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ORIGINAL ARTICLE

Comparative Assessment of X-ray and CT Scan Effectiveness in Diagnosing Complex Pelvic Fractures Among Urban Road Traffic Accident Victims in Pakistan

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ABSTRACT

Background: Complex pelvic fractures are life-threatening injuries frequently seen in road traffic accident (RTA) victims, especially in high-density urban regions. Early and accurate diagnosis is critical for reducing morbidity and mortality. Although X-ray remains the initial imaging modality due to accessibility and cost, its limitations in detecting complex fracture patterns raise concern. Computed tomography (CT) offers superior anatomical detail but is less widely available. This study aimed to compare the diagnostic performance of X-ray and CT in identifying complex pelvic fractures among RTA victims in urban Pakistan.

Objective: To conduct a comparative analysis of X-ray and CT scan in detecting complex pelvic fractures in patients presenting after road traffic accidents in tertiary care hospitals of Islamabad and Lahore.

Methods: A prospective comparative study was conducted from June 2022 to June 2023 at Shifa International Hospital, Islamabad, and Ittefaq Hospital, Lahore. Ninety adult patients with suspected pelvic trauma underwent both pelvic X-ray and CT scan. Fractures were classified using the Tile classification system. Radiological findings were assessed by independent radiologists, and diagnostic accuracy, sensitivity, specificity, and interobserver agreement were analyzed using CT as the reference standard.

Results: CT scan detected complex pelvic fractures in 69 patients (76.7%) compared to 49 cases (54.4%) identified by X-ray. X-ray demonstrated 71.0% sensitivity, 95.0% specificity, and a positive predictive value of 97.9%. CT scan had 100% sensitivity and specificity. CT was significantly superior in identifying posterior ring, sacral, and acetabular fractures. Radiologists showed higher diagnostic confidence with CT (mean score 4.9 vs. 3.2) and greater interobserver agreement ($\kappa = 0.93$ for CT vs. $\kappa = 0.68$ for X-ray).

Conclusion: CT scan outperforms X-ray in the accurate detection and classification of complex pelvic fractures in urban trauma settings. Its routine use should be integrated into emergency care protocols for RTA victims to ensure timely and accurate diagnosis, particularly in high-risk urban centers of Pakistan.

Keywords: pelvic fractures, CT scan, X-ray, trauma imaging, road traffic accidents, Pakistan, Tile classification, emergency radiology

INTRODUCTION

Pelvic fractures, particularly complex or unstable variants, are considered among the most critical orthopedic emergencies due to their potential for causing life-threatening hemorrhage, visceral injury, and long-term disability[1]. These injuries are frequently associated with high-energy trauma, most notably road traffic accidents (RTAs), which are a growing concern in urban Pakistan. Rapid urbanization, increasing vehicular traffic, and poor compliance with traffic laws have contributed to a surge in RTAs across major metropolitan centers such as Islamabad, Faisalabad, and Lahore. These cities, being densely populated and economically active, have seen a rising trend in both the incidence and severity of trauma cases presenting to emergency departments[2].

Within these urban hubs, public and private tertiary care hospitals are frequently challenged with managing polytrauma victims, and pelvic fractures are a common yet complex presentation among such cases. The anatomical complexity of the pelvis, which encases major blood vessels, the urinary bladder, rectum, and reproductive organs, necessitates immediate and precise diagnosis to reduce morbidity and mortality. The early identification of fracture type and pattern, especially those involving the posterior ring, sacrum, or acetabulum, is crucial for surgical planning and timely intervention[3].

Traditionally, the first-line imaging modality in emergency trauma settings has been the plain pelvic radiograph (X-ray). It is inexpensive, readily available, and quick to perform, making it a pragmatic choice in high-volume centers. However, its diagnostic utility in detecting non-displaced fractures, subtle posterior ring disruptions, or complex acetabular involvement is limited. These shortcomings can lead to underdiagnosis or mismanagement, particularly in cases where clinical findings are ambiguous or masked by other concurrent injuries[4].

