RADIOGRAPHERS' UTILISATION OF RADIOGRAPHIC CRITIQUE OF ROUTINE SHOULDER PROJECTIONS

By

Ida-Keshia Sebelego

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Department of Clinical Sciences
Faculty of Health and Environmental Sciences
Central University of Technology, Free State

BLOEMFONTEIN

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Supervisor: Dr B Van der Merwe
Co-supervisor: Dr J du Plessis

DECLARATION

I, the undersigned, hereby declare that *Radiographers' utilisation of radiographic critique of routine shoulder projections* is my own work and that it has not been submitted before by me or any other person to any university for the obtainment of a qualification, and that all the sources I have used have been indicated and acknowledged as references.

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SUMMARY

Radiographers have a responsibility towards their patients to provide optimal patient care. Patient care involves, but is not limited to, positioning and applying radiation protection measures to ensure that optimal x-ray images are obtained (Brask & Birkelund, 2014:26). Optimal routine shoulder projections, namely, an anterioposterior (AP) projection (external rotation) and a lateral (LAT)-Y projection of the shoulder were investigated at the participating imaging department because it became evident to the researcher that the radiographers find it challenging to provide optimal routine shoulder images that adhere to specific radiographic criteria that contribute to patient care.

The two research questions that were addressed for the research study were, (1) do radiographers and radiography students at the imaging department under investigation find it challenging to use/apply radiographic criteria to critique routine images of the shoulder, and (2) will a radiographic criteria checklist assist the researcher to determine the reasons for repeat shoulder routine projections at the participating imaging department? Therefore, the aim of the study was to determine the utilisation of radiographic criteria to evaluate the quality of routine shoulder images produced by the radiographers at the participating imaging department.

A pragmatism paradigm was utilised for this research study. The research approach that was used in conjunction with the paradigm was mainly quantitative, with a few qualitative elements. A quantitative radiographic criteria checklist and quantitative radiographer critique questionnaire were compiled by the researcher with the assistance of literature to achieve the aim.

Firstly, the researcher collected data utilising the radiographic criteria checklist that was pilot tested to evaluate 578 routine shoulder images obtained by student, qualified, community service and supplementary radiographers. The purpose of the radiographic criteria checklist was to determine the causes contributing to images not meeting the radiographic criteria and, therefore, the reasons for repeating routine shoulder projections. A simple/proportional random sampling technique was utilised to select the routine shoulder projections for evaluation on the display monitors. Raw/static routine shoulder images on the display monitors were evaluated, because these images did not undergo post-processing.

Secondly, a pilot tested radiographer critique questionnaire was utilised to determine the knowledge of the participants regarding the anatomy of the shoulder and the way the routine shoulder images are evaluated for optimal positioning and exposure factor selection. A group-administered survey was utilised. All the participants gathered as a group and

answered the radiographer critique questionnaire individually. This method contributed to the trustworthiness of this research study, by preventing the participants discussing the answers with each other. The researcher organised three sessions for participants to complete the radiographer critique questionnaire. The researcher converted the radiographer critique questionnaire into a clicker session to support the Go Green initiative and limiting printing. A total population sampling method was utilised for the participating radiographers because there was a small population at the participating imaging department, therefore, the whole population working at the participating imaging department could be included in the study. The questions were designed specifically to obtain information on how radiographers critique shoulder images and how they perform their radiographic technique to obtain projections of the shoulder.

The radiographic criteria checklist shown that 89% of AP (external rotation) shoulder images and 73% of LAT-Y shoulder images had the incorrect centring point. Therefore 53% of the AP (external rotation) and 52% of the LAT-Y images did not demonstrate four-sided collimation. Utilising the incorrect centring point and not applying collimation effectively resulted in unnecessary exposed anatomical structures to radiation. Furthermore, the radiographers placed digital lead markers after an exposure was made for 34% of AP (external rotation) shoulder images and 39% of LAT-Y shoulder images. This practice is unethical and can have medico-legal complications. Ninety-four percent (94%) of AP (external rotation) projections and 71% of LAT-Y shoulder projections were repeated once due to positioning as the common reason for the repeats.

There were significant differences in percentages for the radiographer critique questionnaire between radiographers and students in relation to identifying anatomical structures of the shoulder. The Fisher's exact test was utilised to determine the significance (p-values). Moreover, there was a significant difference ($p= 0.0076$) among radiographers and students in identifying an AP (external rotation) shoulder image with optimal mAs. In addition, 85% of students and 71% of radiographers indicated that the AP (external rotation) image is positioned incorrectly ($p= 0.4105$), but only 56% of students and 50% of radiographers knew how to correct the shoulder image ($p= 0.5800$). Furthermore, 74% of students and 86% of radiographers could clearly identify a LAT-Y shoulder image that did not demonstrate correct positioning ($p= 0.6925$), but only 45% of students and 43% of radiographers could identify what corrective measures to obtain to ensure correct positioning ($p= 0.7839$). No significant difference in percentages between the radiographers and students were observed, however, a gap between practical application and theoretical knowledge has been clearly identified in this research study.

The findings of the research study contributed significantly to identifying the contributing factors that lead to non-optimal shoulder images. Recommendations were made to address the factors contributing to non-optimal shoulder images to enhance optimal diagnostic imaging of the shoulder, which can contribute to an improvement in patient care at the participating imaging department.

Key terms: routine shoulder projections, evaluation of image, optimal image, radiographic criteria checklist, radiographer critique questionnaire

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CONCEPTUAL FRAMEWORK FOR THIS STUDY

GLOSSARY OF TERMS

Critique: evaluate a theory or practice in a detailed and analytical way (Oxford Dictionary, 2014:Online). In this study it means that radiographic criteria are utilised by radiographers to evaluate shoulder images.

Good radiation practices: involve following the ALARA (as low as reasonably achievable) principle. Some aspects of practices involve positioning, utilising correct exposure factors and protecting patients from radiation. The purpose of good radiation practice is to prevent the occurrence of radiation-induced non-stochastic effects by adhering to dose-equivalent limits that are below the threshold, and to limit the risk of stochastic effects to a reasonable level compared with non-radiation risks and in relation to society's needs, benefits gained and economic factors (McQuillen Martensen, 2011:30-33).

Image: the body part that is viewed on a computer or other recording medium (Ballinger & Frank, 1999:79; Bontrager & Lampignano, 2014:15).

Projection: the direction of the central ray as it exits the x-ray tube and passes through the body, projecting an image onto the image receptor. Most projections are based on the anatomical position of the patient, therefore indicating the entrance and exit point of the central ray through the body (Ballinger & Frank, 1999:71; Bontrager & Lampignano, 2014:29).

Radiographic criteria: the definable standard/s by which an image can be evaluated. The standard includes five factors, namely, (1) structures shown, (2) exposure criteria, (3) lead markers, (4) position and collimation, and (5) central ray (Bontrager & Lampignano, 2005:30).

Routine projections: projections commonly performed on patients who can cooperate fully (Bontrager & Lampignano, 2014:33).

X-ray (noun): (1) Electromagnetic wave with a short wavelength that is able to pass through materials, and (2) image of an internal structure of an object produced by x-rays (Compact Oxford English Dictionary for Students, 2006:1202).

LIST OF ACRONYMS & ABBREVIATIONS

AAOS	American Academy of Orthopaedic Surgeons
AC	Acromioclavicular
ACR	American College of Radiology
AEC	Automatic exposure control
ALARA	As low as reasonably achievable
AP	Anterioposterior
AVN	Avascular necrosis
B.Rad	Bachelor of Radiography
CPD	Continuous professional development
CPPD	Calcium pyrophosphate dehydrate deposition disease
CR	Computed radiography
CT	Computer tomography
CUT	Central University of Technology
DoH	Department of Health
EI	Exposure index
GH	Glenohumeral
GT	Greater tubercle
HADD	Hydroxyapitie deposition disease
HPCSA	Health Professions Council of South Africa
IR	Image receptor
kV	Kilovolt

kVp	Kilovolt peak
LAT	Lateral
LT	Lesser tubercle
mA	Milliampere
mAs	Milliampere per second
MRI	Magnetic resonance imaging
ms	Millisecond
MTA	Modified trauma axillary
N.Dip	National Diploma
OA	Osteoarthritis
PACS	Picture Archiving Communication System
RA	Rheumatoid arthritis
ROI	Region of interest
SC	Sternoclavicular
SOC	Synovial osteochondromatosis

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CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This research study focused on the quality of the two routine shoulder x-ray projections in relation to radiographic positioning, and the utilisation of radiographic critique as an aspect for enhancing patient care. Stated differently, if radiographers produce optimal images, it may enhance patient care in relation to quality diagnosis and treatment. Therefore, the researcher endeavored with this research to determine the causes of non-optimal imaging of the shoulder with the intention of enhancing practice and limiting unnecessary repetition of projections caused by sub-optimal positioning and selection of exposure factors.

All general diagnostic imaging departments examine patients referred for x-ray projections of the shoulder. These imaging departments utilise imaging protocols, which include routine and additional projections of the shoulder. Many government hospitals in South Africa in the Free State province execute an anterioposterior (AP) projection (external rotation) of the shoulder and a lateral (LAT) -Y projection of the shoulder as routine projections. The routine AP projection (external rotation) and LAT-Y projection of the shoulder must adhere to specific technical and positioning requirements to ensure quality imaging of this complex joint. The radiographic criteria requirements for routine shoulder projections are utilised by radiographers to critique shoulder images. Ensuring the routine projections adhere to the radiographic criteria as outlined by literature will enhance the quality of shoulder imaging and consequently patient care within the imaging department.

One of the obligations of a radiographer, as stated in the South African Health Professions Act 56 (South Africa, 1974:2), is that radiographers need to provide good patient care to all their patients at all times. Patient care can be defined as the close dealings between patients and healthcare professionals (Brask & Birkelund, 2014:27). In radiography, patient care includes a broad spectrum of actions, such as good communication, respecting patients, obtaining optimal images that assist with diagnosis and treatment, having specialised knowledge of anatomy to assist in patient positioning, and protecting the patient against unnecessary radiation during imaging (Brask & Birkelund, 2014:26; Ehrlich & Coakes, 2016:90). Currently, more patients than in the past are familiar with their rights, they have more insight about their illnesses and understand what type of care they are supposed to be receiving at a healthcare institution. Therefore, patients are often involved in decision-making regarding diagnostic processes and treatment offered (Brask & Birkelund, 2014:23). This adds to one of the reasons why radiographers must demonstrate skills resulting in good quality imaging as part of good patient care.

The aim of this chapter is to familiarise the reader with the background of the research study, and to provide the problem statement, the research question, the overall goal, and aim and objectives of the study. The research design and methods are presented briefly in this chapter. This chapter also focuses on the significance and value of the study and, furthermore, on the validity, reliability and trustworthiness of the methods employed to accumulate the data. The chapter is concluded by an explanation of the layout of the following chapters and a summative conclusion.

1.2 BACKGROUND TO THE STUDY

Although the goal of every imaging department should be to deliver high quality x-ray images, the researcher observed in clinical practice that it is often challenging for radiographers to obtain routine x-ray projections of the shoulder that adhere to the radiographic criteria as described in literature. This research study thus investigated, by means of a retrospective analysis and a quantitative enquiry, why radiographers often fail to execute routine shoulder projections successfully. The researcher collected images of routine shoulder projections and evaluated them by means of a radiographic checklist of criteria; the evaluation was followed by the radiographers who participated in the study by completing a questionnaire. The purpose of the checklist was to identify the reasons contributing to the necessity to repeat routine projections of the shoulder. The purpose of the questionnaire was to determine if the radiographers possessed knowledge of the radiographic criteria recommended by literature and whether they used this knowledge when they critiqued the routine shoulder images.

1.2.1 Radiographic criteria for routine shoulder projections

A key responsibility of a radiographer is to ensure that all x-ray projections obtained are optimal for diagnosis (Hobbs, 2007:501). Factors such as positioning, exposure, collimation, utilising the correct lead marker and including all required anatomy in the image (Brown, 2013:252; ACR, 2014a:4) must be considered. When radiographers pay attention to providing images that adhere to the criteria, they contribute to providing good quality images and ultimately good patient care, as stated by Brask and Birkelund (2014:26); good quality images improve diagnosis and decision-making regarding the treatment of patients. To the contrary, x-ray projections that do not meet the requirements could impair diagnosis and require repeat projections, which increase the radiation dose to the patient unnecessarily (Bushong, 2008:605; Bontrager & Lampignano, 2014:61).

According to various authors of radiography textbooks, the routine AP projection (external rotation) and LAT-Y projection of the shoulder have to adhere to four basic criteria to be accepted for diagnostic purposes. The various radiographic criteria described by different authors will be discussed in detail in the next chapter. Bontrager and Lampignano (2014:30) indicate that a system can be used to review any x-ray projection obtained to determine if it is of diagnostic value. When a radiographer wants to critique the images obtained he/she needs to evaluate four sections/elements, namely, (1) the anatomy demonstrated, (2) the positioning of the anatomical part, (3) the exposure factors selected and (4) the visibility of the anatomical lead markers.

The anatomy being demonstrated should clearly indicate the anatomical structures that must be included in the x-ray image. Secondly, the positioning of the specific anatomical structure should be such that it demonstrates collimation, correct centring and the optimal positioning of the part. Thirdly, the evaluation of the exposure refers to the kilovoltage (kV) and milliamperage per second (mAs) that was used and whether the consequent x-ray image demonstrates unsharpness. Lastly, all x-ray images must clearly display the correct anatomical lead marker. The lead marker indicates the anatomical side (right or left) that was imaged (Bontrager & Lampignano, 2014:30). Therefore, the researcher will use these criteria when evaluating the shoulder images in the sample for this investigation. The routine projections of the shoulder that were investigated in this study will be defined next.

1.2.2 Anterioposterior projection (external rotation)

The AP shoulder projection forms part of the routine for imaging the shoulder, as stated by Bénédict (2013:Online) and the American College of Radiology (ACR, 2014a:4). Each imaging department will, however, decide which AP projection (internal rotation, external rotation or neutral position of the humerus) it will utilise as part of the imaging protocol for the specific department. The imaging department involved in this study utilises the AP projection (external rotation) as one of the routine projections for imaging of the shoulder. The arm is rotated externally until the hand is in supination and the epicondyles of the distal humerus are parallel to the Bucky/imaging receptor (IR) (McQuillen Martensen, 2015:239; Bontrager & Lampignano, 2014:187). The AP projection with external rotation of the hand can expose various pathologies, such as glenohumeral (GH) arthritis, fractures of the coracoid process, glenoid fractures and proximal humerus fractures (eOrif, s.a.:2 of 8). Additionally, this projection allows for the soft tissue to be distributed uniformly, thereby providing excellent osseous detail of the shoulder (Sanders & Jersey, 2005:207).

1.2.3 Lateral-Y projection

The LAT-Y projection is considered to be one of the routine projections for imaging the shoulder (Williams, Yamaguchi, Ramsey & Galatz, 2005:68; Bénédict, 2013:Online; ACR, 2014a:4). The LAT-Y projection assists in detecting pathologies, such as dislocations, Hill-Sachs lesions and fractures, and is also helpful for determining acromial morphology (eOrif, s.a.:3 of 8; Sanders & Jersey, 2005:209; Goud, Segal, Hedayati, Pan & Weissman, 2008:4). The AP projection (external rotation) and the LAT-Y projections must be acquired at 90º from each other (Brown, 2013:251; Bontrager & Lampignano, 2014:33). The two routine shoulder projections mentioned must adhere to specific radiographic criteria to ensure they are optimal for diagnosis.

1.3 PROBLEM STATEMENT AND RESEARCH QUESTIONS

The problem addressed in this study relates to an observation that radiographers and radiography students at one of the imaging departments in South Africa in the Free State province find it challenging to use/apply radiographic criteria to critique routine images of the shoulder (see 1.2). This difficulty often necessitates repetition of projections to ensure that the acquired images adhere to the set criteria. To ensure optimal images, it is important that the images meet the necessary criteria before they are sent to the radiologist or referring doctor for reporting or interpretation. Considering that routine projections of the shoulder form part of the shoulder imaging protocol in the specific department, the reasons why projections are repeated thus needed to be investigated.

No specific research studies could be traced on the evaluation of routine shoulder projections to meet set criteria. Searches were done on the Nexus database system, Ebscohost and Proquest central database, but no relevant dissertations/theses were found for the evaluation of shoulder projections according to specific radiographic criteria. However, information from various radiography textbooks assisted the researcher to compile a radiographic criteria checklist (Appendix A1 and Appendix A2) to address the problem statement. Various keywords/terms, such as routine shoulder projection, shoulder x-rays, orthogonal views of the shoulder, shoulder x-rays in two planes, radiographic criteria of the shoulder, in-service training for shoulder x-ray quality, and radiographic evaluation of the shoulder were utilised for the electronic search.

Additionally, the researcher did a search of radiography textbooks and journals via Science Direct. The radiography textbooks assisted in identifying articles in support of the research study and relevant to radiographic criteria for shoulder imaging. Examples of articles include *Radiographic evaluation of the shoulder* (Goud *et al*., 2008), *Conventional radiography of the shoulder* (Sanders & Jersey, 2005), *Patient care in radiology - the staff's perspective* (Brask & Birkelund, 2014) and *Radiographer use of anatomical side markers and the latent conditions affecting their use in practice* (Titley & Cosson, 2014). The books and articles published internationally and nationally that the researcher consulted, and the imaging protocol used at the imaging department in South Africa, Bloemfontein, Free State province, where the study was conducted, were included in the information gathered from the literature.

In order to address the problem stated, the following two research questions were posed:

"Do the routine images of the shoulder adhere to the radiographic criteria?"

"Will a radiographic criteria checklist assist to determine the reasons for repeat shoulder routine projections at the specific imaging department?"

1.4 OVERALL GOAL, AIM AND OBJECTIVES OF THE STUDY

Before sending images for reporting, radiographers critique images to evaluate if these images meet certain requirements. The overall goal of the study was to enhance the radiographic technique of the radiographers in relation to imaging of the shoulder and, as a result, to improve patient care. A radiographic criteria checklist has the potential to assist radiographers, in a structured way, to critique shoulder images for errors in positioning, exposure factor selection, and other technical requirements in order to improve the quality of such images, with consequent optimisation of diagnosis and patient management. Additionally, the knowledge of the participants regarding the anatomy of the shoulder and how to evaluate for optimal positioning and exposure were evaluated using a quantitative questionnaire.

1.4.1 Aim

The aim of the study was to determine the utilisation of a radiographic criteria checklist to critique of routine images of the shoulder.

1.4.2 Objectives

To achieve the aim, the following objectives were pursued:

1. To benchmark from literature the radiographic criteria for routine AP projection (external rotation) and LAT-Y projection of the shoulder. The information from literature assisted in the compilation of the radiographic criteria checklist and quantitative questionnaire.
2. To identify by means of the radiographic criteria checklist the causes contributing to images failing to meet the requirements.
3. To determine by means of a quantitative questionnaire the knowledge of the participants regarding the anatomy of the shoulder and to determine the evaluation of routine shoulder images for optimal positioning and exposure factor selection.

1.5 RESEARCH METHODOLOGY

The following section briefly describes the methodology utilised for the investigation.

1.5.1 Demarcation and scope of the study

The research study was conducted in the field of radiography in the imaging department of a level three government hospital in South Africa, Bloemfontein, Free State province. The study was conducted from 2014 to 2016, with the empirical research phase taking place from August 2015 to January 2016 (critique of 578 images by means of a checklist) and November to December 2015 (questionnaire for radiographers).

1.5.2 Design of the study and modes of enquiry

The research design for the study was descriptive, explanatory, and evaluative. According to Fouché and De Vos (2011:96), descriptive research focuses on the "how" and "why" questions. In this study, the researcher evaluated shoulder images retrospectively to determine how radiographers critique routine shoulder images for quality and why many shoulder projections at the specific department are being repeated. Thus, explanatory research was done on a known situation to determine why things were done in a certain manner (Fouché & De Vos, 2011:96). Ultimately, the researcher anticipated gaining a clear understanding of the reasons for the repeat of shoulder projections. Therefore, evaluative research was done to determine the reasons for the repetition of shoulder projections. The mode of enquiry for this investigation was mainly quantitative, and utilised a checklist and a questionnaire.

1.5.3 Research instruments for the investigation

The research instruments utilised to accumulate the data included a radiographic criteria checklist (see Appendices A1 and A2), complemented by a radiographer critique questionnaire (see Appendix B) compiled by the researcher using information from literature. The two instruments are described briefly below, but are discussed in more depth in Chapter 3.

1.5.3.1 The radiographic criteria checklist

According to Vijayalakshmi and Sivapragasam (2008:63) checklists are useful tools for gathering facts, recording behaviour, analysing and evaluating objects and rating personalities. In this research study the checklist was useful for gathering facts in relation to the quality of the shoulder images produced by the participating radiographers and for determining the reasons for the repeat of shoulder projections.

The checklist used in this study consisted of a list of radiographic criteria that was used by the researcher to retrospectively critique the routine shoulder projections acquired by the radiographers at the participating institution. The radiographic criteria checklist was compiled by the researcher after consulting various literature sources regarding radiographic criteria that could be used to evaluate routine images of the shoulder for quality (Leedy & Ormrod, 2005:185; Delport, & Roestenburg, 2011:202, 203) (see 3.2.5.1).

