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Ottawa versus Pittsburgh knee rules in screening acute knee injury

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Abstract

Introduction: Acute knee injuries account for eight percent of all injuries. Ottawa and Pittsburgh knee rules (OKR and PKR) were developed to assess the need for radiographs in acute knee injury. The objective of the study is to analyse the applicability of OKR and PKR to rule out fractures in acute knee injury.

Method: This prospective cross-sectional study included 120 patients presenting with acute knee injury. Patients were assessed based on Ottawa and Pittsburgh knee rules (OKR and PKR) and radiographs were evaluated for fractures. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of OKR and PKR were calculated along with possible reduction in radiographs. Association of sex and age with outcome of acute knee injury was also analysed.

Result: Among the 120 patients, 74(61.67%) were males and 46(38.33%) were females. Sensitivity, specificity, PPV and NPV of OKR were 95% CI 0.94(0.83-0.99), 95% CI 0.40(0.28-0.52), 95% CI 0.53(0.42-0.63) and 95% CI 0.90(0.74-0.98) respectively with possible reduction in radiographs by 31(25.83%). Sensitivity, specificity, PPV and NPV of PKR were 95% CI 0.88(0.76-0.05), 95% CI 0.57(0.45-0.69), 95% CI 0.59(0.47-0.71) and 95% CI 0.87(0.75-0.95) respectively with possible reduction in radiographs by 46(38.33%).

Conclusion: OKR and PKR are highly sensitive in ruling out fractures in patients with acute knee injury and more than one-fourth of radiographs can be avoided if these rules are applied.

Keywords: Acute Knee Injury; Ottawa Knee Rules; Pittsburgh Knee Rules

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Introduction

Acute knee injuries are commonly seen in practice with an incidence of six per thousand persons per year.[1,2] Acute knee trauma may lead to fracture of the patella, distal femur, proximal tibia and proximal fibula or injury to ligaments or menisci.[3–5] Radiographs are requested in almost all acute knee injuries but only about 6% have fractures.[1] Over ordering of the radiographs may lead to excessive radiation exposure, prolonged waiting time of patients and increased economic burden for the patient and country.[6]

Ottawa knee rules (OKR) and Pittsburgh knee rules (PKR) are clinical guidelines that were developed to evaluate the need for radiographs in acute knee injuries.[5,7] Sensitivity of OKR was reported from 71-100%.[1,8–13] Sensitivity of the PKR was reported from 86-99%.[8,14] Potential reduction in the ordering of radiographs was 23-79%.[5,8,9,12,15]

This study was conducted to evaluate if OKR and PKR can be applied to rule out fractures in patients with acute knee injury and to predict the need for radiographs in our setting. If found to perform well in our setting, application of these rules can help reducing unnecessary usage of radiography and radiation exposure, healthcare costs and waiting times. These rules can also be helpful in rural areas of our country in deciding the need for radiographs.

Method

This prospective, observational cross-sectional study was conducted at the Department of Orthopedics and Trauma Surgery and Department of Emergency Medicine at Patan Hospital. This site was chosen because this study was conducted as a part of my thesis research during my residency in the same instituton. After obtaining ethical approval from Institutional Review Committee (IRC) of Patan Academy of Health Sciences (PAHS) (Ref: PSO2201181587), data was collected from February 2022 through Jan 2023.

The main objective of this study was to assess if the Ottawa and Pittsburgh knee rules can rule out fractures in patients with acute knee injury and thus be applied to predict the need for radiographs in our setting. All eligible cases throughout the duration of study were included. The total number of cases in study was 120.

