Asian Journal of Medicine and Health

Volume 22, Issue 5, Page 46-52, 2024; Article no.AJMAH.114956
ISSN: 2456-8414

Comparison of Conventional Radiography and Multidetector Computed Tomography Scan in Knee Trauma in Rajavithi Hospital

W. Mani [a*], K. Yindee [a] and C. Sawarin [a]

[a] *Department of Radiology, Rajavithi Hospital, Bangkok, Thailand.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJMAH/2024/v22i51009

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/114956

Original Research Article

Received: 21/01/2024
Accepted: 27/03/2024
Published: 30/03/2024

ABSTRACT

Objective: This study aimed to compare the diagnostic results and agreement among XR, MDCT, and combined examination between XR and MDCT in diagnosing knee bone fractures.
Methods: A retrospective was conducted of 243 patients who experienced knee trauma and underwent both XR and MDCT scans between January 1, 2016, and January 1, 2021, at Rajavithi Hospital in Bangkok, Thailand.
Results: Out of the 243 patients, 147 were male (60.5%), and 96 were female (39.5%), with 226 (93%) displaying fractures. MDCT identified a total of 319 fractures in various anatomic regions. Computed tomography scans compared with the two combined methods showed no difference in results. However, the radiography results were significantly different compared to the two methods combined ($p<0.05$). MDCT+XR proved more effective in diagnosing fractures than XR alone. The agreement between MDCT versus MDCT+XR exceeded 0.98, whereas the agreement between XR

**Corresponding author: E-mail: wmani2006@gmail.com;*

versus MDCT+XR was less than 0.9, except for femoral fractures (0.935). Overall, utilizing both MDCT and XR together significantly enhanced the diagnostic effectiveness compared to using XR alone.

Conclusion: MDCT imaging provides more accurate results, while XR imaging is still valuable for certain fractures. The combined methods were more accurate, especially in cases where the fracture type and characteristics cannot be determined with XR alone. The high level of agreement between XR and MDCT supports the combined use of both methods in clinical practice for diagnosing knee injuries.

Keywords: Knee injury; knee bone fractures; multidetector computed tomography; conventional radiography.

