Palestine Ahliya University Journal for Research and Studies
مجلـة جامعة فلسطين الأهلية للبحوث والدراسات
ISSN: 2959-4839
Vol. 02 Issue 03 (2023)

Radiographic Positioning Standards for Joint Radiography Quality Assessment at Al Makkased Hospital-Jerusalem

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Received:25/08/2023 Accepted:30/09/2023 Published:01/12/2023

Abstract:

The fact that anatomical structures overlap makes imaging the body challenging. Radiograph diagnostic accuracy generally refers to the degree to which an examination can be used to forecast the existence (or absence) of an illness or condition. By supplying diagnostic images, the technologist plays a crucial part in increasing diagnostic accuracy. To isolate and provide a clearer view of a body area being scanned, a technologist must be knowledgeable about the many postures and techniques needed. Different projections not only make anatomical parts easier to perceive, but they also aid in the anatomization of abnormalities and the localization of foreign bodies. This study focused on the precise positioning of patients' X-rays in the Al-Makkased Hospital emergency room when they reached there as a consequence of various accidents, falls, or other causes. Emergency photos from January to June (2020) were examined as part of our examination of digital radiography (DR) imaging, and problems with the photos were discovered. Our research revealed that the percentage of examination errors is just 14.6%, which is not a very significant number. The four joints that were evaluated in this investigation were the elbow, wrist, knee, and ankle. The three fundamental flaws that were examined while assessing projections were parallelism, location, and anatomy additional exposure errors were also found. Specifically, this project discussed standards for joint radiography quality, technique, framework, structure, and findings.

Keywords: *Radiography Quality; Radiographic Positioning; Joints; Parallelism; Anatomy; Location.*

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معايير تحديد المواقع الشعاعية لتقييم جودة التصوير الشعاعي المشترك في مستشفى المقاصد–القدس

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تاريخ الاستلام:2023/08/25 تاريخ القبول:2023/09/30 تاريخ النشر:2023/12/01

ملخص:

حقيقة أن تداخل الهياكل التشريحية تجعل تصوير الجسم أمرًا صعبًا. تشير دقة التشخيص بالأشعة بشكل عام إلى الدرجة التي يمكن بها اســـتخدام الفحص للتنبؤ بوجود (أو غياب) مرض أو حالة غير طبيعية. ومن خلال توفير الصـور التشـخيصـية، يلعب التقني دورًا حاسـمًا في زيادة دقة التشـخيص. لعزل منطقة الجسـم التي يتم مسحها ضوئيًا وتوفير رؤية أوضح لها، يجب أن يكون التقني على دراية بالكثير من الأوضاع والتقنيات اللازمة. إن الإسقاطات المختلفة لا تجعل الأجزاء التشريحية أسهل في الإدراك فحسب، بل إنها تساعد أيضًا في تشريح التشوهات وتحديد موضع الأجسام الغريبة. ركّزت هذه الدراسة على تحديد الموقع الدقيق للأشعة السينية للمرضى في غرفة الطوارئ بمستشفى المقاصد عند وصولهم إلى هناك نتيجة لحوادث مختلفة أو سقوط أو لأسباب أخرى. تم فحص صـور الطوارئ في الفترة من يناير إلى يونيو (2020) كجزء من فحصـنا للتصـوير الشـعاعي الرقمي (DR)، وتم اكتشاف المشاكل في الصور. كشف الدراسة أن نسبة الأخطاء في الامتحانات تبلغ 14.6% فقط، وهو رقم ليس كبيرًا جدًا. فالمفاصل الأربعة التي تم تقييمها في هذا التحقيق هي الكوع والمعصم والركبة والكاحل. كانت العيوب الأساسية الثلاثة التي تم فحصها أثناء تقييم التوقعات هي التوازي والموقع والتشريح، كما تم العثور على أخطاء تعرض إضافية. على وجه التحديد، ناقشت هذه الدراسة معايير جودة التصوير الشعاعي المشترك وتقنياته وإطاره وبنيته ونتائجه.