1.5.3.2 The radiographer critique questionnaire

The researcher utilised the radiographic criteria checklist to formulate the questions in the questionnaire for the participants. The radiographer critique questionnaire (see Appendix B1) consisted mainly of closed questions. The questionnaire was designed to obtain specific information about 1) the demographics of the sample (Section A), 2) how the participants critique shoulder images before they are sent to the PACS (Picture Archiving Communication System) (Sections B and C), and 3) how the participants apply radiographic technique to obtain routine projections of the shoulder (Sections B and C). The questionnaire was converted into an electronic response system, also known as clickers, which is a paperless method of data accumulation. With the aid of the clickers, participants could immediately view the results of each question that was posed and reflect on their radiographic technique and how they apply the radiographic criteria to critique shoulder images.

1.5.4 The study population

1.5.4.1 The target population

The target population refers to a group of people that will benefit from the research study and are interested in the findings of the research study (Goddard & Melville, 2001:35). The target population for this research study included healthcare professionals with knowledge of the field of radiography, namely diagnostic radiographers and diagnostic student radiographers working at the participating imaging department in Bloemfontein.

1.5.4.2 Sample selection and size of the sample

All the radiographers (qualified, supplementary, community service and students) from the participating imaging department, who were registered with the Health Professions Council of South Africa (HPCSA), took part in the study. A simple random sampling method was utilised by the researcher to select the shoulder projections obtained by the radiographers. This means that all the shoulder images that adhered to the inclusion criteria (see 3.2.5.1.8) and which had been generated from August 2015 to January 2016 were evaluated by the researcher – this ensured that the researcher was not biased during data accumulation. In total 578 routine shoulder images were selected from the image archive for evaluation as part of the data accumulation.

Four supplementary, two community service and 20 qualified radiographers employed at the imaging department were selected to participate in the study. Additionally, 15 second-year Bachelor of Radiography (B.Rad), one second-year National Diploma (N.Dip) and 15 third-year N.Dip students were selected to participate, accounting for a total sample of 57 participants. The researcher included the whole population that was working at the participating imaging department during the time of the data collection as participants in the study, therefore a total population sampling method was utilised.

A comprehensive explanation of the population, sampling methods, data collection techniques, data analysis, reporting of the data and ethical considerations are provided in Chapter 3. Figure 1.1 gives a schematic overview of the study.

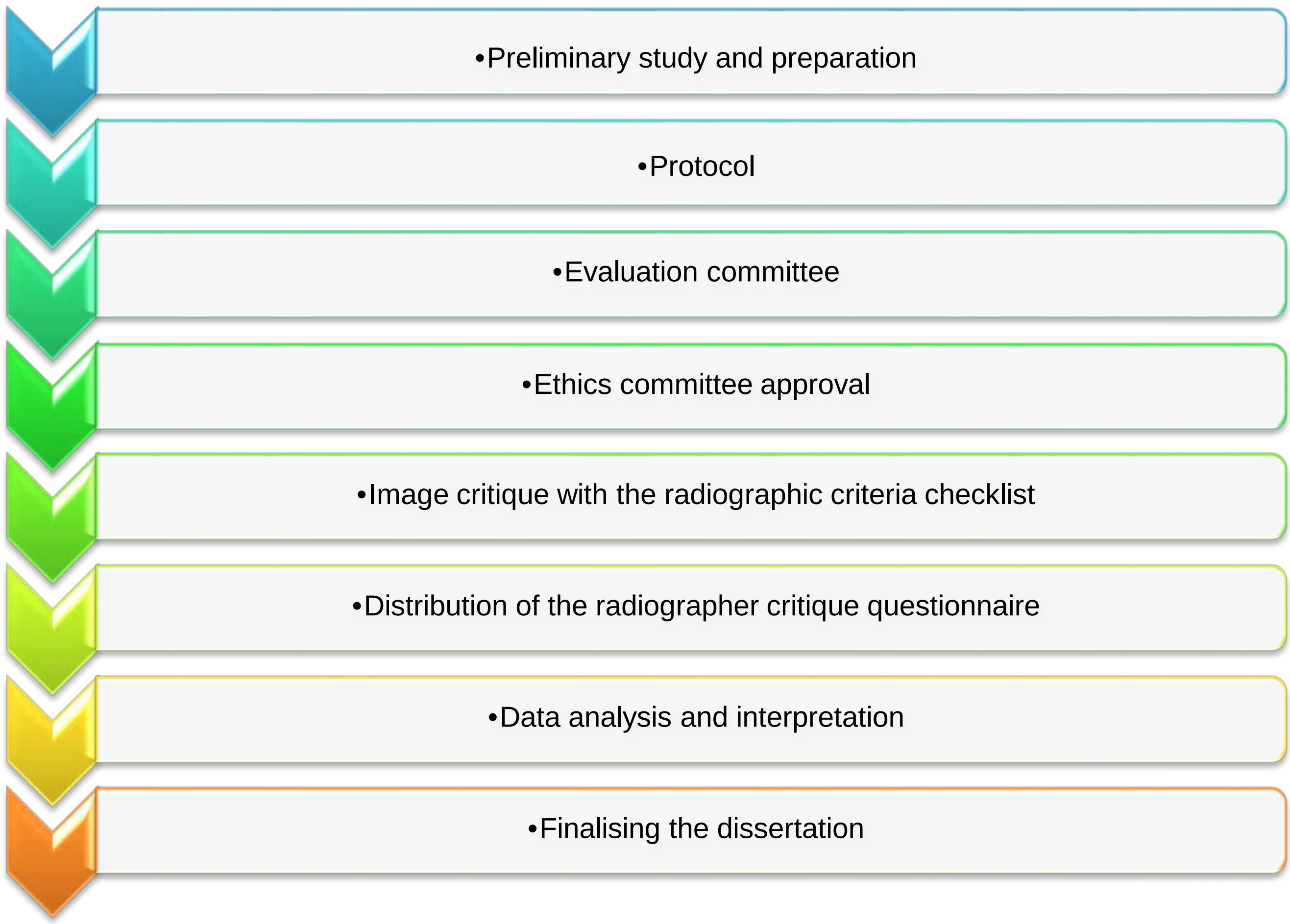

Figure 1.1: Schematic overview of the study
(compiled by the researcher, Ida-Keshia Sebelego, 2014)

1.5.4.3 Ethical considerations

The researcher obtained approval from the Research Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS 100/2015) and permission from the Department of Health (DoH), Free State (see Appendix E). Further permission was obtained from the head of Clinical Services (see Appendix F1) and the director/head of department (see Appendix F2) of the participating hospital.

The participants at the participating imaging department gave informed consent to participate in the radiographer critique questionnaire. No informed consent was required from patients to evaluate their shoulder images, because no names of patients were mentioned or utilised for the study.

1.6 VALIDITY, RELIABILITY AND TRUSTWORTHINESS

Validity and reliability are viewed as measurement instruments for any research study (Goddard & Melville, 2001:41). The Institute for Work and Health (2007:1 of 1) indicates that a researcher cannot prove reliability or validity conclusively. However, when a researcher ensures that the research is as valid and reliable as possible, the results of the study will be considered accurate and trustworthy.

1.6.1 Validity

The validity of a study confirms that what it was supposed to measure was indeed measured (Wilkinson, 2000:42; Goddard & Melville, 2001:41). For this research study the researcher endeavoured to ensure content validity by pilot testing the two research instruments, namely, a radiographic criteria checklist and a radiographer critique questionnaire. The pilot testing of the research instruments aimed to determine if the two instruments would measure what they were intended to measure in the actual study. The construct validity was determined by the answering of the questions, the causes of repeats and if the radiographers successfully critiqued routine shoulder images.

1.6.2 Reliability

Researchers need to confirm that their study is reliable by test-retest to ensure consistency (Institute for Work and Health, 2007:1 of 1). Therefore, the results of the research had to be consistent if the study was repeated under the same conditions and with the same people. The radiographic criteria checklist and the radiographer critique questionnaire proved to be reliable, because it focused on critique of the shoulder. The research instruments were pilot tested to exclude unclear criteria and questions. The checklist proved to be an instrument that could be repeated for all the quantitative elements of the images.

1.6.3 Trustworthiness

The trustworthiness of quantitative research is assessed by means of internal validity, external validity, reliability and objectivity (Key, 1997:5 of 8). The feedback received from the pilot study confirmed that the results would be trustworthy, since it proved to be valid and reliable (see 1.6.1 and 1.6.2). All participants answered the same questions of the questionnaire in the presence of the researcher. Hence, the participants could not consult one another during the completion of the questionnaire; they also had to sign a consent form stating that they would not discuss the questionnaire with the other radiographer who did not complete the questionnaire. Pre-set criteria were used for the radiographic criteria checklist to evaluate all the routine shoulder images, therefore, all images were evaluated utilising the same baseline. A detailed discussion on validity, reliability and trustworthiness follows in Chapter 3.

1.7 SIGNIFICANCE AND VALUE OF THE STUDY

All imaging departments should obtain routine x-ray projections of the shoulder that meet the radiographic critique requirements necessary for diagnosis. The value of this study lies in the identification of the factors that contribute to the necessity to repeat shoulder projections at the participating imaging department. Sensitising radiographers to utilising a radiographic criteria checklist optimally for evaluation of shoulder images for quality can promote optimal diagnostic imaging of the shoulder which, in turn, can contribute to an improvement in patient care.

1.8 IMPLEMENTATION OF THE FINDINGS

The report containing the findings of the study will be communicated to the participating imaging department. In Chapter 6 the researcher will make recommendations based on the findings of the study. The researcher aims to submit the research findings to appropriate academic journals for publication.

1.9 ARRANGEMENT OF THE REPORT

The report of the study includes information about the methods utilised and the results of the research study that will provide the reader with more insight into the topic. The report will be arranged as follows:

Chapter 1: Introduction and background, provided the background to the study, the problem statement, the research question, the overall goal, aim and objectives and the research design and methods used for the study. The demarcation and value of the study were also discussed briefly.

Chapter 2: Conceptual framework for this study, discusses literature relevant to the study, such as that relating to an outline of the anatomy of the shoulder and various pathological conditions that can affect the shoulder. The shoulder protocol used at the participating imaging department formed part of the literature study, because it provides the reader with more insight into the projections that were obtained. Only the routine shoulder projections are discussed comprehensively. Various literature sources in relation to the radiographic criteria utilised for the routine shoulder projections are delineated. The radiographic criteria apply to determining if an x-ray of the routine shoulder projection is acceptable, and are defined and described accordingly in this chapter.

Chapter 3: Criteria checklist and questionnaire for shoulder critique, discusses the data collection methods, data analysis done for the radiographic criteria checklist, and the radiographer critique questionnaire. This chapter also discusses how the radiographic criteria checklist and the radiographer critique questionnaire were compiled, and outlines the advantages of using clickers for completion of the questionnaire.

Chapter 4: Results and discussion: radiographic criteria checklist, provides a report on the routine shoulder projections that were evaluated by the researcher using a criteria checklist.

Chapter 5: Results and discussion: radiographer critique questionnaire, focuses on the responses of the radiographers in the questionnaire survey. This chapter also reports on the manner in which radiographers apply radiographic technique to obtain projections of the shoulder and the method they use to critique shoulder images**.**

Chapter 6: **Conclusion, recommendations and limitations,** supplies a summative conclusion and recommendations that can be considered by the participating institution. The limitations of the study are outlined in this chapter.

1.10 CONCLUSION

Chapter 1 provided the background and introduction to the study into radiographers' utilisation of radiographic critique for routine shoulder projections. This chapter underlined the importance of ensuring that the projections obtained by radiographers meet the requirements for quality imaging, patient care and best practice in the profession.

Chapter 2, entitled ***Conceptual framework of this study,*** will provide a detailed discussion of the relevant literature.

CHAPTER 2
CONCEPTUAL FRAMEWORK FOR THIS STUDY

2.1 INTRODUCTION

"I praise you because in an awe-inspiring way I am wonderfully made" (Bible, Psalm 139:14). The aforementioned text points to the fascinating nature of the human body. By taking time to study the formation of the human body, it can be clearly seen how uniquely it was created. Ostermeier (s.a.:1 of 2), Millett (2007:1 of 1) and Funk (2013a:1 of 1) all point out that the shoulder is the most complicated and complex joint in the human body, due to its range of movement possibilities. Because of its mobility this joint can rotate 360º, which makes it unstable and prone to dislocation.

A shoulder can be injured easily when someone participates in sport, falls or is involved in a motor vehicle accident. In 1895, Willem Conrad Roentgen discovered x-rays and since then it has been used for medical imaging purposes (Ehrlich & Coakes, 2016:2) to visualise injuries or pathologies of the shoulder sustained during traumatic incidents. Modern x-ray imaging offers different modalities to image the shoulder, such as magnetic resonance imaging (MRI), computer tomography (CT), ultrasound (US), arthrography and general radiography (Bontrager & Lampignano, 2014:180). Despite modern imaging modalities, plain x-ray imaging (general radiography) is still often the first imaging modality in the diagnostic algorithm when a patient arrives at the imaging department with complaints about shoulder pain (ACR, 2010:6; Brown, 2013:249).

The advantages of plain x-ray imaging are that it is fast to obtain, it produces a low radiation dose, and demonstrates bony injury sufficiently. Unfortunately, plain x-ray images cannot optimally image all soft-tissue injuries, though it can identify soft-tissue pathology, such as impingement (Basavaraj, Abhishek & Hifz, 2014:365; McKinnis & Mulligan, 2014:6). Plain x-ray images are utilised to identify certain pathologies, such as fractures, and are also a stepping stone to determine which specialised imaging can be utilised to demonstrate specific pathologies optimally (McKinnis & Mulligan, 2014:5). Therefore, plain x-ray images remain the first modality for assessing injuries.

Obtaining optimal images to ensure that a diagnosis can be made during patient management in the imaging department is the responsibility of the radiographer. The images of this complex joint, the shoulder, must be of diagnostic value in relation to aspects such as the anatomy demonstrated, positioning, selected exposure factors and anatomical lead markers. The aforementioned aspects form part of the radiographic criteria for any image. If the images produced by radiographers are inadequate, referring doctors might find it difficult to make a diagnosis and decisions about further imaging (Brask & Birkelund, 2014:26).

Chapter 1 highlighted the importance of producing high quality x-ray images of the shoulder. Delivering high quality x-ray images of the shoulder contribute to quality imaging and the optimisation of patient care and management. Currently, the radiographic criteria for the AP (external rotation) projection and LAT-Y projection of the shoulder can be utilised to determine if an image is diagnostically acceptable. Chapter 1 listed the four basic criteria that can be applied to critique x-ray images obtained by a radiographer (see 1.2.1).

Chapter 2 will provide background to the research study, establish a framework against which the investigation will be conducted and assist the researcher to determine what still needs to be investigated (Wilkinson, 2000:27, Study and Learning Centre, 2005:1 of 1, Yunus & Tambi, 2013:124). Chapter 2 will also discuss the radiographic criteria in greater depth, specifically in relation to routine shoulder projections.

2.2 CONCEPTUAL FRAMEWORK FOR THE INVESTIGATION

Radiographers are not only familiar with the anatomy of the shoulder, but also the indications/pathologies for shoulder imaging, so that they know the reason for a specific examination (Bontrager and Lampignano, 2014:xv). In order to obtain a projection of a specific body part, the radiographer needs to be cognisant of the anatomical structures to be included in the image. Moreover, radiographers must have a basic knowledge and understanding of pathology, specifically in relation to how the pathology impacts the exposure factors, but also of the way the pathology appears on the x-ray image. Knowing about pathology gives purpose to the examination and gives an indication of the structures that should be included to demonstrate a specific pathology optimally.

When x-ray projections of the shoulder are acquired, the most sensitive organs in the region of the shoulder that may receive ionising radiation are the thyroid and the breast. Radiographers have a responsibility towards their patients to provide radiation protection (Bontrager & Lampignano, 2014:61). According to the European Commission (2012:8), international standards for radiation protection are based on justification, optimisation and dose limitation.

Justification refers to justifying why a certain radiographic procedure is done and considering the risks and benefits of such an examination. Optimisation requires that the ALARA (as low as reasonably achievable) principle is applied to reduce the radiation dose the patient receives. Dose limitation entails applying standards to limit the amount of dose a patient receives to minimise any biological effects on the human body. These standards form part of good radiation practices. Applying these standards during imaging will mean that the radiographer utilises the correct exposure factors for the various examinations to demonstrate the anatomy best, will reduce repeats during imaging, and will utilise lead shielding and collimation to protect the patient from unnecessary radiation (European Commission, 2012:8).

Repeating x-ray projections due to positioning error, wrong selection of technique factors, poor communication and improper collimation, all contribute to unnecessary patient dose, which could have been avoided by the radiographer (Bushong, 2008:605; Bontrager & Lampignano, 2014:61). According to Bushong (2008:605), unnecessary patient dose refers to "radiation dose that is not required for the patient's well-being or proper management and care". Repeating shoulder projections due to one of the above factors leads to a higher radiation dose to the patient in general and the sensitive organs in that region in particular. Thus, limiting repeat imaging will reduce patient dose, and contribute to radiation protection and patient care.

Reducing the number of repeats might, at times, require radiographers taking a step back and evaluating their own radiographic technique in terms of positioning and selection of exposure factors involved in imaging the shoulder. When x-ray projections are repeated, the evaluation of the repeated images will indicate why the images obtained did not adhere to the criteria. Repeat imaging implicates unnecessary radiation dose; therefore, monitoring is justified. Monitoring in imaging departments refers to the execution of reject analysis as part of a quality assurance programme. According to Lloyd (2004:19) and Andersen, Jorde, Taossi, Yaqoob, Konst and Seierstad (2012:174), reject analysis determines why radiographers repeat projections and gives an indication of the aspects that radiographers can improve on to reduce repeat projections. This study attempted to investigate the possibility of limiting repeat projections by means of a checklist.

Figure 2.1 displays a diagrammatic overview of the conceptual framework (Chapter 2) and will guide the reader in what to expect.

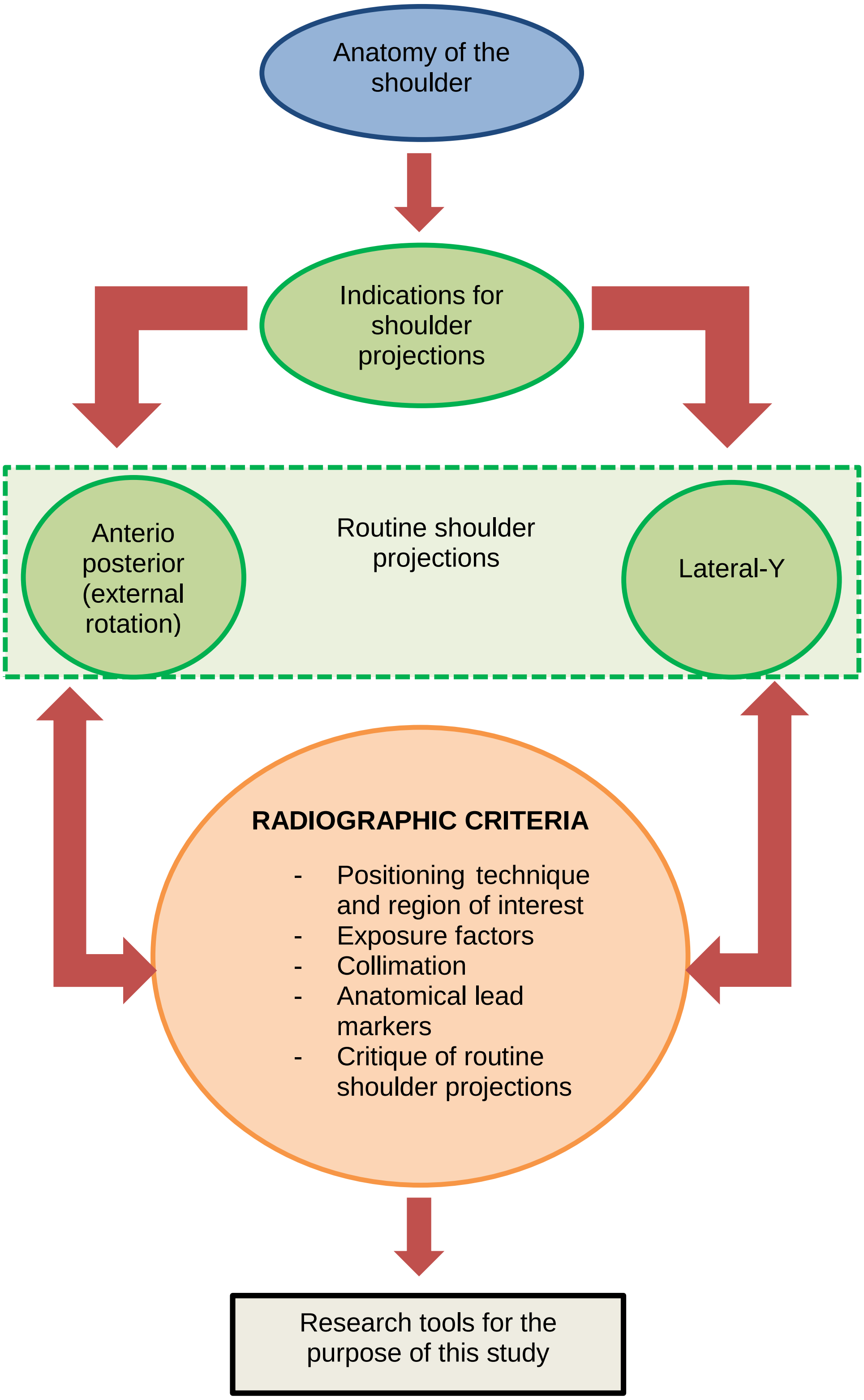

Figure 2.1: Diagrammatic overview of the conceptual framework of the study (compiled by the researcher Ida-Keshia Sebelego, 2016)

2.2.1 Anatomy of the shoulder

Since the interpretation of the anatomy is an important aspect of the evaluation of the shoulder by means of the radiographic critique of the shoulder, this section will discuss the anatomy of the shoulder girdle with reference to the following sections: bones, joints, ligaments, muscles and nerves. The shoulder is made up of four joints and two bones, which allow a lot of movement. There are a series of ligaments and muscles that keep the joint intact. The shoulder is built and connected by various layers. The deepest layer is that of the bones and joints of the shoulder. The bones that form the shoulder are the scapulae and the clavicle. The humerus attaches to the scapula and the humerus is seen as an important bone of the shoulder joint. Another layer comprises the ligaments; the tendons and the muscles form the next layer. The four joints that make up the shoulder joint are the glenohumeral (GH) joint, acromioclavicular (AC) joint, sternoclavicular (SC) joint and the scapulothoracic joint (Funk, 2013a:1 of 1, Bontrager & Lampignano, 2014:175, Marieb & Hoehn, 2014:261). Figure 2.2 provides an overview of the anatomy of the shoulder.

