

Radiographic Quality Assurance and Patient Radiation Safety: A Repeat and Reject Analysis of Plain Radiographs at a Tertiary Hospital in Kano, Nigeria

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ABSTRACT

Background: Rejected radiographs necessitate repeat examinations, thereby increasing patient radiation dose, operational costs, waiting times, and occupational exposure for personnel. Film reject analysis (FRA) is an essential quality control tool in conventional medical imaging departments that provides valuable assessment of imaging quality and patient dose.

Methods: A prospective cross-sectional study was conducted over a six-month period at a tertiary hospital. A total of 3,021 plain radiographic films were examined, of which 193 were rejected. Rejected radiographs were collected daily and analysed weekly by senior radiographers using a viewing box. Data on film size, examination type, patient age group, and cause of rejection were recorded on a data capture sheet. Data were analysed and computed.

Results: The overall film reject rate was 6.39% (95% confidence interval: 5.57%–7.32%). The lumbosacral spine radiographs had the highest number of rejected films (n = 38, 19.7%), while the abdominal radiographs had the lowest (n = 1, 0.5%). The commonest causes of rejection were overexposure (n = 57, 29.5%) and underexposure (n = 53, 27.5%). The most frequently rejected film sizes were 35 × 35 cm (n = 69, 35.8%) and 35 × 43 cm (n = 62, 32.1%). Adults accounted for 172 (89.1%) of rejected films, compared with 21 (10.9%) for paediatric patients.

Conclusion: The overall reject rate of 6.39% exceeds the 5% threshold recommended by the World Health Organization. Overexposure and underexposure were the predominant causes of rejection. These findings underscore the need for strengthened quality assurance programs, including technique chart implementation, equipment quality control testing, and regular reject analysis monitoring at the study facility.

Keywords: *Film reject analysis; quality assurance; radiography; repeat rate; patient radiation do*

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Introduction

Every diagnostic radiograph represents a delicate balance between image quality and patient safety.¹ A rejected radiographic image that fails to provide the necessary anatomical information for clinical decision-making triggers a cascade of consequences such as unnecessary radiation exposure, increased departmental costs, prolonged waiting times, and heightened occupational risk for staff.^{2,3} For an image to be considered diagnostic, it must demonstrate the anatomy under examination, include appropriate anatomical markers, and contain accurate patient identifiers and examination dates.⁴ Film reject analysis (FRA) is a structured programme for evaluating rejected radiographs to identify patterns, causes, and trends in image rejection. It serves as a fundamental component of quality assurance (QA) programmes in diagnostic radiology departments.^{3,5} The primary goal of QA in diagnostic imaging is to produce consistently high-quality radiographs with the minimum radiation exposure necessary.⁵ Through systematic reject analysis, departments can identify weaknesses in radiographic technique, equipment performance, and processing protocols, enabling targeted interventions to improve practice.⁶

Despite the global transition toward digital imaging, conventional radiography remains an essential diagnostic modality worldwide, particularly in low- and middle-income countries where they continue to serve as the backbone of basic imaging services.⁷ However, poor-quality radiographs leading to repeat examinations remain a significant concern, increasing costs, radiation exposure, waiting times, and diagnostic delays.² The International Commission on Radiological Protection (ICRP) recommends that medical exposures should be kept as low as reasonably achievable (ALARA), and film reject analysis is a practical approach to achieving this objective.⁸ The Conference of Radiation Control Program Directors

(CRCPD) Committee on Quality Assurance suggests that facilities should strive for a repeat rate not exceeding 5–7%,⁹ while the World Health Organization (WHO) recommends a permissible reject rate of 5%.¹⁰

Despite the established importance of reject analysis, data from sub-Saharan Africa, and particularly from Northern Nigeria, remain limited. This study was therefore conducted to determine the plain radiographic rejection rate and to identify the main causes of rejection according to examination type, film size, and patient age group.

