Vol-3 Issue-1 2025
Scientific Research Journal of Medical and Health Science
ISSN: 2584-1521, Peer Reviewed Journal

Improving adequacy of orthopaedics lumbosacral spine X-rays and minimizing re-exposure rates: A study in a tertiary hospital

Suman Kumar Basel, KIST Medical College and Teaching Hospital
Pramod Bhandari, KIST Medical College and Teaching Hospital
Gaurav Bir Bajracharya, KIST Medical College and Teaching Hospital
Shriraj Shrestha, KIST Medical College and Teaching Hospital

Abstract

Background

Lumbosacral spine (LS) X-rays are essential diagnostic tools in orthopaedic and spinal practice, aiding in the evaluation of conditions such as trauma, degenerative diseases, infections, and deformities. However, inadequate imaging can lead to diagnostic uncertainty, repeat radiographs, increased radiation exposure, delayed clinical decision-making, and unnecessary healthcare costs. This audit aimed to assess the adequacy of LS spine X-rays ordered by the Orthopaedics Department in a tertiary hospital, identify factors contributing to poor-quality imaging, and implement interventions to reduce re-exposure rates.

Aim

This study aimed to improve adequacy rates of Orthopaedic lumbosacral spine X-rays and decrease re-exposure rates.

Methods

This was a three-phase observational audit conducted over 1 year at a tertiary hospital, evaluating all lumbosacral spine X-rays ordered by the Orthopaedics Department. Each phase lasted three months, followed by stakeholder meetings to review findings and implement interventions. Image adequacy was assessed using predefined radiographic criteria based on international guidelines. Interventions included radiographer training, standardized imaging protocols, and a quality control checklist. The primary outcome was the proportion of adequate X-rays, while the secondary outcome was the re-exposure rate. Data were analysed using descriptive statistics (percentage change) to assess improvements across phases.

Results

The adequacy of image improved significantly from 82.5% at the first phase to 95.1% in the final phase, and re-exposure rates dropped from 3.125% to 0%.

Keywords: Lumbosacral spine, Radiograph adequacy, Clinical audit, Re-exposure, Quality improvement

---

Introduction

Lumbosacral spine (LS) radiographs are commonly requested by orthopaedic surgeons for evaluating lower back pain, trauma, degenerative disorders, and spinal deformities(1,2). The diagnostic value of these X-rays heavily depends on image quality, which must meet defined anatomical and technical standards. Inadequate imaging can obscure key spinal structures, necessitate repeat exposures, increase radiation dose, delay diagnosis, and elevate healthcare costs(3,4). Despite established imaging protocols and guidelines, such as those from the

Royal College of Radiologists (RCR) and institutional radiographic standards, inconsistencies in image adequacy and frequent re-exposures remain a concern in clinical practice.

This clinical audit was conducted in a tertiary care setting to assess the adequacy of LS spine X-rays ordered by the Orthopaedics Department, identify common reasons for inadequacy, and implement corrective measures. Through a structured three-phase audit cycle with stakeholder involvement, this study aimed to improve the adequacy of X-rays up to 95% and minimize the re-exposure rate to 1% over 1 year.

Methodology

Study Design

This was a three-phase observational clinical audit assessing the adequacy of lumbosacral spine (LS) X-rays ordered from the Orthopaedics Department in a tertiary hospital. The audit aimed to evaluate image quality, identify factors contributing to inadequate imaging, and implement targeted interventions to reduce re-exposure rates.

Study Setting

The study was conducted in the Radiology and Orthopaedics Departments of a tertiary hospital, where lumbosacral spine X-rays were performed based on clinician requests.

Sampling method and size

A convenient sampling method was used. The total sample size was 373, with 160 in the first phase, 111 in the second phase, and 102 in the third phase.