1. INTRODUCTION

Acute knee injuries can occur due to various reasons, including accidents, sports injuries, falls, or direct impact to the knee. These injuries can lead to fractures in the knee bones, such as the distal femur, proximal tibia, proximal fibula, and patella [1]. Diagnosis of knee fractures often requires multiple diagnostic tests, including evaluating symptoms such as pain, swelling, knee flexion, bruising, and deformity. Conventional radiography (XR) is commonly used as the initial method for evaluating knee fractures, but it may have limitations in detecting complex fractures and demonstrating injuries in patients with limited mobility or unstable knee joints. Multidetector computed tomography (MDCT) can provide more detailed and precise images of knee injuries in multiple planes and 3D views, enabling accurate diagnosis and timely treatment planning [2-3]. In a retrospective study, Stiell et al. [4] reviewed 1967 patients with knee injuries and knee radiography alone was found to have a low sensitivity in detecting fractures, with only 5.2% of patients with confirmed fractures identified through conventional radiography. In the study by Mustonen et al. [5], the evaluation of knee fractures was conducted using XR and MDCT. In a retrospective cohort of 409 patients, 356 (87%) had knee fractures. The overall sensitivity of radiographs in detecting fractures was 83%, while the negative predictive value was 49%. The study recommended the use of MDCT in patients with tibial plateau fractures or complex knee injuries to adequately evaluate the fractures due to its fast and accurate examination. According to the studies by Pinto et al [6], XR imaging is still valuable for fracture assessment. A fracture may be missed because it is radiologically invisible or equivocal. Therefore, additional study may be required by examining other methods. Capps et al [7], most fractures around the knee are easily detected on XR. However, some fractures have subtle findings and may be difficult to detect with XR images; these injuries include tibial plateau fractures, Segond fractures, stress fractures, fibular head fractures and dislocations, injuries to the patella and extensor mechanism, and Salter type fractures. Other imaging modalities such as MDCT should be obtained for evaluating the extent of fracture and displacement. Verma et al. [8], the evaluation of knee fracture with XR imaging of a single lateral view as a screening tool. The 214 patients (24.8%) had a knee fracture. The sensitivity of the single lateral view in the detection of knee fractures was 100% (95% confidence interval [CI] = 94.3, 100). The lateral view of the traumatized knee was normal in 143 patients (66.8%). The probability of not having a fracture if the lateral view was normal (NPV) was also 100% (95% CI = 97.9, 100). The need for additional radiographs was reduced 67%. A single lateral view as a screening tool for knee fractures has a very high sensitivity and NPV. There can be a considerable amount of savings in terms of radiology services for these patients. Avci et al.[9], conducted a comparative study of XR and MDCT in the assessment of ankle injuries. The sensitivity and specificity of radiography in detecting fractures compared to MDCT were 75% and 93%, respectively. The study also found that 20% of patients had two simultaneous fractures, with radiography demonstrating a sensitivity of 56% and specificity of 94% in detecting these fractures. Chang et al [10] found that MCDT can provide more detailed information about fracture anatomy, intra-articular fractures and the relationships between fracture fragments in Schatzker type IV medial tibial plateau fractures. Bo Cui et al. [11] analyzed sports-related knee fractures using XR and MDCT. The study recommended selecting either a single ordinary XR or MDCT scan based on the patient's specific situation. For patients with suspected unstable fractures, a combination of ordinary XR and MDCT examination was suggested to improve diagnostic accuracy and avoid missed fractures. In the study by Avci et al. [12], knee fractures and fracture characteristics were studied by comparing XR and MDCT. XR imaging demonstrated 89% sensitivity, 95% specificity, 92% positive predictive value, and 92% negative predictive value in identifying fracture. According to the kappa value, there was determined a perfect concordance between the XR imaging and CT scans in angulation, stepping off, and extension of the fracture into the joint space. This concordance was moderate in growth plate fractures. The study emphasized that MDCT scanning should be performed when fracture type and characteristics cannot be accurately determined using XR imaging in knee injuries. Ranjeet et al. [13] conducted a comparison between XR and MDCT with 3D reconstruction in the evaluation, classification, and management of tibial plateau fractures. Two patients (4.76%) were initially diagnosed as having no fractures based on plain radiography, but MDCT examination revealed fractures in 100% of the cases and provided more detailed classification of tibial plateau fractures compared to normal radiography. The study also noted a gradual decrease in the sensitivity of conventional radiography as the number of fractured bones increased, potentially due to the increased complexity of anatomical deterioration with multiple fractures. Overall, the study concludes that there is a significant difference between the diagnostic results of knee injuries obtained through XR and MDCT imaging. MDCT imaging is more sensitive in detecting certain types of fractures, and there is a high level of agreement between the two methods. The purpose of this study was to compare the diagnostic results and agreement, fracture localization, and characterization of knee bone fractures using XR and MDCT in patients with knee injuries. Although previous research has explored the diagnostic accuracy of these imaging modalities, no such study is available at our hospital. Therefore, this study aims to reduce the misdiagnosis of fractures on plain radiographs by incorporating additional examinations, such as MDCT, to improve accuracy in diagnosing and treating patients in the emergency room.

2. MATERIALS AND METHODS

This study included patients with knee injuries from accidents between January 1, 2016, and January 1, 2021 at Rajavithi Hospital in Bangkok, Thailand. Patients of all age groups who underwent knee XR and MDCT imaging were included in the study. Patients who underwent imaging for non-traumatic reasons and those with unavailable XR or MDCT images were excluded. The sample size was calculated using two proportions (Paired) formula with a significant level of 0.05 and a power of 80%. Based on a study of Avci M [12], fragmented fractures were identified using XR imaging and CT of 12% and 22%. The minimum requirement of the subjects was 224, and almost 10% was increased. The 243 samples that met the inclusion criteria were then included in the analysis. The XR and MDCT images were reinterpreted by two radiologists. All MDCT scans were performed using a 128-section multi-detector scanner, following a standardized knee MDCT examination protocol. The images were reevaluated by the radiologists for fracture location in the distal femur, proximal tibia, proximal fibula, and patella. Descriptive statistics were used to report the demographic data of the patients, including categorical data reported as percentages and continuous data reported as means with standard deviations for normally distributed data and medians with minimum and maximum values for abnormally distributed.

2.1 Data Analysis

Data was analyzed using IBM SPSS version 22. For descriptive statistics, baseline data are presented as categorical data using percentages, while continuous data are reported as means with standard deviations if normally distributed. For inferential statistics, categorical data was compared using the McNemar's test**.** Instrument consistency, the agreement of diagnosis results of knee bone fractures, was analyzed using Kappa statistics. All statistical tests were considered significant at a p-value < 0.05.