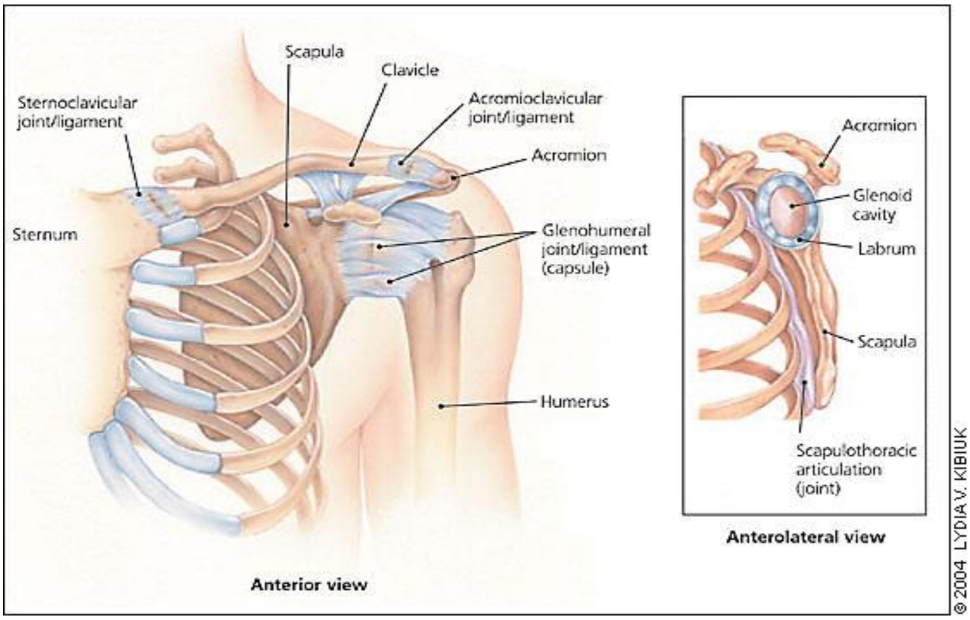

Figure 2.2: Anatomy of the shoulder (Courtesy to Kubiuk, 2004)

2.2.1.1 *Bones of the shoulder girdle*

<u>The clavicle</u>

The clavicle is a slender, S-shaped bone that fractures easily. This bone articulates with the sternum at the medial end and with the acromion of the scapula at the lateral end. The articulation between the acromial end of the clavicle and the acromion of the scapula forms the roof of the shoulder. The medial sternal end of the clavicle attaches to the sterna manubrium and the lateral end of the clavicle articulates with the scapula. The clavicle can anchor many muscles and acts as a brace. It can hold the scapulae and arms out laterally, away from the thorax. This bracing function becomes obvious when the clavicle is fractured, because then the entire shoulder region collapses medially (Funk, 2013b:1 of 3; Marieb & Hoehn, 2014:262).

<u>The scapula</u>

The scapula is a flat, triangular bone that lies on the dorsal surface of the ribcage, between ribs two and seven (Funk, 2013b:1 of 3; Marieb & Hoehn, 2014:262). The flat blade of the scapula glides along the chest, allowing the arm to move extendedly. The scapula consists of three processes, namely, the acromion, spine and coracoid processes. This forms the back portion of the shoulder girdle (Funk, 2013b:1 of 3).

According to Marieb and Hoehn (2014:262) each scapula has three borders, namely, the superior border, medial border and lateral border. The superior border is the shortest and sharpest border. The medial border is parallel to the vertebral column and thus is it called the vertebral border. The thick lateral border abuts the armpit and ends superiorly in a small, shallow fossa, namely, the glenoid cavity. This cavity articulates with a third of the head of the humerus, forming the shoulder joint. Thus, the cavity is deepened by means of the glenoid labrum. The glenoid labrum is a rubbery, fibro-cartilaginous structure that encircles the glenoid cavity, deepening the socket by 50% and providing 20% stability to the GH joint. The glenoid labrum has three purposes, namely, to increase surface contact area, to provide support and serve as an attachment site for GH ligaments (Funk, 2013c:1 of 2; Marieb & Hoehn, 2014:262).

The superior border of the scapula meets the medial border at the superior angle. The superior border meets the lateral border at the lateral angle. The medial and lateral borders join at the inferior angle, which moves extensively when the arm is raised and lowered. The posterior surface of the scapula bears a prominent spine that can be felt very easily. The spine ends laterally in an enlarged, roughened, triangular projection called the acromion. The acromion articulates with the lateral end of the clavicle and forms the AC joint. Located anteriorly from the superior scapular border is the coracoid process. The coracoid process helps anchor the biceps muscle of the arm (Marieb & Hoehn, 2014:262).

Humerus

The humerus articulates with the scapula at the shoulder. The humerus has a head, neck and two tubercles, namely, the greater and the lesser tubercles. The head of the humerus is half-spherical in shape and projects into the glenoid cavity. Inferiorly to the head of the humerus is the anatomical neck. The greater and lesser tubercles are prominent landmarks on the humerus and serve as attachment sites for the rotator cuff muscles. Distal to the two tubercles is the surgical neck of the humerus (Funk, 2013b:2 of 3, Marieb & Hoehn, 2014:262).

2.2.1.2 *Joints and movements*

The six synovial joint types are the plane, pivot, condylar, hinge, saddle (gliding) and ball-and-socket joints. A ball-and-socket joint is formed where one bone is ball-shaped and the other bone has a rounded surface that fits properly into the socket. A synovial joint is formed between these two bones, and allows movement of 360º. The shoulder and hip are examples of ball-and-socket joints. The difference between the shoulder and hip joint is that the hip is a more stable joint than the shoulder. The hip joint does not dislocate as easily as the shoulder joint (Joseph, 2012:3 of 5, Bontrager & Lampignano, 2014:14, Marieb & Hoehn, 2014:294, 300). Three of the four joints in the shoulder, namely, the SC joint, AC joint and the GH joint, are classified as synovial joints (fibrous capsule containing synovial fluid) (Bontrager & Lampignano, 2014:178). The three joints mentioned above are freely moveable (Bontrager & Lampignano, 2014:178).

2.2.1.3 *Ligaments and muscles*

The head of the humerus fits in the glenoid cavity that is deepened by the glenoid labrum; this contributes little to joint stability. "The few ligaments reinforcing the shoulder joint are located anteriorly of the shoulder. The coracohumeral ligament provides the only strong thickening of the articular capsule to support the weight of the humerus" (Marieb & Hoehn, 2014:300).

The muscle tendons across the shoulder joint also contribute to the stability of the shoulder. The tendon of the long head of the biceps brachii muscle attaches to the superior margin of the labrum, travels through the joint cavity and then runs within the intertubular sulcus of the humerus. This brachii muscle ensures that the head of the humerus is adjacent to the glenoid cavity (Marieb & Hoehn, 2014:300).

The four other tendons and their associated muscles make up the rotator cuff. The muscles included in the rotator cuff are the sub-scapularis, supraspinatus, infraspinatus and teres minor. The rotator cuff muscles and GH ligaments provide joint stability and allow a wide range of motion. The fact that the shoulder is so moveable makes it vulnerable to injury (WebMD, 2010:1 of 2; Marieb & Hoehn, 2014:300). Figure 2.3 demonstrates all ligaments and muscles of the GH joint that contribute to the stability of the shoulder.

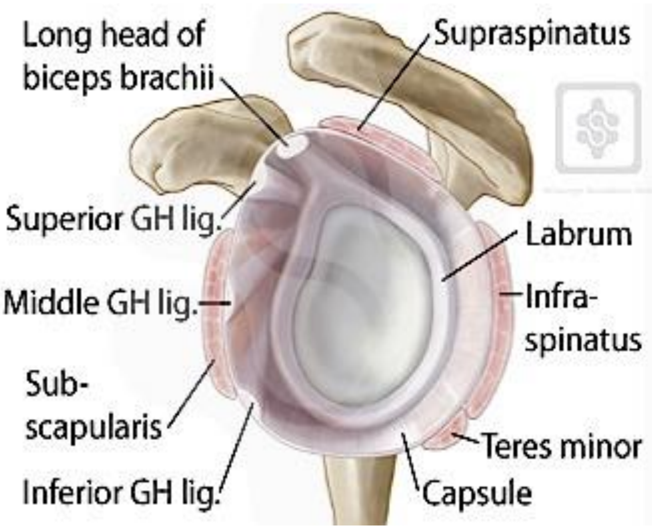

Figure 2.3: Ligaments and muscles that contribute to shoulder stability (Courtesy to Funk, 2013c:1 of 2 (shoulderdoc.co.uk)

Between the rotator cuff muscles and the outer layer of large bulky muscles of the shoulder lies the subacromial bursa. This bursa is a sac that is located between two surfaces; this sac contains a small amount of lubricating fluid, which reduces friction. The bursa can become inflamed and consequently cause a great deal of pain in the shoulder joint (Funk, 2013d:1 of 2).

Various nerves travel down the shoulder joint. According to Funk (2013e:1 of 2) and Marieb and Hoehn (2014:552) all the nerves that pass through the axilla are known as the brachial plexus before they start dividing into individual nerves, such as the axillary nerve and subscapular and suprascapular nerves. The nerves carry signals from the brain to the muscles that move the arm. They also carry sensation signals, such as touch, pain and temperature, from the muscles back to the brain. With severe shoulder injuries such as direct blows to the top of the shoulder, the brachial plexus can be injured. The brachial plexus is a soft-tissue structure and, thus, injury of this plexus cannot be visualised on plain x-ray images, but soft-tissue pathology can be identified (see 2.1 and 2.3.1.2). Weakening of the whole upper limb or paralysis of the upper limb indicates a brachial plexus injury.

2.3 INDICATIONS FOR X-RAY IMAGING OF THE SHOULDER

An indication is defined by the Farlex Partner Medical Dictionary (2012:Online) as the basis for initiation of a treatment or a diagnostic test. This indication may be informed by the knowledge of the cause of the indication, called a causal indication, by the symptoms present in the patient, called a symptomatic indication, or by the nature of the disease, called a specific indication. The Mosby's Medical Dictionary (2009:Online) defines indication as a reason to prescribe medication or to perform a treatment. In the same way, there are specific indications for performing diagnostic imaging, such as in the case of imaging of the shoulder. Radiographers should have a thorough knowledge of these indications, because an indication can supply information on the type of projections to be done to demonstrate pathology optimally.

Due to the instability and vulnerability of the shoulder (see 2.2.1.3), the shoulder can sustain various types of injuries. The injuries can be either non-traumatic or traumatic in nature, depending on whether the injury was sustained during a trauma event or not. Trauma to the shoulder can have a variety of causes, including falls, motor vehicle accidents or even blows to the shoulder. Pathologies of the shoulder can be categorised as follows: (i) tendon inflammation or tendon tear, (ii) instability, (iii) arthritis, and (iv) fractures (WebMD, 2010:1 of 2; AAOS, 2010:1 of 4; AAOS, 2011:1 of 5). According to the literature consulted the pathologies discussed in 2.3.1 to 2.3.4 are the most common pathologies of the shoulder that patients present with.

2.3.1 Tendon inflammation/tendon tears

Tendon inflammation may involve bursitis and tendonitis. Bursitis involves inflammation and swelling of the bursa. When the bursa sac contains more fluid than it is supposed to, due to the inflammation process, it causes swelling that leads to a painful shoulder. Bursitis is often associated with rotator cuff tendonitis and subacromial impingement of the shoulder (WebMD, 2010:2 of 2; AAOS, 2010:1 of 4; AAOS, 2011:1 of 5; Funk, 2013d:1 of 2). According to WebMD (2010:2 of 2), tendonitis refers to inflammation of one of the tendons in the rotator cuff. The rotator cuff tendons can be either irritated or damaged. There are two types of tendonitis, namely, acute and chronic. Acute tendonitis is caused by repetitive movements, such as excessive ball throwing or overhead activities during work or sport. Chronic tendonitis is due to degenerative diseases, such as arthritis, or repetitive wear and tear due to age (AAOS, 2010:2 of 4; AAOS, 2011:1 of 5).

Hydroxyapitie deposition disease (HADD) refers to calcified tendonitis, and affects the shoulder joint more than any other joint in the body. Calcified tendonitis or bursitis is quite common in the shoulder. The supraspinatus tendon is mostly involved with HADD (Sanders & Jersey, 2005:218; Goud *et al*., 2008:12). Figure 2.4 shows calcification of the supraspinatus on an AP projection of the shoulder.

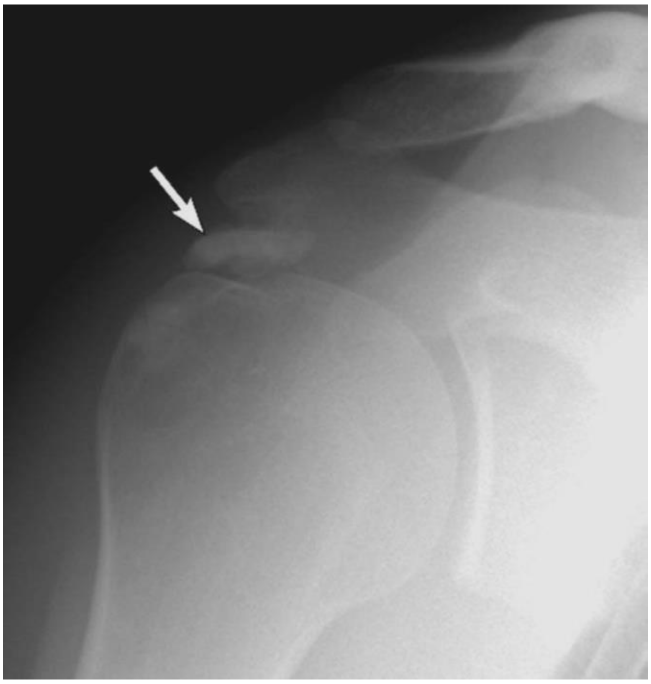

Figure 2.4: AP projection of the shoulder showing a distinct collection of calcification within the supraspinatus tendon, which indicates HADD (Courtesy to Sanders & Jersey, 2005:219)

2.3.1.1 *Rotator cuff pain*

Rotator cuff pain is commonly found in both young athletes and middle-aged people. Young athletes who are involved in swimming, tennis and baseball are vulnerable to rotator cuff pain. People who take part in construction, painting and paper-hanging activities can also experience rotator cuff pain (AAOS, 2011:2 of 5). According to AAOS (2010:2 of 4) tendon tears involve splitting and tearing, either partially or completely. Tendon tears may result from acute injury or degenerative changes in the tendons, and may be due to advancing age, long-term overuse and wear and tear, or a sudden injury. Tendon tears occur most commonly in the rotator cuff and biceps tendons. Figure 2.5 illustrates a rotator cuff tear on a radiographic image. Rotator cuff tears usually involve the muscles or tendons surrounding the top of the humerus. The glenoid labrum can also tear due to an accident or overuse of the GH joint (WebMD, 2010:2 of 2).

Figure 2.5: A radiographic image showing a rotator cuff tear with a high humeral head under the acromion. The arrows points to bursal distension of the nearby fat pad (Courtesy to Goud *et al.*, 2008:14)

2.3.1.2 *Shoulder impingement*

Shoulder impingement occurs when the acromion presses on the rotator cuff when the arm is lifted, as seen in Figure 2.6. Acromion impingement on the rotator cuff and bursa can lead to bursitis and tendonitis, which can cause severe pain and limitation of movement. Severe impingement can lead to rotator cuff tear (AAOS, 2010:2 of 2; WebMD, 2010:2 of 4).

Pathologies of the nerves of the shoulder are rare; the most commonly affected nerves are the axiallary nerve (most commonly stretched with shoulder dislocations) and the long thoracic nerve, which can cause winging of the shoulder. Another nerve, the suprascapular nerve, supplies the supra and infraspinatus muscles, can also be affected. The muscolocutaneous nerve supplies the biceps muscle. The brachial plexus nerve can become weak and consequently cause muscle wasting and weakness of the shoulder, which is known as brachial neuritis (Funk, 2013e:1 of 2).

Figure 2.6: An AP projection of the shoulder demonstrating the acromion pressing on the rotator cuff (Courtesy to Goud *et al.*, 2008:12)

2.3.2 Instability: subluxation and dislocation

Shoulder instability is a common indication for imaging of the shoulder and many patients arrive at the imaging department to assess for this pathology. Shoulder instability occurs when the humeral head is forced out of the glenoid cavity. This normally occurs when the shoulder has been overused, or due to a sudden force being applied to the shoulder. Most shoulder dislocations are caused by direct trauma and sports injuries, such as those suffered by rugby players. In the elderly, shoulder dislocations are mostly due to falls; these dislocations are commonly accompanied by fractures (Quillen *et al.*, 2004:1950; AAOS, 2009a:2 of 3; AAOS, 2010:2 of 4; Rozbruch, 2013:2 of 4).

When the humeral head is partially out of the glenoid cavity it is known as subluxation. When the humeral head comes out of the glenoid cavity completely, it is known as dislocation. Dislocations and subluxations can occur repeatedly once the ligaments, tendons and muscles around the shoulder have loosened or torn. Repeated episodes of dislocation and subluxation can lead to arthritis of the shoulder joint. A dislocated shoulder can damage the nerves around the shoulder joint, especially if it is not treated. Most patients undergoing shoulder examinations present with dislocations of the GH joint (AAOS, 2009b:1 of 4; AAOS, 2010:2 of 4; Rozbruch, 2013:2 of 4).

As stated by AAOS (2009b:2 of 4), Goud *et al.* (2008:8-9) and Sanders and Jersey (2005:212) severe trauma is often the main cause of shoulder dislocations. When the humeral head dislocates, the glenoid fossa and ligaments positioned anteriorly of the shoulder are injured. Dislocations in patients under 35 years of age usually result in a tear of the labroligamentous complex from the inferior glenoid fossa, referred to as a Bankart lesion (see 2.3.4.3). Dislocations in patients over the age of 35 years are less likely to develop Bankart lesions of the anterio-inferior labrum. Older patients normally experience either disruption of the rotator cuff, avulsion of the greater tuberosity, or avulsion of the subscapularis muscle and anterior capsule from the lesser tuberosity (Sanders & Jersey, 2005:212-213).

Dislocations can occur in anterior, posterior or inferior directions. According to Cluett (2012:1 of 1), Goud *et al.* (2008:8-9) and Sanders and Jersey (2005:212), about 95% of patients present with anterior shoulder dislocations, and 5% of patients present with posterior dislocations. Conversely, Quillen *et al.* (2004:1950) state that 90% of dislocations occur anteriorly and 10% posterior. Thus, we can conclude that most dislocations will occur anteriorly, and posterior dislocations are unusual. It occurs among cyclists and skiers, and in participants in other athletics-type sports. This dislocation could be misdiagnosed as frozen shoulder due to the fact that the patient's arm is in adduction and cannot rotate externally (Sanders & Jersey, 2005:212-213). Figure 2.7 shows a patient presenting with posterior dislocation of the GH.

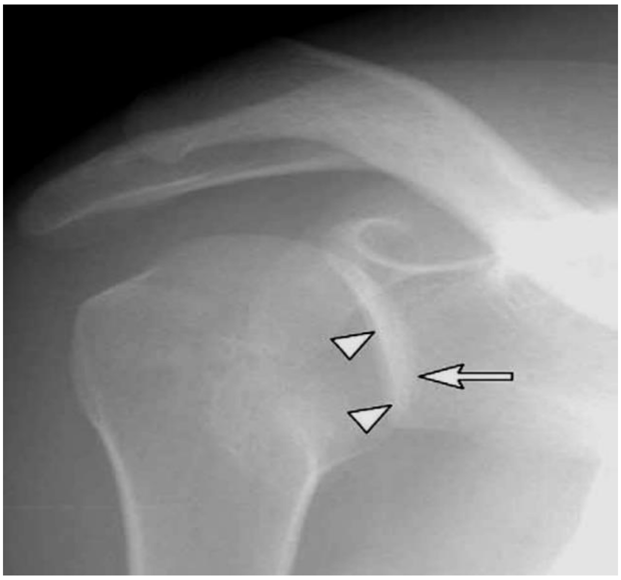

Figure 2.7: Medial cortex of the humeral head superimposes the glenoid fossa, as illustrated by the arrow heads and the arrow, demonstrating posterior dislocation of the shoulder (Courtesy to Sanders & Jersey, 2005:215)

Inferior shoulder dislocation, also known as luxatio erecta, is rare; this type of dislocation represents only 0.5% of shoulder dislocations. Inferior dislocations are often accompanied by fractures and neurovascular injuries (Quillen *et al.*, 2004; Goud *et al.*, 2008). Figure 2.8 demonstrates an inferior dislocation.