Acute knee injury was defined as any injury to the knee that is <7 days old.[4,5] We considered knee to include the patella, head and neck of fibula, proximal 8 cm of tibia and distal 8 cm of femur.[4]

According to OKR, a knee X-ray series is only required for knee injury patients with age≥55 years or, isolated tenderness of patella or, tenderness at head of fibula or, inability to flex to 90^{o} or, inability to bear weight immediately and during presentation (4 steps).[4]

According to PKR, an X-ray is required for acute knee injury patients with blunt trauma or fall as mechanism of injury plus either age <12 years or >50 years or, inability to bear weight (4 steps).[5]

Patients presenting with acute knee injury who needed radiographic examination of the knee were recruited in the study. Informed consent was taken from the patient or patients' caretaker (parent/guardian) if patient was a minor. Patients with altered level of consciousness, pregnant patients, paraplegic patients, those <2 years of age, knee injuries occurring more than 7 days prior to presentation, open fractures and penetrating injuries, patients with multiple injuries and spinal injuries, patients whose X-rays are not acceptable and those who are not willing to participate in the study were excluded.[4,5,16]

Patient details, mechanism of injury and ability to bear weight immediately after the injury were recorded during history taking. Clinical assessment findings that were recorded include isolated tenderness of patella, tenderness at the head of fibula, ability/inability to flex the knee to 90^{o} and ability to bear weight during presentation.

Patients then underwent radiographic examination of the knee. X-ray views routinely taken included Antero-Posterior (AP) and lateral views of the knee.[17] Skyline Laurin view of the knee was done in cases of suspected patella fracture.[17] After evaluation of the radiographs, the patients underwent further evaluation or treatment as per the department protocol.

Data analysis was performed using Microsoft Excel 2016, EPI Info version 7.2.4.0 and R version 4.1.2. Data was analysed to calculate the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the Ottawa and Pittsburgh knee rules.[18,19] Possible reduction in radiographs that could have been achieved using each rule was also calculated. Comparison of Ottawa and Pittsburgh knee rules were done using the McNemar Chi-square test.[20]

Result

One hundred and twenty patients presenting with acute knee injury were enrolled in the study. The

Table 1. Characteristics of patients with acute knee injury (N= 120)

Characteristics		Number (%)
Total no. of patients enrolled		120
Mean age		38.51±15.96 years
<18 years		9(7.5%)
≥18 years		111(92.5%)
Sex	Male	74(61.67%)
	Female	46(38.33%)
Side involved	Right	55(45.83%)
	Left	65(54.17%)
	Road Traffic Accident	52(43.33%)
	Fall Injury	44(36.67%)
Mechanism of injury	Twisting	22(18.33%)
	Direct blow	2(1.67%)
	Others	0
Ottawa Knee Rules (OKR)	Positive	89(74.17%)
	Negative	31(25.83%)
Pittsburgh Knee Rules (PKR)	Positive	74(61.67%)
	Negative	46(38.33%)
Diagnosis	Soft tissue injury	69(57.50%)
Fracture- 50(41.67%)	Distal femur fracture	4(3.33%)
No fracture-70(58.33%)	Patella fracture	20(16.67%)
	Proximal tibia fracture	25(20.83%)
	Proximal fibula fracture	1(0.83%)
	Others	1(0.83%)

Table 2. Mechanisms of injury in patient presenting with acute knee injury (N=120)

Mechanism of injury	Fracture	No fracture	Total
RTA	26	26	52
Fall injury	21	23	44
Twisting	2	20	22
Direct blow	1	1	2
Total	**50**	**70**	**120**

Table 3. Comparison of Ottawa and Pittsburgh knee rules (N=120)

	Sensitivity	Specificity
Ottawa knee rules	95% CI 0.94(0.83-0.99)	95% CI 0.4(0.28-0.52)
Pittsburgh knee rules	95% CI 0.88(0.76-0.05)	95% CI 0.571(0.45-0.69)

mean age of participants was 38.51±15.96 years. Male participants outnumbered females with 74(61.67%) of participants being males, Table 1. The left knee was more commonly involved and the most common mechanism of injury was road traffic accident (RTA), Table 1. Ottawa Knee Rule (OKR) and Pittsburgh Knee Rule (PKR) were positive in 89(74.17%) and 74(61.67%) respectively while fractures were seen in 50(41.67%) of participants, Table 1.