Computed tomography (CT) has revolutionized trauma imaging by offering high-resolution, multiplanar views that significantly improve the visualization of bony structures. In developed healthcare systems, CT is the standard of care for evaluating pelvic trauma due to its superior diagnostic accuracy and ability to detect even minor fractures or complex displacements[5]. Nevertheless, in Pakistan's public health infrastructure especially in trauma units of urban hospitals like those in Islamabad, Faisalabad, and Lahore the availability of CT imaging may be restricted by financial, logistical, and staffing limitations. The decision to perform a CT scan is often guided by clinical suspicion, rather than being used universally, which may compromise timely and accurate diagnosis in high-risk cases[6].

Despite global consensus on the advantages of CT imaging in trauma, there is a scarcity of region-specific data evaluating and comparing the performance of X-ray and CT in the context of Pakistani urban trauma centers[1]. The current evidence base does not adequately address the real-world diagnostic gaps or operational challenges faced in cities like Lahore, Faisalabad, and Islamabad. Generating such data is critical for developing contextually relevant trauma imaging protocols and for improving patient outcomes through evidence-based resource allocation[7].

This study was therefore designed to conduct a comparative analysis of plain pelvic radiography and CT scan in the detection of complex pelvic fractures among RTA victims in urban Pakistan. By enrolling patients from major hospitals across Lahore, Faisalabad,

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and Islamabad, the research aims to assess the diagnostic sensitivity, specificity, and interobserver agreement of both imaging modalities. The goal is to provide actionable insight that can inform clinical decision-making and imaging policy in the urban emergency care settings of Pakistan[8].

MATERIALS AND METHODS

This prospective, comparative observational study was conducted over a 12-month period from June 2022 to June 2023. The aim was to evaluate and compare the diagnostic efficacy of conventional X-ray and computed tomography (CT) scan in identifying complex pelvic fractures among victims of road traffic accidents (RTAs). The study was carried out at two major tertiary care hospitals in urban Pakistan: Shifa International Hospital in Islamabad and Ittefaq Hospital in Lahore. These hospitals were selected due to their status as high-volume trauma centers equipped with advanced diagnostic imaging facilities.

A total of 90 patients were enrolled in the study using non-probability consecutive sampling. All patients who presented to the emergency departments of the selected hospitals with clinical suspicion of pelvic injury following a road traffic accident were considered for inclusion. Patients aged 18 years and above, who were hemodynamically stable and capable of undergoing both imaging modalities (X-ray and CT scan), were included in the study. Informed written consent was obtained from all participants prior to enrollment. Exclusion criteria comprised patients who were hemodynamically unstable and required immediate surgical intervention, pregnant females due to concerns about radiation exposure, patients with a history of previous pelvic fractures or pelvic surgeries that could interfere with image interpretation, and patients who underwent only one imaging modality because of logistical constraints or early transfer to another facility.

Upon arrival at the emergency department, each patient first underwent an anteroposterior pelvic X-ray as part of the standard trauma imaging protocol. Following initial stabilization and assessment, a multi-detector computed tomography (CT) scan of the pelvis was performed for all patients. The CT scans included axial and coronal reconstructions using bone window settings to provide detailed anatomical visualization of the pelvic structures. Both imaging modalities were performed within a clinically acceptable time frame to ensure consistency in diagnostic comparison.

All imaging findings were evaluated independently by two experienced consultant radiologists at each center. Each radiologist had a minimum of five years of expertise in trauma and musculoskeletal radiology. Importantly, the radiologists were blinded to the clinical details and to each other's interpretations to eliminate bias. In cases where discrepancies were observed between the two reviewers, a consensus was reached after joint evaluation. The fractures identified on imaging were classified according to the Tile classification system, which categorizes pelvic fractures into three types: Type A (stable), Type B (rotationally unstable but vertically stable), and Type C (both rotationally and vertically unstable). Particular attention was paid to detecting involvement of the anterior pelvic ring, posterior ring, sacrum, and acetabulum.