Figure 2.8: Humeral head is displaced inferiorly and the arm is abducted (Courtesy to Goud *et al.*, 2008:10)

2.3.3 Arthritis

Shoulder pain, such as that of tendonitis, can cause arthritis. Arthritis is the inflammation of one or more joints, and it can cause pain and stiffness (WebMD, 2010:2 of 2). The different types of arthritis are briefly discussed in the sections that follow.

2.3.3.1 *Osteoarthritis*

There are various types of arthritis, but the most common arthritis found in the shoulder is osteoarthritis (OA). Arthritis, and specifically OA, affects the cartilage space of the glenoid (Goud *et al*., 2008:11). OA is caused by wear and tear that occurs with aging. It destroys the joint lining, namely, the articular cartilage of the bone, as seen in Figures 2.9. As the cartilage wears away, the protective space between the bone decreases and the bones of the joint rub against each other, causing severe pain. OA is more commonly found in the AC joint than in the GH joint, and affects mostly people over 50 years of age. OA may also be related to sports or work injuries and chronic wear and tear (WebMD, 2010:2 of 2; AAOS, 2010:2 of 4; AAOS, 2013:2 of 6). Late-stage OA can result in posterior subluxation of the GH joint (Goud *et al.*, 2008:11).

Figure 2.9: Patient presenting with OA of the GH joint (Courtesy to Funk, 2016: 3 of 3 (shoulderdoc.co.uk)

2.3.3.2 *Calcium pyrophosphate dehydrate deposition disease*

Calcium pyrophosphate dehydrate deposition disease (CPPD) presents as a crystal deposition into the hyaline cartilage, labrum and other soft-tissue structures of the shoulder, as illustrated in Figure 2.10. As CPPD progresses, it results in secondary OA of the GH joint (Goud *et al.*, 2008:13). CPPD involves either the AC or GH joint and can lead to the development of OA. Early in the disease, CPPD can be observed in either the fibrocartilage or the hyaline cartilage of the joint. In later stages it will present as OA, joint space narrowing, subchondral sclerosis and osteophyte formation (Sanders & Jersey, 2005:218).

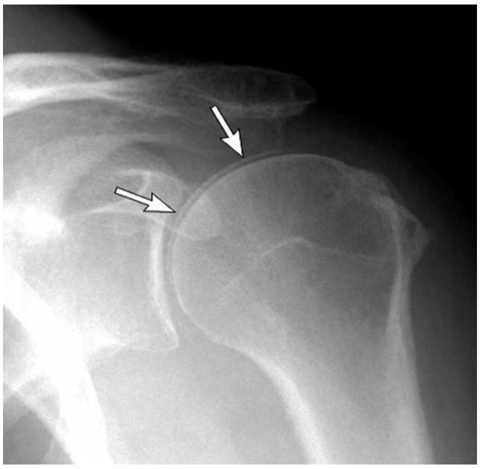

Figure 2.10: An AP projection of the shoulder showing linear collection of chondrocalcinosis within the hyaline articular cartilage of the humeral head (Courtesy to Sanders & Jersey, 2005:218)

2.3.3.3 *Rheumatoid arthritis*

Another type of arthritis that can affect the cartilage space of the shoulder is rheumatoid arthritis (RA). RA is a chronic disease that presents symmetrically, meaning that it affects the same joint on both sides of the body. This type of arthritis is an autoimmune disease, meaning that the immune system attacks its own tissue, namely the joints. Rheumatoid arthritis causes the synovial joints of the shoulder to swell, resulting in pain and stiffness, as explained by AAOS (2013:2 of 6) and WebMD (2010:2 of 2). On x-ray images, RA will show periarticular osteopenia, marginal erosions, and uniform cartilage space narrowing in the absence of osteophytes, subchondral sclerosis and bursitis (Goud *et al.*, 2008:10-11). Figures 2.11 illustrate rheumatoid arthritis.

Figure 2.11: AP projection image displaying deepening of the glenoid fossa due to the erosion of the humeral head (Courtesy to Goud *et al.*, 2008:11)

2.3.3.4 *Posttraumatic arthritis*

Posttraumatic arthritis is a form of OA that develops after injury, such as a fracture or dislocation of the shoulder. It can also develop after a rotator cuff tendon tear that was not treated. If the torn rotator cuff no longer holds the humeral head intact within the glenoid cavity, the humerus moves upwards and rubs against the acromion, causing arthritis (AAOS, 2013:2 of 6).

2.3.3.5 *Avascular necrosis*

Avascular necrosis (AVN) can lead to arthritis and the destruction of the shoulder joint. AVN occurs when the blood supply to the humeral head is cut off. As AVN progresses, the bone cells die. The dead bone collapses, which damages the articular cartilage covering the bone, and leads to arthritis. AVN normally first affects the humeral head, but as it progresses the collapsed humeral head can damage the glenoid cavity (AAOS, 2013:2 of 6).

AVN affects the bone density of the shoulder due to bone cell death. As seen on x-ray images, AVN can cause subtle lucency, sclerosis, fragmentation, sub-articular collapse, and potentially arthritis and joint destruction in the final stage (Goud *et al.*, 2008:10). Figure 2.12 illustrates avascular necrotic shoulder.

Figure 2.12: Grashey projection image displaying lucency with surrounding sclerosis in the humeral head indicated by the arrows. These signs represent avascular necrosis (Courtesy to Goud *et al.*, 2008:10)

X-ray images can help diagnose arthritis and can assist in distinguishing among various types. Regardless of the type of arthritis a patient presents with, an arthritic shoulder will show a narrowing of the joint space and changes in the bone density. The formation of bone spurs, namely, osteophytes, will also present evidence of an arthritic shoulder (AAOS, 2013:3 of 6).

2.3.4 Fractures

Many patients who were involved in direct trauma present with fractures. According to AAOS (2010:2 of 4) shoulder fractures commonly involve the clavicle, humerus and scapula. Clavicle fractures are usually caused by falls on the lateral shoulder, and less commonly by a direct blow or fall on an outstretched arm (Quillen *et al.*, 2004:1948). Scapular fractures are caused by direct trauma, such as a motor vehicle accident, but is very uncommon. Fractures of the glenoid, coracoids and acromion are associated with shoulder dislocation or direct trauma (Sanders & Jersey, 2005:211).

In elderly patients, shoulder fractures are caused by falls from a standing height. In younger patients, shoulder fractures are caused by injuries from contact sports, such as rugby, or due to a motor vehicle accident (AAOS, 2010:2 of 4). According to Bontrager and Lampignano (2014:181) most fractures sustained by women over the age of 50 years are secondary to

OP, which caused a reduction in the quantity of bone or atrophy of the skeletal tissue. Different fractures will be described in the following section.

2.3.4.1 *Humeral fracture*

Proximal humerus fractures most generally occur in elderly people as a result of falls on outstretched arms (Quillen *et al.*, 2004:1949). In younger patients, proximal fractures are caused by direct blows. A proximal humerus fracture may injure the axillary nerve or artery. The brachial artery, brachial plexus or any other nerve is rarely injured by a proximal humerus fracture. Proximal humerus fractures are normally associated with GH dislocations and rotator cuff injuries (Wright, 2010:Online; Quillen *et al.*, 2004:1949). Figure 2.13 shows a patient with a humeral fracture.

Figure 2.13: Fracture of the humerus (Courtesy to Goud *et al.*, 2008:8)

Sanders and Jersey (2005:211) present a system developed by Neer to describe fractures of the proximal humerus and to predict the clinical outcomes of patients. The Neer classification system is used to determine appropriate treatment for fractures of the proximal humerus.

This system delineates a four-segment system representing the four anatomical structures of the proximal humerus, namely, the head, shaft, and greater and lesser tuberosities. Fractures of the proximal humerus can occur between one or all of these four segments. Fractures with minimal displacement may involve one or all of the anatomic segments of the proximal humerus. In a two-part fracture there is displacement of one segment in relation to the three non-displaced, non-angulated segments. A three-part fracture involves either the lesser or greater tuberosity – an anterior or posterior shoulder dislocation is normally associated with this type of fracture. In a four-part fracture both tuberosities are involved, as are dislocations of the shoulder (Goud *et al.*, 2008:6-7).

Many studies into the Neer classification system question its accuracy. These studies suggest that it is important to be aware of the accurate fracture anatomy, rather than to attempt to classify a fracture (Goud *et al.*, 2008:7).

2.3.4.2 *Hill-Sachs lesion*

When an anterior dislocation of the shoulder occurs, the posteriosuperior humeral head makes contact with the anterioinferior glenoid rim, which causes a wedge-shaped humeral head fracture known as Hill-Sachs lesion, as demonstrated by Figure 2.14. A Hill-Sachs lesion is a type of proximal humerus fracture because it affects the humeral head or humeral neck. Hill-Sachs lesions occur in 35-40% of anterior dislocations and in up to 80% of recurrent dislocations. If this lesion is larger than 40% of the articular surfaces of the humeral head it contributes to the recurrent dislocation of the shoulder. As discussed previously, shoulder dislocations can also project posteriorly. When the anterior humeral head presses against the posterior glenoid rim, it results in an anterior humeral head compression fracture known as a reverse Hill-Sachs lesion (Sanders & Jersey, 2005:214; Goud *et al.*, 2008:9-10; Wright, 2010:Online). Figure 2.15 illustrates a reverse Hill-Sachs defect.

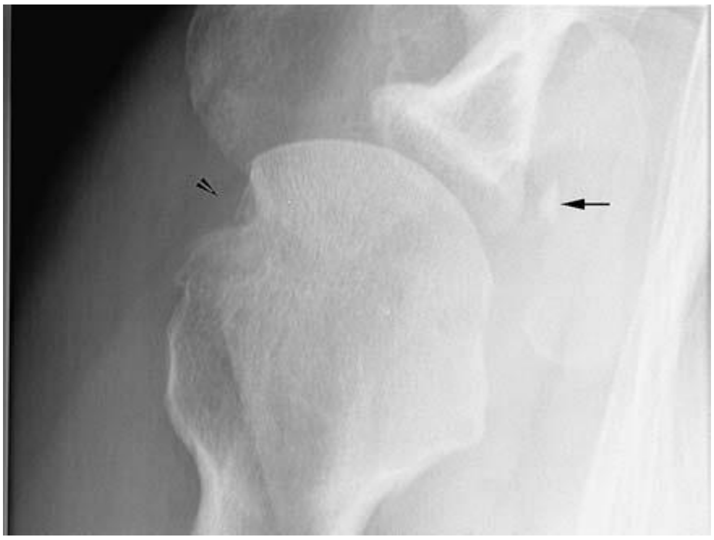

Figure 2.14: Hill-Sachs lesion (shown by the black arrow head) and displaced fracture fragment of the anterior glenoid rim, shown by the black arrow (Courtesy to Geusens, Pans, Verhulst & Brys, 2005:230)

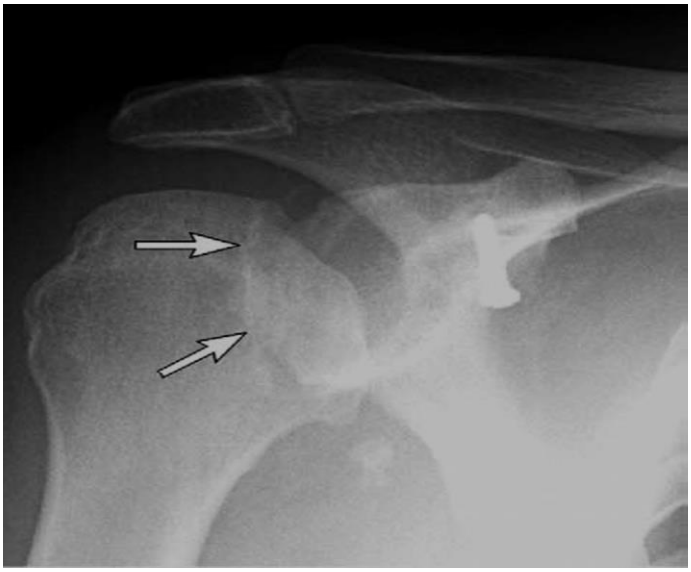

Figure 2.15: AP projection of the shoulder indicates a vertical line running parallel to the medial cortex of the humeral head (see white arrows). That line is referred to as the "trough line" and represents the reverse Hill-Sachs defect (Courtesy to Sanders & Jersey, 2005:215)

2.3.4.3 *Bankart lesion*

Anterior shoulder dislocations can also cause Bankart lesions, which are tears of the anterioinferior glenoid labrum that occur with fractures of the glenoid rim. A Bankart lesion is one of the causes of recurrent dislocations (Goud *et al.*, 2008:8-9). With posterior dislocations, the humeral head moves superiorly and posteriorly. Humeral head fractures occur when the humeral head rubs against the glenoid rim. The anterior humeral head presses against the posterior glenoid rim, resulting in a posterior glenoid rim fracture, also known as reverse Bankart lesion (Sanders & Jersey, 2005:212).

2.3.4.4 *Frozen shoulder*

Frozen shoulder refers to inflammation in the shoulder, which causes pain and stiffness, and which, if it is severe, limits shoulder movement (WebMD, 2010:2 of 2). Frozen shoulder is regarded as an idiopathic disease, meaning the disease is of unknown/uncertain origin (Bontrager & Lampignano, 2014:181).

2.3.5 Other pathological conditions

In this section a few less common pathological conditions of the shoulder will be discussed briefly.

2.3.5.1 *Synovial osteochondromatosis*

Synovial osteochondromatosis (SOC) may occur as primary or secondary damage to the cartilage that results from other conditions, such as synovial membrane proliferation and OA (Goud *et al.*, 2008:14). SOC cannot be seen on x-ray images unless the intra-articular chondroid fragments are calcified, in which case well defined circular opacities are seen within the joint or the bursa of the shoulder, as seen in Figure 2.16. The GH joint widens due to tiny nodules that lodge between the articular spaces. If SOC progresses, it can lead to pressure erosions, and cystic bony changes may occur (Goud *et al.*, 2008:14).

Figure 2.16: Circular calcifications distributed in the GH joint. Capsular recesses illustrate SOC (Courtesy to Goud *et al.*, 2008:14)

2.3.5.2 *Amyloidosis*

Amyloidosis is a systemic disease in which protein fibrils are deposited in the shoulder joint. Amyloidosis results in joint spaces widening due to infiltration, and later the joint space narrows due to cartilage destruction (Goud *et al.*, 2008:14). Amyloidosis can be seen on x-rays as joint space widening due to infiltration of protein fibrils, cartilage destruction that causes joint space narrowing in later stages, erosions, and subchondral cysts that can be sharply marginated (Goud *et al.*, 2008:14).

2.3.5.3 *Neuropathic arthropathy*

Neuropathic arthropathy or Charcot joint is characterised by striking bone changes that occur secondary to the loss of sensation. This disorder is caused by syringomyelia and chronic alcoholism. It can cause bone production, shoulder dislocation, joint space narrowing and the onset of soft-tissue swelling (Sanders & Jersey, 2005:219).

As stated earlier (see 2.3) a thorough knowledge of the indications for shoulder imaging and the related pathologies is essential in order for the radiographer to produce images of diagnostic quality. The two routine shoulder projections utilised in the imaging department under investigation in this study will now be discussed.

2.4 ROUTINE SHOULDER PROJECTIONS

Projections that are commonly performed in an imaging department are referred to as routine projections (Bontrager & Lampignano, 2014:33). Radiographers must be familiar with the routine projections that are obtained for various body parts. Hence, the routine shoulder projections of the investigating imaging department will be discussed.

In many imaging departments, as observed by the researcher in imaging departments in the FS and Northern Cape, it is the norm to have an imaging protocol for any body part that must be examined, including the shoulder. These imaging protocols normally indicate which shoulder projections demonstrate the non-traumatic or traumatic pathologies of the shoulder best.

Most protocols prescribe a minimum of two projections for a routine examination of any joint; these two projections should should be acquired at 90º angulation from each other. The reasons for at least two projections at a right angle to each other are to, (1) ensure pathologies are visualised, (2) ensure detection/localisation of lesions or foreign bodies, and (3) determine alignment of fractures (Brown, 2013:251; Bontrager & Lampignano, 2014:33). All imaging departments should have protocols for “standard projections” in routine circumstances, indicating the examination, correct positioning and the centring point utilised. These protocols also provide necessary diagnostic information, by suggesting the minimum projections that would ensure a good diagnosis while minimising radiation dose to the patient (ACR, 2014a:4; ACR, 2014b:3).

Bénédict (2013:Online), conceptualises that the two routine projections could be an AP and a LAT-Y projection, an AP and an axial projection, or an AP and an oblique projection. However, according to ACR (2014a:4), two routine projections for shoulder imaging are required, namely a LAT-Y projection and an AP or Grashey projection. According to Williams (2005:68), the three orthogonal projections of the shoulder are the AP projection, the LAT-Y projection and an axillary projection. Despite this difference in opinions about the projections that should be performed when doing routine shoulder imaging, many imaging departments have adopted an AP and LAT-Y projection protocol for imaging the shoulder.

2.4.1 Shoulder imaging protocol of the imaging department under investigation

The shoulder protocol at the participating imaging department was consulted to obtain an indication of the shoulder projections utilised. The protocol was retrieved in July 2014. At this imaging department, the routine projections for the shoulder are the AP neutral projection, AP projection (internal rotation), AP projection (external rotation), and the LAT-Y projection of the shoulder. Although four projections are indicated in the protocol as routine, as mentioned above, only the AP (external rotation) and LAT-Y projections are executed as routine.

Additional projections that are suggested are the axial (inferiosuperior, Lawrence method or superioinferior) projection and the transthoracic projection of the shoulder. The projections obtained for trauma of the shoulder are the AP shoulder and the transthoracic projection.

For this investigation, the focus will be on the AP (external rotation) and the LAT-Y projection, but the axillary projection will also be discussed briefly in the following section, as this projection is sometimes requested by doctors together with routine shoulder projections (Du Plessis, 2014).

2.4.2 Anterioposterior projection (external rotation)

The AP projection (external rotation) is done by rotating the arm externally so that the hand is in supination. According to eOrif (s.a.:2 of 8) the AP projection (external rotation) is particularly helpful for GH arthritis, coracoid process fractures, glenoid fractures, proximal humerus fractures and compression fractures of the humeral head. External rotation of the hand results in an overlap of the glenoid and humeral head. The external rotation projection also allows for the soft tissue to be distributed uniformly over the shoulder and, thus, provides excellent osseous detail of the shoulder (Sanders & Jersey, 2005:207). HADD, impingement, rotator cuff tears, CPPD, SOC and amyloidosis are pathologies that affect the soft tissue of the shoulder. With HADD, calcification of the supraspinatus tendon can be seen in profile over the greater tuberosity with an external rotation projection (Goud *et al.*, 2008:12).

The patient is placed with the posterior aspect of the shoulder against the Bucky/IR, as shown in Figure 2.17. The patient's body is rotated slightly towards the affected side, to bring the shoulder in contact with the IR. The affected arm is abducted slightly and rotated externally until the hand is in supination. A perpendicular central ray is utilised (Greathouse, 1998:164; Bontrager & Lampignano, 2014:187).

Figure 2.17: Patient positioning for an AP projection (external rotation)

2.4.3 Lateral-Y projection

The LAT-Y projection is helpful for evaluating anterioposterior dislocations, instability, Hill-Sachs lesions, and fractures of the scapula, acromion, coracoid, and proximal humeral shaft, and for determining acromial morphology (eOrif, s.a.:3 of 8; Sanders & Jersey, 2005:209; Goud *et al.*, 2008:4; ACR, 2010:6; Bontrager & Lampignano, 2014:196). The humeral head is normally centred between the coracoid process and the acromion process. The patient is positioned with the anterior aspect of the shoulder against the IR, as shown in Figure 2.18. The patient is rotated 45-60º away from the affected shoulder, the degree depending on the arm positioning (McQuillen Martensen, 2011:271; Bontrager & Lampignano, 2014:196).

Figure 2.18: Patient positioning for the LAT-Y projection with the hand on the crest

The arm can be positioned either with the hand on the crest (see Figure 2.18) or with the humerus hanging freely. When the patient flexes the elbow and places the hand on the crest, the patient is rotated 60º; whereas a patient is rotated 45º when the humerus is hanging freely. When the patient places the hand on the crest; the scapula slides around the thoracic cavity, resulting in the scapula being positioned more posteriorly, and this requires the patient to be rotated more. The scapula is positioned more anteriorly when the humerus hangs freely, because the scapula is not forced backwards, thus resulting in less rotation to obtain the LAT-Y projection. The affected arm is abducted slightly to ensure that there is no superimposition of the humerus over the ribs (McQuillen Martensen, 2011:271; Bontrager & Lampignano, 2014:196; McQuillen Martensen, 2015:252).

If the shoulder is dislocated anteriorly, the humeral head will show anterior to the "Y" or beneath the coracoid process, and if there is posterior dislocation, the humeral head will show posteriorly to the "Y" or beneath the acromion process, as explained by Ahmad (2002:40), Goud *et al.* (2008:4) and McQuillen Martensen (2015:254). This projection is also considered easier to take, especially if the patient is in extreme pain after an acute traumatic accident, because it can be obtained with little or no movement of the arm (Sanders & Jersey, 2005:209; Goud *et al.*, 2008:4).