Study Phases and Data Collection

The audit was conducted in three consecutive phases, with each phase lasting 3 months:

1. Phase 1 (Baseline Audit)

All lumbosacral spine X-rays ordered by the Orthopaedics Department were retrospectively evaluated, and adequacy was assessed using predefined radiographic criteria based on hospital imaging protocols and international guidelines. Images were classified as adequate or inadequate, with reasons for inadequacy documented. The re-exposure rate was calculated by identifying cases requiring repeat imaging.

2. Phase 2 (Intervention and Reassessment)

Findings from Phase 1 were presented to key stakeholders, including orthopaedic surgeons, radiologists, radiographers, and hospital administrators, during a multidisciplinary meeting. Agreed-upon interventions were implemented, which included:

- Implement a position chart to ensure standardized positioning for each X-ray
- Ensure exposure settings are tailored to the specific person and position requirements to capture the entire lumbar-sacral spine adequately.
- Strive to obtain a perfect image by focusing on the visibility of vertebral bodies, symmetrical transverse processes, and absence of bilateral shadows on the third lumbar spine, and if required, repeat the x-ray after adjusting the setting and position of the patient.
- Consider the patient's size when positioning and the size of the image plate for optimal image quality.
- Aim to achieve high-quality images by utilizing a Digital Radiography (DR) system, which can enhance image clarity.

After implementing these interventions, a second three-month audit cycle was conducted using the same evaluation criteria.

3. Phase 3 (Final Evaluation and Sustained Improvement)

Another stakeholder meeting was held to assess improvements after Phase 2. Additional refinements were made based on findings. A final three-month audit cycle was conducted to evaluate the long-term impact of the interventions.

Audit Standards and Criteria for Image Adequacy

Radiographic adequacy was assessed using the following criteria (5):

AP view parameters

A: Exposure from T11/T12 to sacral region

B: Vertebral bodies at the centre with symmetrical transverse process

C: Intervertebral joint clearly visible

D: Upper and lower margin shadow of the 3rd lumbar spine

Lateral view parameters

E: Exposure from T11/T12 to sacral region

F: Sciatic notch, superior articular surface, upper and lower endplate overlap

G: Sufficient penetration to show trabecular and cortical bone

H: Upper and lower margin shadow of the 3rd lumbar spine.

Outcome Measures

- Primary Outcome:
  - Proportion of adequate LS X-rays in each phase.
- Secondary Outcomes:
  - Re-exposure rate (percentage of patients requiring repeat X-rays).

Inclusion criteria

All patients undergoing X-ray for an Orthopaedic problem.

Exclusion criteria

None

Data Analysis

Descriptive statistics were used to compare the percentage of adequate X-rays across the three phases. The effectiveness of interventions was evaluated based on reductions in re-exposure rates and improvements in compliance with imaging standards. Data was analysed using SPSS v16.

Result

The audit was conducted in three phases, each lasting three months, to evaluate and improve the adequacy of lumbosacral spine (LS) X-rays and reduce re-exposure rates through structured interventions. A total of 373 LS spine X-rays were analysed over the year.

Phase 1: Baseline Audit
In the first phase, 160 LS X-rays were retrospectively reviewed to establish a baseline for adequacy and re-exposure. Of these, 82.5% were deemed adequate according to predefined radiographic criteria. The remaining 17.5% were inadequate, with the most common issue being improper centering of vertebral bodies and asymmetric transverse processes (Figure 1). This issue was captured under Parameter B of the adequacy checklist. Other reasons included limited exposure ranges and insufficient visibility of anatomical landmarks, particularly at the T11/T12 and sacral ends, which are crucial for complete diagnostic evaluation.

Additionally, 3.125% of the cases required re-exposure due to poor image quality or incomplete anatomical coverage. These repeat exposures contribute to increased patient radiation dose and workflow inefficiencies.

Phase 2: Post-Intervention Audit
Following the implementation of corrective measures, including positioning charts, individualized exposure settings, and reinforced training, the second audit phase evaluated 111 X-rays. The adequacy rate increased significantly to 91%. Notably, there were no cases of re-exposure in this phase. Improvements were most prominent in Parameters B and C, indicating enhanced centering and visibility of intervertebral joints (Figure 1). These gains validated the positive impact of stakeholder involvement and intervention protocols.

