



## Reject analysis: A comparison of radiographer and radiologist perceptions of image quality



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### ABSTRACT

This study explores the potential differences in perceptions of image quality between radiographers and radiologists in a large UK hospital and the subsequent impact this has on image rejection. Image rejection, while sometimes necessary, often leads to an increased radiation dose to the patient due to the need to repeat. Moreover, this translates into increased waiting times, departmental costs, and lower patient satisfaction. Adopting a mixed methods approach, this paper first seeks to quantify the differences in radiographer and radiologist perceptions and second establish the underlying causes of such differences through a quantitative and qualitative investigation respectively. Using a standardized psychometric scale of a GP lateral knee, the study reveals significant differences in the perceptions of quality and rejection rates between radiographers and radiologists driven by a conflict in the evaluation criteria used. The study has significant implications for improving departmental performance and proposes a potential solution for reducing reject rates and image repeats.

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### Introduction

Medical imaging is one of the key diagnostic tools used in modern medical practice, providing practitioners with valuable information to make informed decisions at subsequent stages of care. Yet, there is an inherent risk versus benefit trade-off, as the radiographer has to decide whether 'the benefits of imaging outweigh the detrimental costs of ionising radiation.'<sup>1</sup> Over exposure to ionising radiation increases risk of malignancy and other stochastic effects, such as cancer and cell mutations.<sup>2</sup> As such, it is important that radiographers keep patient exposure to radiation to a minimum.

Repeat imaging due to 'rejects' is a common problem in any radiology department and is responsible for the majority of unnecessary patient irradiation doses.<sup>3</sup> Generally, radiographers reject images due to limitations in diagnostic information and subjective opinion regarding image quality. Previous studies have highlighted (1) *exposure*; under penetration vs. over penetration of an image, (2) *patient positioning*, (3) *patient movement*, (4) *artefacts* e.g. jewellery or clothing that restrict imaging, and (5) *processing errors* as main causes of rejection.<sup>4</sup> While some of these factors have been negated in light of today's digital advancements, such as

processing errors and to some degree exposure, rejects are still a pervasive force affecting departmental performance.

Reject analysis is an important quality assurance mechanism that highlights areas of practice that can be improved. By examining the underlying causes for rejection it is possible to identify any technical or training issues<sup>5</sup> of staff and can help increase departmental performance, reduce radiation burden, and decrease waiting times.<sup>1</sup> Thus, managing repeat imaging due to rejects is an essential practice, both from the perspective of the department and level of patient care provided.

Before images are released to radiologists for interpretation, radiographers performing the procedure assess the image for proper positioning, adequate exposure, patient motion blur and other quality defects that could potentially affect diagnosis.<sup>6</sup> The quality assurance process performed by radiographers is subjective and performed visually.<sup>7</sup> Consequently, underlying discrepancies may exist between practitioner judgements. In a study of a US hospital, Whaley et al.<sup>6</sup> found that, in the evaluation of image quality, radiographers and radiologists only moderately agreed in their perceptions. Radiologists tended to be more accepting and rated images on their diagnostic capability, whereas radiographers were more stringent and rated images on technical attributes. Naturally, this begs the question as to whether images are being prematurely rejected.

It is intriguing, however, that no research has explored the impact that differential opinions between practitioners have on

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potential reject rates. This study aims to quantify potential differences in opinion between radiographers and radiologists by first establishing a psychometric scale of image quality using a standardized image procedure of the GP referred lateral knee. Using a case study of a large UK Hospital located in the North of England, this study maps the reject and quality perceptions of radiographers and radiologists across the five lateral knee images that comprise the new psychometric scale and compares the results.

**Methodology**

A two-phased mixed methods approach utilising quantitative and qualitative techniques was used to address the aim of this study. The first phase seeks to establish a psychometric scale of image quality to quantitatively measure differences in perceptions between radiographers and radiologists using maximum-likelihood estimation. The second phase then qualitatively explores the underlying drivers of interpretation using semi-structured interviews.

*Phase 1. Quantitative investigation*

To measure the differences between radiographer and radiologist perceptions, a controlled audit experiment was set up using a newly developed scale of image quality. Since images are generally unstandardized in procedure and positioning, specifying a control mechanism was imperative. To control for differences in procedure and minimise within group variance, GP referred lateral knee images were used as the unit level of analysis. GP referred lateral knee examinations are a non-trauma standard procedure, which enabled meaningful comparisons and aggregation of results for different patient images to construct the scale.

