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# Revalidating the Clinical Importance of Anatomical Side Markers in Radiography Pre- and Post-Computed Radiography Installation: An Audit Assessing Local Practice at a Referral Hospital

Daniel Msuega Chia[1]; Christopher Ishiekwen Abeabe[1]; Williams Terkaa[2]; Secivir Songo[2]; Hilemshima Teryima[2]; Silas Orvave Akumba[2]
[1]Department of Radiology, College of Health Sciences, Benue State University, Makurdi, Nigeria
[2]Department of Radiology, Benue State University Teaching Hospital, Makurdi, Nigeria

**Abstract:- The gold standard in clinical diagnostic imaging is to place a radiopaque anatomical side marker (ASM) prior to exposure; nonetheless, mistakes and errors can be made, resulting in wrong-side surgery, misdiagnoses and medico-legal problems. The goal of computed radiography (CR) with electronic and post-processing image annotation capabilities is to enhance diagnostic imaging practice and reduce these errors. We aim to assess the local practice of image annotation in clinical diagnostic imaging at our center, pre- and post-CR installation and revalidate the clinical importance of ASMs.This cross-sectional retrospective study was conducted between July 2023 to July 2024 at Benue State University Teaching Hospital (BSUTH), Makurdi's radiology department. Data was collected from two departmental sources: physical archive from 2012-2020 and digital archive from 2021-2024, respectively, containing images created before and after CR installation. The data was analyzed using Microsoft Excel 2007 and SPSS version 23 software, with statistical significance determined using a p<0.05 value. Data distribution was displayed using tables, figures, and percentages. The audit recorded no significant difference in the mean age of the patients, which was 40.2years ±18.9 and 41.2years±18.4 respectively, before and after CR installation. Post-CR installation at BSUTH, clinical practice significantly changed regarding ASM use (p=0.000-0.044), with 225(75.0%) and 162(54.0%) ASMs placed in the primary radiation beam, while only 22(3.7%) ASMs obstructed essential anatomy. The incidence of missing markers was generally low 1(0.2%), which is good practice. Prior to CR installation, 52 (17.3%) post-processed and 247 (82.3%) lead markers were used respectively for radiographic image annotation, whereas 300 (100%) digital ASMs were employed exclusively after CR installation, demonstrating an increasing use of technology in radiology. BSUTH implemented a managerial strategy, increasing personnel recruitment 33(45.2%) and employing seven Xray technicians despite a decrease in experienced radiographers. The study comes to the conclusion that, despite not meeting the audit criteria of 100%, the pre- and post-CR installation audit at BSUTH showed a significant shift in anatomical side marker practice, with few missing markers and over 50% compliance with standard ASM placement in the primary radiation beam. Since ASMs are essential for quality control and accurate radiographic identification, their absence on images can lead to patient safety issues, misdiagnoses, wrong-site surgeries, and medico-legal penalties.**

***Keywords:-*** *Anatomical Side Markers, Audit, Clinical Importance, Computed Radiography, Local Practice.*

## I. INTRODUCTION

Lead (Pb) markers for anatomical orientation on radiographs were initially patented in 1998 (1). They are labels placed to the right or left of the image in radiography. Their use on radiographic image is considered "best practice" for clinical diagnostic imaging. A correct ASM must therefore be placed within the primary collimation on the radiograph when the image is acquired to match the anatomical side shown, with the correct annotation checked during image evaluation (2,3).

Therefore, post-processing ASMs should not replace pre-exposure ASMs on radiographs due to increased risk of possible mismarking. If post-exposure ASMs are required, their placement must be double-checked to verify alignment with the anatomic side imaged and, consequently, with the referring clinician's request. Accordingly, radiation workers have a duty of care to patients and a professional obligation to protect their health because they run the risk of being held legally liable for the effects of their professional actions brought on by an act, negligence, or omission (3, 4).

The risk to the patient from the absence of ASM or their omission is so high that a radiologist may elect not to write a report or even make a comment on such an image, resulting in the need for repeat radiation exposure in such cases, thereby delaying or lowering a patient's standard of care (4). The importance of ASM on radiographic images is further reinforced in forensic clinical practice, wherein the image must contain the relevant ASM, the date and time of the examination, the witness's name and initials, typically another radiographer, and the examination anatomic site in order for it to be classified as an admissible medico-legal document (5,6).

Numerous instances exist that demonstrate the consequences of omitting ASMs or placing them incorrectly on images and viewing such images improperly before undergoing treatment or surgery. Following wrong-site surgery in 2002, two surgeons faced charges of negligence and manslaughter because they had relied on radiographs incorrectly displayed on the operating theatre`s viewing box without an ASM (7). In another case, the wrong left kidney was removed instead of the patient's chronically ill right one (8). Another instance involved the wrong-sided treatment of a pneumothorax in two premature infants, one of whom died as a result of the physicians` clinical judgments based on images without ASM (9). Again, a female car accident victim's chest tube was inserted on the wrong side due to a misread CXR with an omitted ASM, in which the heart was positioned in the center of the chest with no annotation of the side, which clinicians misinterpreted as a right-sided pathology and inserted a chest tube on the wrong side. The error was detected by subsequent correctly annotated radiographs, and a successful corrective emergency operation was carried out. Lack of side markers was the primary cause of the confusion (10).

Due to symmetrical human anatomy and variants such as situs inversus, anatomical side markers (ASMs) are critical for proper identification of anatomical sides on radiographs; nevertheless, the use of ASMs in radiography is reported to be on a decline in other communities (11). For instance, a study (12) found that only 32% of subjects had correct ASM placement. A further twist to the decline in the use of ASMs was reported by Tugwell et al. (13), who found that 92% of ASMs placed in the primary collimation fields were infected with harmful micro-organisms, acting as transmitters of infections if hygienic measures weren`t strictly followed. Digital side markers (DSM), which were already in use but were just recently considered good practice during the COVID-19 pandemic, might thus replace ASM because disinfecting the ASM after each usage greatly slows down the workflow (14, 15).