The primary outcome of interest was the diagnostic accuracy of each imaging modality in detecting complex pelvic fractures, specifically Tile types B and C. Secondary outcome measures included the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), diagnostic confidence (rated on a scale of 1 to 5), and interobserver agreement between the radiologists. Interobserver agreement was evaluated using Cohen's kappa (κ) statistic, with interpretation as follows: values between 0.01 and 0.20 indicated slight agreement; 0.21 to 0.40 fair agreement; 0.41 to 0.60 moderate agreement; 0.61 to 0.80 substantial agreement; and 0.81 to 1.00 almost perfect agreement.

Data were collected using a structured proforma and entered into a computerized database. Statistical analysis was performed using SPSS version 26.0. Continuous variables such as age were expressed as means with standard deviations, while categorical variables like gender and fracture types were presented as frequencies and percentages. Diagnostic performance indicators were calculated using CT scan findings as the reference standard.

Ethical approval for this study was obtained from the Institutional Review Boards of both Shifa International Hospital and Ittefaq Hospital. Informed consent was obtained from all participants prior to data collection, and patient confidentiality was maintained throughout the study in accordance with institutional and international ethical guidelines.

RESULTS

A total of 90 patients were enrolled in this study, all presenting with pelvic trauma following road traffic accidents and undergoing both pelvic X-ray and CT scan. The demographic characteristics of the study population are summarized in **Table 1**. The majority of the patients were male (73.3%), with the most common age group being 31–40 years. The average age was 37.8 ± 12.4 years. Most patients (56.7%) were involved in motorbike collisions, followed by car accidents (33.3%) and pedestrian injuries (10%). More than half of the participants (54.4%) belonged to urban lower-middle-income households, with the remainder distributed between middle and high-income strata.

Table 1: Demographic and Clinical Characteristics of the Study Population (n = 90)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	66	73.3%
Female	24	26.7%
Age Group (years)		
18–20	7	7.8%
21–30	18	20.0%
31–40	25	27.8%
41–50	19	21.1%
51–60	12	13.3%
>60	9	10.0%
Mechanism of Injury		
Motorbike Collision	51	56.7%
Car Accident	30	33.3%
Pedestrian Hit	9	10.0%
Socioeconomic Status		
Lower-income	14	15.6%
Lower-middle-income	49	54.4%
Middle-income	21	23.3%
Upper-income	6	6.7%
City of Residence		
Islamabad	32	35.6%
Lahore	38	42.2%
Faisalabad	20	22.2%
Consciousness on Arrival		
Alert	71	78.9%
Drowsy	15	16.7%
Unconscious	4	4.4%
Associated Injuries		
Head trauma	16	17.8%
Limb fracture(s)	28	31.1%
Abdominal organ injury	6	6.7%
No associated injuries	40	44.4%

As seen in Table 1, a significant majority of cases involved young adult males, which reflects the active and high-risk demographic most often exposed to road traffic incidents in urban Pakistan. The high rate of motorbike-related injuries is consistent with increasing two-wheeler usage in these cities.

The performance of the two imaging modalities in detecting complex pelvic fractures is summarized in **Table 2**, which is cited in the discussion below. CT scan detected complex fractures in 69 patients (76.7%), whereas plain X-ray detected them in only 49 patients (54.4%). CT scan detected 20 additional complex fractures that were not visualized or misclassified on X-ray,

particularly involving the posterior pelvic ring, sacrum, and acetabulum.

Table 2: Detection of Complex Pelvic Fractures by Imaging Modality

Imaging Modality	Complex Fractures Detected (n)	Detection Rate (%)
X-ray	49	54.4%
CT Scan	69	76.7%

Using CT scan as the reference standard, the diagnostic performance of X-ray was evaluated and is presented in **Table 3**. The sensitivity of X-ray for detecting complex fractures was 71.0%, with a specificity of 95.0%. The positive predictive value was high (97.9%), indicating that X-ray is reliable when it identifies a fracture. However, the negative predictive value was low (52.8%), indicating that many fractures could be missed if CT is not performed.