الكلمات المفتاحية: *جودة التصوير الشعاعي؛ تحديد المواقع الشعاعية؛ المفاصل؛ تماثل؛ تشريح؛ موقع.*

1. Introduction

One of the most crucial areas of medicine is medical imaging. It is also a method and technique used in clinical analysis. It is used to produce an image for the patient's diagnosis, which is important for doctors. In the hospital, it is the first method for identifying internal diseases in the body. It is also common sense for patients in the emergency room, depending on the type of imaging device appropriate for each image. X-ray radiation was employed as an electromagnetic wave kind of radiation, for medical imaging. Using X-ray imaging, your body's interior can be visualized. The photos depict the various bodily parts in various shades of black and white. This is because various tissues absorb radiation in different ways. Because calcium in bones absorbs the most X-rays, bones appear white. Fat and other soft tissues have a greyish appearance and absorb less. The lungs seem black because the air absorbs the least. Although looking for fractures (broken bones) is the most common application of X-rays, there are other uses as well. For instance, chest radiographs can detect pneumonia. X-rays are used in mammograms to look for breast cancer, and many other radiation kinds, including gamma rays, are also used in radiotherapy. There are many different types of equipment used in the field of medical imaging, such as computed radiography (CR) and digital radiography (DR), which are used to picture bones and some internal organs, CT scans, and MRI scanners, which are used to display inside organs and tissues. To have them display the desired area for us, we must properly examine numerous positions. The evaluation of the shoulder and knee joints as well as several dozen conventional radiographic exams on the positioning are thought to be the most frequently requested studies. Below is a list of some of the most often requested radiographic tests and highlighted patient positioning guidelines Additionally, for the image to take on the appropriate form, rotation, distortion, and artifact must all be taken into consideration. To establish if the photograph is accurate, we must take into account the anatomy depicted, position, exposure, and picture markers. The previously mentioned criterion for the photographs may be affected by several parameters and mathematical modules, including KVp, mAs, SID, Grid factor, Type of film used, patient – size, physical density, and electronic radiography top row: screen-film phantom images; middle row: computed radiography; bottom row: an insert that was removed and magnified from the digital images (bottom row). This requires a technologist to be aware of the various positions and techniques required to isolate and provide a clearer view of a body part being imaged. In addition to better viewing an anatomic part, different projections also help anatomize an abnormality or localize a foreign body (Campbell & Wilbert, 2022). The four joints that were looked at in this investigation were the elbow, wrist, knee, and ankle. The following radiographic standards were used to evaluate projections for the three primary flaws of parallelism, location, and anatomy.

1.1 Problem Statement

Every day, a large number of individuals with limb trauma visit emergency rooms. The early diagnosis of bone fractures, sprains, and joint dislocations depends heavily on routine radiography. Due to their injuries,

individuals with trauma problems typically cooperate less during the imaging process. The positioning inaccuracies that may be caused by patient inclusion may therefore be covered by the radiographers' knowledge as well as their experiences in these circumstances. Additionally, good radiographic images give referring doctors detailed information that will improve the efficacy of the therapy. Contrarily, poor-quality radiographs, particularly those of the joints, may result in ineffective treatment, which could impair movement or induce joint impairment.

1.2 Justification and Objectives of The Study

The primary goal of the study is to evaluate the effectiveness of joint radiography for patients in need of emergency care at Makkased Hospital. In each emergency, radiographic images of the skeletal system are crucial, so patients must have the best possible radiographic images. Therefore, high effectiveness and efficiency as well as a reduction in errors will result from a continuous evaluation of the quality of the radiographic imaging process, including the x-ray equipment and image processing. Additionally, the goal of this study was to evaluate the value of joint radiography for emergency patients to provide key highlights for upcoming studies in this crucial area. The first objective is to evaluate the accuracy of radiographic projections of the upper limb joints, especially those in the elbow and wrist. Secondly, to evaluate the accuracy of knee and ankle joints radiographic imaging using typical radiographic projections.

2. Review of Documentation

This section discusses the theoretical foundations and past research on evaluating positioning errors, as seen below. To figure out how the hand phantom's perceptual picture quality is affected by kilovoltage (kV), milliampere seconds (mAs), and focal spot size. A study was performed by Kei et al. (2014). on the Effects of kilovoltage, milliampere seconds, and focal spot size on image quality by the conclusion that For PA oblique hand imaging, a large focal spot size can be used without degrading perceptual image quality. For a large variety of kilovoltage and milliampere second values, the perceived image quality is good and steady. To prevent receiving more radiation than is necessary, optimizing these technical aspects to attain image quality is essential.