It is debatable whether ASMs should appear in the blurring (less dark) penumbra region or in the entirely blocked (dark) area behind the object in the x-ray beam's umbra. Umbra is preferred to prevent cone-off, according to tradition that has been passed down and is still in use today. However, there is a chance that this practice will obscure important anatomy and result in marker burnout from overexposure. Therefore, the main criteria for marker placement are suggested to be legibility and sparing of essential anatomy (16). According to another research (17), for aesthetic reasons, ASMs should typically be placed at right angles to the images, farther away from important anatomy.

In our center, conventional film-screen radiography (FSR) was in use from 2012 until 2020, after which computed radiography (CR) was installed to replace them. Even though in both the pre- and post-CR technology era, the placement of anatomical side markers is operator dependent and therefore subject to human errors (18), however we hypothesized that digital annotation of images will significantly reduce ASM errors in the post-CR technology era.

Two key standards for the current ASM audit at BSUTH were determined, drawing from the previous research by Chung L et al. (19): whether markers were present in the primary or secondary radiation beams and if they were present or omitted on images. Whether the markers appeared in the primary or secondary radiation field was not too important; their presence or omission served as the benchmark for this research. Nevertheless, the study documented ASMs radiation field characteristics and other specific clinical practice errors even though they were not accepted as standards.

Research and new technologies in radiology at BSUTH are advancing, but clinical audits are not being conducted to ensure compliance with image annotation best practices. The objective of this descriptive audit was to assess the local practice of image annotation in clinical diagnostic imaging at our center, pre- and post- CR installation and revalidate the clinical importance of anatomical side markers. Thus, forming a basis for comparison with studies elsewhere nationally and internationally, when the need arises by clinicians in our environment.

## II. MATERIALS AND METHODS

This cross-sectional retrospective study was conducted between July 2023 to July 2024 at the Radiology department of Benue State University Teaching Hospital (BSUTH), Makurdi, which draws patients from nearby states and acts as a referral and training center for radiology residents due to its acquisition of moderately advanced and basic medical imaging equipments, supported by a public-private service repair, maintenance and replacement agreement with Hospital Assist Nigeria (HAN) between 2018 to 2023. The radiography department at Benue State University (BSU), Makurdi, has already begun using our department as its primary teaching institution, effective November 2024. Located on the south bank of the Benue River, Makurdi, the capital of Benue State, lies between latitudes 7.30 and 8.32 degrees (20).

Prior to data collection, the radiology department's equipment, personnel, and operational setup was physically inspected. Four trained Xray technicians, grouped into pairs collected our data concurrently from two departmental archival sources. The initial source came from the department's physical archive, which houses film screen radiographs produced between 2012 and 2020 during the pre-computed radiography (CR) era. The second source was the main departmental workstation that houses the CR digital archive, where CR images created after CR installation have been stored since 2021.

Inclusion criteria was data extracted from radiographs of patients who presented for general x-ray examinations at

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the radiology department of BSUTH, Makurdi before and after CR installation. Exclusion criteria was cephalometric studies and orthopantomograms as equipment used to perform these studies utilizes fixed markers. Additionally, local procedure prohibited the placement of lead markers on image intensifiers because of infection control concerns, so cases involving operating theaters were excluded. Any radiographs that had become unusable because of moldy growth, fading, cardboard sticking, or dirt was similarly excluded. On the exclusion list were also other general x-ray examinations, including those conducted on mobile devices, outside our hospital facility.

Available film screen radiographs (FSR) and CR images generated from the department were documented for patient demographics, marker presence or absence, marker type-lead, post-processed or digital-as shown in figures 1-3, their location within the radiation beam, marker legibility and preservation of essential anatomy, as well as other unique causes of error.

Fig 1 Lead (Pb) marker on CXR

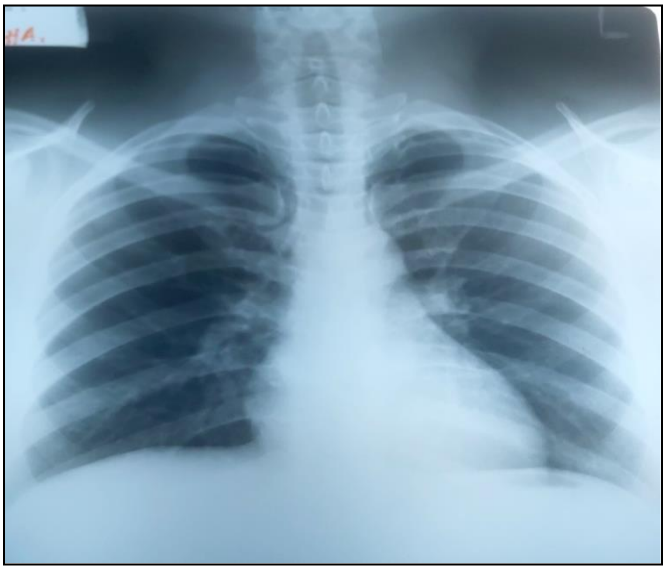
Fig 2 Typical Post-processed marker on CXR

