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To keep or reject, that is the question - A survey on radiologists and radiographers' assessments of plain radiography images

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ABSTRACT

Introduction: This study aimed to survey radiographers and radiologists' assessment of plain radiographs to identify the imaging clinicians' differences in acceptance of image quality.
Method: An online, questionnaire was distributed among radiographers (n = 116) and radiologists (n = 76) in a hospital trust in Norway, including 30 clinical cases (one image and a short referral text) that were divided into 3 categories; keep, could keep and reject, based on European guidelines. When rejecting, the respondents identified the main reason by ticking a list (positioning, collimation, centering, artifact or exposure error). Group differences were explored using 2-tailed chi-squared test. Inter-subjectivity was measured using Cohen's kappa for multi-rater sample.
Results: In total, 36% of the radiographers (n = 42) and 14% of the radiologists (n = 14) responded to the survey. Total response rate was 30% (56/192). Analysis showed significant difference between radiographers and radiologists in the categories of Reject ($\chi^2 = 6.3$, df = 1, p = 0.01), and Could keep ($\chi^2 = 6.3$, df = 1, p = 0.01), identifying radiologists as keeping more images compared to radiographers. Agreement among radiographers (Cohen's κ: 0,39; 95% CI: 0.30–0.48; $p < 0.001$) and radiologists (Cohen's κ: 0,23; 95% CI: 0.09–0.37; $p < 0.001$) respectively, is fair. The most common reason for rejecting an image is suboptimal positioning. Suboptimal collimation constituted 15% of the rejected images among radiographers, compared to 5% among radiologists. Centering, artifacts and exposure error showed quite similar rates as reasons for rejection.
Conclusion: Radiographers and radiologists seem to agree on the assessment of good quality images, however, radiographers seem more reluctant to accept images of lower quality than radiologists.
Implications for practice: Further research on reasons for differences in image quality assessment between radiographers and radiologists is needed. This could enable reduction in reject rates and increase image quality in conventional X-ray examinations.

Introduction

The use of ionising radiation for diagnostic purposes is underpinned by the principles of justification and optimisation.[1] In radiography optimisation of radiation protection is known under the acronym ALARA – to keep doses as low as reasonable achievable.[2] When surveying local diagnostic reference levels, the Norwegian Radiation and Nuclear Safety Authority observed a large variation in doses between hospitals for skeletal examinations.[3] One of the reasons for this variation was reject image rates. Rejected images results in up to three times unwarranted increased radiation dose to patients.[4] Reducing the number of exposures per examination could be one way to reduce radiation dose in concordance with ALARA.[4]

Previous studies indicate that retakes occur in 2–15% of examinations and that errors in patient positioning causes 50–77% of repeats.[4–11] Exposure error constitutes 2–67% of rejects.[5,6,8–10] A potential reason for unnecessary image rejections, as claimed by some radiographers, is that the use of digital techniques makes it easier to retake images compared to analogue techniques.[6] The

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proportion of exposure error rejections have been reduced with the introduction of digital systems from 40 to 60% with film/screen systems to 2–15% in digital systems.[5,9] However, positioning errors have increased with the introduction of digital systems from 23 to 44% in film/screen systems to 30–83% in digital systems.[5,9] Other reasons for rejecting images like artefacts, centering, and collimation also increased with digital systems from 8 to 33% in film/screen to 12–37% in digital systems.[5,9,11,12] However, these changes in observed frequencies are very wide and therefore it is difficult to state statistical significance.

Another consideration is the radiographers and radiologists' perception and attitude towards image quality.[10] Dunn & Rogers[11] found that radiologists kept 50% more of the images that showed positioning errors compared to radiographers. Indicating a difference in clinical judgement between the two groups. Furthermore, Waaler & Hofmann[5] highlight inter-subjectivity of radiographers' perception of image quality to be a challenge in the effort to reduce reject rates. Lack of coherent inter-subjective assessments of images may also be an issue for radiologists. To the authors knowledge this is yet to be explored. In addition, with the introduction of digital systems professional interactions between radiographers and radiologists have reduced. Image quality discussions at the light board no longer take place in radiology departments where images are sent electronically.[5] If we assume that image quality is best addressed by an interdisciplinary approach where the radiographer and the radiologist exchange experience-based knowledge in a clinical context underpinned by research-based knowledge,[14] the lack of arenas allowing such discussions may hamper a joint understanding of what standards should guide assessment of keeping or rejecting images. Subsequently hindering a joint effort to keep retake rates to a minimum and in worst case reducing overall quality of the imaging services provided.[15] One step towards addressing these concerns, is to provide research-based knowledge on whether radiographers and radiologists assess image quality differently.

