The Ottawa Knee Rule: Examining Use in an Academic Emergency Department

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Introduction: The Ottawa Knee Rule is a validated clinical decision rule for determining whether knee radiographs should be obtained in the setting of acute knee trauma. The objectives of this study were to assess physician knowledge of, barriers to implementation of, and compliance with the Ottawa Knee Rule in academic emergency departments (EDs), and evaluate whether patient characteristics predict guideline noncompliance.

Methods: A 10 question online survey was distributed to all attending ED physicians working at three affiliated academic EDs to assess knowledge, attitudes and self-reported practice behaviors related to the Ottawa Knee Rule. We also performed a retrospective ED record review of patients 13 years of age and older who presented with acute knee trauma to the 3 study EDs during the 2009 calendar year, and we analyzed ED records for 19 variables.

Results: ED physicians (n = 47) correctly answered 73.2% of questions assessing knowledge of the Ottawa Knee Rule. The most commonly cited barriers to implementation were “patient expectations” and system issues, such as “orthopedics referral requirement.” We retrospectively reviewed 838 records, with 260 eligible for study inclusion. The rate of Ottawa Knee Rule compliance was retrospectively determined to be 63.1%. We observed a statistically significant correlation between Ottawa Knee Rule compliance and patient age, but not gender, insurance status, or provider type, among others.

Conclusion: Compliance with the Ottawa Knee Rule among academic ED healthcare providers is poor, which was predicted by patient age and not other physician or patient variables. Improving compliance will require comprehensive educational and systemic interventions. [West J Emerg Med. 2012;13(4):366-373.]

INTRODUCTION

Knee pain is a common presenting complaint in the emergency department (ED) and accounts for approximately 1.3 million ED visits annually in the United States (US). Despite the prevalence of acute knee trauma, fractures are only observed in approximately 6% of patients. Knee radiographs to detect fractures, however, remain one of the most commonly ordered studies and account for $1 billion in healthcare spending annually. The Ottawa Knee Rule was published in 1995 by Stiell et al as a tool for determining whether knee radiographs should be obtained to detect a fracture in the setting of acute knee trauma. The rule states that knee radiographs are indicated in these patients if at least one of the following criteria is satisfied: the patient is at least 55 years old, has an inability to bear weight immediately after trauma and in the ED for four steps (regardless of limp), has isolated patellar tenderness, fibular head tenderness, or an inability to flex the knee to 90°. Stiell et al validated the rule in 2 prospective studies,
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which showed the criteria to be 100% sensitive for identifying clinically-significant fractures. Additionally, Bachmann et al published a meta-analysis concluding that the Ottawa Knee Rule was 99% sensitive and 49% specific for knee fracture. While the criteria were initially validated in adults, prospective studies and meta-analyses also demonstrated that they are 99-100% sensitive and 43-46% specific in children over 5 years of age.5,9

When used appropriately the Ottawa Knee Rule has been shown to reduce unnecessary imaging. In an implementation trial conducted by Stiell et al, educational interventions on the Ottawa Knee Rule targeting ED physicians decreased the proportion of knee radiographs by 26.4%, ED visit costs by $34 per patient, and time spent in the ED by 33.1 minutes.10 Another prospective trial demonstrated a 35% decrease in knee radiographs.11

Despite evidence supporting use of the Ottawa Knee Rule, its adoption has been limited. A multi-national survey of ED physicians 10 years ago investigated this issue.12 According to the results, self-reported knowledge of the Ottawa Knee Rule was highest in English-speaking countries, yet use of the rule among those with knowledge of the criteria was lowest in the U.S. While the majority of respondents agreed that clinical decision rules are intended to reduce healthcare costs and improve quality of care, physicians in the U.S. were most likely to agree that such rules are oversimplified, increase the likelihood of being sued, and challenge physician authority. These studies suggest that a multitude of factors contribute to limited use of the Ottawa Knee Rule and consequent radiograph overuse. Knee radiographs remain one of the most commonly performed imaging studies and, despite low fracture rates, are obtained in 60-80% of acute knee trauma cases.3,13,14 While the low adoption rate of the Ottawa Knee Rule is known, there are currently no published studies assessing physician knowledge of the rule, or patient or physician predictors of compliance with it.