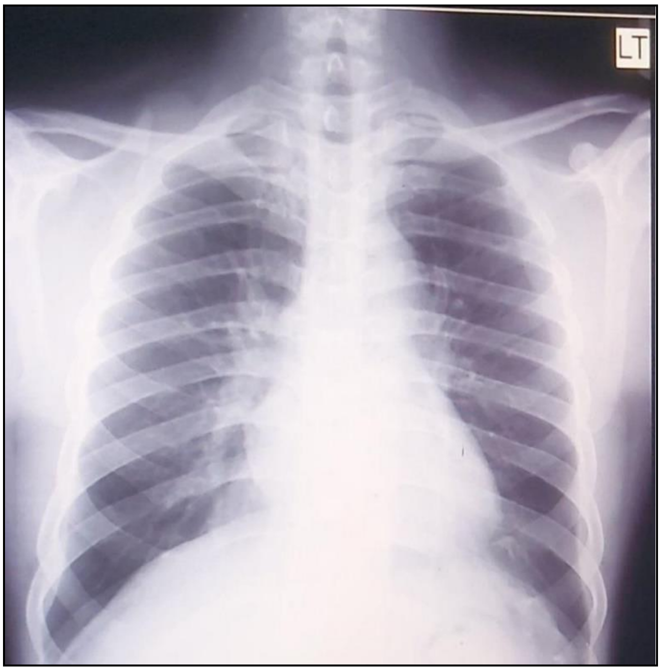

Fig 3 Digital marker on CXR

For ease of comparison, an equal number of FSR and CR radiographs was sorted and shortlisted for the years in which the examinations were performed. Once the sample size of 300 previously adopted from FSR was reached, data collection for CR images was stopped. The study was conducted with complete confidentiality and all collected data was entered into a data worksheet.

Two static x-ray machines at BSUTH were used to acquire the images. The majority of FSR images were created on a Philips medical system x-ray machine with model and tube numbers LNMA8C1003 and 989600085271, machine and tube serial numbers 17299A211452 and 060002894, maximum kVp 150, maximum mAs 630, permanent filtration 2.5mm AL, manufactured in November 2006, and installed in July 2012. This x-ray machine was no longer operational at the time of the research. In 2021, the CR system, made up of an AGFA medical system digitizer, equipment ID 10261788, and a Daystar 5503 AGFA printer, was linked to a 2017 Toshiba Rotanode BPLHRAD32 x-ray machine with the machine and tube model numbers as 17G1010 and E7239X, machine and tube serial numbers PS697 and 00654000, max kVp 125, max mAs 630, permanent filtration 0.9 mm AL/75, whose undercouch and erect potter-bucky trays were functional and still been used in the producing of all the CR images.

Data analysis was conducted using Microsoft Excel 2007 edition and the statistical package for social science (SPSS) version 23 software was used to analyze the data. *P* value of $< 0.05$ was defined as threshold for statistical significance. The data distribution was displayed using tables, figures, and percentages.

## III. RESULTS

The audit recorded no significant difference in the mean age of the patients, which was 40.2years ±18.9 and 41.2years±18.4 respectively before and after CR installation as depicted in table1.

Table 1 Distribution of Descriptive Statistics of the Respondents' Age, Pre- and Post-CR Installation

| | Age (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | Min. | Max. | Mean | Median | Mode | Std. dev. |
| **Pre-CR installation** | 300 | 1 | 83 | 40.2 | 40 | 60 | 18.9 |
| **Post-CR installation** | 300 | 1 | 90 | 41.2 | 41 | 61 | 18.4 |

Table 2 shows the distribution of patient age with incidence of present or absent ASM. As noted, pre- and post- CR installation, people in their third decade of life and beyond accounted for more than three quarters of the ASM present in 502 (83.7%) radiographs, with only 1 (0.2%) being responsible for the missing markers.

Table 2 Distribution of Patient Age with Incidence of Present or absent ASM

| | Age (years) | | | | |
|---|---|---|---|---|---|
| **Pre-CR installation** | 1-20 | 21-40 | 41-60 | ≥61 | **Total** |
| **ASM Present** | 51(17.0%) | 104(34.7%) | 102(34.0%) | 42(14.0%) | 299(99.7%) |
| **Absent** | 0(0.0%) | 0(0.0%) | 1(0.3%) | 0(0.0%) | 1(0.3%) |
| **Total** | 51(17.0%) | 104(34.7%) | 103(34.3%) | 42(14.0%) | 300(100.0%) |
| **Post-CR installation** | | | | | |
| **ASM Present** | 46(15.3%) | 99(33.0%) | 102(34.0%) | 53(17.7%) | 300(100.0%) |
| **Absent** | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) |
| **Total** | 46(15.3%) | 99(33.0%) | 102(34.0%) | 53(17.7%) | 300(100.0%) |

Out of a total of 600 radiographs, consisting of 300 images each, pre- and post-CR installation, there was gender discrepancy, with female predominance having a male to female (M: F) ratio of 1:1.2 before CR installation. However, the ratio reversed in favor of men after the installation of CR as displayed in figure 4.

