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SCIENTIFIC ARTICLE

Reduction of unnecessary repeat knee radiographs during osteoarthrosis follow-up visits in a large teaching medical center

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Abstract

Background Professional organizations recommend against repeat radiographs for routine follow-up of osteoarthrosis. However, clinics frequently obtain radiographs during or before the clinical visit. The purpose of our project was to determine the baseline frequency of unnecessary knee radiographs and whether educational interventions can reduce this frequency.

Methods This QI project was exempt from IRB review. Radiology reports of knee radiographs were searched in our database filtered by presence of the words "severe", "degenerative", "osteoarthritis", and similar variants. We reviewed 500 consecutive corresponding medical records to confirm the presence of severe osteoarthritis, and presence of a repeat radiograph within 6 months. Indications for repeat radiographs were determined. Repeat radiographs were counted as "non-indicated" when medical records revealed no new symptoms. A focused educational intervention was provided to the orthopedic and family practice departments. An additional 500 radiology reports were evaluated 9 months after intervention in the same manner and the rate of non-indicated radiographs was calculated. Follow-up review of additional 500 radiology reports at 1-year time point was performed.

Results Our initial search returned 1517 reports. Upon evaluation of 500 studies, there were 112/500 repeat radiographs (22%); 77/500 (15%) of knee radiographs were not indicated. Upon initial follow-up evaluation of 500 studies, there were 52/500 repeat radiographs (10%) and 40/500 (8%) radiographs were not indicated. The reduction of unnecessary repeat knee radiographs rate was sustained at 1 year.

Conclusions Focused educational intervention results in a substantial (50%) reduction of the number of unnecessary repeat knee radiographs in patients with known severe OA.

Keywords Quality improvement · Radiograph · Knee · Osteoarthritis · OA · X-ray

Introduction

Knee osteoarthritis or osteoarthrosis (OA) is a very common disorder that affects at least 14 million US adults who are clinically symptomatic from this disease [1]. Globally, OA is a widely prevalent disease and affects 250 million people or 4% of the world's population [2]. Radiographic evidence of OA is found in 80% or more of knee radiographs among patients older than 75 years [3]. The Kellgren–Lawrence (KL) scale [4, 5], ranging from grades 0 to 4 in increasing severity, is a widely used and validated method for the evaluation of OA. The KL scale is described in Table 1. Various studies report the prevalence of "severe" OA using the KL scale. Some elderly populations demonstrate rates of severe osteoarthritis based on KL scale as high as 21–25% [6].

When patients present to primary care providers, urgent care clinics, and emergency rooms with complaints of knee pain, most of them are evaluated with knee radiographs (XR), and many are referred to specialists for further care with concerning findings on the knee XRs. Similarly, it is a common practice at our institution to obtain XRs in orthopedic and

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Table 1 Kellgren–Lawrence scale of OA

Classification	KL definition	Features
Grade 0	Normal	Normal
Grade 1	Doubtful	Possible JSN, possible osteophytes, possible subcortical sclerosis
Grade 2	Minimal	Definite, but minimal JSN, and/or definite small osteophytes, and/or definite subcortical sclerosis
Grade 3	Moderate	Moderate JSN without bone on bone contact and at least one of the following: osteophytes, subcortical sclerosis, subcortical cysts
Grade 4	Severe	Bone on bone contact, large osteophytes, large subcortical cysts, severe eburnation

KL Kellgren–Lawrence, *JSN* joint space narrowing, *OA* osteoarthrosis

various other outpatient clinics for patients with knee complaints. However, it is also a common practice to obtain XRs during their follow-up serial visits despite known moderate or severe OA, and whether indicated or not. This creates unnecessary cost to the patient and to the health care system, patient discomfort, loss of time, and unnecessary radiation exposure.

The European League Against Rheumatism (EULAR) recommends against repeat knee radiographs for the routine follow-up of OA [7, 8]. While some clinicians may choose to monitor chronic disease by imaging on an annual basis, it is completely unclear what rationale may exist for obtaining repeat knee radiographs for routine short-term follow-up within a 6-month period in the absence of new symptoms or new trauma.