In the present study, 15 years after publication of this clinical decision rule, we aimed to (1) evaluate knowledge, attitudes and self-reported practice behaviors regarding the Ottawa Knee Rule among attending academic U.S. ED physicians; (2) determine Ottawa Knee Rule adherence among ED providers; and (3) examine if patient level characteristics predict guideline noncompliance. We hypothesized that Ottawa Knee Rule adherence is poor. Additionally, we hypothesized that systems-based barriers inherent to the ED setting and patient factors prevent appropriate application of the rule.

METHODS

The Institutional Review Boards of the participating hospitals and the university approved all aspects of the study protocol.

ED Physician Survey

To assess ED physician knowledge, and barriers to implementation, of the Ottawa Knee Rule, the authors designed a 10-question online survey. The questions were developed by extrapolating scenarios from the rule criteria, and by phrasing inquiries about basic demographic and other information in plain language agreed upon by all authors. The survey was administered to all 76 ED attending physicians (all board certified in emergency medicine and/or pediatric emergency medicine) who were faculty at one of the nation’s largest academic emergency medicine departments in June 2010. The three study institutions’ EDs were staffed by members of the same university-based physician group and included an academic trauma center, a community teaching hospital and an academic pediatric specialty hospital with a combined annual volume of approximately 200,000 ED visits. Of the questions, 2 related to the demographics of the respondents, 5 evaluated knowledge of the Ottawa Knee Rule through case vignettes and guideline questions, one probed for self-reported adherence to the rule, and 2 inquired about potential barriers to implementation (see Appendix for full survey questions). One of the barriers-to-implementation questions asked respondents to identify the top three reasons (out of nine choices) for ordering a knee radiograph in the absence of the Ottawa Knee Rule criteria being met; many of these answer choices were adapted from Graham et al’s12 physician survey. We disseminated the survey link via email. All data were collected with identification of the respondent, and a $5 gift card was offered for survey completion. The survey responses, however, were not linked to the respondent’s name.

We evaluated knowledge of the Ottawa Knee Rule by comparing the proportion of participants who answered the 5 vignettes and guideline questions correctly with the total number of participants. Similarly, we calculated simple percentages for the responses to the 2 survey questions relating to the most commonly reported barriers.

Medical Record Review

To corroborate self-reported data on adherence to the Ottawa Knee Rule, as well as collect patient level characteristics that may influence guideline compliance, we conducted a retrospective ED medical record review. The review notes were not directly linked to the physicians who responded to the survey.

Our study population consisted of patients 13 years of age and older who presented with acute knee trauma to the three study institutions’ EDs between January 1, 2009 and December 31, 2009. To include the entire teenage population and broaden the potential data set we chose 13 as a lower age limit. Patients were initially identified by querying the ED billing database for 16 International Classification of Diseases 9 (ICD-9) codes related to acute knee and lower extremity trauma (716.1, 717, 718.86, 822, 823, 823.1, 823.8, 823.9, 827, 836, 844, 891, 916, 924, 928, 959.7). We then applied the same exclusion criteria used in the Ottawa Knee Rule’s
validation studies (except for age less than 18 years), which excluded patients who were referred from outside hospitals with knee radiographs, sustained knee trauma more than seven days previously, returned for reassessment of the same injury, had isolated skin injury, had multiple trauma, were pregnant, were paraplegic or had an altered level of consciousness. Two data abstractors then examined medical records of eligible patients for 19 principal variables gathered from ED nursing records, ED physician records and radiology reports. We entered data into Microsoft Excel; any missing data were noted. The authors managed any discrepancies between nursing and physician records by deferring to physician documentation for assessment of principal variables.

