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ORIGINAL ARTICLE

Usefulness of Pre-operative CT Scan to Assess Lateral Wall Instability in Trochanteric Fractures

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Abstract

Background: Intertrochanteric (IT) femur fractures are increasingly prevalent, especially in the aging population, necessitating precise diagnostic tools for optimal surgical management. Conventional classification systems using plain radiographs have limitations in accurately assessing unstable fracture patterns, particularly those involving lateral wall deficiency. **Methods:** This prospective, single-centre study (September 2023–November 2024) evaluated the role of preoperative computed tomography (CT) in managing IT fractures with lateral wall involvement. The study included 33 patients (aged ≥55) with unstable lateral wall fractures treated with Proximal Femoral Nail (PFN). Preoperative CT parameters, including lateral wall thickness and fracture morphology, were assessed and correlated with intraoperative findings. **Results:** CT scans significantly altered fracture classification compared to radiographs alone. While 85.7% of fractures were classified as AO 2 on X-ray, CT reclassification revealed 63.6% as AO 2 and 36.4% as AO 3. The addition of CT led to a classification upgrade in 45.5% of cases, enhancing the detection of complex fractures. However, statistical analysis showed a weak agreement between X-ray and CT (Kappa = 0.012, p = 0.854), suggesting that while CT provides additional details, its impact on classification significance remains debatable. **Conclusion:** CT imaging enhances the assessment of intertrochanteric fractures, particularly in evaluating lateral wall integrity and comminution. While its statistical significance remains inconclusive, CT remains a valuable adjunct for improving surgical planning, optimizing fixation strategies, and potentially reducing failure rates in IT fractures.

Keywords: Intertrochanteric fractures, pre-operative CT scan, Lateral wall fractures

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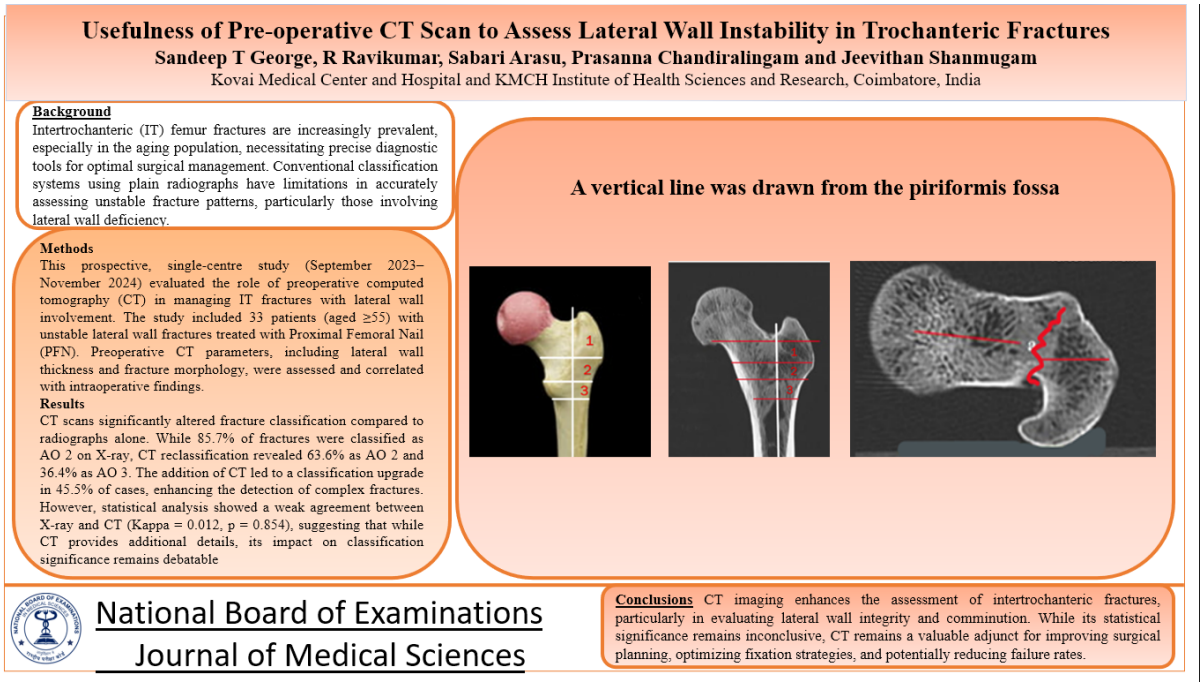
Graphical Abstract



Introduction

Intertrochanteric (IT) femur fractures are becoming an increasingly significant challenge in healthcare, particularly due to the growing aging population [1]. These fractures predominantly affect elderly individuals and necessitate accurate diagnostic tools for effective surgical treatment [2-4].