3. RESULTS

The study included 243 patients with knee injuries, with 147 (60.5%) being male and 96 (39.5%) being female. The mean age of the patients was 44.33 ± 18.08 years (Table 1).

Table 1. Characteristics of knee injury patients in Rajavithi Hospital (n=243)

Characteristics	Number (n)	Percentage
Sex		
Male	147	60.5
Female	96	39.5
Age (years) mean±SD.	**44.33 ± 18.08**	

Table 2. Comparison of diagnostic results of knee bone fractures among conventional radiography (XR), computed tomography (MDCT) and the combination of both methods (MDCT+XR)

Bones	MDCT image n(%)	XR image n(%)	MDCT+XR (2 methods) n(%)	(MDCT vs 2 methods) p-value	(XR vs 2 methods) p-value
Tibial fractures	160 (65.8)	149 (61.3)	162 (66.7)	0.500	< 0.001*
Femoral fractures	64 (26.3)	59 (24.3)	65 (26.7)	1.000	0.031*
Patellar fractures	28 (11.5)	14 (5.8)	28 (11.5)	1.000	<0.001*
Fibular fractures	67 (27.6)	45 (18.5)	67 (27.6)	1.000	<0.001*

p-value of the McNemar's test

Table 3. Agreement of the diagnosis of knee bone fractures by conventional radiography (XR), computed tomography (MDCT), and both methods (MDCT+XR)

Bones	MDCT vs 2 methods		XR vs 2 methods	
	Kappa	p-value	Kappa	p-value
Tibial fractures	0.982	< 0.001	0.884	< 0.001
Femoral fractures	0.989	< 0.001	0.935	< 0.001
Patellar fractures	1.000	< 0.001	0.639	< 0.001
Fibular fractures	1.000	< 0.001	0.748	< 0.001

Of the 243 patients, 226 (93%) had fractures, and 17 (7%) had no fractures. Fractures detected only through MDCT imaging: included 11 tibia, 5 femur, 14 patella, and 22 fibular fractures. The most commonly fractured bone was the tibia. Diagnosis of knee injuries from accidents using conventional radiography (XR), computed tomography scans (MDCT), and two methods for four types of bone fractures, including tibial, femoral, patellar, and fibular fractures, are presented in Table 2. Diagnosis results of knee injuries using MDCT compared with the combination of the two methods showed no difference (p>0.05). While the results of the XR examination compared with the two methods were significantly different (p<0.05), the results of the XR examination alone are less accurate than those of the results from both methods combined. These results were similar for all four fractured bones.

Kappa statistics and corresponding p-values for the agreement between different imaging methods (MDCT/MDCT+XR and XR/MDCT+XR) for various types of fractures as shown in Table 3. The Kappa coefficients for the agreement between the MDCT and combined two methods ranged from 0.982 to 1, while the agreement between the XR and two methods ranged from 0.639 to 0.935, depending on the bone fractures being assessed. In tibial fractures, Kappa coefficients for MDCT versus MDCT+XR is 0.982 (p-value<0.001), indicating high agreement. The Kappa coefficients for XR versus MDCT+XR is 0.884 (p-value<0.001), indicating substantial agreement. Agreement was higher in femoral fractures, the Kappa coefficients for MDCT versus MDCT+XR is 0.989, while the Kappa for XR versus MDCT+XR is 0.935, (p-value <0.001). In patellar fractures, agreement between the MDCT and two methods was high (Kappa = 1, p-value<0.001); agreement between the XR and MDCT+XR was substantial (Kappa = 0.639, p-value<0.001). In fibular fractures, the Kappa for MDCT versus MDCT+XR is 1.000, indicating high agreement. Kappa for XR versus MDCT+XR is 0.748, indicating substantial agreement. Both p-values are < 0.001, signifying highly significant agreement for both comparisons.