2.4.4 Axillary projection

The axillary projection is normally done with the arm abducted either inferosuperior or superoinferior (Ballinger & Frank, 1999:168, 170, 174). The advantage of this projection is that the GH joint can be assessed for subluxation and dislocation anteriorly or posteriorly and osseous Bankart fractures can be detected (Sanders & Jersey, 2005:208; Goud *et al.*, 2008:3). Axillary projections are also helpful for AC arthrithis, os acromionale, Hill-Sachs lesions (eOrif, s.a.:3 of 8) and, according to Goud *et al*. (2008:12), calcification of the subscapularis.

The two axillary projections are the West-point and Lawrence projection. The patient is in a prone position on the x-ray table for the West-point projection (Greathouse, 1998:168), whereas the patient lies supine on the x-ray table for the Lawrence projection (Greathouse, 1998:166). The West-point and Lawrence projections are difficult to obtain in the setting of acute trauma, because the patient has to abduct the arm, thus, modified axillary projections have been developed by researchers to apply in order to obtain axillary projections for trauma patients.

A study was undertaken to replace the LAT-Y projection with a modified trauma axillary (MTA) projection (Neep & Aziz, 2011:188-192). The MTA projection can be taken with the patient in either a seated or supine position, as seen in Figures 2.19 and 2.20. As Figures 2.19 and 2.20 show, the patient does not have to abduct the arm for this projection.

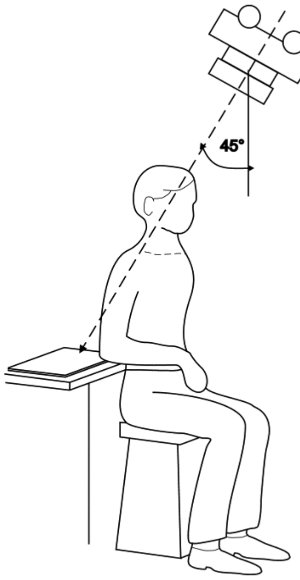

Figure 2.19: MTA projection with a 45º caudal tube angulation (patient sitting) (Neep & Aziz, 2011:189)

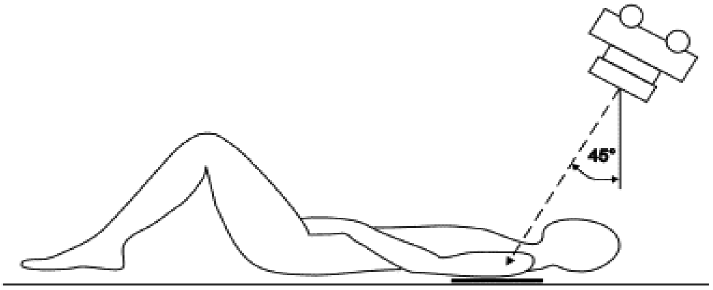

Figure 2.20: MTA projection with a 45º caudal tube angulation (patient supine) (Neep & Aziz, 2011:190)

The AP (external rotation) and the LAT-Y projection are the most common projections done by the various imaging departments in the Northern Cape and the FS. Table 2.1 displays these two routine shoulder projections and the pathology demonstrated by each projection.

TABLE 2.1: SHOULDER PROJECTIONS WITH PATHOLOGY DEMONSTRATED

SHOULDER PROJECTION	**PATHOLOGY ILLUSTRATED**
Anterioposterior (external rotation)	• Tendon inflammation (HADD) • Rotator cuff tears • Impingement • Arthritis • Fractures • CPPD

	• SOC
Lateral-Y	• Instability • Fractures • Hill Sachs lesion

2.5 RADIOGRAPHIC CRITERIA

Since it is important that all x-ray projections obtained display optimal quality, the following section will discuss various aspects to be considered to obtain optimal images for diagnosis.

X-ray images obtained by radiographers are evaluated by the radiologist to provide a diagnosis in the form of a report. Does that mean radiographers do not have the responsibility to evaluate their images before sending it to the radiologist? According to Hobbs (2007:501), radiographers have the responsibility to evaluate if the images they obtain are optimal, as the image "plays an integral role in the diagnosis and subsequently the care of patients". Therefore, by ensuring that the positioning is correct, exposure factors are correct, region of interest (ROI) is included (Brown, 2013:252) and the necessary radiation safety is applied, for instance, by applying collimation, radiographers contribute to optimal imaging and patient care (see 2.4). The ALARA principle does not mean that the lowest radiation dose must be utilised, which could produce poor diagnostic images, but rather that the patient must be exposed to as little radiation as possible while providing optimal images necessary for a quality diagnosis (Uffmann & Schaefer-Prokop, 2009:203). Therefore, the ALARA principle entails more than just the selection of low exposure.

Factors such as utilising the correct focal spot, collimation and using the correct source to image distance (SID) are essential to ensure optimal images for diagnosis. Unfortunately, radiographers often neglect the aforementioned factors because they can post-process the exposed image in the digital radiography environment to improve the image quality manually (Uffmann & Schaefer-Prokop, 2009:204). According to Carlton and Adler (2006:471), "the art of image critique is the application of scientific knowledge to analyse the image". Radiographers are in the front line of critiquing their images to determine if they are of diagnostic value. Thorough knowledge of all aspects of radiography is required to conclude if an image is optimal. For this study the researcher focused on collimation and not the focal spot or SID, because the researcher cannot evaluate if the correct focal spot and SID had been utilised by the radiographers.

X-ray images that are obtained should adhere to the following technical considerations: 1) it must include certain patient information, such as the name and surname and the date of birth, as well as the examination date; 2) collimation should be utilised to minimise radiation exposure to the patient; 3) images should be labelled clearly "right" or "left side" for anatomy orientation; and 4) the exposure factors utilised must produce optimal diagnostic images, thus indicating the image will have optimal density and contrast. To ensure optimal image quality, it is essential that all images are evaluated for these technical qualities to ascertain diagnostic quality. The radiographer will be the person who evaluates the images, and when the images are not optimal, repeat projections are required (ACR, 2014a:4, Bontrager & Lampignano, 2014:30).

The various factors that play a fundamental role in obtaining optimal imaging of the shoulder will now be discussed briefly.

2.5.1 Positioning technique and region of interest

Knowledge of positioning technique that makes visualisation of the anatomy of interest possible is of the importance; this ensures that the image adheres to certain requirements that contribute to diagnosis and patient care. It is essential that the radiographer possesses the necessary knowledge about the way to demonstrate a specific anatomical structure in order to provide the radiologist/reporting doctor with the information needed to make a diagnosis. Understanding how to position a patient and what the image is supposed to look like by using the positioning criteria assist radiographers to determine if a projection should be repeated (McQuillen Martensen, 2015:17). According to Herrmann, Fauber, Gill, Hoffman, Orth, Peterson, Prouty, Woodward and Odle (2012:11) most repeats in digital radiography are due to positioning errors.

Incorrect positioning of the anatomy being imaged can lead to distortion (Carlton & Adler, 2006:242). To eliminate distortion, correct centring of the body part is of the utmost importance during positioning. The radiographer has to ensure that the anatomical structure is centred in relation to the IR, due to the fact that x-rays diverge when they leave the x-ray tube. As a result, if the anatomical structure is not centred, the x-ray beam will divert and "expose the IR at an angle", causing a distorted image (McQuillen Martensen, 2015:20). Distortion is the misrepresentation of the size and shape of the anatomy being imaged. In digital radiography, size distortion has occurred if the anatomy appears minimised or magnified. Shape distortion involves elongation or foreshortening. Elongation refers to the anatomy appearing longer than it is supposed to; it tends to happen when the x-ray tube is angled or an incorrect centring point was used. In contrast, with foreshortening, the anatomy appears shorter than it is and it occurs when a perpendicular angle is used, and the anatomical structure of interest was "inclined" or not parallel with the IR or beam (Carlton & Adler, 2006:456, 461; McQuillen Martensen, 2015:23). Correct centring thus results in the ROI being included in the image and a true representation of the anatomy being achieved.

2.5.2 Exposure factors

The exposure factors that are selected by the radiographer on the control panel influence the image that is obtained. It is important for radiographers to have knowledge about the effect the exposure factors have on the image. Exposure factors, namely, kilovoltage peak (kVp), milliamperage (mA) and the exposure time measured in milliseconds (ms) influence the diagnostic value of the image (Bontrager & Lampignano, 2014:36).

The kVp controls the energy of the x-ray beam – the energy makes it possible for the x-rays to pass through (penetrate) the anatomical structure of interest (Bontrager & Lampignano, 2014:36). The selection of kVp has an impact on the speed and energy of the electrons as they cross in the x-ray tube from the cathode to the anode. When the kVp is increased, the speed and the energy of the electrons increase, thus resulting in more x-ray photons passing through the anatomical structure, which comprises various densities. Hence, less dose is absorbed by the patient's body when an increased kVp is utilised (Bushong, 2008:154; Carlton & Adler, 2006:173, 175, 423; Ehrlich & Coakes, 2016:23).

The x-ray quantity and the quality of the beam are affected by the kVp factor. X-ray quantity refers to the number of x-ray photons in the useful beam and the x-ray quality refers to a measurement of the penetrating ability of the x-ray beam. Therefore, kVp controls the different densities of the various tissues of the human body, and it is known as contrast. Image contrast is defined as the difference between "adjacent densities" as stated by Carlton and Adler (2006:418). These densities can differ from clear white, to various shades of grey, to black. When an image presents with many shades of grey, it indicates that a high kVp was used, and the image has a low contrast. An image that presents with few shades of grey, indicates the radiographer used a low kVp and the image has a high contrast (Carlton & Adler, 2006:173, 177, 418; McQuillen Martensen, 2011:46).

Milliampere (mA), refers to the amount of x-rays produced, and seconds (s), refers to the duration of the exposure. Consequently, the mAs setting controls the x-rays produced at a specific speed (Bontrager & Lampignano, 2014:47). The mAs is directly proportional to the x-ray exposure. Thus, if the mAs is increased, the exposure to the patient also increases (Carlton & Adler, 2006:174).

It is important that radiographers provide optimal images, though patient dose must be taken into consideration; therefore, it is important for radiographers to have knowledge of the exposure factors, namely, kVp and mAs. Utilising a low kVp requires using a high mAs, resulting in absorbtion of radiation in the patient's body because the x-ray beam does not have enough energy to penetrate through the body to reach the IR, thereby increasing patient dose. However, with a higher kVp, a lower mAs can be utilised, because the photons have a greater ability to penetrate the body tissue and reach the IR. Since mAs is directly proportional to patient dose, utilising a low mAs with a high kVp will result in reducing patient dose (Bushong, 2008:154, 224, 225; Carlton & Adler, 2006:196, 203, 423; Ehrlich & Coakes, 2016:23, 28). Utilising either low kVp and high mAs or high kVp and low mAs will result in an optimal image, because the kVp and mAs compensate for one another, but a low kVp and high mAs will have an effect on increased patient dose.

Most modern x-ray machines utilise automatic exposure control (AEC). An AEC system terminates the exposure time when the desired dose has been produced. Since the AEC system controls the exposure time, the radiographer cannot select the time of the exposure. However, the Phillips digital x-ray machine that the researcher utilised for this study allows the radiographers to change the kVp and mA settings (Carlon & Adler, 2006:101, 538; McQuillen Martensen, 2015:53; Hermann *et al.*, 2012:8). It is also the responsibility of the radiographer to select the correct imaging protocol such as the correct focal spot and SID, correct patient size (extra-large, normal, small or child) and correct examination (AP shoulder or LAT shoulder) when using an AEC system. Ideally, when AEC systems are utilised for shoulder imaging, the kVp ranges from 70 to 80 kVp, as stated by Greathouse (1998:164, 174) and Bontrager and Lampignano (2014:187, 196). It however became evident to the researcher that the participants utilise an AEC system that provides a minimum of 73 kVp for both routine shoulder projections when the shoulder images were evaluated by means of the radiographic criteria checklist. Even though radiographers can adjust the kVp and mA when using AEC, it is clear that no adjustment were made because the kVp parameters were the same for various patients, therefore a minimum of 73 kVp were used. Therefore, the kVp of the AEC system of the participating imaging department correlates with literature; as a result the researcher viewed the 70-79 kVp range as the correct kVp range for this study.

The AEC systems of most modern x-ray machines utilise three ionisation chambers (Carlton & Adler, 2006:538) to measure the amount of exposure received by the IR, though the newer machines have five ionisation chambers (Hermann *et al.,* 2012:8) (see Figure 2.21). For the ionisation chambers to function optimally, correct positioning of the patient is very important.

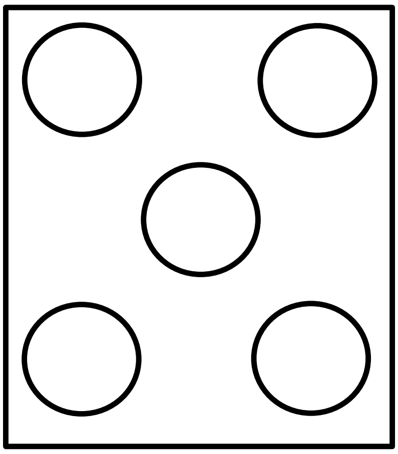

Figure 2.21: An x-ray Bucky/IR with five ionisation chambers (compiled by the researcher)

To ensure that the correct dose has been measured by the AEC and the exposure is terminated on time, the anatomical structure that is being imaged must be positioned over the correct ionisation chamber. The radiographer must position accurately and select the correct chamber for the specific anatomical structure, otherwise the AEC will produce images that are not optimal for diagnosis – they will be either overexposed or underexposed. If the specific anatomical structure is not positioned correctly over the ionisation chamber, or the anatomical structure of interest is too small for the ionisation chamber, then an underexposed image will be produced because the AEC measures the tissue that is over that active ionisation chamber. If the anatomy is not positioned correctly over the active ionisation chamber, the AEC system will terminate the exposure when the ionisation chamber has received adequate radiation, limiting the number of photons reaching the IR and leading to quantum mottle. Hence, utilising AEC during pediatric imaging needs to be considered carefully (Carlton & Adler, 2006:538, 540; Hermann *et al.,* 2012:9).

At the participating imaging department two different type of x-ray machines are utilised namely a Philips and Siemens. For the purpose of this study, the researcher will focus and elaborate on the Phillips x-ray machine as a significant number of the images that the researcher used was acquired from the Phillips digital x-ray machine. The image acquisition for the AEC system at the participating imaging department operates as follows for the Philips x-ray machine: after the radiographer selects the patient's name, the radiographer has to select the anatomical structure namely shoulder and then the projection (AP -external rotation or LAT-Y). The AEC system is automatically on. Therefore, the ionisation chamber for the shoulder projection is automatically selected, the kVp for a normal size patient is provided and the broad focal spot is automatically selected. The Philips x-ray machine has five ionisation chambers therefore when shoulder projection is selected, the AEC system activates the middle chamber, hence it is important to position the shoulder joint over the activated ionisation chamber (middle chamber) where the exposure will be measured. Also important is to take note that a small focal spot must be utilised for shoulder imaging (Bontrager & Lampignano, 2014:180) which increases the visibility of bony trabeculae (McQuillen Martensen, 2011:27). Therefore, the radiographer is responsible to change the focal spot to small focus and to change the patient size respectively for various patients. Various kVp's are provided for different size patients namely 81 (extra-large), 77 (large), 73 (normal), 70 (small), 63 (child and baby) and 55 for new-born. Interesting to note is that if the patient size is selected either for child, baby or new-born, the AEC is automatically de-activated by the machine, and as a result the radiographer must set his/her own exposures. The radiographer can adjust the kVp and mA for all types of patient sizes when the AEC system is utilised. The radiographer can de-activate the AEC system to set manual exposures especially for paediatric radiography. If the AEC is de-activated respectively for an AP projection (external rotation) and LAT-Y projection of the shoulder, the Phillips machine automatically provides 73 kVp and 12.5 mAs (AP -external rotation) and 73 kVp and 16 mAs (LAT-Y) for normal size patients. Even though a starting point of exposures are given when the AEC is de-activated, the radiographer can adjust the exposures accordingly for individual patients.

It is important that the AEC is calibrated properly by using multiple kVps, because calibration will ensure that the AEC works optimally for all patient sizes. A qualified medical physicist is responsible for ensuring that the AEC system has been calibrated properly. Also, as mentioned, it is important that radiographers position the ROI correctly over the active ionisation chamber to ensure that images produced using AEC are optimal (Williams, Krupinski, Strauss, Breedan, Rzeszotarski, Applegate, Wyatt, Bjork & Seibert, 2007:381; ACR, 2014c:7; Campeau & Fleitz, 2016:166).

The next section will elaborate briefly on the selection of exposure factors for use in digital imaging.

2.5.2.1 *Image density of digital images*

In digital radiography, film density is referred to as brightness. Brightness is defined as "the level of the display monitor light emission" (Carlton & Adler, 2006:400), thus implicating that brightness can make an x-ray image appear dark or light. The brightness can be manipulated on the monitor after an exposure by means of digital post-processing algorithms (Carlton & Adler, 2006:400; McQuillen Martensen, 2015:518; Hermann *et al.*, 2012:8), which is not the case with conventional radiography, where the image cannot be manipulated after the image has been acquired.

In digital radiography, brightness is not controlled by the mAs, instead, the window level controls brightness (Carlton & Adler, 2006:402; McQuillen Martensen, 2015:59, Bontrager & Lampignano, 2014:48). Window level has the function of changing the brightness, thereby controlling the image density. The window level is directly proportional to the image density. If the window level is increased the density on the image will also increase. Therefore, it is important to adjust the window level accordingly to provide optimal images (Carlton & Adler, 2006:349, 400). For the purpose of this study the researcher will refer to density and not brightness.

When insufficient photons reach the IR, the image will appear grainy, which is known as quantum mottle (noise). Quantum mottle refers to insufficient x-ray photons reaching the IR due to an extremely low mAs, which means the mAs must be increased. Increasing the mAs will reduce the quantum mottle on the x-ray image. Hence, the radiographer will have to double the mAs, because adjustments to increase the mAs in digital imaging requires that mAs are adjusted in increments of doubles (Carlton & Adler, 2006:322, 404, 442).

In digital imaging, dose and signal-to-noise ratio (SNR) are inversely proportional. When the dose (mAs) is low, the image will present with an increase in noise, and if the dose (mAs) is optimal, the image will present little or no noise. When the noise on the image is in abundance, diagnostic information will be lost and the radiologist will not be able to make an accurate diagnosis (Uffmann & Schaefer-Prokop, 2009:205).

2.5.2.2 *Contrast on digital images*

In digital radiography, kVp controls contrast on the display monitor. Contrast refers to the difference between light and dark areas on an x-ray image, which can be manipulated by the window width. The window width is defined as the digital processing that changes the

density to control the image contrast. The window width is inversely proportional to the image contrast. If the window width is increased, the image contrast decreases, as a result, the window width must be adjusted to provide optimal contrast to the final product (Carlton & Adler, 2006:349, 418; Hermann *et al.*, 2012:8; Bontrager & Lampignano, 2014:48).
The same kVp utilised for conventional radiography can be used for digital radiography systems, but currently, with digital radiography systems, processing of the image contrast (controlled by kVp) can be done independently in the sense that it can be adjusted after the exposure by means of the window width (Williams *et al.*, 2007:379; Uffmann & Schaerfer-Prokop, 2009:204).

2.5.2.3 *Exposure index and region of interest*

The exposure index (EI) is a numeric value that indicates the amount of x-ray photons the IR has received. However, it does not provide information about the amount of radiation a patient was exposed to. Different manufacturers have different EI value ranges that radiographers need to adhere to. The acceptable EI value indicates that the x-ray image produced is of diagnostic value and that the patient received the least possible dose (Uffmann & Schaefer-Prokop, 2009:207; Herrmann *et al.*, 2012:13; Bontrager & Lampignano, 2014:49).

The EI value is based on the ROI that was selected on the digital workstation. The ROI is selected on the digital radiography system under the examination type, for example, shoulder AP. Once the examination type has been selected the image processing and the exposure factors are selected automatically through an image analysis algorithm. When the ROI is selected incorrectly, the EI value will be incorrect. The ROI can also be incorrect due to the radiographers' positioning or the system EI not being calibrated properly (Don, Whiting, Rutz & Apgar, 2012:1338). The EI is influenced by various factors, such as "collimation detection, manufacturer-specific calibration and the examination-specific image processing", as stated by Uffmann and Schaefer-Prokop (2009:207).

At the participating imaging department (2015), the EI values from the different manufacturers are displayed on the monitors for the radiographers' reference. For extremities (upper and lower), the EI values normally range from 345 to 689 for non-Bucky examinations, and for Bucky examinations, the EI values normally range from 145 to 344 for the imaging systems used at the department.

2.5.3 Collimation

In digital imaging, collimation does influence the diagnostic value of the image. Utilising collimation minimises scatter radiation, and improves the visibility of the recorded detail (either conventional or digital), reduces the dose to the patient (Uffmann & Schaefer-Prokop, 2009:204; McQuillen Martensen, 2015:14; Herrmann *et al.*, 2012:10; Bontrager & Lampignano, 2014:53), and reduces histogram analysis errors when using digital imaging (McQuillen Martensen, 2015:14). A histogram is the graph containing information of the raw data/static image, with the pixel brightness value on the x axis and the number of pixels with that brightness value on the y axis. When collimation is not applied correctly, scatter radiation strikes the IR and it may result in the EI being misrepresented (either being too high or too low); therefore, the information on the histogram will not be a true reflection and the image may present with a low image contrast that can lead to quantum mottle. The IR in digital radiography systems is very sensitive to low levels of radiation, therefore collimation during imagining is important (McQuillen Martensen, 2015:38, 39; Herrmann *et al.,* 2012:10; Bontrager & Lampignano, 2014:53).

