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Reject analysis in digital radiography: A local study on radiographers and students' attitude in Iran

Sajjad Rastegar[1, 2], Jalal Beigi[1, 2], Ehsan Saeidi[1, 2], Ali Dezhkam[1, 2], Tofigh Mobaderi[3], Hamed Ghaffari*[4,5], Ali Mehdipour[2], Hamid Abdollahi*[6]

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Abstract

Reject analysis is as a quality indicator and critical tool for dose and image quality optimization in radiology departments. By reducing image rejection rate (RR), radiation dose to patients can be reduced effectively, yielding increased total cost-effectiveness. The aims of this study were to assess the rate of image rejection at 2 direct digital radiography (DR) departments to find the sources of rejection and to observe how radiology students and radiographers deal with image rejection.

Two radiology departments were surveyed during a 3-month period for all imaging procedures. Type of examination, numbers, and reasons for digital image rejection were obtained by systems and questionnaire. A predefined questionnaire, including 13 causes for rejection, was filled by radiographers and students.

Out of the 14 022 acquired images, 1116 were rejected, yielding an overall RR of 8%. Highest RRs were found for examination of cervical spine and lumbosacral. Positioning errors and improper patient preparation were the main reasons for digital image rejection.

The image RR was small, but there is a need for optimizing radiographic practice, and enhancing radiographer's knowledge may enhance the performance.

Keywords: Digital radiography, Image rejection, Quality assurance, Radiation safety

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Introduction

Film reject analysis (RA) has been considered as an important component of quality assurance (QA) program in radiology departments for many years (1). Also, film RA is used to determine the extent to which as low as reasonably achievable (ALARA) principle is adhered in radiology units (2). Reject/retake of diagnostic x-ray images impose several important consequences within radiological imaging, including an unnecessary radiation exposure to patient, occupational costs such as radiology staff time, the cost of purchasing and maintaining processing chemicals, and the cost of purchasing x-ray films (3-6). In film-based radiology departments, reject/retake rates range between 10% and 15% (5), and the most important reason can be attributed to incorrect exposure conditions owing to limited dynamic range of screen/film systems. However, the advent of new radiological technologies, such as

Corresponding author: *Dr Hamid Abdollahi, hamid_rbp@yahoo.com*
Hamed Ghaffari, hamedghaffari@yahoo.com

1. Student Research Committee, Paramedical Faculty, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
2. Department of Radiology Technology, Paramedical Faculty, Rafsanjan University of Medical Sciences, Rafsanjan, Iran
3. Department of Biostatistics, School of Health, Iran University of Medical Sciences, Tehran, Iran
4. Department of Medical Physics, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
5. Student Research Committee, School of Medicine, Iran University of Medical Sciences, Tehran, Iran
6. Department of Radiologic Sciences and Medical Physics, Faculty of Allied Medicine, Kerman University of Medical Sciences, Kerman, Iran

↑What is "already known" in this topic:
Film reject analysis is a main component of quality assurance program at a film-based radiology department. The number of rejected films can be an indicator of image quality, and it also shows that as low as reasonably achievable (ALARA) principle is adhered in radiology units. The rejection rate of images can reduce with digitalization of medical images.

→What this article adds:
With the advent of new radiology technologies, such as direct digital radiography, the rejection rate of images did not fall to zero. Positioning errors and improper patient preparation were main reasons for rejection.

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computed radiography (CR), direct digital radiography (DR), and the digitalization of medical imaging, can reduce the reject/retake rates. Studies have shown that even with digitalization of medical imaging, the rejection rate did not fall to zero due to mispositioning, improper collimation, examining a wrong patient, wrong exposures, etc. (7). In recent years, many studies have been published on RA in digital radiology for QA and on reducing unnecessary radiation exposure, processing, and occupational costs. Studies have shown that rate of image rejection has been decreased by digital systems and many of source of errors have been eliminated (5, 8).

A study by Khafaji et al obtained a RR of 15% in DR departments (3). Foos et al reported a RR of 4.4% in CR departments that seem to be an optimized value (9). In another study, Andersen et al evaluated radiographer reasons for image rejection and found that positioning errors has the highest reason for image rejection in DR departments and reported a RR of 12% (6).

In Iran, in addition to radiographers who work alone or as a team, radiology technology students are trained in academic hospitals under the supervision of expert and experienced trainers. They perform imaging procedures in their last 2 years of education course. Students have a scientific relationship with radiographers and learn from them. Although student's imaging is supervised by their trainers, they may reject images alone. However, radiographers can independently make a decision to reject images.

