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Collimation And Radiation Safety: A Comparative Study Of Digital And Analogue Lumbar Spine Imaging

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Abstract
In medical imaging, proper collimation is essential to minimize patient radiation exposure while ensuring diagnostic quality. With the introduction of digital radiography, concerns have arisen that collimation practices may have deteriorated due to the flexibility of digital imaging systems, which can mask excessive collimation. This study aimed to investigate whether collimation practices in lumbar spine frontal radiographs have changed since the adoption of digital radiography. A total of 150 radiographs were included in the study, with 75 images from each of two hospitals. Collimation was assessed by measuring the proportion of the irradiated field outside the area of diagnostic interest (ADI) for both digital and analogue samples. The results revealed that digital samples exhibited significantly larger irradiated areas, with 60.5% of the irradiated field outside the ADI compared to 42% in analogue samples. The mean irradiated field size was also larger in digital samples (791 cm^2) compared to analogue samples (541 cm^2). The study found no significant effect of patient age on the irradiated area outside the ADI, indicating that the observed differences were primarily due to the shift from analogue to digital technology. These findings suggest that digital radiography may inadvertently lead to reduced attention to collimation, thereby increasing patient radiation exposure. Radiography departments should prioritize the enforcement of proper collimation practices despite the flexibility provided by digital imaging systems. Further research is needed to assess the long-term impact of these changes on patient safety and image quality.

Keywords: Digital radiography, analogue radiography, collimation practices, radiation exposure, lumbar spine, area of diagnostic interest (ADI).

Introduction
In medical imaging, it is crucial to minimize patient radiation exposure while maintaining diagnostic quality. One essential practice to achieve this is proper collimation, which ensures that only the area of diagnostic interest (ADI) is irradiated. This is important because the radiation dose increases in proportion to the irradiated area within the field of interest [1, 2]. However, with the advent of digital image processing, programs can mask excessive collimation, making it difficult to discern whether an image has been correctly collimated or edited electronically [3, 4]. As a result, there may be less incentive for practitioners to maintain proper collimation practices. Despite its significance, this issue has not been thoroughly investigated in previous studies [5, 6]. Therefore, the aim of this article is to test the hypothesis

that collimation practices in radiography have declined since the introduction of digital radiography.

Material and Methods

To prevent any temporary changes to collimation practices, the data collection process was completed prior to informing the relevant staff. This approach ensured that the collimation procedures remained unaffected during the study.

Samples

A total of 150 frontal radiographs were included in the study, with 75 from each hospital. There were no alterations in lumbar spine radiography procedures at either hospital during the study period. A study image was eligible if it was taken without fluoroscopic guidance, did not reveal osteosynthesis materials, and involved patients older than 18 years. The radiographs were selected by reviewing envelopes from the last four years before the year 2000, starting from an arbitrary birthdate. Each hospital's sample was continued until the required number of radiographs was reached.

Collimation Assessment

Analog film sizes were measured using a ruler to assess collimation. Neither the radiography rooms' workstations nor the preliminary images provided by the radiography rooms displayed the entire non-masked irradiated field. Physical rulers were used to measure the images on the workstation monitors, which were displayed on reduced-size monitors. The proportion of the irradiated field outside the area of diagnostic interest (ADI) was calculated for both analog and digital images. These proportions were then compared between the digital and analog samples. The ADI was defined based on the literature, standard projection, and measurement guidelines. Specifically, the area was bordered cranially by the S1 vertebra, caudally by the caudal border of the 12th rib, and laterally by vertical lines at the transverse processes on each side. The distance from each edge of the total irradiated field to the ADI was measured. All measurements were made by a single observer. To assess measurement consistency, ten analog and ten digital samples were measured twice by the observer. The mean (maximum) difference for analog measurements was 1.4% (7.8%), while for digital measurements, it was 2.0% (7.8%) [3].

For calculating the ADI outside the cranial area, the cranial area height was divided by the total height of the irradiated field and then multiplied by 100. Four digital samples and eight analog samples lacked an ADI, but these were included in the study as they met all other inclusion criteria.

Field Size and Scaling

A mean irradiated field size of 100 square centimeters was calculated. The measured mean value for analog samples was used, while for digital samples, the measured mean value was adjusted upwards due to the smaller monitors used. It was assumed that the ADI in square centimeters was comparable between both digital and analog samples. To calculate the scaling factor, the ADI for analog samples was divided by the ADI for digital samples.

The total irradiated area in digital samples was determined by multiplying the measured area by the scaling factor (f). A test sample with an embedded steel ruler in the hospital supported the assumption that the ADI is consistent in square centimeters. The ruler, measuring 10.0 cm, appeared vertically at 5.2 cm and horizontally at 4.9 cm on the monitor. To calculate the ADI

on this monitor, the following formula was used: 1/(0.526 + 0.49).