We organized the principal variables by categories such as “patient characteristics” (e.g. age, gender, insurance status, previous knee injury), “injury features” (e.g. mechanism, setting, the 5 Ottawa Knee Rule criteria, diagnosis), “radiograph ordering” (e.g. imaging, type of provider ordering films), and “other” (e.g. time spent in the ED, returned to the ED within 2 weeks for reassessment). From these, we evaluated Ottawa Knee Rule compliance by comparing the proportion of patients who had knee radiographs obtained with the proportion of patients in whom knee radiographs were indicated according to the rule. We assessed potential association of Ottawa Knee Rule adherence with patient variables, adjusted for multiple comparisons, using the Fisher’s Exact test, which was calculated in Statistical Analysis System 8.2 (SAS, SAS Institute Inc., Cary, NC). Calculations involving time spent in the ED excluded patients who were admitted to the hospital or taken to the operating room, and were made using the Wilcoxon Rank Sum Test. We determined inter-rater reliability between the 2 reviewers by calculating the Cohen’s kappa value based upon whether the Ottawa Knee Rule criteria were met from a random subset of 33 medical records.

RESULTS
ED Physician Survey

Forty-seven out of 76 ED physicians responded to our survey (61.8% response rate). On average, respondents worked 22.3 (standard deviation (SD) 7.8, 95% confidence interval (CI) 20.1-24.5) hours per week in the ED and had 8.7 (SD 8.3, CI 6.4-11.1) years of experience.

Physicians scored an average of 73.2% (CI 66.6-79.8) on questions assessing Ottawa Knee Rule knowledge, with 2.1% of respondents correctly answering all of the questions, 78.7% answering all but 1 of the questions correctly, and 0% answering all of the questions incorrectly. Only 36.2% of responding physicians, however, chose to withhold diagnostic imaging in a case vignette that did not satisfy the Ottawa Knee Rule criteria (an ambulatory adolescent with a severe limp who exhibited full range of motion of the knee with no focal tenderness).

Generally, self-reported adherence to the Ottawa Knee Rule was poor. More than one-third (36.2%) of physicians reported never using the guideline, while only 23.4% of physicians used the rule “always” or “most of the time.” The most commonly cited barriers to rule implementation were “patient expectations” and “patient satisfaction” (Figure). Other barriers frequently identified included an orthopedics referral requirement and lack of confidence in physical exam findings. Finally, ED physicians reported that the majority (53.2%) of radiographs for knee injury patients were ordered by non-attending physician providers (e.g. residents, triage nurses and physician assistants).

Medical Record Review

The ED billing database query for ICD-9 codes, restricted by target ages and dates, identified 838 patient visits. Upon review of these records, 437 did not have knee trauma, 129 met exclusion criteria, and 12 did not record sufficient information to determine if the Ottawa Knee Rule criteria were met. Consequently, 260 records were eligible for study inclusion. The inter-rater reliability was high (Cohen’s kappa = 0.939). The demographics, community setting, and etiology of acute knee trauma in our study population are summarized in Table 1. Of the 260 patients, 198 (76.2%) had a knee radiograph and 1 had a magnetic resonance image (Table 2). Forty-one patients had clinically-significant fractures (39 involving the patella). Only 17 patients returned to the ED within 2 weeks for reevaluation of the same injury. Of these patients, 16 had radiographs at the initial visit and none had a revised diagnosis based on reevaluation. The mean time spent in the ED was 4.1 hours (median 3.4; interquartile range 2.7 hours). Upon excluding the 12 patients who were admitted or taken to the operating room, the mean time was 3.9 hours (median 3.3; interquartile range 2.3 hours). Patients who had a radiograph spent more time in the ED (mean 4.1, median 3.5, interquartile range 2.5 hours) than those who did not (mean 3.2, median 2.8, interquartile range 1.6 hours) (p < 0.05). Ottawa Knee Rule criteria fulfillment is summarized in Table 3. While some data were missing from the medical records, all cases had sufficient information to assess rule implementation.