Traditional classification systems, such as Evans, Jensen, Boyd-Griffin, and AO/OTA, have been used to assess fracture patterns and stability [3,4]. However, these systems often have limitations, particularly regarding the challenges posed by plain radiographs, which may struggle to accurately capture the complex morphology of unstable fractures, especially those with oblique fragments or significant comminution [4-7].

Recent advancements in imaging technologies, particularly computed tomography (CT) and three-dimensional CT, address these challenges. These modalities provide detailed visualization of fracture patterns, enhancing diagnostic accuracy, improving surgical planning, and increasing agreement among observers [8-10]. CT is particularly valuable for assessing crucial aspects such as lateral wall integrity, which is a key factor in determining fracture stability and guiding implant selection [9].

This study emphasizes the benefits of CT imaging in the clinical management of unstable trochanteric fractures, particularly in cases involving lateral wall deficiency. We will analyse the correlation between pre-operative CT findings and intraoperative observations, focusing on comminution and stability. Additionally, we aim to assess the predictive value of CT-based lateral wall measurements on fixation outcomes and introduce a novel approach to fracture mapping. Our ultimate objective is to improve the understanding of intertrochanteric fracture patterns and morphology. By utilizing CT scans, we hope to facilitate more informed surgical

strategies, reduce fixation failures, and enhance outcomes for elderly patients.

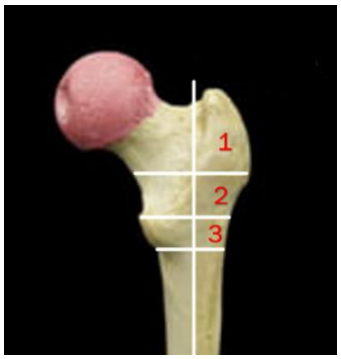
Materials and Methods

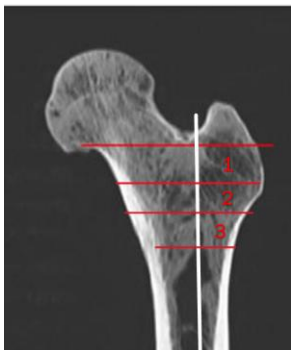
This prospective single-center study assessed the effectiveness of preoperative CT scans in managing intertrochanteric (IT) fractures with lateral wall involvement. Conducted between September 2023 and November 2024, the study included patients aged 55 and older who underwent intramedullary nailing for IT fractures. To be included in the study, patients needed radiographically confirmed lateral wall fractures within one week of their injury. Patients with pathological fractures, neglected fractures, associated shaft fractures, polytrauma, or those who lost follow-up were excluded from the study.

A total of 51 patients with IT fractures were initially enrolled, of which 33 patients with unstable lateral wall fractures treated with Proximal Femoral Nail (PFN) were included in the final analysis. Upon admission, all patients underwent standardized imaging, including anteroposterior (AP) and lateral radiographs and preoperative CT scans with GE-Optima, 16 Slice.

Parameters assessed in CT scan:

1. In the CT scan, the proximal femur was marked using a vertical line drawn from the piriformis to the Centre of the medullary cavity. Lateral to this line, three horizontal markings were made, one at the level of the innominate tubercle (a), second from the proximal level of the lesser trochanter (b), and third at the distal level of the lesser trochanter (c). This divides the lateral proximal femur into three segments: the greater tuberosity marked as 1, the upper lateral wall segment marked as 2, and the lower lateral wall segment marked as 3. (Figure 1).
2. Lateral wall thickness was assessed in both axial and coronal sections with the above-mentioned lines b and c in their respective sections (Figure 1).
3. Sagittal sections to assess comminution, coronal split, and displacement of the fracture fragment (Figure 1).

(A) 

(B) 

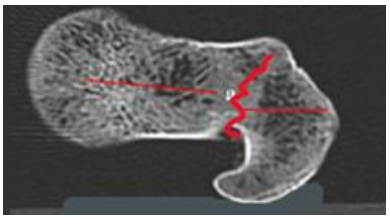
(C) 

Figure 1. (A), (B) A vertical line was drawn from the piriformis fossa to the centre of the medullary cavity, Lateral to this line, three horizontal markings were made. These markings divided the lateral proximal femur into three segments: **Segment 1:** Greater tuberosity, **2:** Upper lateral wall, **3:** Lower lateral wall. (C) Lateral wall thickness was assessed in both axial and coronal sections with the above mentioned lines b and c in their respective sections.