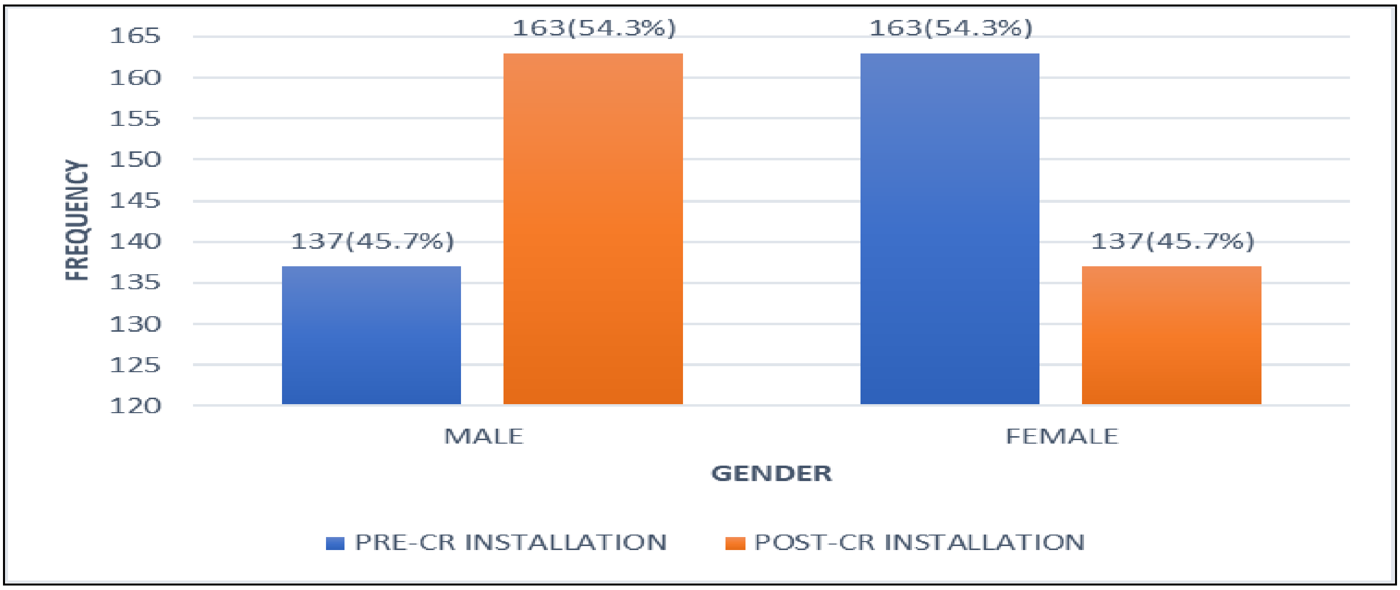


Fig 4 Distribution of Respondents' Gender, Pre- and Post-CR Installation

Our data indicated that chest x-rays were the most frequently performed examination at our hospital among the audited radiographic images, which also included those of the abdomen, spine, skull, pelvis, upper and lower limbs. Among the radiographs examined during the period under review, 174(58.0%) and 152(50.7%) were chest x-rays, pre-and post-CR installation respectively. Of the 174(58.0%) chest radiographs acquired before CR installation,154(51.3%) had lead (Pb) markers, whereas 20(6.7%) contained post-processed ASMs. All the 152(50.7%) chest radiographs done after CR installation had digital ASMs. The second commonest anatomical site examined was the spine, with 47(15.7%) and 50(16.7%) radiographs before and after CR installation as depicted in table 3.

Table 3 Distribution of Radiographic Images Pre- and Post- CR Installation according to ASM site and marker type

| **Pre-CR installation** | | | | | |
|---|---|---|---|---|---|
| | | ASM type | | | |
| **ASM site** | Post-processed | Lead (Pb) | Digital | None | Total |
| **Chest** | 20(6.7%) | 154(51.3%) | 0(0.0%) | 0(0.0%) | 174(58.0%) |
| **Spine** | 11(3.7%) | 36(12.0%) | 0(0.0%) | 0(0.0%) | 47(15.7%) |
| **Lower limb** | 5(1.7%) | 14(4.7%) | 0(0.0%) | 0(0.0%) | 19(6.3%) |
| **Skull** | 4(1.3%) | 13(4.3%) | 0(0.0%) | 0(0.0%) | 17(5.7%) |
| **Abdomen** | 4(1.3%) | 11(3.7%) | 0(0.0%) | 0(0.0%) | 15(5.0%) |
| **Pelvis** | 5(1.7%) | 9(3.0%) | 0(0.0%) | 0(0.0%) | 14(4.7%) |
| **Upper limb** | 3(1.0%) | 10(3.3%) | 0(0.0%) | 1(0.3%) | 14(4.7%) |
| **Total** | 52(17.3%) | 247(82.3%) | 0(0.0%) | 1(0.3%) | 300(100.0%) |
| **Post-CR Installation** | | | | | |
| **ASM site** | | **ASM type** | | | |
| **Chest** | 0(0.0%) | 0(0.0%) | 152(50.7%) | 0(0.0%) | 152(50.7%) |
| **Spine** | 0(0.0%) | 0(0.0%) | 50(16.7%) | 0(0.0%) | 50(16.7%) |
| **Pelvis** | 0(0.0%) | 0(0.0%) | 24(8.0%) | 0(0.0%) | 24(8.0%) |
| **Lower limb** | 0(0.0%) | 0(0.0%) | 21(7.0%) | 0(0.0%) | 21(7.0%) |
| **Abdomen** | 0(0.0%) | 0(0.0%) | 19(6.3%) | 0(0.0%) | 19(6.3%) |
| **Upper limb** | 0(0.0%) | 0(0.0%) | 18(6.0%) | 0(0.0%) | 18(6.0%) |
| **Skull** | 0(0.0%) | 0(0.0%) | 16(5.3) | 0(0.0%) | 16(5.3%) |
| **Total** | 0(0.0%) | 0(0.0%) | 300(100.0%) | 0(0.0%) | 300(100.0%) |

In table 4, the images obtained before CR installation, show that 225(75.0%) radiographs appeared with ASMs located in the primary beam, while 22(7.3%) appeared in the secondary radiation beam. Two hundred and twenty-four (74.7%) and 22(7.3%) ASMs respectively in the primary and secondary beams did not obstruct essential anatomy, while only 1(0.3%) in the primary beam had some level of obstruction of essential anatomy. The post-CR radiographic images, however revealed that 162(54.0%) radiographs appeared with ASMs located in the primary beam, while 138(46.0%) appeared in the secondary radiation beam. One hundred and forty-one (47.0%) and 138(7.3%) ASMs respectively in the primary and secondary beams did not obstruct essential anatomy, whereas 21(7.0%) exclusively in the primary beam had some level of obstruction of essential anatomy. By implication, all ASMs in the secondary radiation beam did not obstruct essential anatomy before or after CR installation even though the ASMs on radiographic images during the post-CR installation were more associated with obstruction of essential anatomy. An incontrovertible anatomical side marker that is added to the primary beam before exposure is the recommended method for radiography image annotation.