A survey comparing radiographers and radiologists' assessment on what image quality is acceptable may point towards differences in quality assessment that could influence clinical practice. Such a survey could form a basis for developing knowledge, which could contribute to reducing image retake rates, and ensure high quality radiographic practice.

This study is part of a larger project investigating different aspects of image quality assessments in clinical practice that may influence retake rate; the aim of this study was to survey among radiologists and radiographers in medical imaging to explore assessments of usability of images and the need for image retake in specific cases.

Methods

In this study, a survey was conducted using a semi-structured questionnaire. Respondents from four different hospitals in the same hospital trust were invited to participate. The hospital trust includes two small local hospitals and two larger central hospitals covering a population of 500,000 people in an area of 15,960 km^2. The four imaging departments combined conduct more than 150,000 plain radiography examinations annually.

An information meeting was arranged at each hospital before distributing the online survey by email in January/February 2020. Two reminders were sent. The data collection ended in March 2020. Radiographers (n = 116) and radiologists (n = 76) working in conventional radiography were eligible to participate in the survey. The respondents gave written, informed consent.

The questionnaire included demographics of the respondents and 30 clinical cases. Each case included one image and a short referral text. In each case, the respondents decide whether the image should be kept or rejected. When rejecting an image the respondents had to choose the main reason for rejecting the image based on a predefined list with the following options: positioning is suboptimal, centering is suboptimal, artifact in the image, collimation is suboptimal or exposure error. Respondents always had the option to elaborate on the choice made, thus providing both qualitative and quantitative data. This paper focuses on the quantitative results of the survey.

An overview of the type of examination in the cases and initial image quality assessment is presented in Table 1. Initial image quality assessment was done by the authors based on European guidelines on quality criteria for diagnostic radiographic images.[16] Five cases were paediatric radiographs. Examination types included chest, spine, upper and lower limbs, representing examinations shown to have high rejection rates.[10] Cases were divided into 3 categories; keep, could keep and reject. The main flaws in the quality of the images in the categories reject and could accept cases were suboptimal *positioning* (36.4%; one case of wrong extremity imaged), *collimation* (22.7%), *exposure error* (18.2%), *centering* (13.6%) and *artifacts* (9.1%).

Statistical analysis

R (R Core Team, 2020) was used to perform 2-tailed chi-squared tests to explore group differences. To measure inter-subjectivity Cohen's kappa for multi-rater sample was used, agreement evaluated as: $k \leq 2$ as slight; $0.2 < k \leq 0.4$ as fair; $0.4 < k \leq 0.6$ as moderate; $0.6 < k \leq 8$ as substantial and $k > 0.8$ as almost perfect.[17] P values less than 0.05 for all statistical tests were considered significant.

This study was approved for data handling by the Norwegian Centre for Research Data (Reference: 987929). The Data Protection Official at the hospital trust approved the survey.

Results

In total, 56 clinicians responded to the survey, comprising 36% of the radiographers (n = 42) and 14% of the radiologists (n = 14), providing an overall response rate of 30%.

Demographics of the respondents is presented in Table 2. There were more females than males among the respondents and most respondents were under the age of 50. For each cohort there was an

Table 1
Type of image and initial image quality assessment for the 30 cases in the questionnaire.

Type of image	Keep (n)	Could keep (n)	Reject (n)
Chest (AP/PA)	1		2
C-spine (open mouth)		1	
Total spine		1	1
Lumbosacral spine (Lateral)		1	1
Shoulder/humerus (AP)	1	3	1
Elbow (AP)			1
Elbow (Lateral)	1		
Wrist (PA)	1	1	1
Wrist (Lateral)		2	1
Finger (Oblique)	1		
Hip (Axiolateral)	1		2
Hip (AP)		1	
Knee (Lateral)	1		
Leg (AP)			1
Ankle (Lateral)	1		
Foot (Lateral)		1	
Total	8	11	11

Table 2
Demographics of respondents in the survey.