A musculoskeletal radiologist reviewed CT images, including axial, sagittal, and coronal reconstructions (Figure 2 and 3). Intraoperatively, the operating surgeon assessed the fractures, focusing on lateral wall comminution and fracture morphology. Comminution was defined as fractures with three or more fragments [11].

Anteroposterior (AP) and lateral radiographs obtained were classified using AO/OTA classification, including 31A1 to 31A3. The preoperative CT findings were compared to intraoperative observations to assess fracture stability and lateral wall integrity.

The institutional review board granted ethical approval, and informed consent was obtained from all participants. Data analysis evaluated the concordance between CT imaging and intraoperative findings, particularly regarding lateral wall integrity and its impact on surgical planning and fixation outcomes.

Figure 2. A 59-year-old male patient with AO Type 31 A3.3 left intertrochanteric fracture. (A) pre-operative radiograph, (B) A 3D-CT scan shows a fracture extending into the greater trochanter and neck, along with a multi-fragmented lateral wall fracture. (C) Sagittal sections to assess comminution and coronal split.

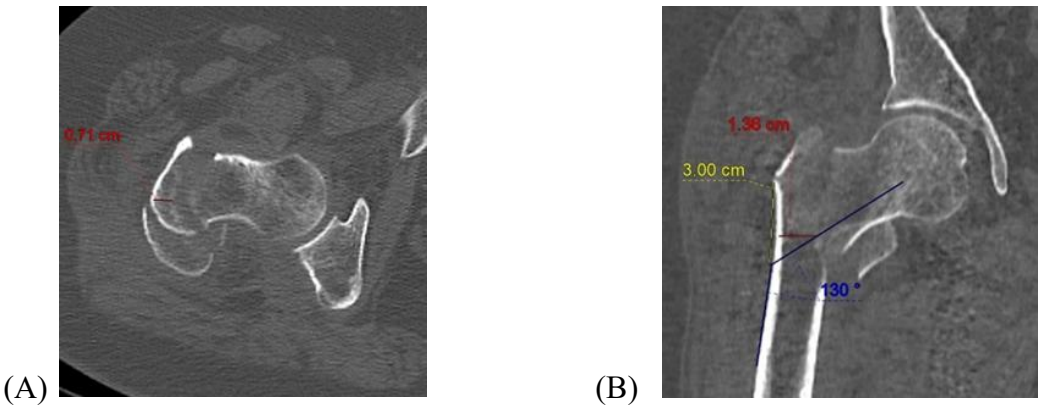


Figure 3. (A) Axial - CT Scan image measuring the lateral wall thickness at the central quadrant as 0.71cm. (B) Coronal - CT Scan image measuring lateral wall thickness, 3cm below lateral ridge along 130-degree neck shaft angle as 1.36cm

Results

When only using X-ray, most of the fractures were classified as AO Classification 2 (85.7%), with a smaller portion being classified as AO Classification 1 (15.2%). No fractures were classified as AO Classification 3 using X-ray alone (Tables 1 and 2).

Table 1. Distribution of study population according to AO fracture and study type

	AO Classification					
Modality	**1**		**2**		**3**	
	F	**%**	**F**	**%**	**F**	**%**
Only X-RAY	5	15.2	28	84.8	-	-
Xray + CT	-	-	21	63.6	12	36.4

Table 2. Distribution of study population according to grade

	FREQUENCY	**PERCENTAGE**
No change	18	54.5
One level upgrade	13	39.4
Two level upgrade	2	6.1

In contrast, when using X-ray combined with CT, 63.6% of fractures were classified as AO Classification 2, and 36.4% were classified as AO Classification 3. This shows that the addition of CT identified fractures that were not captured with X-ray alone (i.e., AO Classification 3).The majority of cases (54.5%) showed no change in the AO classification between X-ray and X-ray + CT, suggesting that CT did not alter the fracture classification in many cases compared to X-ray. A substantial number of cases (39.4%) experienced a level upgrade, meaning that CT provided a more detailed view of the fracture, potentially leading to a more accurate or higher classification. A small proportion (6.1%) experienced a two-level upgrade, indicating that CT contributed significantly in some cases by identifying more severe fractures (Table 3).