Methodology

This prospective cross-sectional study was conducted at the National Orthopaedic Hospital, Dala, Kano State, Nigeria, over a six-month period from July to September 2019. The hospital is a tertiary specialist orthopaedic facility serving patients from Kano State and surrounding regions. All conventional (analogue) plain radiographic films exposed for diagnostic purposes during the study period were included using a consecutive sampling method, whereby all rejected plain radiographs were collected prospectively. Radiographs of diagnostic quality, digital radiographs, and contrast studies were excluded. Ethical approval for this study was obtained from the Research Ethics Committee of the National Orthopaedic Hospital, Dala (Reference No: NOHD/REC/2019/047), and permission to conduct the research was sought from the hospital management. All rejected radiographs were handled confidentially and stored securely in the hospital archives after analysis.

The instruments for data collection included a structured data capture sheet, a film bin for gathering rejected radiographs, and a viewing box. Rejected radiographs were collected on a daily basis from three conventional diagnostic rooms. Films rejected by attending radiologists or senior radiographers were analysed weekly using a viewing box under standardised room lighting and temperature conditions by two

senior radiographers. The following variables were recorded for each rejected film: radiographic examination type (body part imaged), film size, patient age group (adult or paediatric), and cause of rejection. Causes of rejection were classified into the following categories: overexposure, underexposure, double exposure, positioning error, fog, motion blur, artifact, cut-off, equipment fault, and processing fault. To ensure consistency in the classification of rejection causes, a random sample of 20% of the rejected films was independently reviewed by two senior radiographers. Inter-rater agreement was assessed using Cohen's kappa coefficient ($\kappa = 0.84$), indicating substantial agreement.¹¹ Discrepancies were resolved by consensus discussion before final classification. Data were entered into Microsoft Excel 2007 and analysed using Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics, including frequencies and percentages, were computed. The film reject rate was calculated as: (Number of rejected films / Total number of films used) $\times 100$. The 95% confidence interval for the overall reject rate was computed using the Wilson score method.

Results

A total of 3,021 radiographic films were exposed during the study period, of which 193 were rejected. The overall film reject rate was 6.39% (95% confidence interval: 5.57%–7.32%).

Figure 1 shows Adult patients accounted for the majority of rejected radiographs ($n = 172$, 89.1%), while paediatric patients accounted for 21 (10.9%) of rejections.

Distribution of Rejected Radiographs by Age Group (n = 193)

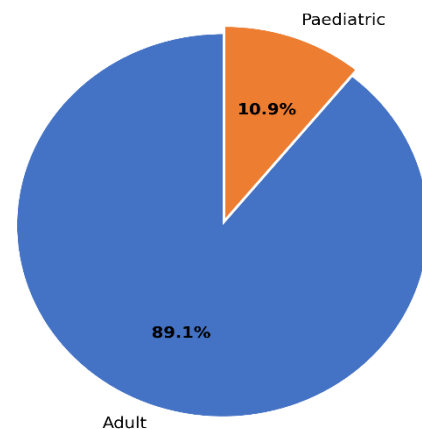


Figure 1. Distribution of rejected radiographs by age group (n = 193)

Table 1 presents the distribution of rejected films according to radiographic examination type. The lumbosacral spine had the highest number of rejected films ($n = 38$, 19.7%), followed by the chest ($n = 27$, 14.0%) and the leg ($n = 22$, 11.4%). The abdomen had the lowest reject rate ($n = 1$, 0.5%).

Examination Type	Frequency (n)	Percentage (%)
Shoulder	6	3.1
Arm	6	3.1
Forearm	2	1.0
Elbow	8	4.1
Hand	2	1.0
Thigh	11	5.7
Knee	18	9.3
Leg	22	11.4
Ankle	2	1.0
Foot	3	1.6
Hip	7	3.6
Pelvis	17	8.8
Abdomen	1	0.5
Cervical spine	11	5.7
Thoracic spine	10	5.2
Lumbar spine	38	19.7
Chest	27	14.0
Skull	6	3.1
Total	193	100.0

Table 1. Distribution of rejected films according to radiographic examination type

Table 2 shows the distribution of rejected films according to the stated cause of rejection. Overexposure was the most common cause ($n = 57$, 29.5%), closely followed by underexposure ($n = 53$,

27.5%). Equipment fault accounted for 21 (10.9%) of rejected films, while fog and cut-off were responsible for 17 (8.8%) and 14 (7.3%) rejections, respectively. Motion blur was the least common cause ($n = 1$, 0.5%).

