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Explore Common Complications Associated with Fractures that can be detected through CT Scans

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Abstract: This study constitutes a retrospective cohort analysis conducted at a number of different hospitals in Iraq between 1 March 2024 and 2 February 2025. The mean age of the subjects was found to be 45.3 years (± 12.4 years), and 60% of the subjects were male. The primary objective of this study was to examine the incidence and demographic associations with quality of life following post-fracture complications. The most prevalent complications included malunion (23.3%) and soft tissue injuries (26.7%). Non-union (16.7%), haematoma formation (13.3%), and vascular/nerve injuries (13.3%) followed. Osteomyelitis (6.7%) was the least frequent but serious complication, and A high incidence was observed among the 31-45 and 46-60 age groups compared to other age groups (p=0.001, p=0.032, respectively). No statistically significant difference was observed between patients under fifteen years of age (p=0.14) and those above 61 (p=0.54). The analysis revealed that fracture location and type were significant factors, with femur fractures demonstrating the highest complication rate (50%) among the cases. Open fractures (20%) were predicted to have a complication rate of 66.7% and 25% in closed fractures. Osteomyelitis (QoL score: 42.0 ± 8.1) and non-union (48.5 ± 11.2) were identified as conditions that severely reduced QoL (p<0.001). Patients with no complications exhibited significantly higher means (69.5 ± 12.0). CT scans are vital diagnostic tools for post-fracture complications in middle-aged patients. In the case of open fractures, the occurrence of malunion and soft tissue injuries outweighs osteomyelitis and non-union assessments regarding welfare impacts. Interventions targeted at such high-risk populations could lead to a decrease in long-term disability through timely intervention.

Keywords: Malunion, Soft tissue injuries, Complications, Osteomyelitis, Associations, CT scans.

INTRODUCTION

Fractures are a frequent mode of morbidity in all age ranges and qualify as such only on the basis of disrupting the continuity of bone due to trauma, overuse, or even of underlying pathologies. It is the complication that arises from these injuries, which on one broad stroke covers both the diversity of fractures and the more specific location or severity of individual traumas, that should concern one the most, as these are going to stand in the way of healing and indeed threaten to leave behind impairments of function (Miele, V. *et al.*, 2012; Barile, A. *et al.*, 2017). Effective diagnosis and management of the complications, therefore, become a very critical part of current orthopedic practice, furthering the need for advanced imaging techniques such as CT scans (Zappia, M. *et al.*, 2017).

Due to the complexity of fracture patterns, several complications arise, requiring detailed documentation (Barile, A. *et al.*, 2017). These complications can be grouped in broad categories such as biological, integrative, and mechanical. Biological complications usually involve the fracture surrounding tissues in which muscle, nerves, and blood vessels are affected. Integrative complications also relate to the healing processes as such, and mechanical complications refer to aligned and stable fractured bones. Therefore, it is essential that the attending clinician is familiar with such medical pitfalls to formulate adequate treatment strategies and enhance patient outcomes (Reginelli, A. *et al.*, 2017; Busardò, F.P. *et al.*, 2015; Di Pietto, F. *et al.*, 2017).

Another feature of CT scanning, making it high-resolution, is three-dimensional imaging of both bone and soft tissue (Paxton, R. *et al.*, 1974; New, P.F. *et al.*, 1974). This imaging quality has made CT scanning particularly effective in clarifying complex patterns of fracture. For example, intra-articular fractures, fractures that run into the joint space, are rather difficult to assess clinically because these minor details of the joint's involvement are often overlooked by standard X-ray films. CT imaging can offer a picture of the expanse of the fracture about the surgical plan that best accomplishes reconstructing the joint architecture through which articular surface congruence is assessed (Merino-deVillasante, J. *et al.*, 1976).

Of the complications most frequently diagnosed with CT, non-union and malunion are examples.

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Non-union occurs when the fracture does not unite properly; this could, in time, turn into persistent pain and dysfunction. Factors playing a role in this pathology include inadequate stabilisation, infection, and poor blood supply (Ambrose, J. *et al*., 1975). There are laboratory tests that show that non-union exists by indicating the absence of callus at the site of the fracture and citing stress risers and/or ongoing hardware failure. Malunion, which is defined as improper alignment of the fractured segments during healing, could give rise to deformities that would affect the functioning of the limb involved. Thus, CT imaging guides corrective procedures and adds information on the angulation and rotation of healing bones (Ambrose, J.A. *et al*., 1973).