The purpose of our project was to determine the baseline frequency of unnecessary knee radiographs obtained for the follow-up of OA within 6 months of the initial XRs in our large teaching institution's clinics and medical centers. We also determined whether clinician education can reduce the frequency of unnecessary radiographs.

Methods

All knee radiograph reports obtained during a 1-year period from January 2017 to December of 2017 were queried for the term "severe", which returned 1517 reports. This was followed by repeat search through the same reports for terms "degenerative", "osteoarthritis", "DJD", "joint space", "compartment", and "narrowing". The resulting database of 1227 reports was manually reviewed to confirm the diagnosis of severe osteoarthritis in 500 consecutive studies (Fig. 1). Each patient's medical records were searched for the presence of repeat XRs of the same knee within 6 months of the study by a medical student in conjunction with musculoskeletal fellowship trained attending radiologist (OA). Relevant medical records were reviewed to determine whether repeat XR was obtained for routine follow-up, or whether new symptoms were present that prompted repeat XR. Since the study was retrospective, in ambiguous cases, XRs were counted as "necessary and indicated". The frequency of non-indicated repeat knee XRs was calculated.

Educational material was created in the form of PowerPoint slides that provided the background of the problem, our initial findings including the frequency of unnecessary XRs, EULAR recommendations for OA imaging, and slides on potential cost savings based on Medicare reimbursement of knee XRs and other ancillary savings. This was distributed via electronic communications to the ordering attendings, fellow and resident physicians, physician assistants and nurse practitioners in the departments of family practice and orthopedic surgery at our large academic medical center in March of 2018. A brief presentation was also made using the same PowerPoint to a family medicine grand rounds audience in May of 2018.

Approximately 9 months after the educational interventions, we repeated the report search and review of medical records using a methodology identical to the pre-intervention analysis. Repeat follow-up review was also performed at a 1-year time point after the initial intervention.

Statistical analysis

Microsoft Excel was used for tabulation and calculation of percentages. Fisher's exact test was used to compare pre- and post-intervention frequencies. A p value of less than 0.05 was considered statistically significant.

Results

Pre-intervention analysis

There were 112 repeat XRs (22%) within 6 months in a subsample of manually reviewed 500 radiograph reports; 77/112 (69%) knee radiographs were classified as "not indicated" (Fig. 2). The rate of "not indicated" repeat radiographs was thus, 15% for the total sample of 500 manually reviewed radiograph reports (Fig. 3).

Fig. 1 Severe knee osteoarthrosis in a 75-year-old woman. Frontal (**a**) and lateral (**b**) views of the knee demonstrate severe medial joint space loss, and large medial, lateral, and patellar osteophytes. The images obtained 4 months later (c, d) are nearly identical to the initial study apart from slight differences in positioning and projection.

Post-intervention analysis

The post-intervention initial search returned 2177 reports, and further filtering resulted in 2136 XR reports that described severe OA. Five hundred consecutive reports were again manually reviewed by the same observers. There were 52 repeat XRs (10%) within 6 months in the subsample of manually reviewed 500 radiograph reports (previously 112, 22%); 40/52 (77%) knee XRs were classified as "not indicated," (previously 77, 69%, Fig. 2). The rate of "not indicated"

