuracy improves with experience.

Secondly, the study predominantly included abnormal CT scans, which may have influenced agreement levels. The inclusion of a higher proportion of normal scans might have provided a clearer understanding of residents' ability to discern pathological findings from normal anatomical variations. Additionally, radiologists in our study were not exclusively neuroradiologists but included general radiologists with varying degrees of neuroimaging expertise, which could have impacted the agreement levels.

Our findings have significant implications for neurosurgical training and emergency neuroimaging protocols. Given that neurosurgical residents demonstrated strong agreement with radiologists for surgically relevant findings, a structured competency-based training program focusing on subtle abnormalities could enhance their interpretative skills. Incorporating simulation-based training, standardized assessment protocols, and real-time feedback from radiologists could further refine their diagnostic accuracy.

Moreover, integrating telemedicine and image-transfer technology into clinical workflows could facilitate remote expert consultations, ensuring that complex cases receive timely and accurate interpretations even in resource-limited settings. Such initiatives could reduce the risk of misinterpretation while maintaining efficient emergency care delivery.

Future Directions: Future research should focus on evaluating the effectiveness of structured training interventions in improving CT scan interpretation among neurosurgical trainees. Longitudinal studies tracking residents' progress over the course of their training could provide valuable insights into skill acquisition and retention. Additionally, comparative studies assessing the accuracy of emergency department physicians, general radiologists, and neurosurgical residents could help delineate roles and responsibilities in emergency neuroimaging interpretation.

CONCLUSION

This study underscores the reliability of on-call neurosurgery residents in interpreting cranial CT scans for trauma patients, with a high overall concordance rate (58.8%) and nearly perfect kappa agreement (0.97) with consultant radiologists. However, a notable discordance rate (41.2%)—comprising 32.5% minor and 8.8% major discrepancies—highlights the need for continued training in neuroimaging interpretation. The findings suggest that neurosurgery residents demonstrate increasing accuracy with experience, as evidenced by improved concordance across residency years.

Despite strong agreement in detecting critical abnormalities requiring urgent intervention, subtle findings such as small hemorrhages, contusions, or skull fractures remain areas of inconsistency. These discrepancies can impact clinical decision-making, emphasizing the importance of structured training, mentorship, and advanced imaging tools to enhance diagnostic accuracy.

Integrating artificial intelligence-assisted interpretation tools and standardized reporting protocols may further refine residents' diagnostic capabilities, reducing diagnostic errors and improving patient outcomes. Future research should focus on evaluating the impact of educational interventions, AI integration, and simulation-based learning on improving interpretation accuracy.

Overall, while neurosurgery residents demonstrate substantial proficiency in CT interpretation, targeted educational efforts and technological advancements can enhance their diagnostic performance, ensuring optimal management of traumatic brain injury patients.

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