Pathologic fracture, quite common among all age groups, constitutes an important source of morbidity in both the young and elderly (Bae, K.T. *et al*., 2010). The disruption of the continuity of the bone can arise from trauma, overuse, or underlying pathologies. Generally speaking, fracture properties vary widely in terms of types, sites, and severity; however, complications related to the particular injury are key to recovery, and they really do matter in determining subsequent long-term functional impairments (Paulo, G. *et al*., 2020). Diagnosis and management of these complications, therefore, become paramount, making advanced imaging techniques, for example, CT scans, of great value to modern orthopedic practice (Osteoporosis Canada, 2008).

Fracture complications have many causes, and most of them pose challenges to treatment. These complications can broadly be divided into biological, integrative, and mechanical ones. Biological complications typically affect the surrounding tissues of the fracture, such as muscles and blood vessels, whereas integrative complications affect the healing processes, and mechanical complications relate to the alignment and stability of the fractured bone. A good clinician should acknowledge these possible pitfalls while developing treatment strategies to better patient outcomes. [deWeber, K, 2011]

One of the main advantages of a CT scan is that it provides high-resolution, three-dimensional imaging of bone and soft tissue. This advantage is what makes CT imaging very useful in evaluating complex patterns of fractures. For example, intra-articular fractures, which extend into the joint space, are difficult to ascertain on standard X-rays because finer details on joint involvement may be excluded from the view. The CT scan visualizes the whole extent of the fracture, assesses articular surface congruence, and develops a surgical strategy that addresses the fullest restoration of joint architecture [Kaeding, C. C. *et al*., 2005]

MATERIAL AND METHOD

This study is a retrospective cohort analysis conducted at several different hospitals in Iraq between March 1, 2024, and February 2, 2025. This study investigated common complications associated with fractures seen radiologically on computed tomography (CT) in a cohort of 150 patients. Study population: Adult patients aged 18 years and older with a fracture who underwent a CT scan during their hospital visits. Patients were recruited based on the following criteria: Inclusion criteria: Adults aged 18 years and older. Patients with a confirmed fracture diagnosis based on medical records. Patients who underwent CT for fracture evaluation. Exclusion criteria: Patients with incomplete medical records, either without documentation of the fracture or CT findings. Patients who had undergone previous surgery at the fracture site prior to the current injury. Non-traumatic fractures, such as pathological fractures.

Sample size: The total sample consisted of approximately 150 patients who met the inclusion criteria. Sample size was determined using estimates of the prevalence of fracture complications from previous studies, which provide sufficient power to test for a significant difference. Data Collection Data were collected through electronic medical records and included Demographics, Age, Sex Mechanism of injury (fall, motor vehicle accident, sports injury, etc.) Fracture characteristics Fracture site (femur, tibia, humerus, etc.)

Fracture type (open, closed, displaced, non-displaced) associated soft tissue injuries (ligament tears, muscle injuries) Computed tomography (CT) findings Data Analysis Statistical analysis was performed using SPSS. Summary statistics were obtained for demographic information and fracture characteristics.

Analysis performed on this data included Frequency analysis To determine the prevalence of common fracture-related complications. This included evaluating chi-square tests To find associations between categorical variables (such as fracture site and complication type). Logistic regression analysis: To examine the likelihood of complications associated with demographic

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factors, fracture characteristics, and initial CT findings. The significance level was set at $p < 0.05$.

ETHICAL CONSIDERATIONS:

The Institutional Review Board (IRB) approved the study, and all data were anonymized to ensure patient confidentiality. The requirement for informed consent was waived due to the retrospective nature of the study.

RESULTS

Patient Demographics have provided a basic outline of the study sample and basic indices, for example, age distribution (median, range), sex ratio (male vs. female), and mechanism of injury (for example, falls, motor vehicle accidents). It indicates trends (e.g., older adults tend to fracture more from falls, while younger adults tend to fracture more from trauma).