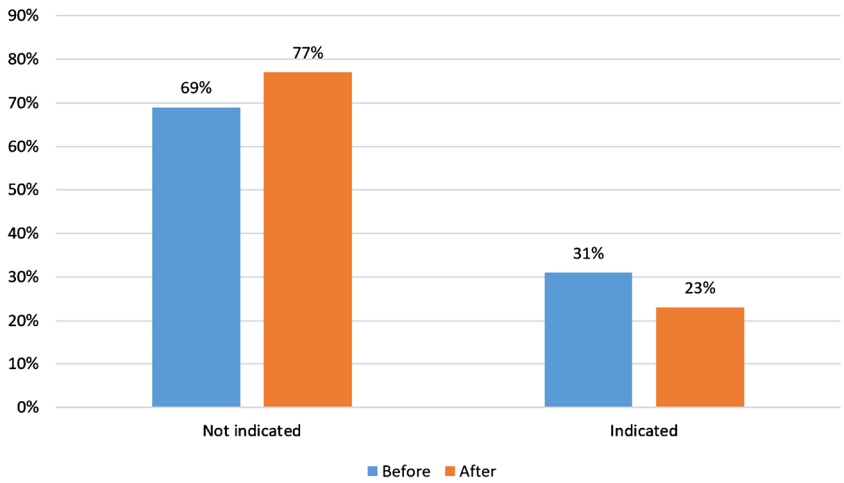

Fig. 2 Percentage of repeated knee radiographs that were not indicated and indicated

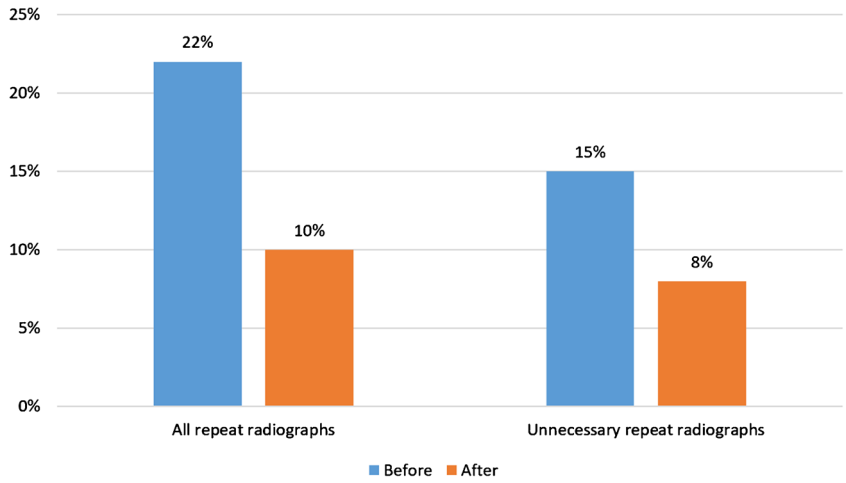

Fig. 3 Bar graph of rate of repeat radiographs before and after educational intervention

repeat radiographs was 8% for the total sample of 500 manually reviewed radiographs reports (previously 15%, Fig. 3).

Our repeat analysis of 500 most recent knee XRs performed in April of 2019 (1 year since the initial intervention) demonstrated 40/500 (8%) of repeat XRs with 24/500 (5%) determined to be "not indicated".

Statistical analysis

Fisher's exact test demonstrated a statistically significant difference between the pre- and post-intervention frequencies of repeat radiographs ($p = 0.0004$). The proportion of "not indicated" radiographs within the repeated knee radiographs subsamples (77% after intervention and 69% before intervention) did not demonstrate statistical significance ($p = 0.3543$) based on Fisher's exact test. There was no statistically significant difference between the results of initial post-intervention follow-up and 1-year follow-up analysis.

Discussion

Every test and intervention performed in the delivery of health care is associated with a certain amount of risk and expense. While the radiation exposure and cost of a single knee XR is not substantial, the unnecessary repetition of such examinations within a large population adds up to large cost and radiation exposure within the healthcare system as a whole. With the formation of new affordable care organizations and a plethora of ordering providers, practice management projects are essential for conservation and proper utilization of health care resources.

Based on the total Medicare reimbursement of approximately $60 per knee XR [9] and our initial sample of approximately 1200 radiographs with severe knee OA obtained during 2017, a 15% reduction in unnecessary expense calculates to $10,800 of savings per year. This calculation does not take into the account our auxiliary site that includes a large county hospital and its outpatient clinics, which was not included in this project.

During knee imaging, the radiation risk to small body parts is extremely low [10]. However, based on the widely used principles of "As Low As Reasonably Achievable" (ALARA), unnecessary radiation to the patient should be avoided. In the case of severe OA in patients with no new symptoms, it is extremely difficult to justify the risk, even if minimal, as the likelihood of discovering a new significant finding in a patient with no new symptoms is extremely low.