In the present study, it was aimed to assess the rate of image rejection at 2 direct DR departments, to find the sources of rejection, and to observe how radiology students and personnel deal with image rejection. This study was conducted in 2 academic general hospitals in Rafsanjan, a city in southeast of Iran. To the best of our knowledge, no similar study has been done in Iran.

This prospective study was approved by the ethics committee of Rafsanjan University of Medical Sciences. Also, permission was obtained from the Head of Radiology Departments. No repeats were taken for the purpose of the present study. Also, patients' information was not recorded.

Data for reject analysis were collected during a 3-month period (July-September 2017) from 2 direct DR departments at 2 local hospitals in Rafsanjan, Iran. Both hospitals were general and perform all radiology examinations for outpatients and hospitalized patients. These hospitals are operative 24/7. The x-ray laboratories that were included in the present study had similar equipment (installed 2007, X-ray tube by Sedecal, model Millennium Plus, with detector model DRX-CS wireless (43 × 43 cm)).

In these departments, radiology personnel work as team or alone; and students are trained under the supervision of 3 expert trainers. The staffs decide to keep or reject images immediately after exposure alone or consult with one another. Image rejections for students are based on trainers' decision directly or consulting with experienced personnel. All rejected and accepted images were sent to Picture Archiving and Communication System (PACS) and were recorded along with the name of the relevant radiographer.

To analyze image RR and main its causes, all rejected images were counted and the relevant radiographer was questioned. To simplify RR analysis, 13 predefined causes, including artifacts caused by jewelry, wrong use of the equipment, artifacts caused by equipment errors, poor inspiration, incorrect information in the referral, low dose, patient motion, positioning errors, additional picture, and improper patient preparation were provided. To analyze radiographers and students' attitudes against image rejection, a questionnaire was distributed to them (Table 1). Also, the items listed in the rejection causes and questionnaire (Table 1) were developed based on existing literature (3, 4, 6, 8). Radiographers and students participated in the present study voluntarily.

A total of 14 022 digital images were taken during a 3-month period. Of them, 1116 were rejected during this period (Table 2). The number of acquired images, rejected images, and the RRs for the different imaging examinations are presented in Table 2. The results showed an overall RR of 8%. The chest, knee, ankle, pelvic, foot and wrist, as most frequently occurring examinations, had reject rates of 5%, 4%, 0%, 17%, 3% and 3%, respectively.

A total of 18 personnel and 27 students completed the questionnaire on rejection attitude. The answers to the questions are summarized in Table 1. About 6% of the personnel had less than 1 year and 17% had more than 10 years of radiography experience. About 66% of radiographers had a range between 1 and 5 years of radiography experiences.

Moreover, 78% of personnel reported that they have enough experience to reject the images and 22% believed that it is always easy to select a reason for rejection (Table 1). However, 72% of students reported that they have enough experience to reject the images and 18% believed that it is always easy to select a reason for rejection. Nevertheless, only 15% of students rejected images without their trainers' decision or personnel support.

The distribution of identified reasons for image rejection is outlined in Table 1. In response to scenarios of suboptimal image quality, the selection of reasons by both radiographers and students had a large variety, and positioning errors and improper patient preparation were the main reasons for rejection. As displayed in Table 1, 67% and 70% of the personnel and students expressed that they have not worked with automatic exposure control (AEC)–an x-ray exposure termination device, respectively.

A brief discussion on results and comparison with similar studies in the world

To the best of our knowledge, this was the first study on digital image rejection analysis in Iran. The total number of rejected images during the study period was 1116 and the overall RR was 8%, which can be considered as an acceptable RR. The reject rate obtained from this study is in line with reject range obtained from similar studies in digital departments. With a CR system, a RR of 6.6% and 7.3% were reported (4, 10). In good agreement with both

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Table 1. Question and scenarios given to radiographers to assess variation in the selection of the reasons for rejection