Table 4 Distribution of Radiation Field Characteristics of ASM Pre- and Post-CR Installation within the X-ray Beam

| | **ASM OBSTRUCT ESSENTIAL ANATOMY** | | | **Total** |
|---|---|---|---|---|
| **Pre-CR installation** | Yes | No | Not Applicable | |
| **ASM location Primary beam** | 1(0.3%) | 224(74.7%) | 0(0.0%) | 225(75.0%) |
| **Secondary beam** | 0(0.0%) | 22(7.3%) | 0(0.0%) | 22(7.3%) |
| **Neither** | 0(0.0%) | 0(0.0%) | 1(0.3%) | 1(0.3%) |
| **Post-processed** | 0(0.0%) | 52(17,3%) | 0(0.0%) | 52(17.3%) |
| **Total** | 1(0.3%) | 298(99.3%) | 1(0,3%) | 300(100.0%) |
| **Post-CR installation** | | | | |
| **ASM location Primary beam** | 21(7.0%) | 141(47.0%) | 0(0.0%) | 162(54.0%) |
| **Secondary beam** | 0(0.0%) | 138(46.0%) | 0(0.0%) | 138(46.0%) |
| **Neither** | 0(0.0%) | 0(0.0%) | 0(0.0%) | 0(0.0%) |
| **Total** | 21(7.0%) | 279(93.0%) | 0(0.0%) | 300(100.0%) |

With the inclusion of post-processed annoted radiographs, we found out that 365 (60.8%) and 234 (39.0%) images had ASM on the radiographic's left and right, respectively. This means that only 1(0.2%) of the images included in the audit had an absent anatomical side marker, as seen in figure 5.

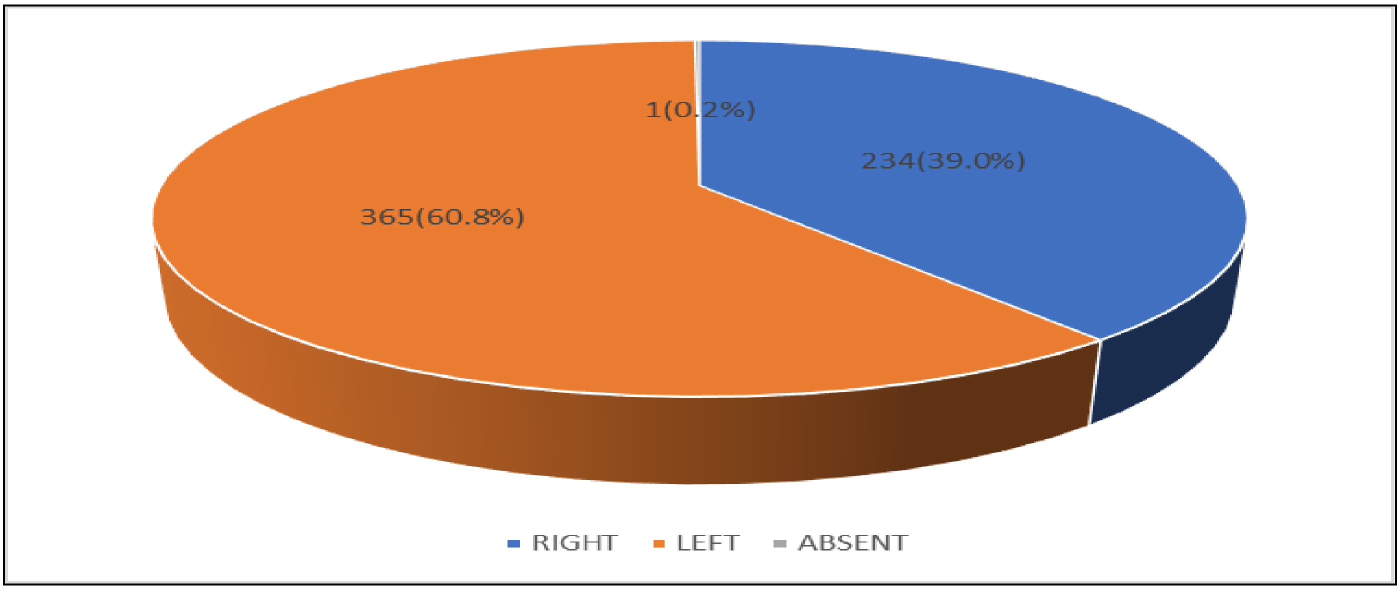


Fig 5 Distribution of Presence or Absence of ASMs on Correct Anatomical side of Radiographic Images Pre- and Post- CR Installation

We used paired sample T-test inferential statistics as shown in Table 5, to investigate potential shift in the use of ASMs at BSUTH following CR installation. With a *p*-value between 0.000 and 0.044, the use of ASMs at BSUTH was statistically significant, indicating an overwhelming positive change in clinical practice with regard to anatomical side markers, however in a minority of cases there was statistical non-significance as noted with ASM presence and ASM correct R- or L-side annotations, with *p values of* 0.318 and 0.453, respectively

Table 5 Distribution of Inferential Statistics to Compare Change in Practice, with regard to ASMs Pre-and Post-CR Installation.

| **Pre-and Post-CR installation pairs** | **Paired differences** | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | **95% C.I difference** | | | |
| | **Mean** | **Std. Dev.** | **Std. error mean** | **lower** | **upper** | **t** | **Sig. (2-tail)** |
| i.ASM site -ASM site | -0.310 | 2.651 | 0.153 | -0.611 | -0.009 | -2.025 | 0.044 |
| ii.ASM present -ASM present | 0.003 | 0.058 | 0.003 | -0.003 | -0.010 | 1.000 | 0.318 |
| iii.ASM correct side- ASM correct side | -0.030 | 0.691 | 0.040 | -0.109 | 0.049 | -0.752 | 0.453 |
| iv.ASM type-ASM type | -0.167 | 0.400 | 0.023 | -0.212 | -0.121 | -7.230 | 0.000 |
| v.ASM radiation field- ASM radiation field | -0.380 | 0.614 | -0.035 | -0.450 | -0.310 | -10.722 | 0.000 |
| vi.ASM obstruct essential anatomy- ASM obstruc essential anatomy | 0.070 | 0.268 | -0.015 | 0.040 | 0.100 | 4.518 | 0.000 |

The BSUTH radiology departmental personnel and modalities as well as equipment, and operational setup as physically inspected is as shown in figures 6-8 below.