Collimation should be restricted to the ROI and all four collimation borders must be present on the x-ray image. If an x-ray image does not present with four collimation borders, it indicates that the primary beam was not restricted and the correct centring point was not utilised (McQuillen Martensen, 2015:14, 39, 41, 42; Bontrager & Lampignano, 2014:62). In order to determine what central point was used, the radiographer can divide the image by means of an imaginary X (see Figure 2.22) from the four corners of the image obtained. When imaging extremities it is important to collimate within 1.25 cm of the skin line where the thickest ROI is present, to prevent the anatomy being cut off (McQuillen Martensen, 2015:14).

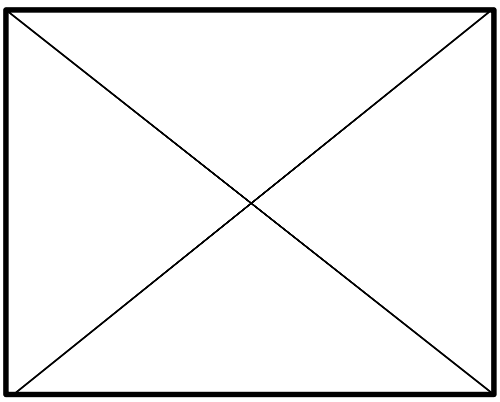

Figure 2.22: Use an imaginary X to illustrate the centring point that is used (compiled by the researcher)

According to McQuillen Martensen (2015:6) and Herrmann *et al.* (2012:10), a digital radiography system has a function for using electronic collimation/masking/shuttering. This function must be used to improve viewing conditions on the display monitor. After a specific anatomical structure has been exposed, brightness surrounds the exposed area. Utilising the electronic collimation, those surrounding areas are blackened out. The electronic collimation must not be used to cut off anatomy that was unnecessarily included in the exposure field – doing so does not demonstrate good collimation practice.

2.5.4 Anatomical lead markers

Anatomical lead markers or lead markers are utilised to identify the side of the body that is being imaged. The markers are made of lead, which makes it radiopaque, meaning x-rays cannot penetrate it. These lead markers need to be placed on the cassette/IR before an exposure is made. The marker must be in the collimation field and must not superimpose the ROI. Radiographers must ensure that the lead marker indicates the correct anatomical side, if not, it may lead to misdiagnosis (Bontrager & Lampignano, 2014:31, McQuillen Martensen, 2015:10).

It is not good practice to write the anatomical side on the x-ray image after it has been exposed during conventional radiography, or to use the digital markers of the digital workstation during digital imaging. Annotating images incorrectly, especially after exposure, can give rise to medico-legal complications. By law an x-ray image that does not have an anatomical lead marker must be repeated. This repeated projection leads to radiation exposure to the patient that could have been prevented (Bontrager & Lampignano, 2014:31; McQuillen Martensen, 2015:13, 14). According to Image Gently (s.a.:9) and McQuillen Martensen (2011:9), an x-ray image with a lead marker is considered to be legal documentation in a court of law, which confirms that failing to place the lead marker on a cassette/imaging plate (IP) before an exposure can have medico-legal implications.

Imaging departments that use digital radiography systems should apply good practice in relation to the placement of lead markers. The digital radiography system has the function of placing digital/electronic anatomical side annotations on an x-ray image after an exposure has been made. According to the law of the profession, it is unacceptable to annotate a digital x-ray image after an exposure has been made (Platt & Strudwick, 2009:293; Herrmann *et al.*, 2012:10; Bontrager & Lampignano, 2014:31).

It is considered best practice for radiographers to use anatomical lead markers in the primary beam. Failure to use lead markers is an indication of failure to act in a patient's best interest (Platt & Strudwick, 2009:293). Radiologists can refuse to report on an x-ray image that has not been marked prior to exposure, which means the radiographer has to obtain further images (Platt & Strudwick, 2011:294; Titley & Cosson, 2014:42). It is the responsibility of all radiation workers to apply ALARA principles and to minimise the dose the patient receives. One way a radiographer can do this is to always use anatomical lead markers correctly prior to exposing an anatomical structure. All healthcare workers who are registered with the HPCSA, including radiographers, must have the patient's best interest or well-being at heart (HPCSA, 2008:2); this implies that radiographers should not cause any harm to a patient while the patient is in their care. It is the opinion of the researcher that, when radiographers do not place lead markers on the IR prior to the exposure, the radiographers do not have their patients' best interests at heart, because images without lead markers will require repeat projections, which increase the radiation dose a patient receives.

Titley and Cosson (2014) conducted a research study on "Radiographer use of anatomical side markers and the latent conditions affecting their use in practice". The study demonstrated that various factors contribute to the poor use of lead markers. Radiographers fail to use lead markers on lateral projections and unilateral projections. Collimation is considered to be more important than the placement of lead markers. The radiographer reasons that, if they have to place a lead marker, they will have to increase the collimation field to avoid superimposing the ROI (Titley & Cosson, 2014:43, 46).

The technical aspects discussed in the previous section all form part of the radiographic criteria for critiquing x-ray images. The following section will discuss specific radiographic criteria to evaluate routine shoulder images of the participating imaging department.

2.5.5 Radiographic criteria for routine shoulder projections

Various sources highlight the radiographic criteria that should be applied to critique the two routine shoulder projections (AP external rotation and LAT-Y). The sources that were consulted are (1) *Textbook of radiographic positioning and related anatomy* (Bontrager & Lampignano, 2014), (2) *Radiographic image analysis* (McQuillen Martensen, 2011, 2015), (3) *Merrill's atlas of radiographic positions and radiologic procedures* (Ballinger & Frank, 1999), and (4) *Radiographic positioning procedures*, Volume 1 (Greathouse, 1998). The authors of these textbooks each have at least 10 year's clinical experience in radiography.

Two of the four books are recent editions; therefore, these two books have been updated for use in the current digital imaging environment.

The radiographic criteria for the AP projection (external rotation) and the LAT-Y projection of the shoulder as described by the four sources will be discussed below.

2.5.5.1 *Radiographic criteria for the anterioposterior (external rotation) projection of the shoulder*

The AP projection (external rotation) illuminates various pathologies (see 2.4.1). This projection demonstrates an overlap of the glenoid cavity and the humeral head. Table 2.2 outlines the radiographic criteria for the AP projection (external rotation) as stated by Bontrager and Lampignano (2014:187).

Table 2.2: RADIOGRAPHIC CRITERIA FOR THE AP PROJECTION (EXTERNAL ROTATION) OF THE SHOULDER (Bontrager & Lampignano, 2014:187)

Structures shown	• The structures that must be seen on the image are the proximal humerus, two thirds of the clavicle and the upper scapula. • The relationship of the glenoid cavity and humeral head must be seen.
Position **External rotation means that the epicondyles of the elbow are parallel to the image receptor**	• The greater tubercle (GT) must be visualised in full profile on the lateral aspect of the proximal humerus if the arm is fully rotated externally. • The lesser tubercle (LT) is superimposed over the humeral head.
Collimation and central ray **Centring should be 2.5 cm below coracoid** **Determined by 2.5 cm inferior lateral part of clavicle**	• Collimation must be visible on all four sides of the region of interest. • Correct positioning is demonstrated when the central ray and the centre of the collimation field are at the GH joint.
Exposure criteria	• Optimum density and contrast. • No motion visible on x-ray. • Sharp bony trabecular markings with soft-tissue detail must be visible.

The radiographic criteria for the AP projection (external rotation) of the shoulder as stated by McQuillen Martensen (2015:235, 236) are as follows:

- Lead marker must be clearly visible without it superimposing the area of interest;
- Good radiation practices must be evident;
- No artifacts must be visible;
- Identification must be visible on the image;
- Bony trabecular patterns and cortical outlines must be sharply defined;
- Contrast and density must be uniform in order to demonstrate soft-tissue and bony structures;
- Penetration must be sufficient to visualise bony trabecular patterns and cortical outlines of the shoulder;
- Superolateral border of the scapula should not be superimposed with the thorax;
- Clavicle demonstrated horizontally, and the medial end of the clavicle is near the vertebral column;
- Superior scapular angle is superimposed by the midclavicle;
- The humerus is aligned parallel to the body;
- Glenoid cavity is partially visualised facing laterally;
- The GT is seen in profile laterally and the humeral head is in profile medially;
- The superior scapular body is at the centre of the exposure field; and
- The superior scapula, two thirds of the clavicle, proximal third of the humerus and the GH joint are included in the collimation field.

Ballinger and Frank (1999:162) outline the following radiographic criteria that a radiographer who evaluates the AP projection (external rotation) of the shoulder must consider:

- The superior scapula, lateral half of the clavicle and the proximal humerus must be included on the image;
- Bony trabecular detail and soft tissue around the shoulder must be seen on the image;
- GT must be seen in profile on the lateral aspect of the humerus and the LT must be seen between the GT and the humeral head;
- The humeral head must be seen in profile; and
- Humeral head must overlap the glenoid cavity slightly.

The radiographic criteria utilised by Greathouse for an AP projection (external rotation) of the shoulder are specifically aimed at positioning and are described as follows (Greathouse, 1998:164):

- The distal two thirds of the clavicle, proximal humerus and most of the scapula should be demonstrated;
- The GT must be in profile on the lateral aspect of the humerus; and
- The humeral head should be slightly superimposed on the glenoid fossa.

Table 2.3 displays a summary of the radiographic criteria for the AP projection (external rotation) of the shoulder from the four sources consulted.

Table 2.3: A SUMMARY OF THE RADIOGRAPHIC CRITERIA FROM VARIOUS SOURCES FOR THE AP PROJECTION (EXTERNAL ROTATION) OF THE SHOULDER

	Bontrager & Lampignano (2014)	**McQuillen Martensen (2015)**	**Ballinger & Frank (1999)**	**Greathouse (1998)**
AP PROJECTION (EXTERNAL ROTATION)				
Anatomy included (2/3 of clavicle, superior scapula, proximal humerus)	X		X	
Anatomy included (2/3 of clavicle, most of the scapula, proximal humerus)				X
Anatomy included (2/3 of clavicle, superior scapula, proximal 1/3 humerus and GH joint)		X		
GT is in profile on lateral aspect of humerus	X	X	X	X
LT superimposed over the humeral head	X			
LT is between the GT and the humeral head			X	

Humeral head seen in profile		X	X	
Humerus is aligned parallel to the body		X		
Humeral head slightly overlaps the glenoid cavity	X	X	X	X
GH joint at centre of collimation field	X			
Superior scapular body is at centre of exposure field		X		
Superolateral border of the scapula not superimposed by thorax		X		
Clavicle demonstrates horizontal, medial end of clavicle near the vertebral column		X		
Superior scapular angle is superimposed by the midclavicle		X		
Collimation seen on all four borders	X			
Contrast and density uniform to demonstrate soft tissue and bony structures	X	X		
Penetration is sufficient to visualise bony trabecular patterns and cortical outlines		X		
Bony trabecular patterns and cortical outlines defined sharply	X	X	X	
No motion visible	X			
Visible lead markers do not superimpose on region of interest		X		

Good radiation practices must be evident	X	X	X	X
No artifacts visible		X		
Identification is visible on the image		X		

2.5.5.2 *Radiographic criteria for the lateral-Y projection of the shoulder*

The LAT-Y projection of the shoulder helps to demonstrate various pathologies. The acromion, coracoid processes and the body of the scapula forms a Y if the patient has been rotated correctly. The humeral head is thus positioned over the base of the Y (see 2.4.2). Table 2.4 outlines the radiographic criteria as stated by Bontrager and Lampignano (2014:196).

Table 2.4: RADIOGRAPHIC CRITERIA FOR THE LATERAL-Y PROJECTION OF THE SHOULDER (Bontrager & Lampignano, 2014:196)

Structures shown	• A true lateral projection of the scapula, proximal humerus and GH joint must be visible.
Position	• The body of the scapula must be seen on end without rib superimposition. • The acromion and coracoids processes should appear symmetrical on the Y • The humeral head must superimpose the base of the Y if the humerus is not dislocated.
Collimation and central ray **Central ray is directed to the scapulohumeral joint (5-6 cm) below the top of the shoulder.**	• Collimation must be visible on all four sides of the region of interest. • Correct positioning will be demonstrated when the central ray and the centre of the collimation field are at the humeral head and surgical neck region.
Exposure criteria	• Optimum density and contrast. • No motion visible on x-ray. • Sharp bony borders and the outline of the body of the scapula through the proximal humerus must be visible.

The radiographic criteria for the LAT-Y projection as stated by McQuillen Martensen (2015:236, 253) are as follows:

- Lead marker must be clearly visible without it superimposing the area of interest;
- Good radiation practices must be evident;
- No artifacts must be visible;
- Identification must be visible on the image;
- Bony trabecular patterns and cortical outlines must be sharply defined;
- Contrast and density must be uniform in order to demonstrate soft-tissue and bony structures;
- Penetration is sufficient to visualise bony trabecular patterns and cortical outlines of the shoulder;
- The scapula must not be demonstrated with magnification;
- Lateral and vertebral borders are superimposed;
- The acromion, coracoid processes and scapular body must form a Y;
- Relationship between humeral head and glenoid cavity must be visible;
- Midscapular body is at the centre of the exposure field/image; and
- Inferior and superior angles of scapula, coracoid processes, acromion processes and proximal humerus must be included in the collimation field.

When a radiographer evaluates the LAT-Y projection of the shoulder, he/she must look at the following radiographic criteria, as outlined by Ballinger and Frank (1999:180):

- The scapular body must not superimpose the thorax;
- The acromion must be projected laterally and not be superimposed;
- The coracoid is possibly superimposed or situated below the clavicle; and
- The scapula presents in a lateral profile.

The radiographic criteria utilised for a LAT-Y projection of the shoulder are specifically aimed at positioning, and can be described as follows (Greathouse, 1998:174):

- The scapula should be in a true lateral position and not superimpose the ribs; and
- The shaft of the humerus should superimpose the body of the scapula.

Table 2.5 is a summary of the radiographic criteria for the LAT-Y projection of the shoulder.

Table 2.5: A SUMMARY OF THE RADIOGRAPHIC CRITERIA FROM VARIOUS SOURCES FOR THE LATERAL-Y PROJECTION OF THE SHOULDER

	Bontrager & Lampignano (2014)	McQuillen Martensen (2015)	Ballinger & Frank (1999)	Greathouse (1998)
LATERAL-Y PROJECTION				
Anatomy included (proximal humerus and GH joint)	X			
Anatomy included (proximal humerus, coracoids processes, acromion processes, inferior and superior angle of scapula)		X		
Scapula in a true lateral profile			X	X
Lateral and vertebral borders of scapula superimposed		X		
Scapula not superimposed by ribs	X		X	X
Humerus not superimposed on body of scapula				X
Scapula not magnified		X		
Acromion, coracoid processes and scapular body form a Y	X	X		
Acromion projected laterally and not superimposed			X	
Coracoid processes superimposed or projected below clavicle			X	
Relationship between humeral head and glenoid cavity is seen clearly		X		

Humeral head superimposed on base of the Y	X			
Midscapular body at centre of exposure field		X		
Humeral head and surgical neck at centre of collimation field	X			
Collimation seen on all four borders	X			
Contrast and density uniform to demonstrate soft tissue and bony structures	X	X		
Penetration is sufficient to visualise bony trabecular patterns and cortical outlines		X		
Bony trabecular patterns and cortical outlines defined sharply	X	X		
No motion visible	X			
Visible lead markers do not superimpose on region of interest		X		
Good radiation practices must be evident	X	X	X	X
No artifacts visible		X		
Identification is visible on the image		X		

The researcher was guided by the literature to compile a radiographic criteria checklist for the AP projection (external rotation) and LAT-Y projection (see Appendices A1 and A2) of the shoulder. All the radiographic criteria from the various sources were considered in compiling the checklist to evaluate the two routine shoulder projections. The researcher did not list all the radiographic criteria statements from the different sources individually, but grouped similar, related radiographic criteria to evaluate the AP projection (external rotation) and the LAT-Y projection. It was evident that the radiographic criteria from McQuillen Martensen (2015) were more specific than the other sources, thus, most of the criteria from this source were included in the radiographic criteria checklist, though they were grouped with similar criteria from the other sources.

Patient identification, such as name, surname and the date of birth, is of importance on an x-ray image. Before x-ray images are interpreted the radiographer needs to ensure that the patient's personal information appears on the image (McQuillen Martensen, 2015:236). As mentioned by Brown (2013:252) and ACR (2014a:4), it is also important that the correct anatomical lead marker and the examination date appears on the image.

The radiographic criterion, "good radiation practices", as outlined by McQuillen Martensen (2015:32-36), refers to all aspects of the radiographic technique. It involves positioning, exposure factors utilised, protecting patients from unnecessary radiation by means of lead shielding, applying collimation, utilising compensating filters and the importance of effective communication that contributes to good radiation practices by the radiographer. The above-mentioned aspects and all the criteria for imaging of the AP (external rotation) and LAT-Y projections contribute to good radiation practices.

The radiographic criteria mentioned above to evaluate the two routine shoulder projections should ideally be applied by all radiographers when they evaluate shoulder images. Application of these criteria can be beneficial to the radiographers, but also to the patient, since the optimal shoulder images will indirectly contribute to patient care.

2.6 RESEARCH TOOLS FOR THE PURPOSE OF THIS STUDY

It is important that radiographers know of all the factors that contribute to optimal images, and also how to critique the x-ray images obtained in relation to anatomy, positioning, and radiation practices. All the factors mentioned previously contribute to optimal imaging and patient care within the imaging department. Although it is assumed that, after undergoing training, radiographers do know all these factors, it is necessary to refresh their knowledge from time to time. To do this, certain tools can be utilised to enhance the radiographer's skills in relation to the evaluation of routine shoulder images. Two such tools will be discussed briefly in the following section.

2.6.1 Radiographic criteria checklist

Various radiographic criteria for routine shoulder projections were discussed (see 2.5.5.1 and 2.5.5.2). The radiographic criteria, if utilised, will assist radiographers to send optimal shoulder images to the PACS for reporting by the radiologist. The radiographic criteria checklist was formulated from various textbooks (see 2.5.5) that outline the radiographic criteria that should be applied to routine shoulder images.

A checklist is a useful tool to evaluate objects (Vijayalakshmi & Sivapragasam, 2008:63). Consequently, the radiographic criteria checklist can be utilised to evaluate the shoulder images obtained by radiographers. When shoulder images do not adhere to the criteria for imaging of routine shoulder projections, the radiographer will be able to, for instance, determine how to rectify the positioning and apply collimation to include the ROI. Thus, by critically evaluating shoulder images by means of the checklist, radiographers might be assisted to enhance their skills in relation to their radiographic technique.

As mentioned in Chapter 1 (see 1.5.3.2) the radiographic criteria checklist (see Appendices A1 and A2) was utilised to formulate the questions of the radiographer critique questionnaire. The radiographic criteria checklist addressed the following factors: anatomical structures included, positioning, technicality and exposure. Chapter 3 elaborates on these aspects in relation to the radiographic criteria checklist and the radiographer critique questionnaire.

2.6.2 Radiographer critique questionnaire

Objective 3 of the research study was to determine by means of a quantitative questionnaire the knowledge of the participants regarding the anatomy of the shoulder and the evaluation for optimal positioning and exposure factor selection. The radiographer critique questionnaire (see Appendix B1 and 3.2.5.2) was made available in the form of an electronic response system that would provide the researcher with information on the way radiographers determine whether an image is of diagnostic value or not.

The rules relating to continuing education and training for registered healthcare practitioners require that all healthcare professionals continue with learning within their profession to stay up to date with any developments and to ensure provision of the best possible services. Failure to comply with continuing learning could have various consequences. This continuous learning is known as CPD (continuous professional development) activities, and can take various forms, such as in-service training, workshops or seminars (HPCSA, 2011:12). It is the opinion of the researcher that, in order to encourage engagement, these CPD activities must be interesting, must make limited use of traditional teaching methods, whereby the presenter does all the talking. Presenting interesting activities will reduce participant boredom and increase radiographers' knowledge through engagement in CPD activities.

An electronic response system, also known as clickers, can be used to enhance engagement. Clickers can be used for adults and students (Blasco-Arcas, Buil, Hernández-Ortega & Sese, 2012:103). Questions are posed and a few answer options are offered, and the participant has to select the correct answer. The results (responses) of discussions are downloaded and saved for record keeping and utilised for future purposes. Therefore, utilising clickers ensures that all participants participate in the discussion (Martyn, 2007:Online; Preszler, Shuster, Dawe & Shuster, 2007:30).

The main reason why participants engage in activities is due to the anonymity offered by the clickers (Kennedy & Cutts, 2005:262; Martyn, 2007:Online; Trees & Jackson (2007:26). The fact that participants can engage anonymously increases involvement; the participants do not feel pressure to participate and the anonymity creates a safe environment in the sense that the participant does not feel humiliated or anxious about giving wrong answers (Martyn, 2007:Online; Trees & Jackson, 2007:26).