Among the 52 patients with RTA, 26(50%) had fracture and among two patients presenting with history of direct blow, one (50%) patient had fracture. Of the 44 patients with fall injury, 21(47.73%) had fracture and among 22 patients with twisting of knee, two (9.1 0 %) had fractures, Table 2.

Sensitivity of OKR was calculated to be 95% CI 0.94(0.83-0.99) with specificity of 95% CI 0.40(0.28-0.52). The PPV and NPV were 95% CI 0.53(0.42-0.63) and 95% CI 0.90(0.74-0.98) respectively. In our study, 31(25.83%) of radiographs could have possibly been avoided if OKR were used. However, three (9%) patients with negative OKR were found to have fractures on radiographs.

Sensitivity of the PKR was calculated to be 95% CI 0.88(0.76-0.95) with specificity of 95% CI 0.57(0.45-

0.69). The PPV and NPV were 95% CI 0.59 (0.47-0.71) and 95% CI 0.87(0.75-0.95) respectively. In our study, 46 (38.33%) of radiographs could have possibly been avoided if PKR were used. However, six (13%) patients with negative PKR were found to have fractures seen on radiograph. The sensitivity of OKR 0.94 and that of PKR 0.88. However, the difference was not statistically significant (p=0.375) , Table 3.

Fractures were seen in 38(51.35%) of the 74 male patients presenting with acute knee injury whereas, fractures were seen in only 12(26.09%) of the 46 females who presented with acute knee injury. Fractures were seen in 48(43.20%) of the 111 adults presenting with acute knee injury while only two (22.20%) of the nine children who presented with acute knee injury had fractures.

Discussion

Standard emergency medicine textbooks imply that radiographs should be routinely ordered in every case of knee injury.[21–24] Despite being able to rule out fractures clinically, reasons for the unnecessary use of radiographs include patient expectations, fear of lawsuits, and unclear histories.[5] Ottawa and Pittsburgh knee rules have been developed to clinically rule out fractures and thus, reduce the use of radiographs in acute knee injury.[5,7]

One hundred and twenty patients were enrolled in the study with mean age of 38.51±15.96 years. Mean age in this study is similar with other studies of Nepal.[1,13] Mean age was also similar to studies done in other countries such as the United states, Iran and Belgium.[12,25–28]

Of the 120 patients, 74(61.67%) were males and 46(38.33%) were females . This was most probably because males are involved in outdoor activities and sports more than females and higher proportion of drivers are males. Similar results were observed in studies conducted in Nepal, Canada, Iran and Spain.[1,7,12,29] However, females outnumbered male patients in studies conducted in the United States of America (USA).[30,31]

Road traffic accident was the most common mechanism of injury in our study, occurring in 52(43.33%) patients. A study conducted in USA also showed RTA to be the most common mechanism of injury.[32] RTA is more common in our setting probably because of unmanaged roads, weak traffic system and greater use of two-wheelers in our setting. Also, cases of low energy trauma such as twisting of knee usually present late to the hospital.

Fractures were seen in 50(41.67%) of patients. In comparison to previous studies, the incidence of fracture was higher in this study.[1,4,5,7,8,12,14,29–31,33,34] One of the reasons for this finding might be that RTA and fall injury were the most common mechanisms of injury in our study, which are high velocity injuries with higher probability of fractures while twisting was the most common mechanism in most of the previous studies. Since relatively minor cases of acute knee injury were not referred for Orthopaedics consultation, such cases of soft tissue injury might not have been included in this study resulting in lower proportion of cases with no fracture.

Fractures were seen in 38(51.35%) of the 74 male patients presenting with acute knee injury whereas, fractures were seen in only 12(26.09%) of the 46 females who presented with acute knee injury. The proportion of males presenting with high velocity trauma such as had RTAs or fall injuries was also higher while low velocity trauma such as twisting injury was more common in females. Among nine children, only two (22.2%) had fractures while among 111 adults, 48(43.2%) had fractures.