	Radiographer	Radiologist
n	42	14
Sex		
Male	10	5
Female	32	9
Age		
20–29	12	–
30–39	16	4
40–49	8	9
50–59	4	1
60->	1	–
Years of practice		
<5	13	4
5–10	15	5
>10	14	5

even distribution of participants in the category describing years of clinical practice.

Both radiographers (47%) and radiologists (59%) kept on average about half of the assessed images. Radiologists rejected 11.4 (38%) of the images while radiographers rejected 13.8 (46%), indicating no significant difference.

Results per case

Table 3 presents all cases included in the questionnaire. In cases 24 and 26 (italic in Table 3) all respondents agreed to keep the image. All radiographers and all except one radiologist wanted to reject the image in case 02. In case 23, the image was of the wrong extremity. About 30% of the radiographers and none of the radiologists made a comment on this error.

The chi-square test was used to compare radiographers and radiologists total proportion of kept images within each category of image quality (Table 4). Radiographers kept on average 82% of images initially assessed as good enough to keep, while radiologists on average kept 88% of these images, showing no statistical significant difference, thus, there was agreement among the clinicians on assessment of images in the keep category.

For images assessed as reject initially, radiographers rejected on average 65% of the images while radiologists rejected on average 54%. This was a significant difference indicating that radiographers reject more images than radiologists in this category ($\chi^2 = 6.3$, df = 1, p = 0.01). In the could keep category radiologists also rejected a significantly lower proportion of the images (41%) compared to the radiographers (54%) ($\chi^2 = 6.3$, df = 1, p = 0.01).

Comparing the number of kept images in each category after sorting respondents per sex or years of clinical experience gave no significant differences in keep rate in any category.

Inter-subjectivity among radiographers and radiologist

To test whether there was agreement on which images to keep or reject among the group of radiographers and radiologists respectively, Cohen's kappa was used. Agreement among radiographers on when to keep an image is relatively low as given by the Cohen's kappa coefficient of 0.39 (95% CI: 0.30–0.48; p < 0.001). However, this falls in the descriptive category *fair* according to Chmura Kraemer et al.[17] Agreement is fair among radiologists as well (Cohen's κ: 0.23; 95% CI: 0.09–0.37; p < 0.001), however, the Kappa coefficient is in the lower range of the evaluation interval compared to the results for the radiographers but the confidence interval suggest this difference is not significant.

Table 3
All cases with type of examination and initial quality assessment with number of kept images per profession.

Case no.	Initial assessment	Type of examination	Radiographer assessment		Radiologist assessment	
			Keep		Keep	
			n	%	n	%
01	Keep	Upper extremity	36	85.7	12	85.7
02	Reject	Upper extremity	0	0	1	7.1
03	Reject	Spine	4	9.5	3	21.4
04	Could keep	Upper extremity	29	69	8	57.1
05	Keep	Lower extremity	37	88.1	13	92.9
06	Reject	Lower extremity	32	76.2	10	71.4
07	Could Keep	Lower extremity	5	11.9	4	28.6
08	Keep	Upper extremity	29	69	10	71.4
09	Could keep	Upper extremity	31	73.8	9	64.3
10	Reject	Upper extremity	18	42.9	6	42.9
11	Keep	Lower extremity	39	92.9	13	92.9
12	Reject	Lower extremity	8	19	4	28.6
13	Reject	Lower extremity	34	81	12	85.7
14	Could keep	Upper extremity	15	35.7	6	42.9
15	Keep	Upper extremity	31	73.8	11	78.6
16	Reject	Spine	26	61.9	11	78.6
17	Keep	Lower extremity	18	42.9	11	78.6
18	Reject	Chest	1	2.4	2	14.3
19	Could keep	Spine	13	31	4	28.6
20	Could keep	Upper extremity	37	88.1	11	78.6
21	Could keep	Total spine	35	83.3	11	78.6
22	Reject	Upper extremity	10	23.8	7	50
23	Reject	Upper extremity	23	54.8	9	64.3
24	*Keep*	*Upper extremity*	*42*	*100*	*14*	*100*
25	Could keep	Spine	3	7.1	5	35.7
26	*Keep*	*Chest*	*42*	*100*	*14*	*100*
27	Could keep	Upper extremity	18	42.9	9	64.3
28	Could keep	Upper extremity	22	52.4	11	78.6
29	Could keep	Lower extremity	6	14.3	12	85.7
30	Reject	Chest	6	14.3	7	50

Compliance with initial image quality assessment.