Schibilla and Moores (1995) indicated that the specification of necessary picture details, the functionality of the imaging system, and the suitable selection of radiographic parameters are all quality criteria for diagnostic radiography images. A framework for the optimization of these three categories of Quality Criteria has been built through actions. Their development, application, and efficacy will be shown for both traditional and digital radiography. We'll talk about the connection between the Quality Criteria and staff and patient exposure. The historical analysis of these factors will recognize the work done across Europe since the 1920s and highlight the potential for ongoing improvement in diagnostic radiology in various areas, including day-to-day practice, innovative technology design, and radiological concepts.

Image quality criteria and evaluation methods for digital radiography by Udupa et al. (2013) concluded that Four criteria were shown to have an impact on the image in this article's examination of the relationship between quality parameters and images: noise, spatial resolution contrast, artifacts, and color. The researchers in this article took into account the technology transfer between DR and CR modality that increased the radiation dose. They discussed every parameter and its effects, such as how pixel size affects spatial resolution, but they focused on the process of taking the image, such as the patient's position. Important aspects that depend on the worker to complete the procedure flawlessly to have a good image include the dose and patient mobility, the SID, and the OID. In addition, the worker must provide the patient with the appropriate instructions. The contrast resolution that the KVP, mAs that the worker chooses by the patient's hippest as well as the part of the interest that will be imaged the artifact that could be from the computer itself or the patient like a ring or something else that could affect the image diagnostic and at the end of the article, they discuss the parameters that affect the image.

To produce tungsten target x-ray spectra, a semi-empirical model by Tucker et al. (1991) was proposed that the model builds on their work in two key ways. First, it is presumable that different depths within the target will produce both bremsstrahlung and distinctive X-rays. Second, nonlinear

least-squares methods were used to extract the model's ideal parameters from experimental spectra. As a result, for a variety of target angles and X-ray tube potentials, good agreement is found between computed and measured X-ray tube spectra and output The situation with previously released models is different.

Lehnert et al. (2011) concluded that using 75% of the conventional dose and aluminum filtering, the skin entrance dose can be reduced by 31.1 percent for imaging bony structures without noticeably impacting image quality.

Internationally, there is consensus on what constitutes a high-quality X-ray image. However, opinions on whether or not low-quality or subpar photographs are still relevant medically when compared to image criteria vary. The justifications for maintaining images that did not meet image standards were diagnostic capabilities and radiation protection. In clinical practice, there seems to be a requirement for diagnostic quality to be considered while evaluating images (Kjelle & Chilanga, 2022).

Diagnostic radiology relies on the complex interplay of numerous elements to produce pictures. Obtaining a picture that is sufficient for the clinical goal while using the least amount of radiation is the optimal balance. Radiation quality, photon fluence, and scattered radiation removal are three categories under which factors affecting radiation dose and picture quality can be categorized. Applying a technique for picture quality and dose analysis at each stage of the construction and operation of X-ray equipment is crucial for achieving optimal performance since these factors affect radiation dosage and image formation (Martin et al.,1999)

For Tapiovaara (2008) A review of the connection between physical measurements and clinical image quality has produced some findings that have been summarized. There were contradictory findings: some research showed no association at currently accepted dose levels, while others showed a definite correlation. Conclusion: Different techniques work well for the various picture quality evaluation jobs in an X-ray department. Exact physical measurements are currently not as important in speculating and assessing technical performance as they are in determining whether or not clinical images are acceptable.

Wang et al. (2021) utilize computed tomography (CT) scans and the maximum intensity projection technique to place the knee joint laterally for radiography. Between males and females, there were variations in the optimal posture. Most patients in the optimized group had complete superimposition of the posterior condyles of the femoral epiphysis. The usual group members weren't, though. In comparison to the 1.841.15 score in the standard position, the average quality score of the lateral knee-joint X-ray pictures in the optimized position was 3.760.98. Additionally, the variation in the mean quality score was statistically significant.