Cause of Rejection	Frequency (n)	Percentage (%)
Overexposure	57	29.5
Underexposure	53	27.5
Double exposure	3	1.6
Positioning error	3	1.6
Fog	17	8.8
Motion blur	1	0.5
Artifact	10	5.2
Cut-off	14	7.3
Equipment fault	21	10.9
Processing fault	12	6.2
Others	2	1.0
Total	193	100.0

Table 2. Distribution of rejected films according to cause of rejection

Table 3 shows the most frequently rejected film sizes were 35 x 35 cm ($n = 69$, 35.8%) and 35 x 43 cm ($n = 62$, 32.1%), followed by 24 x 30 cm ($n = 30$, 15.5%) and 30 x 40 cm ($n = 29$, 15.0%). The 18 x 24 cm size had the lowest rejection rate ($n = 3$, 1.6%).

Film Size	Frequency (n)	Percentage (%)
18 x 24 cm	3	1.6
24 x 30 cm	30	15.5
30 x 40 cm	29	15.0
35 x 35 cm	69	35.8
35 x 43 cm	62	32.1
Total	193	100.0

Table 3. Distribution of rejected films according to film size

Table 4: compares the overall reject rate from the present study with those reported in previous studies from various countries. The reject rate of 6.38% in the present study falls within the range reported in similar

studies conducted in Nigeria and other developing countries.

Study	Location	Reject Rate (%)
Present study	Kano, Nigeria	6.38
Teferi et al. (2008)	Addis Ababa, Ethiopia	4.94
Jwanbot et al. (2017)	Jos, Nigeria	7.30
Jabbari et al. (2012)	Urmia, Iran	7.20
Benza et al. (2018)	Windhoek, Namibia	8.00
Akintomide et al. (2011)	Calabar, Nigeria	8.86
Joseph et al. (2015)	Bauchi, Nigeria	9.62
Usha et al. (2014)	Delhi, India	22.12
Sadiq et al. (2017)	Maiduguri, Nigeria	29.34

Table 4. Comparison of overall reject rates with previous studies

Discussion

This study assessed the rate and causes of plain radiograph rejection at the National Orthopaedic Hospital, Dala, over a three-month period. The overall reject rate of 6.39% (95% CI: 5.57% - 7.32%) exceeds the 5% threshold recommended by the WHO¹⁰ but falls below the 10% upper limit suggested by the CRCPD Committee on Quality Assurance.⁹ The finding is consistent with previous studies conducted in Nigeria, including reports from Calabar (8.86%)¹², Jos (7.3%)¹³, and Bauchi (9.62%).¹⁴ The lower rates reported in Ethiopia (4.94%)¹⁵ and Ghana (5.6%)² may reflect differences in departmental quality assurance infrastructure, equipment maintenance protocols, or categorisation schemes for causes of rejection.

The reject rate of 6.39% in the present study falls within the range reported in similar studies conducted in Nigeria and other developing countries (table 4), though it remains higher than the WHO benchmark. The wide variation in reported reject rates ranging from 4.94% in Ethiopia to 29.34% in Maiduguri Nigeria, highlights the influence of local contextual factors, including equipment age, maintenance schedules, radiographer training, and the presence of formal QA programmes.³ Notably, the highest reported rates originate from facilities with predominantly conventional radiography systems and limited QC infrastructure, underscoring the vulnerability of analogue imaging to

technique and processing errors. The present study's rate positions the National Orthopaedic Hospital, Dala, within the moderate-risk category, suggesting that while the department does not face a crisis-level rejection burden, systematic quality improvement is warranted to approach the 5% target.