Phase 3: Sustained Improvement and Final Evaluation
The final phase included 102 X-rays and demonstrated further improvement, with 95.1% adequacy, exceeding the original target. No re-exposures occurred in this phase, confirming the sustainability of the implemented changes. While most parameters showed improvement or stability, Parameter H (visibility of the third lumbar spine margin in the lateral view) showed a slight decline in adequacy (Figure 1). This may suggest a need for ongoing technical refinement or more precise positioning adjustments, especially in patients with larger body habitus or spinal curvature.

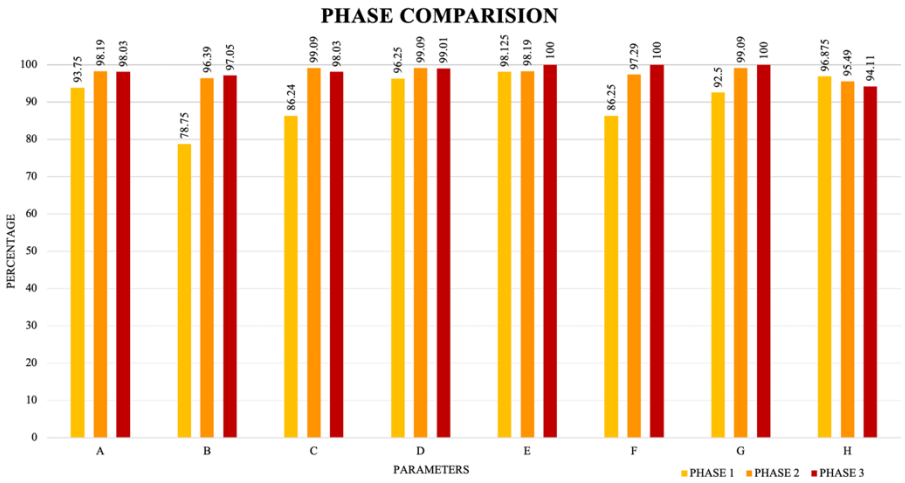

Figure 1: Bar diagram showing comparison between adequacy of different parameters of LS-spine X-rays during different phases of the study.

Comparative Summary
Throughout the audit, progressive improvements were observed across all radiographic adequacy parameters. Parameter B remained the leading cause of inadequacy but showed notable improvement from phase to phase. Re-exposure, a significant patient safety concern, was eliminated by the second and third phases. These results indicate a robust and sustainable quality improvement process in radiographic practice. The phased approach, combined with data feedback and multidisciplinary collaboration, proved effective in enhancing both the quality of imaging and patient safety.

These improvements reflect findings from Pazanin et al., who reported a 48% reduction in effective dose and a 24% improvement in image quality with optimal collimation technique (6). Zetterberg and Espeland observed a 46% increase in irradiated field size after the adoption of digital systems, raising concerns about collimation quality (7). Similarly, Ching et al. emphasized structured exposure adaptation systems to mitigate dose creep and image degradation in digital radiography (8).

Discussion

This clinical audit set out to address a common yet critical concern in radiographic practice: the adequacy of lumbosacral spine (LS) X-rays in patients referred by the Orthopaedics Department. Over one year and three audit phases, we observed a meaningful improvement in image quality-from an initial adequacy rate of 82.5% to 95.1%, and notably, a complete elimination of re-exposures by the end of the study.

Improving Image Quality Through Structured Intervention
The audit's success was largely driven by targeted, practical interventions. Simple but impactful changes, such as introducing positioning charts, tailoring exposure settings to individual patients, and emphasizing anatomical landmarks, helped radiographers consistently meet technical standards. These steps were especially important for parameters like the symmetrical positioning of transverse processes, which was identified early on as the most frequent cause of inadequacy.
These findings are in line with earlier studies highlighting technical errors as a key factor in poor radiographic quality. Nol et al. (2005), for instance, found that repeated imaging was often the result of poor positioning or inconsistent technique issues that improved with better training and clearer protocols (6,7).