Among 50 patients with fractures, the 25(50%) had fracture of the proximal tibia, 20(40%) had fracture of the patella, four (8%) had distal femur fracture and one (2%) had proximal fibula fracture. Similar result was seen in study conducted in Pittsburgh and Cleveland.[8] In other studies, patella fracture was the most common.[1,4,12–14,29,31]

In this study, the sensitivity of the OKR was found to be 95% CI 0.94(0.83-0.99). Most of the studies have reported the sensitivity to be around 1.0.[1,10,13,16,29] A large proportion of cases were those with fractures in this study and thus more fractures missed by OKR might have been revealed. However, the sensitivity calculated in our study was similar to study conducted in Iran (0.95) and higher than that given by studies done in Australia(0.71) and Netherlands(0.86).[9,12,14] In this study, the sensitivity of PKR was found to be 95% CI 0.88(0.76-0.95) which was similar to the the study done in Netherlands.[14] This was lower than that shown in studies in Canada, and another study conducted in children.[5,8,35] The sensitivities of the two tests were not found to be significantly different (p=0.375) while the specificities of the two tests were found to be significantly different (p=0.023). Studies from Canada and Netherlands also suggested the two tests had similar sensitivities with PKR having statistically higher specificity.[8,14]

Specificity of OKR was found to be 95% CI 0.40(0.28-0.52) in this study. This was similar to the specificity found in studies conducted in Nepal, Australia and Canada.[1,9,12,13,16] Specificity of the Pittsburgh knee rules was calculated to be 95% CI 0.57(0.45-0.69) in this study which was similar to the results in studies from Netherlands and Canada.[8,14]

The PPV of OKR from this study was found to be 95% CI 0.53(0.42-0.63). This was higher than in most other studies.[1,12,13,25,29] The PPV of PKR in this study was 95% CI 0.59(0.47-0.71) which was higher than suggested in the study from UK(0.19).[33]

The NPV of OKR in this study was 95% CI 0.90(0.74-0.98). NPV in our study was lower than that found in other studies in Nepal, Spain and Ireland which showed NPV of 1.[1,10,13,29] The NPV of PKR was 95% CI 0.87(0.75-0.95) which was lower than that suggested in the study done in the UK. (0.967).[33]

If the OKR were used, 31(25.83%) of radiographs could have possibly been avoided while three fractures would be missed by OKR. Fractures that were missed included two tibial spine fractures and one avulsion fracture of the inferior pole of patella. This possible reduction was similar to studies in Nepal, Belgium and United Kingdom (UK).[1,28,33] If the PKR were used, 46(38.33%) of radiographs could have possibly been avoided while missing six fractures. Fractures that were missed included three tibial spine fractures and three patella fractures.

We acknowledge that this study has some limitations. We relied solely on radiographs for diagnosis of fractures. Some fractures can be missed on routine plain radiographs and may only be diagnosed after advanced imaging such as computed tomography scan or magnetic resonance imaging are obtained.[33] We are unaware of any missed fractures on radiographs that might have been diagnosed later on advanced imaging. So, it is possible that not all patients with fractures were identified.

We also did not test the intra-observer and inter-observer reliability of these rules, which are relevant factors for broader use. Different physicians may differently interpret the definition of any criterion. The ability to walk, for instance, might be difficult to assess in a reproducible way by two different physicians. This may have resulted in performance bias.

Conclusion

This study showed that both the Ottawa and Pittsburgh knee rules have high sensitivity and more than one-fourth of radiographs can be avoided if these rules are applied. However, there is still a risk of missing a few fractures so, we need to maintain a high index of suspicion even if these rules are negative. These rules can be used to help guide selective ordering of radiographs in resource-limited settings where radiographs are not readily available.