4. DISCUSSION

In knee-injured patients, XR has been the method of choice for the initial radiological evaluation of acute knee trauma. In normal clinical practice, only two views (AP and lateral) are typically taken as a baseline. However, primary radiographs are often suboptimal due to positioning issues, making it difficult to obtain diagnostically sufficient images [4-8]. As a result, a negative radiograph is not reliable for ruling out a fracture. In order to adequately evaluate fractures, MDCT is recommended as an accurate examination for patients with knee injuries. In our study, the choice of imaging method (MDCT, XR, or both) varies in its significance depending on the type of fracture. The results for MDCT compared to MDCT+XR of all fractures show no significant difference, but XR compared to MDCT+XR is different. MDCT+XR is more effective in diagnosing fractures than XR alone. While the agreement between MDCT versus MDCT+XR is higher than 0.98, the agreement between XR versus MDCT+XR is less than 0.9, except for femoral fracture. For femoral fracture, the agreements between MDCT versus MDCT+XR and XR versus MDCT+XR is higher than 0.9. The femur is large and is the longest bone in the body. The femoral fracture is then easily detected with MDCT, XR or both. For all fractures, using both MDCT and XR together appears to be significantly more effective than using XR alone. In the study conducted on acute knee injuries, knee radiography alone was found to have low sensitivity in detecting fractures, with only 5.2% of 1,967 patients with confirmed fractures identified through conventional radiography [4]. In our study of 243 patients, 226 (93%) had fractures, while 17 had no fractures (7%). In another study investigating 409 patients, 356 (87%) had knee fractures. Among the cases with available primary radiographs (316 cases), 225 (71%) underwent MDCT to better visualize the fracture anatomy, and 91 (29%) received subsequent MDCT scans after negative radiographs. The overall sensitivity of radiographs in detecting fractures was 83%, while the negative predictive value was 49%. Tibial articular surface depression measured on radiographs and MDCT images consist of 259 tibial plateau fractures. P-value indicates the statistical difference between these two methods. The study recommended the use of MDCT in patients with tibial plateau fractures or complex knee injuries to adequately evaluate the fractures due to its fast and accurate examination [5].This may be attributed to the increased deterioration of the anatomy with the increase in the number of fractured bones. As deterioration of the anatomy increases, the interpretation of XR imaging becomes more difficult, and the error rate becomes high [6-8]. In a study performed on ankle injuries, the sensitivity and specificity of radiography in detecting fractures compared to MDCT were 75% and 93%, respectively. The study also found that 20% of patients had two simultaneous fractures, with radiography demonstrating a sensitivity of 56% and specificity of 94% in detecting these fractures. The results indicate that XR is insufficient for the imaging of fracture, extension of the fracture into the joint space and growth plate fractures. It was determined that the sensitivity of XR imaging decreased gradually as the number of fractured bones increased. Therefore, using both MDCT and XR together appears to be significantly more effective than using XR alone in patients with complex ankle injuries [9]. In a study conducted on using MDCT based morphological sub-classification of Schatzker type IV medial tibial plateau fractures, MDCT based reconstruction enhanced the understanding of fracture anatomy and the relationships between fracture fragments, a combination of ordinary XR and MDCT examination was suggested to improve diagnostic accuracy and avoid missed fractures [10]. In the study of analysis of sports knee fractures based on XR and MDCT, comparison of the MDCT and XR for the tibial plateau fractures and knee joint free body results statistically significant difference ($P < 0.05$). For patella fractures, there is no statistically significant difference between MDCT and XR results [11]. In our study, there is a high level of consistency between the results of knee injury diagnosis using both XR and MCDT. For tibial and patellar fractures, using both MDCT and XR together appears to be significantly more effective than using XR alone. In study on knee fractures and fracture characteristics were studied by comparing XR and MDCT, for tibial fracture, XR has a sensitivity of 80% and specificity of 96%, with an AUC of 0.881. This suggests that XR is reasonably effective in identifying tibial fractures compared to MDCT. The patellar fracture has a sensitivity and specificity both at 100%, indicating perfect agreement between XR and MDCT for patellar fractures, and an extremely high AUC of 0.998, suggesting excellent diagnostic performance. For avulsion fractures, the XR has a sensitivity of 69% and specificity of 100%, with an AUC of 0.844 and a Kappa value of 0.773. This suggests relatively good diagnostic performance for avulsion fractures using XR compared to MDCT. The study emphasized that MDCT scanning should be performed when fracture type and characteristics cannot be accurately determined using XR imaging in knee injuries [12]. In a comparative study, XR and MDCT with 3D reconstruction were evaluated for tibial plateau fractures. Two patients (4.76%) initially diagnosed with no fractures via plain radiography were found to have fractures in 100% of cases through MDCT examination. MDCT also provided more detailed fracture classification compared to XR. The study highlighted a decrease in XR sensitivity as the number of fractured bones increased, likely due to anatomical complexities with multiple fractures. Therefore, both MDCT and XR can be used together for better diagnosis, preoperative assessment and management of tibia fractures [13]. Our study supports the combined use of XR and MDCT, demonstrating that utilizing both imaging modalities together significantly improves diagnostic efficacy, especially when compared to XR alone. In our study it was found that 243 patients, 226 (93%) had fractures, exclusively detected through MDCT imaging: 11 tibial, 5 femoral, 14 patellar, and 22 fibular fractures. Fibula fractures often accompany tibia fractures, reducing their visibility on XR due to anatomical deterioration from multiple fractures. Additionally, plain radiographs missed tibia fractures, but MDCT identified 11 cases, aiding in accurate diagnosis and appropriate treatment of patients. Overall, the study concludes that there is a significant difference between the diagnostic results of knee injuries obtained through XR and MDCT imaging. MDCT imaging is more sensitive in detecting certain types of fractures. The study highlights the importance of using MDCT imaging to accurately evaluate knee fractures in patients with acute knee trauma. The MDCT imaging offers several advantages in the evaluation of knee injuries. It provides detailed cross-sectional images that allow for better visualization and characterization of fractures, including their extent, displacement, and involvement of surrounding structures. MDCT imaging with multiplanar reconstructions can be especially useful in assessing complex fractures, such as tibial plateau fractures, where accurate classify-cation and treatment planning are crucial.