Time savings is an additional benefit. In the complexities of the current health care system, a simple radiograph requires input of numerous individuals who include clinician ordering the test, scheduling personnel, a technician, and the radiologist. Most importantly, unnecessary tests also create many burdens on the patient, which can range from the relatively minor issue of waiting for test, to the more substantial burden of traveling to distant image acquisition sites or dealing with the insurance issues. Loss of productivity is another burden placed on the patients as they may need to take time off from work to obtain the imaging study.

Some of the factors that may have contributed to the overutilization of radiography for routine follow-up are clinician preferences, and routine practice of obtaining radiographs prior to seeing the patient in the clinic. Some clinicians had preferences for routine acquisition of certain views. The purpose of this project was not to determine the exact factors behind the overutilization of knee radiography, but rather to evaluate whether simple focused educational interventions could reduce the unnecessary radiographs. Further reduction of unnecessary XR frequency is possible, but more granular evaluation of root causes will be needed in a future project.

Similar projects have been done at the University of Texas Health Science Center Houston and the Baylor College of Medicine, and at the University of Texas Southwestern Medical Center, wherein educational interventions upon

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referring clinics and/or clinical faculty resulted in the successful reduction of unnecessary MRIs of knee in the settings of moderate to severe OA [11, 12].

In general, the overutilization of imaging is a well-known problem and has been studied in other settings. For example, a study from Great Britain [13] describes audit and educational reminder messages in six radiology departments and 244 general practices. Similar to our study, educational intervention, which was presented in the form of reminder messages in the other study was effective in reducing unnecessary radiographs. In our department, software solutions based on the appropriateness criteria are implemented for some exams, but not yet for radiographs. We are exploring several approaches to present reminder messages to clinicians to avoid unnecessary radiographs. Some of the potential solutions include warning pop-up messages during order entry workflow and sending periodic electronic communications. However, it is important to note that clinician satisfaction with respect to their practice patterns is also an important variable. Overwhelming number of reminders may negatively affect clinician satisfaction and their cooperation. The final solution will have to carefully balance the beneficence to patients and social justice of appropriate utilization of finite resources while the clinicians follow the best practices guidelines to serve the osteoarthritis patients.

Limitations of our study include its retrospective nature. An additional limitation is our inability to interview patients for more detail about their symptomatology or lack thereof for better determination of whether a radiograph was properly indicated during clinical follow-up. However, such methodology was essential when considering the large size of our study sample. Our data were acquired at a single academic health care system in a large city. However, the authors believe that it is reasonable to apply our results to other health care practices where repeat imaging studies are frequently ordered. Due to the time constraints of our orthopedic grand rounds, we were not able to provide an oral presentation to the orthopedic audience and relied on the fact that the providers would have read the PowerPoint slides. To mitigate the risk of inadequate dissemination, we included two investigators associated with the orthopedic department to assist in the distribution of the findings and recommendations. We acknowledge that direct presentation to the orthopedic faculty and staff may have resulted in a further reduction of unnecessary radiographs.

The Hawthorne effect describes influence on outcome in research studies due to simple awareness of the subjects that they are being studied and not solely by presence of intervention [14]. It is difficult or impossible to control for the Hawthorne effect even in randomized studies as both control and intervention group are aware that they are being studied. We acknowledge that there is a possibility of presence of Hawthorne effect in this study and that post-intervention follow-up results may be affected by the Hawthorne effect.

We only included analysis of severe cases of OA. Inclusion of lower grades of osteoarthritis could also result in further reduction of unnecessary radiographs. In the future, we expect to distribute the post-intervention results to our ordering physicians and implement further education efforts in order to sustain these practice management efforts.

Lastly, we did not perform sub-analysis on which clinical service ordered more repeat radiographs and whether educational intervention affected various clinical services differently. This project was designed to evaluate and start addressing a system-wide issue. Future quality improvement projects can be designed to address more granular issues.

Conclusions

Simple focused educational interventions result in a substantial (50%) reduction of unnecessary repeat knee XRs during routine follow-up of severe knee OA.

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Compliance with ethical standards

Related disclosures None.

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Conflict of interest None.

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