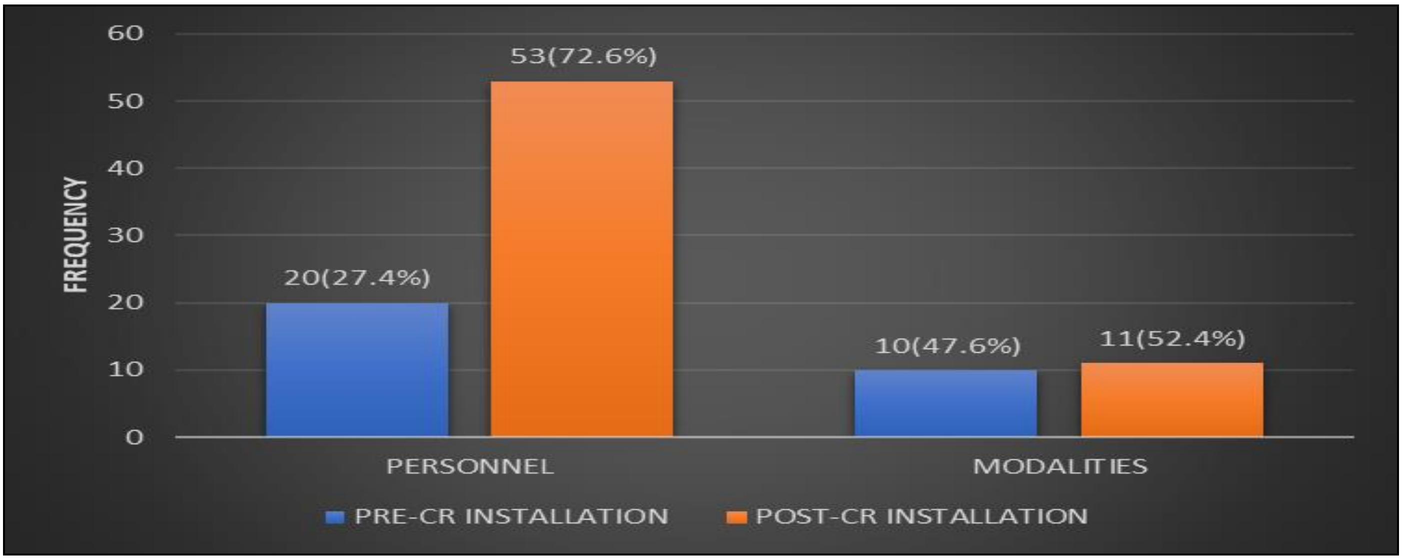


Fig 6 Distribution of Departmental Personnel and Modalities, Pre- and Post- CR Installation