Overexposure (29.5%) and underexposure (27.5%) were the predominant causes of rejection in this study, collectively accounting for 57% of all rejected films. This finding is consistent with previous reports from Bauchi¹⁴, Jos¹³, and Ghana², where exposure errors were similarly identified as the leading causes of rejection. The high prevalence of exposure errors may be attributable to several factors: the absence of standardised exposure technique charts in the study facility, variation in radiographer experience with manual exposure selection, and failure to account for individual patient body habitus when selecting exposure parameters.¹⁶ The lack of a formal quality control programme for X-ray equipment may also contribute to inconsistent output, leading to unpredictable exposure results.

The lumbosacral spine had the highest rejection rate (19.7%), which is consistent with the findings of Akintomide et al.¹² in Calabar, who reported that the lumbosacral spine accounted for the highest proportion of rejected films. The relatively high rejection rate for lumbosacral and chest examinations may reflect the technical challenges associated with imaging thicker body parts, where optimal exposure factor selection is more critical. In contrast, the low rejection rate for abdominal radiography (0.5%) may be due to the limited number of such examinations performed at this orthopaedic-specialist facility.

The predominance of rejections among adult patients (89.1%) compared with paediatric patients (10.9%) is consistent with the study by Alyousef et al.⁴ in Saudi Arabia, where adults accounted for 60% of rejected films. The higher rejection rate

among adults at the present facility is likely attributable to the hospital's specialist orthopaedic focus, which predominantly serves adult patients presenting with musculoskeletal trauma and degenerative conditions. Additionally, the larger body habitus of adult patients presents greater technical challenges in achieving optimal exposure, particularly when technique charts are unavailable.¹⁶

The 35 × 35 cm and 35 × 43 cm film sizes accounted for the majority of rejections (67.9% combined). This is consistent with the findings of Teferi et al.¹⁵ in Ethiopia, who reported that larger film formats had the highest rejection rates. The predominance of these sizes reflects their routine use for examinations of the spine, chest, and pelvis, which together constitute a substantial proportion of the workload at an orthopaedic hospital.

The findings of this study have important implications for radiation protection practice. A reject rate above the WHO-recommended threshold indicates that a notable proportion of patients at this facility are receiving unnecessary additional radiation exposure from repeat examinations. Implementation of systematic quality assurance measures, including the introduction of exposure technique charts, regular equipment quality control testing, and periodic reject analysis monitoring, would be expected to reduce the reject rate and optimise patient doses in line with the ALARA principle.^{3,9}

Conclusion

Conventional radiography remains indispensable in many clinical settings, yet its clinical value is contingent upon disciplined quality assurance. This study establishes a local baseline for image rejection at a tertiary orthopaedic facility in Northern Nigeria, highlighting systemic opportunities for dose optimisation and practice improvement. Rather than viewing reject analysis as an isolated audit, departments should integrate it into a continuous quality cycle one that links equipment performance, technique

standardisation, and staff competency directly to patient safety outcomes. Institutionalising these measures will align local practice with international radiation protection standards while enhancing diagnostic throughput and resource stewardship. The framework proposed here offers a replicable model for similar facilities seeking to transition from reactive error correction to proactive quality governance.

Limitations

The study was conducted at a single specialist orthopaedic hospital, limiting the generalisability of findings to general hospitals or other healthcare settings. Second, the study did not quantify the economic costs associated with rejected films or the additional radiation doses received by patients from repeat examinations.

Recommendations

Based on the findings of this study, it is recommend that the department should establish a formal Quality Assurance Committee with responsibility for planning, monitoring, and evaluating quality improvement initiatives. In addition, standardised exposure technique charts should be developed and made available in each diagnostic room, tailored to specific body parts and patient body habitus.

Conflict of Interest The authors declare that they have no conflicting interests.

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