Eliminating Re-Exposure: A Step Towards Safer Imaging
One of the most encouraging outcomes of our audit was the sharp reduction in re-exposure, from 3.125% in the first phase to 0% in the second and third phases. This not only reflects improved first-time imaging success but also has important implications for patient safety. Studies like those by Simpson et al. (2008) and Alshamrani et al. (2021) have shown that lumbar spine X-rays are associated with relatively high radiation doses compared to other routine radiographs (8,9). Repeating these images unnecessarily adds to cumulative radiation exposure without adding clinical value.
The ability to eliminate repeat imaging within a busy clinical setting demonstrates that radiographic quality and radiation safety are not mutually exclusive but rather go hand-in-hand when guided by evidence-based practices.

Persistent Challenges: Room for Further Refinement
While the audit showed clear improvements overall, some challenges persisted. For example, the visibility of the upper and lower margins of the third lumbar vertebra (Parameter H) declined slightly over the three phases. This could be related to patient body habitus, variability in exposure settings, or limitations in imaging field size.
Research by Chawee et al. (2024) suggests that optimizing filtration (using copper and aluminum) and using automatic exposure control (AEC) can help balance radiation dose and image quality (10). Future audits may consider incorporating these technical refinements into our imaging protocols, especially for patients with larger body sizes.

Reinforcing the Value of Guidelines and Multidisciplinary Collaboration
Our study also reinforces the importance of standardized criteria in evaluating image quality. We adopted structured assessment tools based on international and institutional protocols, similar in spirit to the European Guidelines used by Doktor et al. (2019) (5). These guidelines not only aid in consistent evaluation but also support reproducibility across departments.

A major strength of this audit was the inclusion of multiple stakeholders-orthopaedic surgeons, radiologists, radiographers, and administrators-at each phase. This multidisciplinary collaboration fostered a shared commitment to improvement and ensured that changes were both clinically relevant and practically implementable.

Limitations
This audit was conducted in a single hospital, so the results may not apply everywhere. The relatively short duration of each phase may limit the assessment of long-term sustainability. Since reviewers knew which phase the images came from, some bias is possible. We also didn’t account for patient-related factors like body type or pain, which can affect image quality. Radiation dose wasn’t measured directly, and we didn’t assess how these changes impacted patient experience or clinical decisions. Future studies could benefit from a multicentre design and longer follow-up to assess sustained improvement.

Conclusion

This audit validates that methodical interventions in radiographic technique and quality assurance can enhance image adequacy while minimizing patient radiation risk. The progression from 82.5% to 95.1% adequacy and elimination of re-exposures illustrates a successful quality improvement model. Insights from contemporary literature—including dose audits, collimation studies, and EU regulatory standards—support continued refinement of radiographic practices in alignment with international safety protocols.

In summary, this audit illustrates that systematic, collaborative efforts can meaningfully improve the quality of LS-spine radiographs. By focusing on simple interventions, continuous feedback, and adherence to established standards, we were able to enhance both image adequacy and patient safety within a relatively short timeframe. We recommend ongoing periodic audits and refresher training sessions to maintain these improvements.

Conflict of Interest

None declared.

Author Contributions

Suman K. Basel: Conceptualization and design, Acquisition and analysis of data, Manuscript drafting and review
Pramod Bhandari: Acquisition and analysis of data, Manuscript drafting and review
Gaurav Bir Bajracharya: Acquisition and analysis of data, Manuscript drafting, and review
Shriraj Shrestha: Conceptualization and design, Supervision

Funding

No funding was received for this audit.

Acknowledgments

We would like to express our sincere gratitude to the Department of Radiology for their valuable cooperation and support throughout this audit. Their commitment to quality improvement and active participation in training, protocol development, and feedback discussions were instrumental in achieving the outcomes of this study.

Data Availability Statement

Data available on reasonable request from the corresponding author.