Questions	Alternatives	Radiographer		Student	
		Answers frequency	Answer percent	Answers frequency	Answer percent
How many years have you been working as a radiographer?	<1	1	6	-	-
	1-5	12	66		
	5-10	2	11		
	>10	3	17		
What is your opinion of reject analysis?	Good	1	6	2	7
	Not so good	13	72	18	67
	Bad	4	22	7	26
	Do not know	0	0	0	0
Is it easy to select a reason for rejection?	Yes, it is always easy	4	22	5	18
	No, sometimes it is difficult	13	72	16	60
	No, it is always difficult	1	6	5	18
	Have never selected a reason for rejection	0	0	1	4
Do you feel that you have received adequate training for performing rejection analysis?	Yes	14	78	20	74
	No	4	22	7	26
Do radiology students reject radiographs by themselves or with the help of their trainers or personnel?	Alone	-		4	15
	With trainer/personnel	-		23	85
What reason would you choose for rejecting the images in the following scenarios?					
You forgot the required angularity of the tube for a specific procedure.	Positioning error	11	61	16	59
	Image artefacts	3	17	4	15
	Improper patient preparation	3	17	5	18
	Additional image	1	5	2	8
You have taken a chest x-ray of an elderly audio-impaired man. The patient was unsteady during the examination and the resulting image showed poor inspiration and the left sinus was not projected.	Positioning error	4	22	6	22
	Poor inspiration	13	72	18	67
	Patient movement	1	6	3	11
An image of a young child being held by its parent is acquired. In the obtained image the parents' fingers are projected onto the image.	Positioning error	0	0	0	0
	Image artefact	0	0	2	8
	Patient movement	4	22	8	30
	Improper patient preparation	7	39	9	31
	Additional picture	7	39	9	31
As part of the follow-up of a patient with a shoulder fracture an x-ray image is acquired. Prior to the examination the previous images are not reviewed. The image reveals a more distal fracture and a new image using a humorous procedure is required.	Positioning error	1	6	2	7
	Improper patient preparation	4	22	5	18
	Incorrection information in the referral	13	72	20	75
A lateral chest x-ray is acquired using automatic exposure control (AEC). Due to the presence of soft tissue within the field of view the image is underexposed.	Positioning error	0	0	0	0
	Artefacts	1	6	0	0
	Low dose	5	27	8	30
	I don't work with AEC	12	67	19	70

Honea and Andersen's findings, the present work revealed that the main cause for rejection was mispositioning (6, 7).

In this study, it was found that digital image rejection is a challenging issue and it is not easy to find a feasible reason to reject images. Although the radiographers responded to all answers, there was a lack of knowledge among them to find a reasonable cause for image rejection. On the other hand, the student's response to image rejection analysis was strongly dependent on their trainers, and only a few students could reject the images alone.

There are several reasons for image rejection, including positioning errors, image artefacts, improper patient preparation, and additional images. In addition, wrong exposure is considered as a reason for image rejection which alters imaging features as biomarkers for various clinical applications (11). In this study, the results revealed that the amount of image rejection may change based on the work experience of radiographers and patients' characteristics. Previous studies have also indicated that RRs change by patient population, type of examination performed, the equipment used, how the rejections are registered, and the skills of the radiographers (7, 12-14).

The results showed a low RR in many of examinations which indicates that there is no urgent need for optimizing radiographic practice. As shown in Table 2, the most rejected examinations were cervical spine and lumbosacral. Based on our experience, inappropriate positioning is the most cause of rejection in both cases with direct DR system. Therefore, radiographers at 2 centers may need more training in both examinations (cervical spine and lumbosacral). In the present study, more than 94% of radiographers had more than 1 year of work experience, which could be the reason for low RR. Our data showed that RR was less than previous studies in film-based departments, and the current study confirms that image digitalization can reduce RR (7).

In this study, radiology students' attitude for image rejection was in line with that of the personnel. Although they were under training and not allowed to make independent decisions, it seemed that they had enough and good knowledge to reject the images.

Authors have considered several limitations for this study. First, there was no audit for image analysis and radiographers evaluated the image and the reason for re-

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Table 2. Rejects during a 3-month period in radiology centers

Examination	Images (n)	Rejected images (n)	Rejection rate* (%)
Abdomen	432	90	21
Elbow	774	27	3
Ankle	1656	0	0
Pelvic	1611	270	17
Cervical spine	351	162	46
Foot	1602	45	3
Hip	198	9	5
Hand	783	18	2
Wrist	1350	45	3
Knee	2007	90	4
Lumbosacral	387	171	44
Shoulder	585	0	0
Chest	3456	189	5

* Rejection rate (RR) for individual organ examinations was calculated by dividing the number of rejected images by the total number of acquired images

jection, which might have affected the results. Second, the number of radiographers and departments evaluated were small. Thus, further study with large data may result in better performance and RR analysis. Third, the radiographers could remove images directly and not send them to PACS. In this situation, a specific software may improve the results.

In conclusion, a RR of 8% was found for digital radiography in this study. Also, the results showed that RR is comparable to that of previous studies; however, the cause of rejection may be different. Positioning errors and improper patient preparation were the main reasons for rejection. Highest RRs were found for cervical spine and lumbosacral examinations, and thus further optimization may be required. Moreover, it was found that radiographers varied in image rejection decision making, and this study suggests a regular reject analysis as a part of QA program at radiology departments.

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Conflict of Interests

The authors declare that they have no competing interests.

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