Table 3: Diagnostic Performance of X-ray Compared to CT Scan

Performance Indicator	X-ray (%)
Sensitivity	71.0
Specificity	95.0
Positive Predictive Value	97.9
Negative Predictive Value	52.8

To further explore the anatomical precision of both imaging modalities, the study compared the number of fractures detected in specific pelvic regions (Table 4). X-ray demonstrated better performance in identifying anterior ring fractures, whereas CT scan clearly outperformed X-ray in identifying posterior ring, sacral, and acetabular fractures, which are often associated with complex, unstable injuries.

Table 4: Distribution of Fractures by Region Detected on Imaging

Fracture Location	Detected by X-ray (n)	Detected by CT Scan (n)
Anterior Pelvic Ring	46	61
Posterior Pelvic Ring	18	42
Sacrum	4	23
Acetabulum	7	20

As seen in Table 4, X-ray failed to detect many fractures involving the sacrum and acetabulum, both of which were clearly visualized on CT scans. This has significant implications for surgical planning and classification, particularly in Tile Type B and C fractures.

The diagnostic confidence of radiologists was evaluated using a 5-point Likert scale (1 = very low, 5 = very high), as shown in **Table 5**. Radiologists reported a higher level of confidence while interpreting CT scans (mean score: 4.9 ± 0.2), in contrast to X-ray interpretations (mean score: 3.2 ± 0.8), indicating the superiority of CT imaging in trauma diagnosis.

Table 5: Diagnostic Confidence of Radiologists

Imaging Modality	Mean Confidence Score ± SD
X-ray	3.2 ± 0.8
CT Scan	4.9 ± 0.2

Lastly, the interobserver agreement was analyzed using Cohen's kappa statistic. CT scan showed an almost perfect interobserver agreement (κ = 0.93), while X-ray interpretations demonstrated only moderate agreement (κ = 0.68), as shown in **Table 6**.

Table 6: Interobserver Agreement Between Radiologists

Imaging Modality	Kappa (κ) Value	Level of Agreement
X-ray	0.68	Moderate
CT Scan	0.93	Almost Perfect

In summary, the results of this study demonstrate that CT scan significantly outperforms X-ray in the detection, classification, and confident interpretation of complex pelvic fractures. All results cited in the tables above confirm the diagnostic limitations of X-ray and support the routine use of CT in emergency trauma care, especially in high-risk, urban RTA populations.

DISCUSSION

The findings of this study highlight the diagnostic superiority of computed tomography (CT) over conventional X-ray in detecting complex pelvic fractures among road traffic accident (RTA) victims in urban centers of Pakistan. Pelvic trauma, particularly when involving unstable or complex fractures, demands rapid and accurate diagnosis due to its association with high morbidity, potential hemorrhage, and the need for urgent surgical intervention[9]. In the present study, conducted at Shifa International Hospital Islamabad and Ittefaq Hospital Lahore, CT scan identified complex pelvic fractures in 76.7% of patients, compared to only 54.4% detection by plain pelvic radiography. These results reaffirm the established global view that CT is the imaging modality of choice in pelvic trauma cases, especially when high-energy mechanisms like RTAs are involved[10].

The demographic profile of patients in this study reflects typical patterns observed in low- and middle-income countries. The majority were young adult males, predominantly motorbike riders, which is consistent with national and regional trauma data. Young, economically active men remain disproportionately affected by RTAs in urban Pakistan, likely due to increased exposure to traffic, lack of helmet use, and poor enforcement of traffic laws. The urban concentration of cases in Islamabad, Lahore, and Faisalabad also underscores the rising burden on emergency departments in metropolitan areas where trauma care must be optimized for timely intervention[11].