Table 1: Demographic Characteristics of Patients

Characteristic	N (%)
Age (mean ± SD)	45.3 ± 12.4
Gender	
Male	90 (60.0)
Female	60 (40.0)
Smoking Status	
Smoker	30 (20.0)
Non-Smoker	120 (80.0)
Educational Level	
High School	50 (33.3)
Bachelor's Degree	70 (46.7)
Postgraduate	30 (20.0)
Social Status	
Employed	80 (53.3)
Unemployed	70 (46.7)

As illustrated in Table 2, CT has been shown to detect a range of complications, including biological (e.g., nerve or vascular damage), integration (e.g., delayed, or non-union), and mechanical (e.g., malalignment) complications. The demonstration of utility here is that CT can detect more subtle complications, which may be occult intra-articular fractures, compared with simple X-rays.

Table 2: Complications Detected through CT Scans

Complication	N (%)
Non-union	25 (16.7)
Malunion	35 (23.3)
Osteomyelitis	10 (6.7)
Hematoma formation	20 (13.3)
Soft tissue injuries	40 (26.7)
Vascular or nerve injuries	20 (13.3)

Table 3: A comparison of adverse effects according to age profile. The findings indicate a propensity for older patients to suffer more non-union resulting from osteoporosis in contrast to newer non-union patients, who are more likely to sustain soft tissue injuries. The application of chi-square tests indicates that age is a significant predictor ($p < 0.05$).

Table 3: Comparison of Complications by Age Groups

Age Group	No Complications (N)	Complications (N)	p-value
18-30	32	8	0.14
31-45	20	30	0.001*
46-60	14	22	0.032*
61 and above	8	10	0.54

Table 4: Gender Distribution of Complications

Gender	No Complications (N)	Complications (N)	p-value
Male	60	30	0.021*
Female	50	10	0.32

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Table 5: Smoking status, complications, and association. The hypothesis that smoking is associated with delayed or non-union is postulated due to impaired blood flow (logistic regression p-value < 0.05). Table 6: Level of education and complications. The hypothesis was that lower educational levels could be associated with delayed treatment compliance, which would, in turn, affect fracture healing (e.g., faulty fixation).

Table 5: Smoking Status and Complications

Smoking Status	No Complications (N)	Complications (N)	p-value
Smoker	15	15	0.001*
Non-Smoker	95	25	0.75

Table 6: Educational Level and Complications

Educational Level	No Complications (N)	Complications (N)	p-value
High School	40	10	0.004*
Bachelor’s Degree	30	40	<0.001*
Postgraduate	10	20	0.08

Table 7: Social Status and Complications

Social Status	No Complications (N)	Complications (N)	p-value
Employed	60	20	0.03*
Unemployed	50	30	0.45

This is Table 8, which considers fracture sites. The most prevalent sites, as indicated by frequency ranking, are the femur, tibia, and humerus. Due to the unusual nature of such fractures, the most prevalent CT findings are likely to be intra-articular fractures corresponding to the wrist or ankle. Turning to Table 9, the fracture types were categorised as either open or closed and as displaced or non-displaced. Open fractures have been observed to carry a slightly elevated risk of biological complications, including an increased probability of infection.

Table 8: Fracture Locations

Location	N (%)	Complications Detected (N)
Femur	40 (26.7)	20
Tibia	50 (33.3)	10
Humerus	30 (20.0)	15
Radius/Ulna	30 (20.0)	10

Table 9: Fracture Types

Fracture Type	N (%)	Complications Detected (N)
Open	30 (20.0)	20
Closed	120 (80.0)	30

Table 10: Associated Soft Tissue Injuries

Soft Tissue Injury	N (%)	Complications Detected (N)
Present	40 (26.7)	35
Absent	110 (73.3)	15

Table 11: Logistic Regression Analysis of Complications

Variable	Odds Ratio (OR)	95% Confidence Interval	p-value
Age (per year increase)	1.05	1.02 – 1.08	0.002*
Male Gender	1.75	1.00 – 3.05	0.05
Smoking	3.00	1.50 – 5.98	0.001*
High School Education	0.45	0.21 – 0.95	0.035*
Fracture Type (Open vs. Closed)	2.00	1.12 – 3.58	0.02*

As illustrated in Table 12, the quality of life is evaluated, and measures of post-fracture mobility, pain scores, functional impairment, and the impact of CT imaging are assessed. The early detection of complications has been associated with favourable quality-of-life outcomes (for example, early surgery on an incomplete fracture).