The benefits of using clickers are that clickers provide active, collaborative learning and increase student engagement (Duncan, 2005:2; Martyn 2007:Online; Blasco-Arcas *et al.*, 2012:103; Lam & Tong, 2012:387), increase learning motivation (Lam & Tong, 2012:392), increase class attendance (Duncan, 2005:2) and increase the interest of participants in the topic and in their own learning (Preszler *et al.*, 2007:30).

Using clickers when training students is beneficial since it is important for students to practice the application of knowledge that they have gained. Being actively involved in the learning process will guide them to develop critical thinking skills, especially when they interact with their peers, as stated by Trees and Jackson (2007:22, 23). Active learning enables students to think critically, because students need to reason out all their options and reflect on the knowledge that they have on the topic under discussion before they can select an answer. When the answers of all the students are displayed, the students can reflect on their peers' reasoning regarding certain answers, and the correct answer is revealed to them with the necessary explanation (Kennedy & Cutts, 2005:261; Blasco-Arcas *et al.*, 2012:108).

Another benefit of clickers is that it provides immediate feedback. The feedback is made available to the participant and the facilitator/instructor, who can provide an overview of their understanding of the content under discussion (Duncan, 2005:2; Kennedy & Cutts, 2005:260, 262; Martyn, 2007:Online; Preszler *et al.*, 2007:30, 39; Trees & Jackson, 2007:22; Blasco-Arcas *et al.*, 2012:103). If there are any misunderstandings in relation to the content, the facilitator/instructor can give feedback and correct the participants' understanding (Kennedy & Cutts, 2005:261; Doersam, 2014:Online). This immediate feedback will assist in identifying where participants are lacking in order to improve that specific aspect/need (Doersam, 2014:Online). Engagement enhances the learning environment. As a result, participants' performance on the content under discussion will improve (Preszler *et al.*, 2007:40; Blasco-Arcas *et al.,* 2012:102, 104).

Because of its benefits, clickers can be utilised in radiography for CPD activities. According to the HPCSA (2011:4), complying with CPD will assist radiographers to enhance their knowledge and skills in the profession. The patient will benefit from this CPD in the long run, because the services that will be provided will be more effective. The technology of radiology evolves continuously and, thus, it is important for radiographers to stay up to date with the latest developments in the profession (Laviolette, 2006:Online). Many imaging departments have digital radiography systems in place, thus, in-service training based on various aspects of this system and using clickers might enhance the knowledge and skills of radiographers.

2.7 CONCLUSION

Due to its mobility the shoulder is a very complex joint. Routine shoulder projections are obtained to show injuries to this joint. This chapter outlined the various factors that can contribute to good quality images of the shoulder. The positioning for the AP (external rotation) and LAT-Y shoulder projections, utilising the correct exposure factors and minimising radiation, forms part of good radiation practices. It is important for radiographers to know the positioning, but also how the end result of these images should appear.

Knowing how the end result of these projections must look like means the radiographer must know and understand the criteria applied to evaluate these two images. If radiographers are familiar with these criteria, it will enable them to enhance the quality of the images they obtain, and contribute to patient care. Patient care is enhanced by obtaining optimal images and having specialised radiographic anatomy knowledge (Brask & Birkelund, 2014:26). For this reason a radiographer must know how an image must look in relation to the anatomy being demonstrated, and know how to position that anatomy to determine if the image is optimal before it is sent for evaluation by the radiologist.

Chapter 3, ***Criteria checklist and questionnaire for shoulder critique,*** will discuss the radiographic criteria checklist and radiographer critique questionnaire that were utilised to obtain data. The radiographic criteria discussed in Chapter 2 were utilised to compile the radiographic criteria checklist, which was, in its turn, used to formulate the radiographer critique questionnaire.

CHAPTER 3

CRITERIA CHECKLIST AND QUESTIONNAIRE FOR SHOULDER CRITIQUE

3.1 INTRODUCTION

Obtaining optimal x-ray images is of importance during imaging of the shoulder. Chapter 2 outlined various criteria for imaging AP (external rotation) and LAT-Y projections of the shoulder. These criteria can assist radiographers to ensure that the images they obtain are optimal and contribute to patient care.

The aim of this research study is to determine whether radiographers utilise radiographic criteria to evaluate routine shoulder projections. This chapter will focus on the research design and the research methodology that were utilised for this study. In addition, Chapter 3 will describe two research instruments that were employed to address the aim of the research study.

The researcher endeavoured to obtain an understanding of the current quality of shoulder images taken at the participating imaging department in Bloemfontein, FS, by assessing shoulder images using a radiographic criteria checklist and by determining whether radiographic criteria are utilised by the radiographers when they evaluate shoulder images.

Additionally, the research used a radiographer critique questionnaire that had been developed with reference to literature. The questionnaire was administered to establish what knowledge radiographers possess in relation to imaging of the shoulder.

It is the contention of the researcher that the proposed radiographic criteria checklist will contribute to enhancing imaging quality and patient care by improving the radiographic critique of the radiographer.

3.2 THEORETICAL PERSPECTIVES ON THE RESEARCH DESIGN AND METHODS

3.2.1 Research paradigm

The researcher viewed the research study through the pragmatism paradigm. A pragmatism paradigm focuses on problem solving, specifically problems that arise in the real world (Hall, 2013:76). The researcher selected this specific paradigm because of the problem that was observed by the researcher (see 1.3) at the participating imaging department. Radiographers find producing optimal images of the shoulder challenging, hence, specific research approaches and methodologies were utilised by the researcher during data collection to accommodate the paradigm, to determine the factors that contribute to the problem and to provide solutions to address the problem at hand.

3.2.2 Research approach

There are two types of research approaches that can be utilised in a study, namely, a quantitative and a qualitative approach. A quantitative approach is utilised to gather information that can be transformed into numerical data that is used to explain what a researcher has observed. Qualitative research focuses on obtaining information to gain a better understanding of a specific problem (Thomas, 2003:1, 2; Wyse, 2011:Online; Ben-Eliyahu, 2014:Online). Therefore, qualitative research is regarded as exploratory research (Wyse, 2011:Online). In some instances, information gathered by means of qualitative research may be converted into numerical data, as stated by Ben-Eliyahu (2014:Online). Both research approaches assist the researcher to obtain explanations and evidence in relation to the research question.

The research approach utilised for this research study involved mainly quantitative methods, with a few qualitative elements. The researcher used a quantitative checklist to obtain facts in relation to imaging of the shoulder. This method assisted the researcher to determine whether the shoulder images that were evaluated adhere to the criteria. The checklist was complemented by a quantitative questionnaire, which aided the researcher to gain an understanding of how the participants evaluated routine shoulder images. The checklist comprised open-ended components in the form of comments that was utilised by the researcher during data collection (see Appendices A1 and A2), and the aim was to gather information regarding the problem statement (see 1.3). The qualitative aspect of the checklist enabled the researcher to provide reasons for concluding that a shoulder image failed to adhere to the criteria. The questionnaire had one open-ended question (see Appendix B1 Section A) that gave insight on the experience of the participants. Utilising both research approaches was informative, because the researcher obtained reasons (qualitative) for specific behaviour, while, at the same time, acquiring facts (quantitative data) in relation to the research (Ben-Eliyahu, 2014:Online).

3.2.3 Research methodology

As mentioned in Chapter 1, the researcher wanted to investigate if the shoulder images obtained by the radiographers are of optimal diagnostic value. To achieve this aim and answer the question that had been set, three modes of enquiry were utilised, namely, 1) conducting a literature study, 2) using a radiographic criteria checklist, and 3) administering a criteria questionnaire for radiographers. According to Wilkinson (2000:27), the Study and Learning Centre (2005:1 of 1) and Yunus and Tambi (2013:124) a literature review gives background regarding the research study, therefore, the purpose of the literature review for this study was to gather information to develop the radiographic criteria checklist. The function of the checklist was to determine if routine shoulder images met the criteria, and the questionnaire aimed to determine the knowledge of the radiographers about radiographic criteria, which would enable them to critique routine shoulder images. The literature supporting the research design was presented in Chapter 2.

The research instruments, information on the sample size, data collection, data analysis, ethical considerations, validity, reliability and the trustworthiness of the study will be outlined next.

3.2.4 Research design

As stipulated in Chapter 1, the research design for the study is descriptive, evaluative and explanatory. Descriptive research answers the "how" and "why" questions (Fouché & De Vos, 2011:96). In this study the researcher aimed to determine how radiographers apply radiographic technique and whether they meet the criteria for adequate imaging of the shoulder. Evaluative research is done to assess various types of intervention to determine if an "intervention has produced the intended result" (Fouché & De Vos, 2011:97, 98). Evaluative research has been defined as the gathering of information about the activities of a programme in order to enhance "human effectiveness" (Fouché & De Vos, 2011:98). Hence, using evaluative research, the researcher could evaluate the repeated and rejected shoulder projections obtained by the radiographers and determine why an image was rejected and repeated. Additionally, the researcher could determine how to assist radiographers to enhance their radiographic practice. Explanatory research is done on a known situation and, in this case, the researcher intended to find out why things were done in a certain manner (Fouché & De Vos, 2011:96). The researcher desired to find out why radiographers struggle to obtain shoulder projections that meet the required radiographic criteria, by identifying existing challenges in the execution of shoulder imaging.

The research design provides clarity about the way radiographers critique routine shoulder images. Moreover, routine shoulder projections were retrospectively evaluated using a checklist with specific criteria to determine if these projections met the criteria that ensured optimal images. The radiographer critique questionnaire was aligned with the radiographic criteria checklist, therefore, the two research instruments complemented each other in relation to imaging of routine shoulder projections.

3.2.5 The research instruments

3.2.5.1 *The radiographic criteria checklist*

A checklist consists of a series of items that is stipulated on a sheet. A checklist is formulated from literature and can be used for various purposes. A checklist has many benefits for research. According to Vijayalakshmi and Sivapragasam (2008:63) a checklist is a useful tool for gathering facts, recording behaviour, analysing and evaluating objects and rating personalities. In support of this research study the radiographic criteria checklist was applied to list information from literature to record compliance to radiographic criteria.

The type of checklist that the researcher utilised for this study is a radiographic criteria checklist, which consists of a list of criteria that enabled the researcher to formulate an "opinion or judgment about a particular practice" (Delport & Roestenburg, 2011:203). In other words, the checklist of this study consisted of a list of radiographic criteria that was used by the researcher to retrospectively critique the routine shoulder images acquired by the radiographers at the participating institution. By selecting "yes" or "no" the researcher stated whether the shoulder projections adhered to the requirements as stipulated on the radiographic criteria checklist. This type of checklist can be used to determine if the assessed shoulder images adhere to specific criteria as derived from literature. The radiographic criteria checklist (see Appendices A1 and A2) was compiled by the researcher after she had consulted a variety of literature sources regarding radiographic criteria that could be used to evaluate the two routine projections of the shoulder (Leedy & Ormrod, 2005:185; Delport & Roestenburg, 2011:202).

The radiographic criteria checklist was divided into four main sections, namely, the anatomical structures included in the projection, the positioning factors, technical factors and exposure factors (see Appendices A1 and A2).

3.2.5.1.1 Anatomical structures

The section on anatomical structures refers to the important anatomy that must be included for a specific shoulder examination. Three anatomical criteria for the AP projection (external rotation) were identified, namely, the inclusion of 1) the superior scapula, 2) two thirds of the clavicle, and 3) one third of the proximal humerus. However, five criteria for the LAT-Y projection were listed, that is, the inclusion of 1) the superior and inferior angle of the scapula, 2) GH joint, 3) proximal humerus, 4) coracoid process, and 5) the acromion process.

3.2.5.1.2 Positioning factors

This section lists the appearance of the various anatomical structures if the correct positioning had been utilised by the radiographer for the AP projection (external rotation) and LAT-Y projection of the shoulder. Furthermore, it includes the anatomical structure that must be at the centre of the image, which will indicate if the correct centring point was used.

For the AP projection (external rotation) 10 criteria were listed in relation to positioning, namely,

- No visible motion on the image,
- Greater tubercle (GT) in profile (on lateral aspects of proximal humerus),
- Lesser tubercle (LT) positioned between the GT and the humeral head (LT superimposing the humeral head),
- No superimposition of the superolateral border of the scapula over the ribs,
- Humeral head slightly overlaps the glenoid cavity,
- Humeral head is in profile,
- Humerus is aligned parallel to the body,
- Clavicle demonstrated horizontally,
- Superior scapular angle is superimposed by the midclavicle, and
- GH joint and coracoid process are in the centre of the collimation.

For the LAT-Y projection 12 criteria for positioning were listed, as follows:

- No motion visible on the x-ray image,
- Acromion, coracoid processes and scapular body form a Y (true lateral),
- Acromion projected laterally,
- Coracoid processes superimpose the clavicle or are projected below the clavicle,
- Lateral and vertebral border of the scapula is superimposed,

- Humeral head superimposes the base of the Y,
- Relationship between the humeral head and glenoid cavity is clearly visible,
- Scapular body seen on end without superimposition of ribs,
- Shaft of humerus superimposes body of scapula,
- Shaft of the humerus not superimposed by the ribs, and
- Midscapular body/humeral head and surgical neck are at the centre of the image.

3.2.5.1.3 Technical factors

The section on technical factors lists important aspects, such as the visibility of the correct lead marker, whether the patient information is visible and whether any artefacts superimposed the ROI. Collimation is also listed under technical factors. When the correct centring point had been utilised (under positioning factors), and the radiographer had used collimation prior to an exposure, clear four-sided collimation borders are visible on the image.

3.2.5.1.4 Exposure factors

The exposure factors outlined criteria to determine if the correct exposure factors (kilovoltage peak (kVp) and milliamperage per second (mAs)) had been utilised, and if there had been any repeats. The section on exposure factors included criteria such as whether soft tissue can be visualised, if the EI value is within range and if the images demonstrated good penetration, such as showing the bony trabecular detail of the shoulder.

3.2.5.1.5 Additional comments

The checklist concluded with additional comments, and the researcher could note any information in relation to the projection that had not been addressed by the checklist under this section. Some of the comments related to the pathology of the patient that might have an impact on the positioning, possible reasons why the shoulder projections were repeated and comments about the types of artefacts visible on an image.

The researcher evaluated routine shoulder images (AP external rotation and LAT-Y projections) retrospectively from the display monitors of the participating imaging department. The display station contains all the raw/static data images. The raw data are those images obtained by the radiographer before the radiographer “fixes” (post-processes) the images, such as collimation, after which the image is sent to the image archive (PACS). It is important to evaluate the images from the display monitor to determine if the radiographer manipulated the image prior to sending it to the radiologist for final reporting. The researcher evaluated the raw data by means of the radiographic criteria checklist to acquire an indication of the contributors to the repeat and reject rate during imaging of the shoulder.

3.2.5.1.6 Pilot study for the checklist

A pilot study is a scientific tool that is used to conduct a preliminary analysis of the intended research. This tool is utilised to ensure that the data the researcher wants to collect during the study is reliable and valid. It also ensures that the method that is used is correct, that the questions asked are clear and that the participant will not experience problems when completing the questionnaire (Wilkinson, 2000:46; Shuttleworth, 2010:1 of 3).

The radiographic criteria checklist was evaluated by two lecturers at the Department of Clinical Sciences at the Central University of Technology (CUT), FS, three radiologists and one orthopedic surgeon. The radiologists interpret x-ray images on a daily basis and they added valuable input regarding the radiographic criteria checklist, which the researcher utilised. Orthopedic surgeons utilise x-ray images to make informed decisions about whether patients must undergo surgery. The orthopedic surgeon who took part in the pilot study operates on patients at the participating institution and, therefore, added valuable input. The participants in the pilot study (lecturers, radiologists and the orthopedic surgeon) did not participate in the actual study. To ensure consistency during data collection the checklist was pilot tested by the researcher. The radiographic criteria checklist was evaluated to test its practicability for critiquing the shoulder x-ray images of five patients on a display monitor.

The pilot participants were, in general, satisfied with the checklist, but two participants mentioned that they preferred that the whole scapula be included for the AP (external rotation) projection of the shoulder, and not merely the superior scapula. This opinion is particularly valid for patients who experienced trauma, to ensure that no pathologies, such as fractures, are missed. One of the pilot participants suggested that an axial projection of the shoulder must be part of the routine projections of the shoulder, thus, in Chapter 2 (see 2.4.4), a modified axial projection was outlined under routine shoulder projections at the participating institution. The researcher made the necessary changes to the checklist after receiving input and feedback from the pilot participants.

3.2.5.1.7 The sample for the checklist

The radiographers (qualified, supplementary and community service) at the participating imaging department were primarily responsible for the execution of x-ray examinations of the shoulder. The qualified radiographer decides if a certain image should be sent off or if it must be rejected and repeated. To be fair to all participants, all routine shoulder projections, irrespective of whether they were done by a qualified radiographer or a student radiographer, were included for evaluation.

Sampling

Since the exact number of routine shoulder examinations done in 2015 was not known during the execution of the research study, the statistician who assisted the researcher utilised the statistics of the shoulder x-ray examinations performed in 2014, which was 2 315. Thus, during the period August 2015 to January 2016, approximately 578 shoulder x-ray examinations should have been evaluated with the assistance of the radiographic criteria checklist. The researcher had, indeed, evaluated a total of 578 shoulder x-ray examinations by the end of January 2016.

The researcher utilised a simple/proportional random sampling technique to select routine shoulder projections for evaluation. Random selection ensured that the researcher was not biased and that all routine shoulder projections of every member of the population had a fair chance of being included in the research, as proposed by Goddard and Melville (2001:36) and Strydom (2011:228).

3.2.5.1.8 Inclusion and exclusion criteria

Images of the shoulder that did not include the AP (external rotation) and LAT-Y projections were excluded from the study. The images that were evaluated included all shoulder examinations that consisted of an AP and a LAT projection.

3.2.5.1.9 Data collection

As mentioned previously, the researcher evaluated raw/static images on the display monitors. Since these images are automatically deleted after a certain time to ensure there is always space in the digital storage system, the researcher could not wait until the end of each month to evaluate the shoulder images. To ensure that the data was not lost, the researcher had to evaluate the shoulder images three times a week.

The researcher compiled a schedule for evaluating the shoulder images; this schedule did not interfere with the workflow of the participating imaging department or the lecturing duties of the researcher. The researcher collected data on Mondays, Wednesdays and Fridays, though, if the researcher could not collect data on those specific days, the data was collected on other days. The researcher usually collected the data after 17:00 to accommodate the imaging department and the lecturing duties of the researcher.

The 578 shoulder images that were evaluated using the radiographic criteria checklist consisted of AP (external rotation) and LAT-Y projections. Every time the researcher went to the participating imaging department, she recorded the specific display monitor that was used to search for routine shoulder projections. Once she was done, the researcher recorded the time by which she was finished, and the name of the last patient whose x-rays had been evaluated (see Appendix H). The name of the patient was written only to assist the researcher – to know of the patient name where the researcher ended that data collection session, and from where to proceed at the next data collection session.

For example, upon arrival at the imaging department, the researcher evaluated routine shoulder images on the Phillips display monitor. On this monitor, the researcher selected, on the drop-down key, "all patients". All types of projections that had been obtained appeared under this section. Then the researcher sorted the projections listed on the display monitor so that the latest image appeared at the top of the list and the oldest image appeared at the bottom of the list. The researcher searched for the shoulder images of the last patient evaluated during the previous data collection session. Once the name of the patient had been found on the system, the researcher started collecting data from the next patient.

Once done, the researcher noted the time and the name of the last patient whose shoulder images had been evaluated. This whole process was followed for all the display monitors at the participating imaging department, from August 2015 until January 2016. Every shoulder examination (AP external rotation) and LAT-Y projection) that was evaluated received a unique number.

3.2.5.2 *The radiographer critique questionnaire*

A questionnaire can be used in the form of a mail survey, an email survey, a household drop-off survey or a group-administered survey. A mail survey involves sending the questionnaire to the participants via mail, and the participants sending it back in the same manner. In a household drop-off survey the researcher drops the questionnaire at a participant's house or workplace, and the participant can either send the questionnaire back via mail or the researcher can pick it up again (Trochim, 2006a:1-2 of 2; Yunus & Tambi, 2013:23). A group-administered survey is administered to the participants as a group; they answer the questionnaire individually and return the completed questionnaires to the researcher (Trochim, 2006a:1 of 2).

The three ways of completing questionnaires mentioned above have various advantages and disadvantages. With the household drop-off survey and the group-administered survey, the researcher has personal contact with all the participants, there is a high response rate, and the researcher can explain the study to participants who are uncertain about the way to proceed (Trochim, 2006b:1 of 2). According to Wilkinson (2000:46), handing out questionnaires personally to participants increases the response rate, because the participants meet the researcher and this will encourage them to cooperate. The disadvantage of using household drop-off and group-administered surveys is that the researcher will know who participated in the questionnaire (Trochim, 2006b:1 of 2). However, it is still possible to ensure confidentiality even though the researcher knows who participated in the study, because the participants will not write their personal information on the questionnaires, and they will remain anonymous. The advantages of the mail survey are that it ensures privacy, the cost is low, and participants have time to formulate their answers. The disadvantages include that there is no personal contact between the researcher and the participant, the study cannot be explained to the participant personally; and the response rate is typically low (Trochim, 2006b:1 of 2).

To ensure the trustworthiness of this research study, the group-administered survey was utilised to gather data from radiographers for this study. The researcher organised sessions (date and time) at which the participants completed the radiographer critique questionnaire. The participants were instructed to consider the radiographer critique questionnaire as being confidential, and they were asked to refrain from discussing it with their colleagues (see Appendix C1).