5. CONCLUSION

The study underscores the notable disparity in diagnostic outcomes between XR imaging and MDCT for knee injuries, with MDCT emerging as a more sensitive and precise method. MDCT offers detailed anatomical insights into fractures, aiding precise treatment planning. The strong agreement between XR and MDCT advocates for their complementary use in clinical settings for diagnosing knee injuries, acknowledging their individual strengths and limitations.

6. LIMITATION

This study was studied only the knee injury and bone fracture. In case there no bone fracture is found on XR or MCDT, the patient may have a ligament, tendon or soft tissue injury, which cannot be diagnosed from XR or MDCT. Therefore, additional study may be required by examining other methods.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The retrospective study was approved by the Ethics committee, Rajavithi Hospital (no 139/2565).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Greenspan A. Orthopedic radiology: A practical approach. 2nd ed. New York: Raven Press; 1992.
2. Fagan DJ, Davies S. The clinical indications for plain radiography in acute knee trauma. Injury. 2000;31(9):723-7.
3. Stiell IG, Wells GA, Hoag RH, Sivilotti ML, Cacciotti TF, Verbeek PR, et al. Implementation of the ottawa knee rule for the use of radiography in acute knee injuries. Jama. 1997;278(23):2075-9.
4. Stiell IG, Wells GA, McDowell I, Greenberg GH, McKnight RD, Cwinn AA, et al. Use of radiography in acute knee injuries: Need for clinical decision rules. Acad Emerg Med. 1995;2(11):966-73.
5. Mustonen AO, Koskinen SK, Kiuru MJ. Acute knee trauma: Analysis of multidetector computed tomography findings and comparison with conventional radiography. Acta Radiol. 2005;46(8): 866-74.
6. Pinto A, Berritto D, Russo A, Riccitiello F, Caruso M, Belfiore MP, et al. Traumatic fractures in adults: Missed diagnosis on plain radiographs in the Emergency Department. Acta Biomed. 2018; 89(1-S): 111–123.
7. Capps GW, Hayes CW. Easily missed injuries around the knee. Radiographics 1994;14(6):1191-210.
8. Verma A, Su A, Golin AM, Marrah BO, Amorosa JK. The lateral view: A screening method for knee trauma. Acad Radiol. 2001;8(5):392-7.

9. Avci M, Kozaci N, Yuksel S, Etli I, Yilmaz Y. Comparison of radiography and computed tomography in emergency department evaluation of ankle trauma. Ann Med Res. 2019;26(5):867-72.
10. Chang SM, Zhang YQ, Yao MW, Du SC, Li Q, Guo Z. Schatzker type IV Medial Tibial Plateau Fractures: A computed tomography-based morphological sub-classification. Orthopedics. 2014;37(8):e699-706.
11. Cui B, Liu Y, Chen S. Analysis of sports knee fractures based on X-ray and computed tomography imaging. Comput Math Methods Med. 2021; 2021: 9572363.
12. Avci M, Kozaci N. Comparison of X-ray imaging and computed tomography scan in the evaluation of knee trauma. Medicina (Kaunas). 2019;55(10):623.
13. Kumar R, Juneja J, Kumar R, Sen R, Kadam S, Sahu G. Comparison between standard radiography and spiral CT with 3D reconstruction in the evaluation, classification, and management of tibial plateau fractures. Int J Orthop Sci. 2020;6(2):789-94.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/114956