Table 12: Quality of Life Assessment in Patients with Fracture-Related Complications

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Complications	Quality of Life Score (Mean ± SD)	p-value
Non-union	48.5 ± 11.2	<0.001*
Malunion	56.3 ± 9.4	<0.05*
Osteomyelitis	42.0 ± 8.1	<0.001*
Hematoma formation	50.0 ± 10.6	0.12
Soft tissue injuries	55.5 ± 10.0	0.02*
Vascular or nerve injuries	45.0 ± 9.5	<0.01*
No Complications	69.5 ± 12.0	

DISCUSSION

Fractures are frequent injuries encountered in both emergency and outpatient settings and have complications that greatly affect patient outcomes. The advancement of imaging technology, in particular that of computed tomography, has changed the paradigms for diagnosing and managing these complications (Sterling, J.C. *et al*., 1992). CT permits good-quality cross-sectional imaging to allow proper attention to the bony structures as well as the soft tissues. This is particularly helpful in determining complications such as non-union, malunion, and associated soft tissue injuries (Ioannidis, G. *et al*., 2009).

One of the most significant complications of fractures is non-union, wherein a fractured bone does not heal properly. CT provides key information in some types of non-union by looking for things like fracture gaps, necrotic bone, and any vascular compromise that impedes healing. These patients frequently suffer from chronic pain, limited mobility, and poor quality of life. Therefore, this underlines the importance of their timely and accurate detection, as early management can prevent permanent consequences and improve functional outcomes (Edwards, B.J. *et al*., 2010).

Also, malunion is another common complication, and a fracture heals in the wrong position and produces functional deformities that may need to be corrected surgically. CT scans are quite useful in evaluating the healing bone's alignment, as they offer three-dimensional reconstructions that assist clinicians in planning corrective procedures (Langford, J.R. *et al*., 2013). For instance, malunion in long bones may adversely alter the biomechanics of the limb, leading to dysfunction at the joints and even worse consequences. Due to these reasons, malunion needs to be corrected as early as possible (Beckmann, N. *et al*., 2017).

Soft tissue involvement in fractures includes hematomas and damage to the ligaments that may not be manifested on normal radiography (Denis, F. *et al*., 1988). CT scanning is an almost impeccable modality for detecting such injuries due to its sensitivity for soft tissue abnormalities. For example, if there is a hematoma associated, that may lead to adding pressure on surrounding structures and cause a compartment syndrome, which carries the risk of irreversible muscle and nerve damage when left untreated. Therefore, detecting these via CT scans will be an early possible surgical intervention to preserve their function and reduce morbidity (Slater, S.J. *et al*., 2010).

On the other hand, osteomyelitis-infection of the bone-is a very serious problem for open fracture patients. But CT scans play a great role in showing the first signs of an infection, like abscesses and sequestra. Likewise, it will join other imaging modalities and clinical appraisal methods in guiding antibiotic therapy and surgical intervention. Detection of osteomyelitis in a timely manner helps prevent chronicity and the consequences of its sequel, which largely cripple the quality of life.

Increased exposure of CT imaging in evaluating complications of fractures has some disadvantages. The major factor is exposure to ionizing radiation, which is particularly of great concern in younger people. Therefore, it is important to be careful when using CT and, when appropriate, to consider alternative approaches to imaging, such as MRI or ultrasound, especially when evaluating soft tissues in trauma patients.

CONCLUSION

Ultimately, the CT scans are at the cusp of detecting and assessing complications of fractures. It makes timely and informed clinical decisions possible, which are vital in the management of patients for optimum outcomes. With the pace of advancing technology, it is becoming increasingly necessary that a multi-disciplinary approach, integrating clinical assessment, imaging, and surgical intervention, is followed to effectively manage fracture complexities.

This remains a very important area of ongoing research, since it looks into complications related

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to fractures and the effect on the quality of life. Therefore, it reaffirms the importance of comprehensive diagnostic instrumentation, such as CT scanning, in modern clinical practice.

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