The mean irradiated area for digital samples was 751 cm², which closely matched the mean area for analog samples (773 cm²). However, due to a reorganization of the radiography rooms, test images involving a ruler could not be acquired [4].

Results

The study aimed to compare the collimation practices of digital and analogue lumbar spine frontal radiographs. The analysis showed that digital samples had a larger irradiated area compared to analogue samples. The ADIs in digital samples were positioned farther away from the outermost edge of the irradiated field on both sides.

The data revealed a significant difference between the proportion of irradiated area outside the ADI in both digital and analogue samples across both hospitals ($p < 0.001$). Specifically, in the digital samples, 60.5% of the irradiated field was outside the ADI, compared to 42% in the analogue samples. In addition, measurements showed that the digital radiographs had a higher percentage of distance between the ADI and the irradiated edge, both vertically and horizontally, indicating larger non-collimated areas. The overall mean irradiated field size was significantly larger in the digital group (791 cm²) compared to the analogue group (541 cm²).

Further analysis indicated that the age difference between the digital and analogue groups did not significantly affect the irradiated area outside the ADI. This suggests that factors other than patient age were contributing to the observed differences in collimation practices.

Table 1: Digital and analogue lumbar spine frontal radiographs: irradiated field outside ADI

Measure	Analogue	Digital
% of total irradiated area outside ADI	42	60.5
Distance from ADI to irradiated edge as a percentage of total irradiated height	14.5	21
Distance from the edge of the irradiated field to the ADI as a percentage of the total height of the irradiated field	13.2	18.5
In % of total irradiated width, left lateral distance between ADI and edge of irradiated field	11	17
Irradiated field width as a percentage of right lateral distance from ADI	10.5	19.5

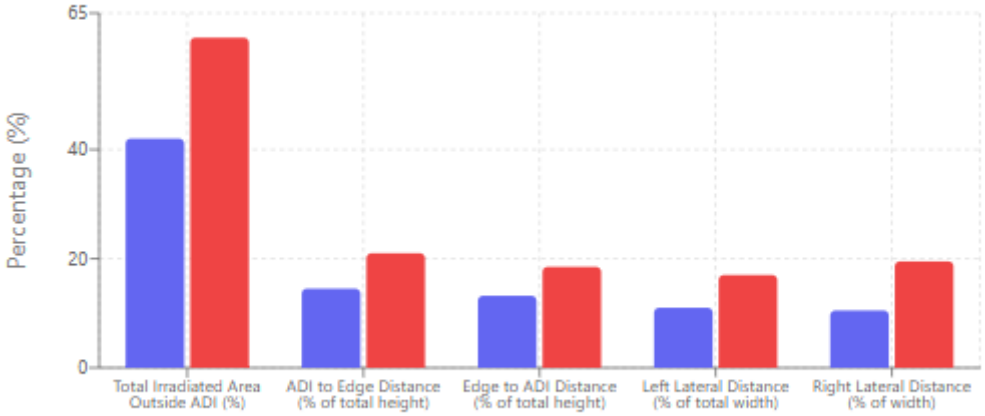

Figure 1. Digital Vs analogue lumbar spine frontal radiographs

Discussion

The results suggest a significant shift in collimation practices since the implementation of digital radiography. Digital samples exhibited a substantially larger irradiated field, with a larger percentage of the area outside the ADI compared to analogue samples [5,6]. This may reflect a decrease in attention to proper collimation, possibly due to digital imaging systems that can mask or alter the irradiated field, reducing the visual cues that would typically guide radiographers in maintaining proper collimation. The observed increase in irradiated field size in digital radiographs could also be due to technological factors, such as smaller monitor displays, which may lead to an underestimation of the true irradiated field when assessing images [7-9]. Additionally, digital imaging systems may provide more flexibility in editing and processing images, which could make it less likely for radiographers to follow the strict collimation practices required in traditional analogue imaging. Although patient age was matched between the digital and analogue groups, it did not have a significant impact on the irradiated area outside the ADI. This highlights that the differences in collimation practices are more likely related to the shift from analogue to digital technology, rather than to demographic factors [10].

Conclusion

This study demonstrates that digital radiography has led to larger irradiated areas outside the ADI compared to analogue radiography. Despite the potential advantages of digital imaging, such as improved image quality and storage, the findings suggest that digital radiography may inadvertently lead to less attention to collimation practices, thus increasing patient radiation exposure. It is important for radiography departments to implement strategies that encourage strict adherence to collimation guidelines, even with the flexibility provided by digital imaging systems. Further research is needed to explore the long-term implications of these findings on patient safety and image quality.

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