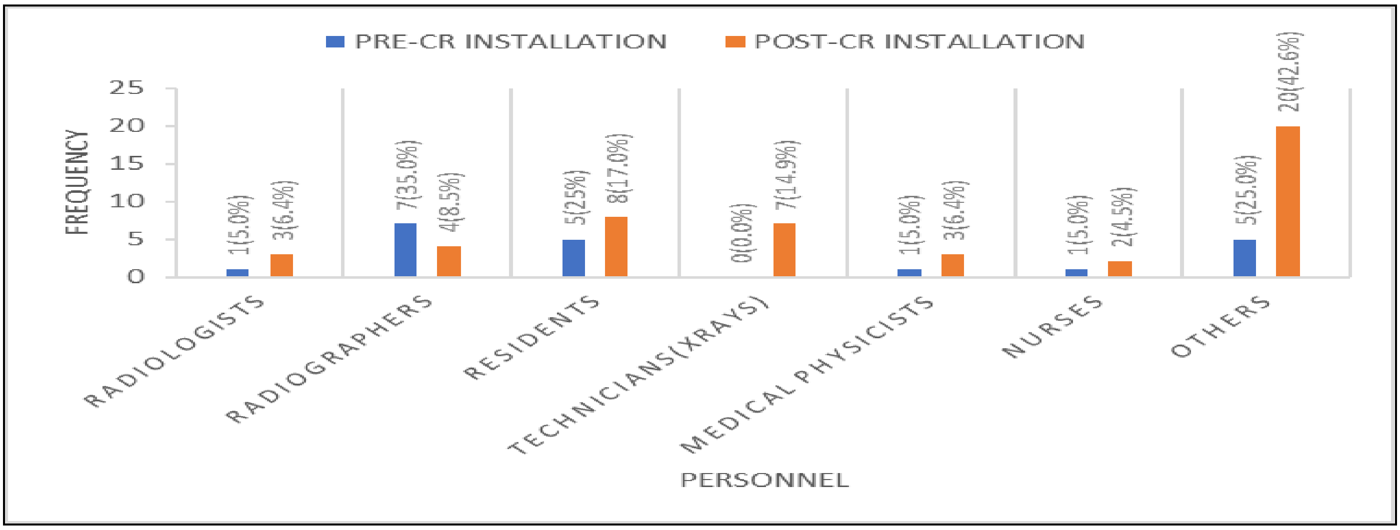


Fig 7 Distribution of Departmental Personnel Pre- and Post- CR Installation

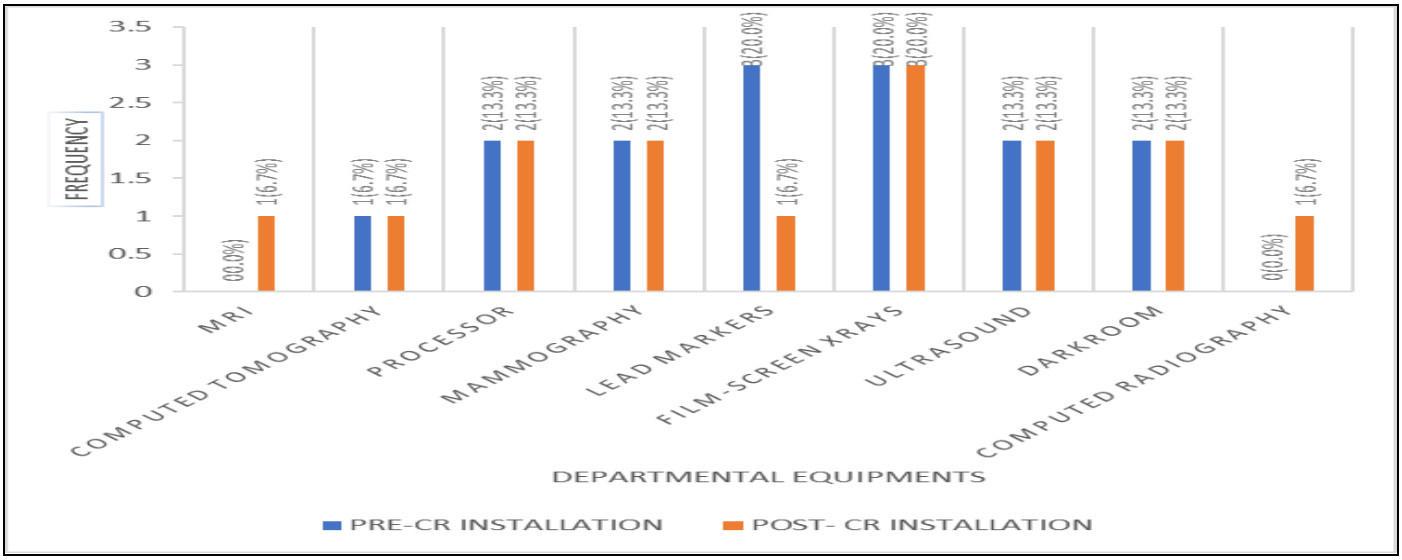


Fig 8 Distribution of Departmental Operational Equipments Pre- and Post- CR Installation

## IV. DISCUSSION

We reported gender discrepancy, with female predominance before the installation of CR at BSUTH. Nevertheless, the ratio reversed in favor of men after the installation of CR as displayed in figure 4. Women's greater use of radiological services at BSUTH prior to CR installation may be linked to their increased pursuit of healthcare information, consultation with numerous resources, and seeking information for themselves, their friends, and family members (21). However, our findings may still just be circumstantial. Be that as it may, the audit recorded no significant difference in the mean age of the patients, which was 40.2years ±18.9 and 41.2years±18.4 respectively before and after CR installation.

Table 2 shows that patients in their third decade of life and beyond accounted for over three-quarters of the ASM present in 502 (83.7%) radiographs before and after CR installation, with only 1(0.2%) at the fifth/sixth decade been responsible for a missing marker. The incidence of extremely low missing markers in our research is good practice, even though the linkage with age may just be a chance finding. Our incidence of extremely low missing ASMs, however contrasted with earlier reports. An audit by Kate B et al. (18) found out that 22(5.5%) of radiographic images had no ASM. Previous studies (3,19), however, reported no evidence of ASMs in 70(14.0%) and 8(1.9%) radiographs, respectively.

Illustrative scenarios of improper use of ASMs include a survey (22), in the USA which found out that 217(21.0%) surgeons performed wrong-site surgery, resulting in 20(9.0%) people with permanent disability and 83(38.0%) with medico-legal repercussions. Finnbogason T et al. (9), in a medico-legal case report involving a chest radiograph that showed left-and-right side confusion due to a missing ASM, described how two premature newborns with pneumothorax had thoracostomies performed on the wrong side, resulting in one death! The survey and case study demonstrate how crucial it is to appropriately mark and place ASMs on all radiographic images. But despite the radiographers having an option to include an ASM, even post-examination, they often choose not to include it in radiographs for a variety of reasons, including a lack of ASM, hectic work schedules, time constraints, and worries about infection transmission, particularly to patients who are immunocompromised (2,13), resulting in an image without side annotations, an undesirable practice that should be avoided (19).

Our data indicated that chest x-rays were the most frequently performed examination at our hospital among the audited radiographic images, accounting for 174(58.0%) and 152(50.7%) exposures, before and after CR installation respectively. This is in agreement with the report (18), in which 56(14.0%) chest radiographs were the most frequent occurring examination, even though our percentage values are comparably much higher. One of the most common investigations performed in any medical imaging department is a chest X-ray for which accurate annotation is crucial to prevent wrong-site surgery, patients` harm, medico-legal issues and misdiagnosis of anatomical anomalies such as pneumothorax, dextrocardia or situs inversus (18).

Prior to CR installation at BSUTH, 52 (17.3%) post-processed ASMs and 247 (82.3%) lead markers were used respectively for radiographic image annotation, whereas 300 (100%) digital ASMs were employed exclusively after CR installation as seen in table 3. The emergence of digital ASMs has created an intriguing trend that supports our significant positive research finding. It serves as a reminder that radiographs did, for the vast majority of cases, contain some form of ASM, and that choosing digital ASMs over lead ASMs represents a clear departure from accepted best practice (19). Our research yielded results that were consistent with those of several other authors (3, 15, 19). In contrast, Titley A et al's study (4) found that the use of lead ASMs (34.5%) was higher than that of digital markers (24.3%), which may need local insight into specific departmental expectations to explain the disparity. Another possible explanation could be related to the increased utilization of lead markers in their study's primary beam, along with potentially stricter managerial control and departmental auditing procedures. The desire for digital ASMs in radiography reflects the growing use of technology in radiology, however, there is a need for clarity on best practice guidelines to avoid a division between lead and digital ASMs usage (19).

Our audit shows that radiographers at BSUTH typically placed ASMs in the primary radiation beam, with 225(75.0%) and 162(54.0%) radiographs pre- and post-CR installation respectively placed in the primary beam (table 4). Researchers (15,17), reported radiographers' anxiety of film rejection due to marker uncertainty, which results in film repeat and ionizing radiation exposure to patients. They suggested adding markers in the primary radiation beams for greater visibility, but discovered no advantage save for non-essential anatomy. Markers were frequently obscured by high density in primary fields, making the idea fall short. Secondary radiation field markers were clear and attractive, but they risked marker cone-off and film repeat.