The primary care doctor, who is frequently the first actor in the situation, can treat many traumatic diseases of the hand and wrist, or at least start the process. He initially had to correctly interpret X-rays taken with particular incidences of the suspected pathology. To interpret by general practitioners easier (Auberson et al., 2020)

In 101 rheumatoid arthritis patients, radiographic and clinical evaluation of the relative severity of wrist versus hand involvement revealed more severe changes in the wrists in 60% of cases, equal involvement in the wrists and hands in 37% of cases and more severe changes in the hands in 3% of cases. In 43 (21%) of the 202 investigated limbs, there were significant alterations in the wrists but little to no bone or joint change in the metacarpophalangeal and proximal interphalangeal joints. Serial exams revealed that the hand modifications eventually took precedence over the wrist changes.

Knowing how these wrist and hand changes develop an assist the doctor to avoid making a diagnosis error (Hendrix et al., 1987)

Commonly, anteroposterior views can be used to understand knee diseases that are obvious on the lateral view. On the other hand, several pathologic processes take place in anatomical regions that are normally hidden on other projections due to overlying osseous structures. Avulsion fractures involving anterior or posterior structures, injuries to the quadriceps or patellar tendons, as well as numerous soft-tissue injuries, are examples of these diseases. To prevent missing these disease processes, it is crucial to be aware of the relevant anatomy and typical pathologies that are typically seen on the lateral radiograph of the knee (Kong et al., 2022)

According to Husseini et al. (2018), the knee's tendons are crucial to the joint's stability and range of motion. The disease of these structures is commonly the cause of knee discomfort, a common clinical complaint. While radiography and magnetic resonance imaging are the mainstays of the radiological evaluation of the knee, ultrasonography can also be an important diagnostic tool and be helpful during guided interventional procedures. Accurate diagnosis requires knowledge of both the normal and pathological imaging appearance of these structures and an understanding of the role each modality plays in assessing tendon pathology.

Traumatic artery injuries to the extremities are a rare but serious occurrence, according to Chen Zhou et al. (2022), the technique of choice for performing CT angiography of the extremities is now known for its ability to quickly and accurately identify arterial abnormalities. Active bleeding, vasospasm, occlusion, post-traumatic arteriovenous fistula, pseudoaneurysm, and patterns of intimal injuries are different types of vascular injuries. Reviewing the normal arterial anatomy of the upper and lower limbs, describing CT angiography technique in vascular trauma of the extremities, describing and illustrating CT-angiography findings of traumatic arterial injuries, and being aware of potential pitfalls when interpreting a CT-angiography of the extremities are the learning objectives of this pictorial essay.

According to a study by Sutter et al. (2021) radiologists of all levels have a variety of difficulties when diagnosing elbow disorders using imaging. Even though medical schools and residency programs cover the fundamentals of elbow trauma, several crucial areas of elbow imaging are rarely given adequate attention. This elbow imaging-specific issue of Seminars in Musculoskeletal Radiology covers a wide range of issues, including those less well-known but essential elements that can enhance patient care and clinical outcomes. You will learn more about the various elements of elbow imaging and be able to make more accurate diagnoses while examining elbow imaging studies thanks to the insights and instructional instances in this issue.

3. Materials and Methods

Sample Collection

The survey was done on many patients, and the results were then analyzed to link variables and draw conclusions (statistical processes), blinding the participants. The study was utilized as an analytical description method and on a statistical sample. Ankle, Knee, Elbow, and Wrist photographs from a collection were used to gather the necessary data, which was then analyzed and reviewed. The results were then shown in tables.

Research Design

The sample was initially between the first of January and the 30th of June 2020, and we discovered 25,430 images across all modalities (fluoroscopy, CT scan, MRI, X-ray, Ultrasound, and catheterization). We divided the images into four groups: wrist, elbow, knee, and ankle, which totaled 1014 images for the X-ray modality; next, we divided the images into three groups, the first of which

has the number 0 and contains images for patients under the age. We filtered all of the images until we had 250 images to evaluate a random sample that was selected by the computer from number 1, we divided it into three parts to evaluate the first one had a low-quality image, the second had a medium-quality, and the last one was high quality. Of the second group, number 1 includes patients over the age of 18, with 354 images, and the third group, number 9, was for the operations patients, its 66 images.