![Figure](image-url) Self-reported barriers to implementation of the Ottawa Knee Rule.
fulfillment. Taken together, 65.4% of patients fulfilled at least 1 of the Ottawa Knee Rule criteria and therefore warranted a knee radiograph. Additionally, the rule was 100% sensitive and 40.7% specific for fracture in the 260 cases. We assessed Ottawa Knee Rule compliance by comparing criteria fulfillment with radiograph obtainment (Table 4). Out of 260 cases, 164 had knee radiographs either appropriately obtained or appropriately not obtained, and were therefore considered compliant with the Ottawa Knee Rule. Conversely, 96 cases had knee radiographs either inappropriately obtained or inappropriately not obtained, and were considered noncompliant. Patients who had a radiograph inappropriately obtained spent an average of 3.7 hours (median 3.5; interquartile range 1.7 hours) in the ED. Overall, the rate of Ottawa Knee Rule compliance was 63.1%.

The association between Ottawa Knee Rule compliance and various patient and provider factors is summarized in Table 5. A statistically significant association (p = 0.01) was only observed with patient age. Compliance was higher in patients aged 13-18 years old (76.5%) and ≥55 years old (68.7%), as compared to 19-54 year olds (54.0%). No statistically significant (p<0.05) differences were noted with provider type, patient gender, patient insurance status, previous ipsilateral knee injury, sports injury or mechanism of injury.

**DISCUSSION**

To our knowledge, this is the first retrospective record review to analyze Ottawa Knee Rule compliance and potential associations between compliance with provider and patient factors.

The survey response rate was acceptable, and consistent with other surveys targeting physicians. The survey demonstrated that ED physician knowledge of the Ottawa Knee Rule was good, but self-reported adherence was poor. Interestingly, of the 5 vignettes, the scenario with the lowest correct response rate (36.2%) was the only case in which imaging was not indicated according to the Ottawa Knee Rule. That is, despite overall acceptable knowledge of the Ottawa Knee Rule criteria and its application, physicians were still hesitant to withhold imaging. This was also found in our record review, where one-third of radiographs were ordered for patients not meeting any criteria. Furthermore, physicians noted that the primary barriers to Ottawa Knee Rule implementation were related to patient and systems barriers rather than the criteria themselves. The results of our recent survey coupled with the early findings by Graham et al suggest that noncompliance with the Ottawa Knee Rule is currently likely more attributable to systemic concerns, such as orthopedic consultation demands and malpractice implications (as indicated by the “Legal concern” column in Figure), than lack of knowledge. Addressing these systemic concerns is important to maximize adherence to the Ottawa Knee Rule.
Poor compliance with the Ottawa Knee Rule, as reported by ED physicians in our survey, was confirmed by retrospective review. This demonstrated a compliance rate of 63.1%. Overall, 76.2% of patients received knee radiographs, consistent with the previously published result of 74% in Stiell et al's retrospective study. Our study population, however, had a fracture rate of 15.8%, which is higher than previously published figures of 6-7%.

This discrepancy may be due to the fact that 2 of our study hospitals are Level I trauma centers. Additionally, physician respondents to our survey reported that the majority of radiographs were ordered by non-attending physician providers. Review of medical records confirmed this – only 34.4% of radiographs were ordered by attending physicians, while 24.2% were ordered by residents, 18.8% by nurses, and 22.6% by physician assistants. Recognizing that other healthcare providers influence radiograph ordering, Matteucci et al performed a prospective study in which both physicians and triage nurses were educated on the Ottawa Knee Rule. This training led to 37% and 21% relative reductions in radiograph ordering among physicians and triage nurses, respectively, although triage nurses still ordered 3.6 times more radiographs than physicians. Our hypothesis that rule compliance would be higher when physicians ordered radiographs proved incorrect, as there was no association with provider type. Future educational efforts should target all ED healthcare providers, as well as consulting and follow-up services such as orthopedics, given the significant proportion of radiographs ordered by non-attending physicians.