A total of 22 (3.7%) ASMs, including 1 (0.3%) and 21 (7.0%) markers, were respectively found to obstruct essential anatomy before and after CR installation at BSUTH (table 4). Our percentage value of 22 (3.7%), markers obscuring anatomy is higher than the 12(2.0%) reported by Adejoh T et al. (17) but much lower than the 45(18.8%) ASMs obscuring essential anatomy as reported by other researchers (2,23), which revealed an annotation obscuring a left clavicular fracture, which was missed during the first visit and later detected following a second X-ray of that shoulder. Placing annotations or an ASM on essential anatomy can obscure diagnostic features, so radiographers and students must follow guidelines to avoid adverse effects and mitigate the possibility of being held accountable for their negligence (2).

We performed inferential statistical analysis, which showed significant shift in clinical practice, with regard to anatomical side markers, after CR installation at BSUTH ($p$=0.000-0.044). While the audit criteria of 100% for the inclusion of an ASM within the primary beam was not met, we find consolation in the fact that both the pre- and post-CR installation reviews recorded more than fifty percentage compliance. The discernible shift in the data, before and after CR installation at BSUTH still does not allow for the conclusion that there is no risk. Patients and healthcare providers run the risk of making mistakes when there is no ASM on a radiograph. Serious repercussions could result from this, including early death (15).

The BSUTH appeared to have a managerial strategy in place to ensure that resources were appropriately harnessed following the installation of CR and additional equipments, resulting in a 33 (45.2%) increase in personnel recruitment, and a fresh employment of seven Xray technicians, who are typically at the frontline of image annotation, despite a decrease in experienced radiographers from seven to four. This is in agreement with a similar hospital administrative audit as reported by another researcher (16). Hospitals that employ mentees, such as the Xray technicians, can evaluate their quality of practice by looking at radiographic image annotation with ASMs (16). This audit also indirectly evaluates the efficacy of the senior radiographers' supervision.

## V. LIMITATIONS

Since our study was retrospective in nature, it was subject to a number of limitations, including lower qualitative evidence and missing data due to the fact that it was not initially intended to collect research-related data, unlike prospective research.

Again, the audit was limited to one location. To enable benchmarking and the determination of error rate, it would have been excellent to compare the outcomes of this clinical audit with those of other medical imaging departments, at least within the state.

Given that some of the authors of this research were mentees of the senior departmental radiographers whose images were evaluated, there is a notable danger of possible performance bias in the auditing process.

## VI. CONCLUSION

The audit highlighted the clinical importance of anatomic side marking in an effort to minimize radiographic image annotation errors, incorrect side surgery and misdiagnoses, all of which have very serious medico-legal consequences. It also introduces digital side markings, which were previously manual, time-consuming and challenging.

Although the benchmark for this audit was the presence or omission of ASMs, there was significant discernible change in anatomical side markers' practice ($p$=0.000-0.044), with more than 50% of markers being positioned inside the primary beam both before and after CR installation. This gives us some hope. It is therefore, fair for any organization to aim for meeting the established best practice of having an unambiguous anatomical side marker that represents the proper anatomical side on 100% of images.

The research revealed that despite only 1(0.2%) of radiographs lacking ASMs, the complexity of their use in clinical practice is evident. Radiopaque ASMs are the recommended best practice, but their use can be influenced by the radiographer's attitude (personal values, beliefs, and habits), environmental or systemic factors like department protocols, technology, and working conditions, as well as image-related factors like the permanence and aesthetic appearance of radiopaque ASMs.The increasing use of digital ASMs in diagnostic imaging has surpassed professional practice norms, encouraging future research to investigate what diagnostic imaging experts consider acceptable practice and whether radiopaque ASMs still have a place in modern radiography.

Our research indicated that very few lead markers were available at BSUTH for anatomic side marking, which may have an impact on radiographic image annotation. Strategies such as staff education sessions and the distribution of customized anatomic side markers have the potential to enhance compliance on an individual basis. Regular monitoring and audits ought to be promoted at the departmental level.

This audit adds to the growing body of knowledge that emphasizes the value of anatomical side marking on radiographic images and the necessity of auditing departmental practices, especially as digital radiography becomes more prevalent. In addition, it has given our hospital fresh data on the imaging scientists` adherence to the use of anatomical side markers, as well as recommendations for future clinical departmental development and annotation practice.

## RECOMMENDATIONS

These recommendations, in part, re-echoes the views earlier expressed by other researchers (8,15) and strongly suggest that:

All staff and management of BSUTH be made aware of our research findings in order to emphasize the dangers of not using ASMs correctly. There should also be audits of all hospitals that have an installed CR, with the enactment of a national policy on the use of ASMs, compelling practitioners to include right/left side annotations on every image. Regular auditing in all areas of clinical diagnostic imaging that use ASMs with their provision to all practitioners, and if possible extra ones bought to replace lost ones or be made available for use when needed. To eliminate cases of missing markers on images in the future, diagnostic imaging experts should consider inserting fixed markers into radiographic equipment design, as has been done in orthopantomography and cephalometric studies. ASMs, the personal accessories used with each patient and kept in the radiographers' pockets when not in use, must be disinfected after each use in order to reduce the transmission of infections in radiography. Additionally, diagnostic imaging centers must follow the

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"Universal protocol for preventing wrong site, wrong procedure, and wrong person surgery," which has been in effect since July 2004. It includes labeling the area to be operated, confirming radiographic image annotation before starting a surgical procedure, and temporarily suspending operations to be sure of the patient`s identity before making an incision.

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- *Ethical Consideration.*

The institutional health research ethics committee granted ethical approval number BSUTH/MKD/HREC/ 2023/026. Informed consent was not considered because the study was retrospective in nature, which eliminated the necessity for patient consent.

- *Conflict of Interest:*

The authors reported none

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