Using a sample dataset of over 500 images compiled from the case Hospital archives, a shortlist of 50 images were extracted with the assistance of a senior reporting radiographer and objective audit tool (Fig.1). A total of 10 images were selected per ordinal level of the proposed scale: (1) poor quality (reject); (2) unacceptable quality; (3) borderline quality; (4) acceptable quality; and (5) good quality. These 50 images were then pitched to a focus group of diagnostic imaging professionals<sup>8</sup> to finalise the five-point scale.

The images that comprised the scale were then randomly presented to 15 radiographers and 15 radiologists who had no prior cognition of the images' ranking in face-to-face meetings. Rankings

were purposely omitted as to force respondents to score images on their individual merit. A maximum of 10 and minimum of 1 point could be assigned to each image, with a score of 5 being the threshold level of acceptance (i.e., images with a score of <5 were rejected). This scoring mechanism ensured that images were evaluated independently and were purely based on the respondent's initial perceptions. The resultant images that comprised the psychometric scale are illustrated in the Appendix.

Maximum-likelihood estimation (MLE) was used to establish parameter estimates for the scores assigned to each image by radiographers and radiologists respectively. MLE is a statistical technique that makes the observed data 'most likely'. Scores for each image were fitted to a specific distribution from which MLE estimates are derived.

*Phase 2. Qualitative investigation*

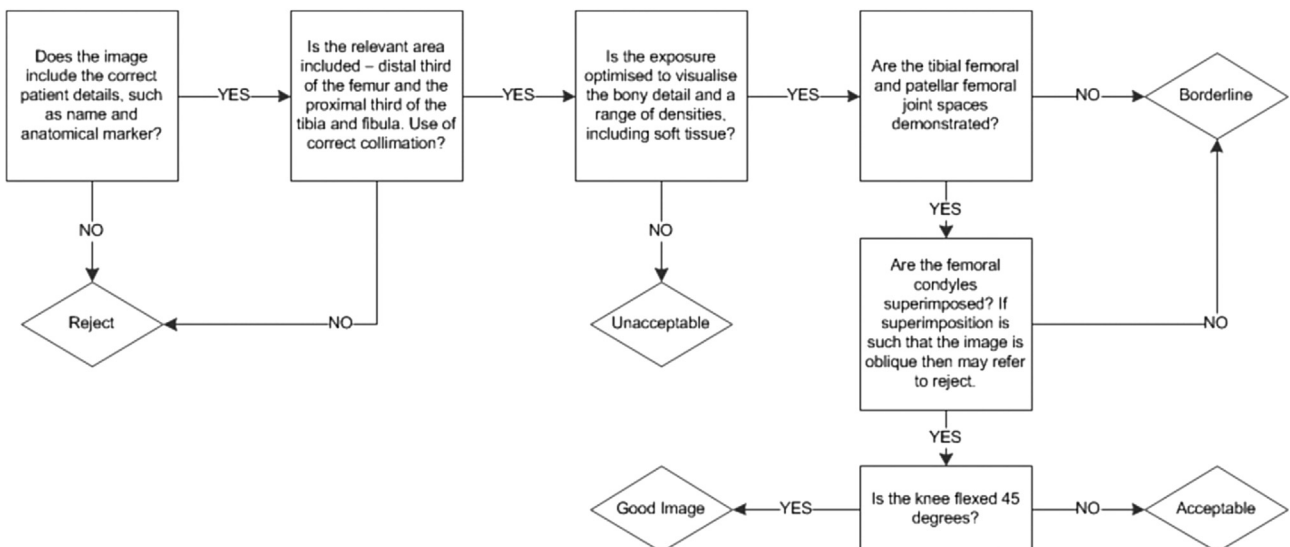
To elaborate on the quantitative findings regarding the differences in radiographer and radiologist perceptions of image quality and rejection, a qualitative exploration of the underlying reasons behind group differences was undertaken. Following the scoring of images that comprised the scale, respondents were asked to reflect on why they chose to accept or reject an image. Semi-structured interviews were used to probe respondents about the objective reasoning behind their decision and the criteria used in scoring. This two-phased approach enables a deeper level of analysis to establish not only the magnitude of difference, but also the root cause of such difference.<sup>9</sup>

**Results**

In this section the results of the quantitative investigation are first reported to establish potential differences in image perception and rejection thresholds between radiographers and radiologists. The qualitative results are presented second to flesh out the reasons of any emerging differences.

*Phase 1. Results*

The results of radiographer and radiologist responses to the GP lateral knee images that comprise the psychometric scale are presented graphically in Fig.2. In each frame, the graphs show the



**Figure 1.** Audit tool for evaluating GP referred lateral knee.

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