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Conflict of interest

None

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None

Author's contribution

Concept, design, planning: SKS, PD, AKT, PMP; Literature review: SKS, PD; Data collection: SKS; Data analysis: SKS; Draft manuscript: SKS; Revision of draft: SKS, PD, AKT, PMP; Final manuscript: SKS, PD, AKT, PMP; Accountability of the work: SKS, PD, AKT, PMP.

References

1. Kashyap N, Shankar A, Thapa SS, Lamichhane A, Mahara DP. Validation of Ottawa Knee Rule at Tertiary Center of Nepal: A Prospective Study. Int J Contemp Surg. 2017;5(1):6. | DOI |
2. Ferry T, Bergström U, Hedström EM, Lorentzon R, Zeisig E. Epidemiology of acute knee injuries seen at the Emergency Department at Umeå University Hospital, Sweden, during 15 years.Knee Surg Sports Traumatol Arthrosc. 2014 May;22:1149-55. | DOI |
3. Azar FM, Canale ST, Beatty JH, editors. Campbell's operative orthopaedics. 14th ed. Philadelphia: Elsevier; 2021. | Weblink |
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 Nov;2(11):966-73. | DOI |
5. Seaberg DC, Jackson R. Clinical decision rule for knee radiographs. Am J Emerg Med. 1994 Sep 1;12(5):541-3. DOI
6. Tandeter HB, Shvartzman P, Stevens MA. Acute knee injuries: use of decision rules for selective radiograph ordering. Am Fam Physician. 1999 Dec 1;60(9):2599-608. | PubMed |
7. Stiell IG, Greenberg GH, Wells GA, McKnight RD, Cwinn AA, Cacciotti T, et al. Derivation of a decision rule for the use of radiography in acute knee injuries. Ann Emerg Med. 1995 Oct 1;26(4):405-13. | DOI |