We further aimed to determine which patient level variables correlated with Ottawa Knee Rule compliance. Patient age was the only factor to have a statistically significant correlation. Compliance was significantly higher in younger (≤ 18 years old) and older (≥ 55 years old) patients, as compared to patients aged 19-54 years. The higher compliance rate in the older group is consistent with the fact that all patients in this age range warrant a radiograph (per rule criteria). Additionally, the higher compliance rate in the

### Table 3. Ottawa Knee Rule criteria fulfillment.

| Criteria                                      | Yes (%) | No (%) | Undetermined (%) |
|----------------------------------------------|---------|--------|------------------|
| Age ≥ 55 years                               | 83 (31.9) | 177 (68.1) | 0 (0)            |
| Isolated patellar tenderness                 | 47 (18.1) | 173 (66.5) | 40 (15.4)        |
| Fibular head tenderness                      | 4 (1.5) | 198 (76.2) | 58 (22.3)        |
| Inability to flex knee to 90°                | 88 (34.2) | 157 (60.4) | 15 (5.4)         |
| Non-weight bearing after injury and in ED    | 17 (6.5) | 88 (33.8) | 155 (59.6)       |
| **Criteria met (overall)**                   | 170 (65.4) | 90 (34.6) | 0 (0)            |

† Refers to cases where limited or missing data precluded an assessment.
* Indicates cases that met at least one of the Ottawa Knee Rule criteria, thus warranting a knee radiograph.

### Table 4. Ottawa Knee Rule compliance as determined by ED medical record review.

| Ottawa Knee Rule Criteria | Knee Radiograph |      |      |
|---------------------------|----------------|------|------|
|                           | Performed      | Not Performed |
| Met                       | 136            | 35   |
| Not Met                   | 61             | 28   |

### Table 5. Association of Ottawa Knee Rule compliance with patient and provider factors.

| Characteristic | Compliance (%) | N   | P (Fisher’s Exact) |
|----------------|----------------|-----|-------------------|
| Provider type* |                |     | 0.75              |
| Attending physician | 65.6 | 64    |
| Resident         | 61.9 | 45    |
| Nurse            | 75.6 | 35    |
| Physician assistant | 71.4 | 42    |
| Age             |                |     | 0.01†             |
| 0-18 years old  | 76.5 | 51    |
| 9-54 years old  | 54.0 | 126   |
| >55 years old   | 68.7 | 83    |
| Gender          |                |     | 0.80              |
| Male            | 61.9 | 134   |
| Female          | 64.0 | 126   |
| Insurance       |                |     | 0.75              |
| Yes             | 62.5 | 208   |
| No              | 65.4 | 52    |
| Previous knee injury |        |       | 0.15†            |
| Yes             | 47.4 | 19    |
| No              | 64.3 | 241   |
| Sports-related injury |       |       | 0.09             |
| Yes             | 75.0 | 36    |
| No              | 61.9 | 224   |
| Mechanism of injury** |       |       |                   |
| Fall            | 63.7 | 157   | 0.90†            |
| Twisting        | 65.8 | 38    | 0.86             |
| Direct blow     | 65.5 | 29    | 0.84             |

* Provider type was undetermined in 12 cases, which have been excluded from above analysis.
† Statistically significant values (p < 0.05).
** Patient may have more than one mechanism of injury. Thus, independent p values were calculated.
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CONCLUSION

Compliance with the Ottawa Knee Rule among academic ED healthcare providers is poor. Patient concerns and system issues, rather than issues intrinsic to the rule itself, continue to serve as barriers to proper implementation of this validated decision tool. Addressing these concerns is essential to maximizing guideline adherence and mitigating unnecessary imaging. Improving compliance will require a comprehensive approach involving both education (of attending and non-attending providers alike) and system interventions, such as have been used with other clinical decision rules.

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