References:

1. A. ESPELAND, G. ALBREKTSEN and J. L. LARSEN: PLAIN RADIOGRAPHY OF THE LUMBOSACRAL SPINE An audit of referrals from general practitioners. Acta Radiologica. 1999, 40:52-9. 10.1080/02841859909174403

2. J G Scavone, R F Latshaw, W A Weidner: Anteroposterior and Lateral Radiographs: An Adequate Lumbar Spine Examination. AJR Am J Roentgenol. . 1981, Apr;136(4):715-7: 10.2214/ajr.136.4.715

3. Jarvik JG, Deyo RA: Diagnostic evaluation of low back pain with emphasis on imaging. Ann Intern Med. 2002, Oct 1;137(7):586-97. 10.7326/0003-4819-137-7-200210010-00010

4. Patel ND, Broderick DF, Burns J et. al.: ACR Appropriateness Criteria Low Back Pain. Journal of the American College of Radiology. 2016, Sep;13(9):1069-78. 10.1016/j.jacr.2016.06.008

5. Doktor K, Vilholm ML, Hardardóttir A, Christensen HW, Lauritsen J: European guidelines on quality criteria for diagnostic radiographic images of the lumbar spine - An intra- and inter-observer reproducibility study. Chiropr Man Therap. 2019, May 1;27:20:10.1186/s12998-019-0241-3

6. Pazanin A, Skrk D, O'Driscoll JC, McEntee MF, Mekis N: Optimal collimation significantly improves lumbar spine radiography. Radiat Prot Dosimetry. 2020, 189:420-7. 10.1093/rpd/ncaa057.

7. Zetterberg LG, Espeland A: Lumbar spine radiography--poor collimation practices after implementation of digital technology. Br J Radiol. 2011, 84:566-9. 10.1259/bjr/74571469

8. Ching W, Robinson J, McEntee M: Patient-based radiographic exposure factor selection: a systematic review. J Med Radiat Sci. 2014, 61:176-90. 10.1002/jmrs.66

9. L González, E Vañó, S Oliete: Report of an image quality and dose audit according to directive 97/43/Euratom at Spanish private radiodiagnostics facilities. British Journal of Radiology. 1999, 72 (854):186-192. 10.1259/bjr.72.854.10365071

10. Teunen D: The European Directive on health protection of individuals against the dangers of ionising radiation in relation to medical exposures (97/43/EURATOM). J Radiol Prot. 1998, 18:133-7. 10.1088/0952 4746/18/2/009

11. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP publication 103.AnnICRP.2007,37:1-332. 10.1016/j.icrp.2007.10.003.

12. Nol J, Isouard G, Mirecki J: Uncovering the causes of unnecessary repeated medical imaging examinations, or part of, in two hospital departments. Journal of Medical Radiation Sciences. 2005, Dec 1;52(3):26-31. 10.1002/j.2051-3909.2005.tb00038.x

13. Wettasinghe MC, Rosairo S, Wickramasinghe ND: Data quality of request forms for lumbar spine X-rays: A clinical audit from a tertiary care hospital in Sri Lanka. Sri Lanka Journal of Radiology. 2023, 31:27-31. 10.4038/sljr.v9i1.118

14. Simpson AK, Whang PG, Jonisch A, Haims A, Grauer JN: The radiation exposure associated with cervical and lumbar spine radiographs. J Spinal Disord Tech. 2008, Aug;21(6):409-12. 10.1097/BSD.0b013e3181568656

15. Alshamrani KM, Alkenawi AA, Alghamdi BN et.al: Patient-Based Dose Audit for Common Radiographic Examinations with Digital Radiology Systems: A Retrospective Cross-Sectional Study. Cureus. 2021, May 13; 13(5):10.7759/cureus.15005

16. Luechabhun C, Prasertdumrongchai S, Pukleeb B, Suwanpradit P, Apipunyasopon L: Optimization of exposure techniques for lumbosacral spine radiographic examination: a phantom. The Thai Journal of Radiological Technology. The Thai Journal of Radiological Technology. 2024, 49(1):103-109.