8. Seaberg DC, Yealy DM, Lukens T, Auble T, Mathias S. Multicenter comparison of two clinical decision rules for the use of radiography in acute, high-risk knee injuries. Ann Emerg Med. 1998 Jul 1;32(1):8-13. | DOI |
9. Sims JI, Chau M, Davies J. Validation of the Ottawa knee rule in adults: A single centre study. J Med Radiat Sci. 2020 Sep;67(3):193-8. | DOI |
10. Mohamed A, Babikir E, Mustafa MK, Mustafa M. Ottawa Knee Rule: Investigating Use and Application in a Tertiary Teaching Hospital. Cureus. 2020 Jun 24;12(6). | DOI |
11. Sims JI, Chau MT, Davies JR. Diagnostic accuracy of the Ottawa Knee Rule in adult acute knee injuries: a systematic review and meta-analysis. Eur Radiol. 2020 Aug;30:4438-46. | DOI |
12. Jalili M, Gharebaghi H. Validation of the Ottawa knee rule in Iran: a prospective study. Emerg Med J. 2010 Nov 1;27(11):849-51. | DOI |
13. Mishra BN, Nepal S, Parajuli SB. Validity of Ottawa Knee Rules at a Teaching Hospital of Eastern Nepal. Birat Journal of Health Sciences. 2021 Nov 3;6(2):1471-5. | DOI |
14. Cheung TC, Tank Y, Breederveld RS, Tuinebreijer WE, de Lange-de Klerk ES, Derksen RJ. Diagnostic accuracy and reproducibility of the Ottawa Knee Rule vs the Pittsburgh Decision Rule. Am J Emerg Med. 2013 Apr 1;31(4):641-5. | DOI |
15. Masaud HB. X Ray in Minor Orthopedic Injuries: Is A Must or There Is Something Else to Trust. AlQalam Journal of Medical and Applied Sciences. 2020 Nov 15;3(2):59-65. | DOI |
16. Bulloch B, Neto G, Plint A, Lim R, Lidman P, Reed M, et al. Validation of the Ottawa Knee Rule in children: a multicenter study. Ann Emerg Med. 2003 Jul 1;42(1):48-55. | DOI |
17. Gorton, S., Murphy, A. Knee series. Reference article, Radiopaedia.org. DOI
18. Carvajal DN, Rowe PC. Research and statistics: Sensitivity, specificity, predictive values, and likelihood ratios. Pediatrics in review. 2010 Dec 1;31(12):511-3. | DOI |
19. Baratloo A, Hosseini M, Negida A, El Ashal G. Part 1: Simple Definition and Calculation of Accuracy, Sensitivity and Specificity. Emerg (Tehran). 2015;3(2):48–9. | PubMed |
20. Kim S, Lee W. Does McNemar's test compare the sensitivities and specificities of two diagnostic tests? Stats Methods Med Res. 2017 Feb;26(1):142-54. DOI
21. Simon RR, Sherman SC, Sharieff GQ, Simon RR, editors. Emergency orthopedics. 6th ed. New York: McGraw-Hill Medical; 2011. 600 p. | Weblink |
22. Wolfson AB, Hendey GW, Ling LJ, Rosen CL, Schaider JJ, Sharieff GQ. Harwood-Nuss' clinical practice of emergency medicine.Anns of Emerg Med. 2012 Sep 11. | DOI |
23. Callaham ML. Current practice of emergency medicine. 2nd ed. Philadelphia: Decker; 1991. | Goggle Scholar |
24. McConnochie KM, Roghmann KJ, Pasternack J, Monroe DJ, Monaco LP. Prediction rules for selective radiographic assessment of extremity injuries in children and adolescents. Pediatrics. 1990 Jul 1;86(1):45-57. | DOI |
25. Tigges S, Pitts S, Mukundan Jr S, Morrison D, Olson M, Shahriara A. External validation of the Ottawa knee rules in an urban trauma center in the United States. AJR Am J Roentgenol1999 Apr;172(4):1069-71. | DOI |
26. Beutel BG, Trehan SK, Shalvoy RM, Mello MJ. The Ottawa knee rule: examining use in an academic emergency department. West J Emerg Med. 2012 Sep;13(4):366–72. | DOI |
27. Szucs PA, Richman PB, Mandell M. Triage nurse application of the Ottawa knee rule. Acad Emerg Med. 2001 Feb;8(2):112-6. | DOI |
28. Ketelslegers E, Collard X, Vande Berg B, Danse E, El Gariani A, Poilvache P, et al. Validation of the Ottawa knee rules in an emergency teaching centre. Eur radiol. 2002 May;12(5):1218-20. | DOI |
29. Emparanza JI, Aginaga JR. Validation of the Ottawa knee rules. Ann Emerg Med. 2001 Oct 1;38(4):364-8. | DOI |
30. Nagpal K, Marathe M. Are Ottawa knee rules useful in actual trauma care? Open Medicine. 2007;2(2): 216-21. | DOI |
31. Weber JE, Jackson RE, Peacock WF, Swor RA, Carley R, Larkin GL. Clinical decision rules discriminate between fractures and nonfractures in acute isolated knee trauma. Ann Emerg Med. 1995 Oct 1;26(4):429-33. | DOI |
32. Verma A, Su A, Golin AM, O'Marrah B, Amorosa JK. The lateral view: a screening method for knee trauma. Acad Radiol. 2001 May 1;8(5):392-7. | DOI |
33. Konan S, Zang TT, Tamimi N, Haddad FS. Can the Ottawa and Pittsburgh rules reduce requests for radiography in patients referred to acute knee clinics? Ann R Coll Surg Engl. 2013 Apr;95(3):188-91. | DOI |
34. Gleadhill DN, Thomson JY, Simms P. Can more efficient use be made of x ray examinations in the accident and emergency department? Br Med J (Clin Res Ed). 1987 Apr 11;294(6577):943-7. | DOI |
35. Rivara FP, Parish RA, Mueller BA. Extremity injuries in children: predictive value of clinical findings. Pediatrics. 1986 Nov 1;78(5):803-7. | DOI |