Reasons for reject

Fig. 1 presents the reasons radiologists and radiographers provided as main reason to reject an image. For radiographers 45% of rejects were mainly due to suboptimal positioning, while 55% of radiologists reported this as main reason for rejection. Collimation was the main reason for rejection for 15% of the rejected images among radiographers compared to 5% among radiologists. Centering, artifacts and exposure error showed quite similar rates as reason of rejection of between the two professional groups, where radiographers reported 28%, 5% and 7% respectively and radiologists 28%, 3% and 9% respectively for these three reject reasons.

Table 4
Total number of kept cases comparing professions, sex and years of clinical practice per category in the initial image quality assessment (Keep, Reject and Could keep).

	Keeps	Cases in total	Keeps	Cases in total	P value
Profession	*Radiographers (n = 42)*		*Radiologists (n = 14)*		
Keep	274	336	98	112	0.19
Reject	162	462	90	154	**0.01**
Could keep	214	462	72	154	**0.01**
Sex	*Female (n = 41)*		*Male (n = 15)*		
Keep	274	328	98	120	0.75
Reject	197	451	59	165	0.09
Could keep	243	451	91	165	0.85
Years in clinical practice	*< 5 years (n = 39)*		*> 5 years (n = 17)*		
Keep	115	136	257	312	0.67
Reject	71	187	163	429	1.00
Could keep	96	187	238	429	0.39

Values in bold indicate statistical significance.

Discussion

In this study, we found that for the images initially assessed as of good quality, radiographers and radiologists highly agree on acceptability. However, for images of lower quality radiologists kept a significantly higher proportion of the images. Suboptimal positioning was reported as the main reason for rejection of the images, followed by suboptimal centering for both radiographers and radiologists. Radiographers reported suboptimal collimation as main reason for rejection three times more often compared to radiologists, representing the most prominent difference in use of specific causes for rejection between the two groups. Years of clinical experience and sex seemed not to have an influence on the clinicians' assessment of whether or not to keep images in this study.

It has been well established that monitoring the rejection rate needs to be included as part of a local quality assurance program.[4,5,6,10,12] Recommended measures to eliminate unnecessary retakes are to identify sets of examinations that cause high retakes rates and target training and education towards these "problem cases".[4,7,8,12] Specifically, education on evaluation of image criteria for relevant cases aimed at radiographers is recommended.[7,8,11,12] The finding presented in this study describing how radiographers tend to reject more images than radiologists is in concordance with Dunn & Rogers.[13] This indicates a need for including inter-professional discussions on image quality as part of local quality assurance programs. Image retake in itself is not necessarily unwarranted and may be necessary in some situations to ensure images of optimal diagnostic information,[11] but should be evaluated in close relation to the principles of ALARA.[1,2] Cross-disciplinary discussions are undoubtedly an important source for knowledge, that would help a collective effort to ensure high quality services in imaging. This has also been recommended by Nol et al.[15]

Furthermore, this study showed collimation as a reason for rejection as more commonly used by radiographers. This can be one example of how experience-based knowledge influence what underlying problem to image quality the clinicians emphasises. Atkinson and colleagues[10] suggest a feedback system between radiologists and radiographers with the aim of reducing the high percentage of positioning errors as a central cause for retakes, as strategic step towards lowering retakes rates. However, it is likely that the radiographers themselves are better suited for identifying what is the underlying cause for errors in positioning, and not by feedback from the radiologists. Positioning errors made by the radiographer are likely caused by a mixture of many factors relating to both equipment, procedure and the individual patients influenced by the workflow in the department for each examination. Combining the expertise of both the radiographers and the radiologists is likely a more efficient strategy towards verifying and improving the overall quality in digital imaging services. Fadden