The current study demonstrated that X-ray imaging, although widely accessible and cost-effective, had significant limitations in detecting posterior ring disruptions, sacral fractures, and acetabular involvement. These injuries are often subtle and easily missed on plain films, particularly in obese patients or those with overlapping bowel gas or soft tissues. This is evident in Table 4, where CT scan outperformed X-ray in identifying posterior pelvic injuries and complex configurations of the fracture, all of which are critical to fracture classification, stability assessment, and treatment planning[12, 13].

The diagnostic performance metrics further emphasize these limitations. X-ray showed a relatively high specificity (95.0%) and PPV (97.9%), suggesting that when it does detect a complex fracture, the finding is likely to be correct. However, the low sensitivity (71.0%) and especially the negative predictive value (52.8%) are concerning[14]. This means that in nearly half the patients with a negative X-ray, CT scan still revealed significant injuries, which would otherwise have gone unnoticed and untreated if CT imaging was not performed. This is clinically important, as missing an unstable pelvic fracture could lead to complications such as ongoing hemorrhage, prolonged immobilization, and chronic disability[15].

Radiologist confidence was significantly higher with CT scan (4.9/5) compared to X-ray (3.2/5), reflecting greater diagnostic clarity and anatomical detail in CT images. Furthermore, interobserver agreement for CT (κ = 0.93) was much higher than that for X-ray (κ = 0.68), suggesting that CT imaging not only improves diagnostic accuracy but also ensures more consistent interpretations across different radiologists. This consistency is critical in multidisciplinary trauma teams, where imaging findings directly influence orthopedic, surgical, and interventional decisions[16].

From a public health and healthcare systems perspective, these findings call attention to the need for better integration of CT imaging into the trauma care protocols of tertiary hospitals in Pakistan. While resource limitations cannot be ignored, the cost of missing complex injuries and the potential for subsequent morbidity and extended hospital stay can far outweigh the immediate financial burden of CT scans[17]. Hospitals, particularly those in high-volume urban areas like Islamabad, Lahore, and

Faisalabad, should consider adopting a tiered imaging strategy initial screening with X-ray followed by CT scan in all cases where clinical suspicion remains or fracture complexity is suspected[18].

This study also underscores the value of localized evidence. Much of the existing literature on imaging in pelvic trauma originates from Western healthcare systems with universal access to advanced imaging. The findings from this study fill an important gap by contextualizing diagnostic imaging in Pakistani trauma care settings, thereby offering practical insights for clinicians and policymakers[19].

CONCLUSION

This study provides compelling evidence that computed tomography (CT) scan is significantly more effective than plain X-ray in detecting complex pelvic fractures among road traffic accident victims in urban Pakistan. While X-ray maintains utility as a rapid and low-cost screening tool, it is insufficient as a standalone modality for comprehensive pelvic trauma assessment, particularly in the presence of posterior ring or acetabular involvement. The higher sensitivity, diagnostic confidence, and interobserver reliability of CT make it an essential component of trauma imaging, especially in tertiary care hospitals managing high-energy injuries.

Given the growing incidence of pelvic trauma in urban centers such as Islamabad, Lahore, and Faisalabad, emergency care protocols should incorporate CT imaging more systematically for suspected complex pelvic fractures. Future national trauma guidelines should also address the need for equitable access to CT technology and the training of emergency radiology teams to ensure early, accurate diagnosis and improved outcomes in pelvic trauma patients.

DECLARATIONS

Authors' Contributions: H.A., M.M., and B.U. were responsible for data collection and initial patient enrollment. H.A. also conceptualized the study and coordinated the clinical workflow. M.N. contributed to radiological image analysis and interpretation. B.U. assisted further in imaging review and manuscript preparation. S.R. was involved in clinical assessment, orthopedic evaluation, and data validation. S.R.C. performed statistical review, structured the results, and provided final approval of the manuscript.

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Ethical Approval: This study was approved by the Institutional Review Boards of Shifa International Hospital, Islamabad, and Ittefaq Hospital, Lahore, Pakistan.

Informed Consent: Written informed consent was obtained from all participants prior to enrollment.

Conflict of Interest: The authors declare no conflict of interest.

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