4. Results

This section offers statics-based graphs and our study's findings.

Projected total Number of patients

Table 1: Shows The number of cases of injury to the ankle, elbow, knee, and wrist joints of patients and their percentages in the period mentioned above.

	Joints	*No*	Percentage
Patient	**Ankle**	**99**	**35%**
	Elbow	**36**	**12.70%**
	Knee	**83**	**29.30%**
	Wrist	**65**	**23%**
	Total exam	**283**	**100%**

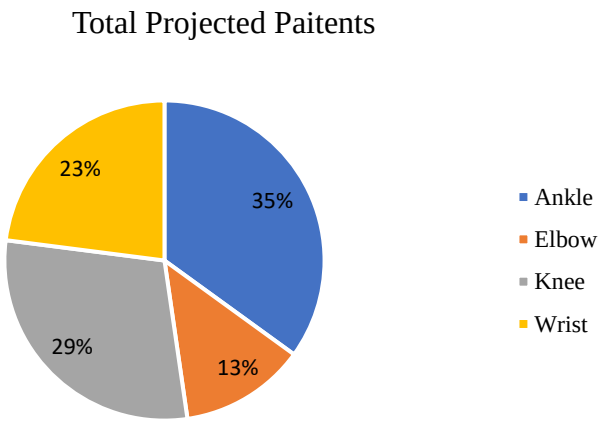

Figure 1: Distribution of percentages of injuries to the ankle, elbow, knee, and wrist joints During the period for information collection.

Table 2: shows the number of exams requested and their percentages for patients throughout the mentioned period

	Exams	*No*	Percentage
Patient	**1st exam**	**219**	**87.60%**
	More exams	**31**	**12.40%**
	Total patient	**250**	**100%**

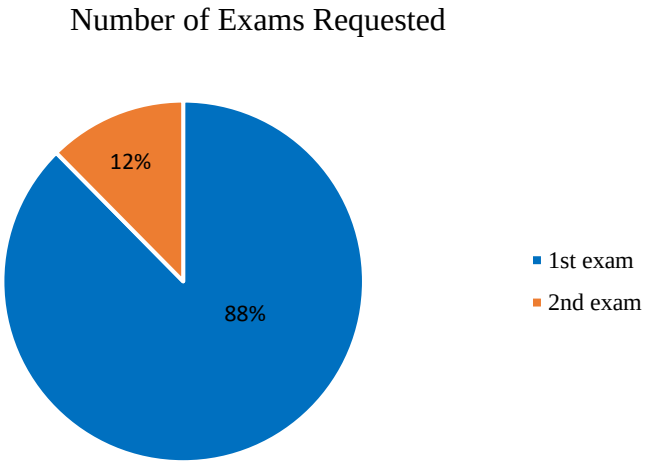

Figure 2: shows the percentages of exams and extra exams requested for patients

5. Discussion and Conclusion

According to our findings, the error rate is 14.66% and represents low-quality images; these images have the correct collimation but the incorrect position and anatomy, which affects the patient's diagnosis. However, the high-quality rate is 30.74% and represents the correct position, collimation, and anatomy; the remaining 54.60% represents medium-quality images that represent the incorrect collimation but the correct positioning. The high proportion of med-quality images tends to lead us to conclude that either the emergency's pressure on the radiographer caused him to make these errors or that the radiographer lacks the necessary experience to work on emergency images. We also conclude that emergency patients are not very cooperative because of the circumstances that force them to visit and the pain they experience as well. According to the statistics that we found when studying the images, we discovered that there were many errors made by the technician. These errors may be caused because the technician is not highly professional and lacks experience, so we arranged and especially put them to make it easier for us to study and analyze them so that we can extract as much information from them as possible.

6. Recommendation

Last but not least, the authors offer some suggestions that could help with avoiding this mistake, and they are:

- Appoint a supervisor to oversee the radiographers' image-taking procedures.
- A training session on emergency pictures for radiographers the objective is to generate and update knowledge based on advances in medicine and stress management techniques.
- When a specific member requests an image, the program shows the patient a picture of the right position for his job and the dosage.
- positioning sponges that will improve the effectiveness of the part position during image capture.

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