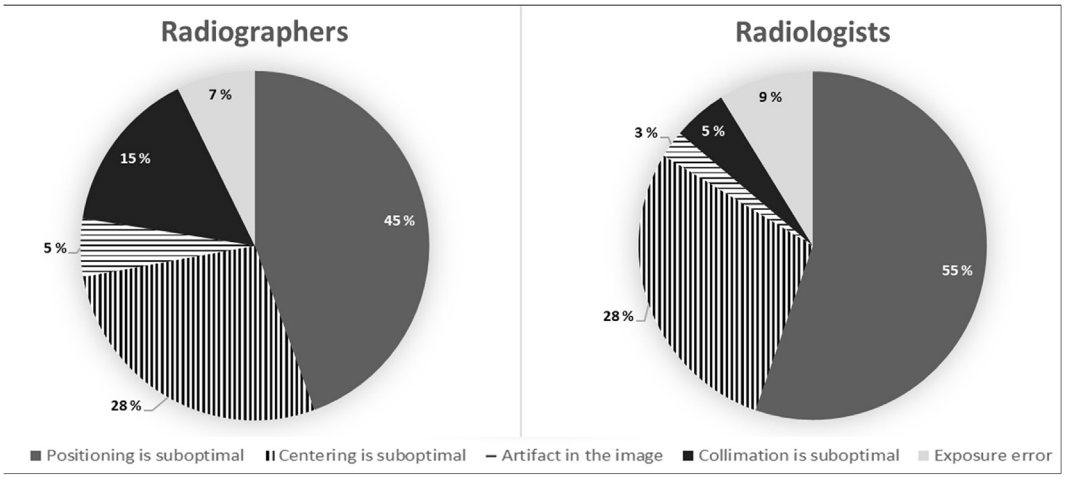

Figure 1. Overview of radiographers and radiologists reason for rejection of images.

and colleagues[18] advocated the need for standardisation of education and training including protocols and exposure parameters to ensure that there is continued adherence to the ALARA principle.[18] This could be a common point of targeting the reduction of retakes founded in both radiography and radiology.

Waaler & Hofmann[5] highlight inter-subjectivity of radiographers' perception of image quality to be a challenge in the effort to reduce reject rates. In this study, we found that agreement on keeping an image is relatively low for both radiographers and radiologists, supporting the need for including the topic of perception of image quality into quality assurance programs.

Strength and limitations

Firstly, the response rate of only 30%, and only 14 radiologists participating challenge the validity of this study. All eligible clinicians had easy access to the survey at work. However, the low response rate may be due to high workload making it difficult to prioritise participation in this survey. The low participation by radiologists is likely because only radiographers got dedicated time by management to participate. Low response rate reduces strength of analysis with regards to producing representative results.[19] On the other hand, the respondents were recruited from different imaging departments that all significantly use conventional X-rays, making it likely that all participants are involved in assessing image quality on a daily basis. As such, the respondents may be seen as representing attitudes present in clinical practice. Secondly, the initial assessment of image quality is based on guidelines not specifically developed for digital radiography. Consequently, the initial assessment of image quality used to guide this study may be criticised. Discussing the cases with other clinicians could have helped to strengthen validity. Lastly, the survey was presented in English because the questionnaire is designed for an international research project. This may have caused a language barrier. On the other hand, radiologists and radiographers in Norway usually read professional literature on radiography and radiology in English because the literature in Norwegian is rarely available.

Conclusion

Evidence based on this survey indicate that radiographers and radiologists seem to agree on keeping images initially assessed as of good quality according to guidelines. However, this study also shows that radiologists tend to accept a higher amount of images that radiographers reject and considered to be of low quality. This supports previous research that advocates for standardisation of what constitutes an optimal image and justifying the acceptance of images that do not adhere to the stipulated standard. A strategic step toward ensuring appropriate clinical practice for image quality assessment could include providing arenas where radiologists and radiographers can engage in cross-disciplinary discussions. This could help to align the two groups of clinicians' attitudes regarding what images to keep and which to reject. Further research that builds on this study and previous research should aim to test the effect of such strategic measurements. This could facilitate for reduction in radiation dose and increase image quality in plain X-ray examinations in concordance with ALARA, and underpin clinicians experience of working together towards the common goal of providing high quality imaging service.

Conflict of interest statement

The authors declare that they have no competing interests.

Data statement

The research data is confidential.

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