Table 3. Association between AO fracture X-ray and AO fracture CT

AO FRACTURE X-RAY	AO FRACTURE CT				KAPPA	P VALUE
	2		3			
	F	%	F	%		
1	3	14.3	2	16.7	0.012	0.854
2	18	85.7	10	83.3		

Kappa Value: A Kappa value of 0.012 suggests an inferior agreement between the X-ray and CT regarding fracture classification. This implies that the results from X-ray and CT are not in substantial agreement, indicating that CT may reveal additional details or a different classification than X-ray alone. P-Value: The p-value of 0.854 is well above the conventional significance threshold (0.05), suggesting that the difference in AO classification between X-ray and CT is not statistically significant. This implies that despite the poor agreement (as indicated by Kappa), the observed differences could be due to random variation rather than a substantial systematic difference (Table4).

Table 4. Association between AO fracture X-ray and AO fracture CT

AO FRACTURE X-RAY	AO FRACTURE CT				KAPPA	P VALUE
	2		3			
	F	%	F	%		
1	3	14.3	2	16.7	0.012	0.854
2	18	85.7	10	83.3		

Discussion

In today's orthopaedic practice, the rising incidence of intertrochanteric fractures has become a significant public health concern [1-4]. Proper management of these fractures during the initial surgical intervention is crucial for minimizing the risk of future revision surgeries, which are often associated with higher morbidity, mortality, increased healthcare costs, and

poorer functional outcomes [4-7]. Therefore, it is essential to thoroughly understand the characteristics of the fracture and to select an appropriate implant for osteosynthesis [7,8].

The failure of treated intertrochanteric fractures depends on various factors, including fracture type, the quality of reduction, fixation stability, the degree of osteoporosis, patient compliance, and existing comorbidities [11-13]. A comprehensive assessment of fracture patterns and geometry is vital for ensuring adequate fixation. In many cases, standard radiographs alone may not provide sufficient detail about the fracture [16-18]. A CT scan can provide a more detailed overview, including the degree of comminution and accurate measurements of various parameters [19].

The recent AO Compendium (2018) has been updated to include an additional variable: lateral wall thickness [17-19]. According to this classification, fractures with a lateral wall thickness of less than 20.5 mm are categorized as A2, while those thicker than 20.5 mm are classified as A1. This classification of fractures is based on both radiographs and CT scans [17]. Variations in different subtypes compared to other studies may arise from previous AO classification codes, which did not consider lateral wall thickness, as well as the involvement of a younger population that experiences higher energy trauma [17-19].

When using dynamic hip screws, both Gottfried and Palm emphasized the critical importance of the lateral wall [1,2]. Hsu et al. cautioned that intertrochanteric fractures with a lateral wall thickness of less than 20.5 mm should not be treated solely with a sliding hip screw [3]. Tan et al. identified superolateral support as a key factor in successful treatment, highlighting its priority over the medial calcar buttress [11]. They also recommended that a CT scan is essential for preoperative planning.

The definition of lateral wall thickness can be somewhat controversial, and its measurement may not be consistent across all radiographs, particularly since rotational angles can influence the values obtained [2-6]. Therefore, measuring lateral wall thickness on 2D CT axial images is recommended, as this method is more reliable than plain radiographs [9-11]. Fixation failure and revision rates in intertrochanteric fractures are often linked to the integrity of the lateral femoral wall, making it a vital consideration for biomechanical decision-making regarding further management. Another significant predictor of surgical success is the presence of coronal fragments [12-14,20,21].

Cho et al. were the first to define coronal fragments in intertrochanteric fractures based on a 3D CT scan study [21]. The impact of CT on fracture classification is notable; the addition of CT imaging has allowed for the detection of AO Classification 3 fractures that were not visible on X-rays. This highlights the additional diagnostic value that CT provides, especially in cases where X-rays might overlook more complex fractures.

Effectiveness of CT in Upgrading Classifications: When CT was added, there was a noticeable shift in fracture classification, with 39.4% of cases being upgraded by one level and 6.1% being upgraded by two levels. This highlights CT's ability to identify fractures in more detail, leading to more accurate treatment planning.

Agreement between X-ray and CT: Despite the differences in classifications between X-ray and CT, the Kappa value

and p-value suggest that the association between X-ray and CT fracture classifications is not strong, meaning that CT provides more detailed and possibly more accurate information. However, the lack of statistical significance ($p = 0.854$) indicates that the differences between the modalities might not be large enough to be considered definitively significant in a clinical setting.

Conclusion

While CT provides additional insights into fracture classification and has the potential to detect fractures that X-ray cannot, the statistical analysis suggests that these differences are not substantial enough to suggest a significant improvement in diagnostic accuracy. However, CT still appears to offer a valuable supplement to X-rays, especially when the classification is unclear or more detailed information is needed.

Statements and Declarations

Conflicts of interest

The authors declare that they do not have conflict of interest.

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