The radiographer critique questionnaire was compiled by the researcher (see Appendix B1). The radiographer critique questionnaire contained closed-ended questions (see Appendix B1 Sections B and C). The closed-ended questions required participants either to answer "yes" or "no", or to select the correct answer from the list provided (Goddard & Melville, 2001:48). The demographics section included two closed-ended questions and one open-ended question (see Appendix B1 Section A).

The radiographer critique questionnaire was compiled in English, because the radiographers did their training in English, thus the participants can speak and write English. The radiographer critique questionnaire consisted of 28 questions about routine shoulder projections. The participants were requested to provide information about their respective positions in healthcare, as this formed part of the data collection (see Appendix B1 Section A). The questions were designed to obtain specific information on how radiographers critique shoulder images before they are sent to the PACS, and how they apply their radiographic technique to obtain projections of the shoulder. The questions were about anatomy and identifying x-ray images demonstrating optimal exposure and positioning for the AP (external rotation) and LAT-Y shoulder projections. The participants also had to indicate whether they instruct patients to apply a breathing technique during imaging of the shoulder.

The researcher decided to collect data from participants in a paperless fashion to contribute to the campaign, Go Green. Thus, the researcher converted the radiographer critique questionnaire for use with an electronic response system, referred to as clickers. The questions were recorded in Microsoft Excel, after which questions were converted using the TurningPoint program to compile the clicker session. The questions were transformed into multiple-choice questions (see Appendix B2) and the correct answer for each question comprised the memorandum. After the conversion of the radiographer critique questionnaire with its 28 questions, the clicker session consisted of 38 questions. The researcher had to ensure that the answers given by the participants were visible, therefore the anonymous setting had to be disabled. Disabling the anonymous setting enabled the researcher to visualise the answers of the participants after completion of the questionnaire, but did not compromise the anonymity of the participants. The participants did not have to provide their personal information on the questionnaire. Each clicker had its own unique number, thus, each participant had a unique number. Once the participants completed the clicker session, the researcher saved the clicker session using the TurningPoint program. The saved results of the clicker session could then be obtained at a later stage for future use.

The radiography students took part in the clicker questionnaire survey at the CUT on 12 November 2015. The students answered the questionnaire after they did an assessment on campus, thus, it did not disrupt their work or studies. The community service, supplementary and qualified radiographers answered the clicker questionnaire in the boardroom of the participating imaging department on either 27 November 2015 or 4 December 2015. The sessions did not disrupt the work of the imaging department nor interfered with the tea or the lunch breaks of the participants.

3.2.5.2.1 The pilot study for the questionnaire

The researcher pilot tested the radiographer critique questionnaire as part of the research study to ensure that the questions asked were clear and the participants would not experience problems when completing the questionnaire. The radiographer critique questionnaire was also pilot tested to eliminate technical errors and to ensure that the responses recorded met the requirements of the statistician. The hard copy radiographer critique questionnaire was completed by three lecturers in the Department of Clinical Sciences at the CUT, three radiologists and one orthopedic surgeon, who all provided valuable input in relation to the questionnaire.

Three lecturers in the Department of Clinical Sciences took part in the clicker session as part of the pilot study. It was important to pilot the study questionnaire because some of the questions of the hard copy questionnaire had to be altered to make them practicable for the clicker session. The pilot testing of the radiographer critique questionnaire in a clicker session assisted the researcher to identify challenges that needed to be addressed before the participants completed the questionnaire (see Appendix B1).

The pilot participants suggested that the researcher use the word "optimal" instead of "best" in the questionnaire, thus, the word "best" was replaced by the word "optimal". Questions 1, 8.1, 10, 22 and 28 were reformulated, because pilot participants were of the opinion that the way the questions were constructed made them unclear. One of the pilot participants commented that the distractors were confusing, because the wording could have different meanings; and duplication of distractors meant formulation had to be reconsidered. Distractors that were changed were those of Questions 16, 17, 22, 26.2, 27 and 28. For example, for Question 17, the distractors were "Slightly", "No" and "A lot". These distractors could be interpreted in different ways, and, thus, the distractors where reformulated to be more specific and to avoid confusing participants.

After the clicker session had been piloted the researcher noticed that the answers of the pilot participants were anonymous, meaning the researcher could not see what their answers were due to a setting in the software. The researcher had to change some settings to ensure that the answers of the participants are visible. The responses of the clicker session were sent to the statistician. The responses did not meet the statistician's requirements, therefore, more settings had to be corrected. Thus, the pilot study of the clicker session was extremely valuable in assisting the researcher to address any potential problems related to the clicker session of the main study.

3.2.5.2.2 The population and sample for the questionnaire

Population

Healthcare professionals, namely, all diagnostic radiographers employed at the participating institution, participated in the research study. The radiographers, who were registered with HPCSA, included qualified, supplementary, community service and student radiographers. The student radiographers were placed at the participating imaging department for workplace learning (WPL), where they performed imaging of the shoulder under the supervision of qualified radiographers, as stipulated by the HPCSA.

Sample

The sample size must be large enough to increase the validity of the research study (Goddard & Melville, 2001:35). Because the population at the participating imaging department is small the total population sampling method was utilised, therefore the whole population working at the participating imaging department was included in the study (Etikan, Musa & Alkassim, 2016:3). There were four supplementary radiographers, two community service radiographers and 20 qualified radiographers employed at the participating imaging department at the time of the data collection. The student participants included 16 second-year students and 15 third-year students, bringing the total potential sample size to 57 participants.

The researcher compiled a schedule (date and time) with the help of one of the managers of the participating imaging department, for the radiographers to complete the questionnaire. The schedule also applied to the radiographers who worked night shifts, so that they also had the opportunity to complete the questionnaire. The planned sample size decreased from 57 radiographers to 41 radiographers, because several qualified radiographers resigned from the participating imaging department during the time of the survey, some of the radiographers were on leave when the questionnaire was administered, some declined to participate, and four students did not participate in the session.

3.2.5.2.3 Data collection

The radiographer critique questionnaire (see Appendix B2) obtained information from the participants regarding utilisation of the radiographic criteria checklist and the critiquing of shoulder images by the participants. The radiographer critique questionnaire was accompanied by an information document (see Appendix C1) and a consent document (see Appendix C2).

The venue at which the clicker session took place was organised beforehand. Three CUT colleagues took over the work of the radiographers in the participating imaging department while the radiographers completed the clicker session. On the day of the clicker session, the researcher distributed the information document for the research, and the consent form. The researcher explained the purpose of the study and requested the participants to read the information document (see Figure 3.1). The researcher also reminded the participants that they could refuse to take part in the survey. After the participants had read the information document they were requested to sign the consent form; the person next to them had to sign as witness. Once all the participants had signed the consent forms, the researcher explained to the participants that they were not allowed to consult the other participants that were in the venue about the answers to select, and that they had to refrain from discussing the questionnaire with their colleagues in the imaging department. The TurningPoint receiver was connected to the computer to link all the clickers to the recording software.

Figure 3.1: A participant reading the information document before signing the consent document (photo by the researcher Ida-Keshia Sebelego, 2015)

The researcher personally presented the clickers to the participants to complete the radiographer critique questionnaire. The researcher requested the participants to switch on the clickers and to ensure that they were set to channel 41 to pick up the receiver – clickers had to be set to channel 41 to transmit the answers to the TurningPoint program. Thereafter the researcher explained to the participants that they had to select the number on the clicker that corresponded to the correct answer, and select Enter to transmit their answers to the program. After the researcher explained the process, the clicker session started. The participants completed the questionnaire in the presence of the researcher. All the radiographers (qualified, supplementary, community service and student radiographers) had 40 minutes to complete the radiographer critique questionnaire. After the completion of the clicker session, the researcher saved the session and thanked the participants. After all the participants had left, the researcher exported the results of the clicker session to Microsoft Excel.

Subheading 2.6.2 outlined the advantages of utilising clickers. The clicker questionnaire was an effective method of administering the questionnaire because the participants saw all the responses of the other participants immediately and could reflect on their radiographic technique. Utilising the clickers did not cause uneasiness among the participants, since the radiographer critique questionnaire was administered anonymously. The results for the questions were only displayed as percentages, and no answers were linked to participants.

The results (responses) of the clicker session can be downloaded, saved for record keeping purposes and utilised for future purposes (Martyn, 2007:Online). The responses of the participants were deemed satisfactory for data analysis.

3.3 DATA ANALYSIS

The data from the radiographic criteria checklist was captured electronically by the researcher in Microsoft Excel. For the radiographic criteria checklist, two sheets were formulated on Microsoft Excel, namely, sheet 1-AP projection (external rotation) and sheet 2 LAT-Y projection. The layout of the radiographic criteria checklist was transferred to Microsoft Excel. The descriptions of the criteria were not typed in Microsoft Excel; the criteria were identified by numbers relating to the respective shoulder projections. Each criterion had a comment section, therefore the comment for each criterion was linked to the respective numbers of the criteria. All additional comments that were collected and were similar were utilised to formulate smaller sections for additional comments. Therefore, the additional comments section comprised 10 smaller sections. This method was utilised to make it easier for the statistician to do further analysis.

The researcher utilised the TurningPoint program for the clicker session. After the questionnaire had been completed by the participants, the researcher saved the clicker session using TurningPoint. The researcher opened the TurningPoint program and selected the function "Manage" at the top of the screen. Under "Manage", the researcher selected the way the results had to be presented. The "Results detail" and "Results by participants" were selected and exported to Microsoft Excel. The Microsoft Excel sheets for the radiographic criteria checklist and the radiographers critique questionnaire were sent to the statistician via email.

Further analysis was done by the statistician using SAS Version 9.2. Descriptive statistics, namely, frequencies and percentages, were calculated for categorical data. Means and standard deviations or medians and percentiles were calculated for numerical data. The results of the analysis were displayed in tabulated forms or as graphs (see Chapters 4 and 5). In order to compare the percentages of the radiographers and students' analytical statistics the Fisher's exact test was used. A significance level (α) of 0.05 was used. If the p-value was greater than 0.05, there was no significant difference in percentages whereas if the p-value is smaller than 0.05 then there was a significant difference in percentages between the radiographers and students (see 5.3).

3.4 VALIDITY, RELIABILITY AND TRUSTWORTHINESS

Validity and reliability are important measurement instruments that prove that a research study is accurate and trustworthy (Goddard & Melville, 2001:41; Institute for Work and Health, 2007:1 of 1). Twycross and Shields (2004:28) make an interesting statement: "just because a research study has been published in a journal does not mean that it is good research or that the results are applicable to your area of clinical practice". Thus, it was of the utmost importance that the researcher delved deep into the research study to ensure that the study is reliable and valid, but also that it is practice oriented for the profession of radiography.

3.4.1 Validity

Validity refers to the "strength of a statement" as indicated by Kvale (2007:122) and relates to whether a study measures what it was supposed to measure (Wilkinson, 2000:42; Goddard & Melville, 2001:41). Essentially, validity will indicate if the aim of the research study was accomplished and how strong the measuring tools were. To ensure validity, researchers must investigate whether the data that has been collected is valid for the study.

Various validity measures can be used, among which is content and construct validity. Content validity of the research instruments must be validated **before** data collection starts. Content validity entails that **all** the content of the instrument measures what it is intended to measure. The content of an instrument that is based on a literature review and that has been consulted with experts in the specific field of study are considered valid (Twycross & Shields, 2004:28; Institute for Work and Health, 2007:1 of 1; Delport & Roestenburg, 2011:173; Brink, Van der Walt & Van Rensburg, 2012:166).

In this case, the research study was about critiquing routine shoulder projections by means of a radiographic criteria checklist that can be used by government imaging departments. The researcher compiled the two research instruments, namely, the radiographic criteria checklist and the radiographer critique questionnaire from literature (see 2.5.5) and consulted experts in the field (in this case, of radiography and shoulder imaging) before collecting data (pilot testing) (see 3.2.5.1.6 and 3.2.5.2.1), to ensure that the research instruments measured content validity. The feedback received during the pilot process regarding the checklist and the questionnaire confirmed that the instruments have the potential to measure reasons for repeat shoulder projections and indicate whether the radiographers can apply the radiographic criteria during imaging of the shoulder.

Construct validity "involves determining the degree to which an instrument successfully measures a theoretical construct" (Delport & Roestenburg, 2011:174). The construct of the research instruments was the critique of routine shoulder projections. The approach that the researcher utilised to determine construct validity was the multi-method approach. The multi-method approach is based on the assumption that different instruments measuring the same construct will produce the same results (Brink *et al.,* 2012:168). In this case, the researcher utilised two different research instruments (checklist and questionnaire) that measured the construct critique of routine shoulder projections. The results of the radiographic criteria checklist and the radiographer critique questionnaire showed the knowledge of the radiographers regarding the radiographic criteria and whether the routine shoulder images adhered to the requirements.

3.4.2 Reliability

Reliability refers to the consistency of the research findings, meaning that, under the same conditions and using the same methods and questions, consistency of findings will be obtained (Wilkinson, 2000:42; Goddard & Melville, 2001:41). If the results from the questionnaire of two applications are consistent, it will mean that the research method is reliable.

In this study, test-retest reliability implies that, if the researcher repeated the radiographer critique questionnaire with the same people who answered the questionnaire, the results would be the same. Dependability among the questions asked, based on the topic of routine shoulder imaging, is an indication of consistency (Institute for Work and Health, 2007:1 of 1). The results of the radiographic critique checklist will be the same if the researcher evaluated the routine shoulder images obtained by the same participants a second time.

A radiographic criteria checklist was utilised to evaluate the shoulder images obtained by the radiographers. The radiographic criteria checklist had a pre-set list of criteria that was used to evaluate the images. The radiographic criteria checklist was reliable, because it focused specifically on the diagnostic value of the x-ray image produced.

Reliability was ensured by applying several criteria, piloting the radiographic criteria checklist, piloting the radiographer critique questionnaire, eliminating unclear criteria or questions and by maintaining consistent scoring procedures with the aid of the same radiographic criteria checklist and a radiographer critique questionnaire under the same conditions (Delport & Roestenburg, 2011:177).

3.4.3 Trustworthiness

Key (1997:5 of 8) uses Guba's model to illustrate four criteria that can be used to assess the trustworthiness of a quantitative and qualitative research study. The four criteria used for quantitative research are internal validity, external validity, reliability and objectivity. The trustworthiness of qualitative research is assessed by means of credibility, transferability, dependability and conformability (Key, 1997:5 of 8).

The tools used in the research study, namely, the radiographic criteria checklist and the radiographer critique questionnaire, were reliable and valid, as mentioned previously. Ensuring the validity and reliability contributes to the trustworthiness of the study. All participants were asked the same questions, and the radiographer critique questionnaire was piloted. All comments given on the radiographer critique questionnaire before it was administered to the participants contributed to the trustworthiness of the research study. The participants had to complete the questionnaire in the presence of the researcher, which also contributed to the trustworthiness of the study. The radiographic criteria checklist that was compiled was also piloted. The feedback received on the radiographic criteria checklist contributed to the trustworthiness of the research study.

3.5 ETHICAL CONSIDERATIONS

3.5.1 Ethical approval

The researcher obtained approval (ECUFS 100/2015) from the Research Ethics Committee of the Faculty of Health Sciences, University of the Free State (see Appendix D) and the DoH in the FS (see Appendix E). Further permission was obtained from the head of Clinical Services (see Appendix F1) and the director/head of department (see Appendix F2) of the participating institution. Additionally, permission was also obtained from the CUT (see Appendix G1 and Appendix G2), because the radiography students had to complete the questionnaire on the premises of the university.

3.5.2 Informed consent

Informed consent was requested from all the participants in the study (see Appendix C2). An information document accompanied the radiographer critique questionnaire that was distributed to the various participants. The information document mentioned the following: overview of the study purpose, explanation of what was required of each participant, and the contact details of the researcher (see Appendix C1). A written guarantee was also included to confirm that participation was voluntary and that the participant could withdraw from the study at any time. All the information received from the participants remained anonymous and was available to the researcher and the supervisor only. The evaluation of the images of the patients did not require informed consent, because no names of patients were mentioned or utilised for the study.

3.5.3 Right of privacy

All the information gathered by the researcher from the participating imaging department was managed in a strictly professional and confidential manner. Participants were not required to indicate their personal details on the radiographer critique questionnaires or even identify the hospital where they worked Therefore, the names of the participating imaging department or the participants were not mentioned. Only the researcher and the supervisors know the true identity of the participating imaging department.

3.6 CONCLUSION

This chapter outlined the two research instruments, namely, the radiographic criteria checklist and the radiographer critique questionnaire. The researcher evaluated 578 shoulder images by means of the radiographic criteria checklist. This method enabled the researcher to determine if the shoulder images that had been obtained adhered to the requirements. In the end, 41 participants completed the radiographer critique questionnaire that provided the researcher with information on the way radiographers at the participating imaging department critique images of the shoulder.

Chapter 4, entitled ***Results and discussion: Radiographic criteria checklist,*** will discuss the results of the checklist. This chapter will report on whether the shoulder images that were obtained during the time frame of the research study are of diagnostic value and if they adhere to the specific criteria applicable to routine shoulder projections.

CHAPTER 4
RESULTS AND DISCUSSION: RADIOGRAPHIC CRITERIA CHECKLIST

4.1 INTRODUCTION

This chapter presents the results of the study involving the radiographic criteria checklist. The checklist was compiled to determine whether the radiographers who participated in the study utilise the criteria to evaluate routine shoulder projections, namely, the AP projection (external rotation) and LAT-Y projection. To ensure optimal images, it is important that the routine shoulder images meet the necessary criteria before they are sent to the radiologist or referring doctor for reporting or interpretation (see 2.5 and 2.6.1). The radiographic criteria checklist focused on the following main aspects, namely, (1) anatomical structures included, (2) positioning factors, (3) technical factors and (4) exposure factors. During imaging of the shoulder, the radiographic criteria relating to the above-mentioned aspects must be applied by student, qualified, community service and supplementary radiographers. By using the radiographic criteria radiographers attempt to obtain optimal x-ray images of the shoulder to enhance patient care (see 2.5). Therefore, for this study the researcher evaluated the routine shoulder projections obtained by the radiographers by applying the radiographic criteria checklist (see Appendices A1 and A2).

The results of the application of the radiographic criteria checklist revealed whether the radiographers use the criteria when evaluating the AP (external rotation) and LAT-Y shoulder images, if any shoulder projections were repeated, and the reasons for repeat projections of the shoulder. The research methods assisted the researcher to address the second study objective, namely, to identify by means of the radiographic criteria checklist the causes contributing to images failing to meet the requirements and therefore the reasons for repeating routine shoulder projections (see 1.4.2).

4.2 SUMMARY OF THE METHODOLOGY UTILISED FOR THE RESEARCH STUDY

Various literature studies were consulted to compile the radiographic criteria checklist (see Appendices A1 and A2). The radiographic criteria checklist was mainly quantitative, with some qualitative aspects (see 3.2.2). The radiographic criteria checklist listed the criteria described in the literature for the AP (external rotation) and LAT-Y projections of the shoulder that assisted the researcher during the evaluation of the shoulder images (see 2.5.5). Additionally, for each criterion a comment section was available for the researcher to utilise, plus a section for general additional comments (see Appendices A1 and A2). The comment sections on the radiographic criteria checklist provided qualitative information that gave deeper insight on the problem statement given in Chapter 1 (see 1.3).

The researcher used the radiographic criteria checklist to evaluate 578 raw data routine shoulder images (AP (external rotation) and LAT-Y) retrospectively from the display monitors of the participating imaging department (see 3.2.5.1.9). Evaluating the raw data shoulder images enabled the researcher to eliminate any image manipulation by the radiographer, thus, allowing evaluation of the image as it was obtained. Each evaluation by means of the radiographic criteria checklist was awarded a unique number. The researcher determined whether each criterion on the checklist had been applied for the AP (external rotation) and LAT-Y shoulder projections. The researcher added comments if images did not adhere to the criteria. The comments were meant to provide insight on reasons why an image did not adhere to the criteria requirements. One of the criteria under the section exposure factors addressed the number of repeats. The researcher recorded repeat projections. All the projections that were obtained for a patient on a particular day appeared (accepted and rejected) on the display monitor, together with the times the projections were obtained. Hence, if an AP (external rotation) projection image was, for example, rejected, and was repeated by obtaining another AP (external rotation) projection, at least two AP (external rotation) projection images were displayed on the monitor. This information on repeat shoulder projections alerted the researcher to investigate reasons for rejecting shoulder projections.

A statistician analysed the data and provided the results to the researcher. The following sections will display the results of the radiographic criteria checklist (see 4.3); it is followed by a discussion (see 4.4).

4.3 RESULTS OF THE APPLICATION OF THE RADIOGRAPHIC CRITERIA CHECKLIST

The results will be presented according to the four sections of the radiographic criteria checklist, namely, the anatomical structures included in the projection, the positioning factors, the technical factors and the exposure factors (see Appendices A1 and A2).

4.3.1 Fully compliant to criteria for 578 routine shoulder projections

A total of 578 raw routine shoulder images were evaluated (AP external rotation and LAT-Y). The criteria to which all 578 routine shoulder images complied are illustrated in Figure 4.1. The results reveal that the participants always ensured that patient identification is visible on the image for both projections (see 2.5 and 2.5.5.1 and 2.5.5.2). Every AP projection (100%) demonstrates the clavicle horizontally with no motion visible, and the superior scapula is never superimposed. The LAT-Y projections were fully compliant in demonstrating the GH joint, coracoid process and acromion process. The anatomical structures that were not present on or excluded from all the images are demonstrated in Figure 4.3.

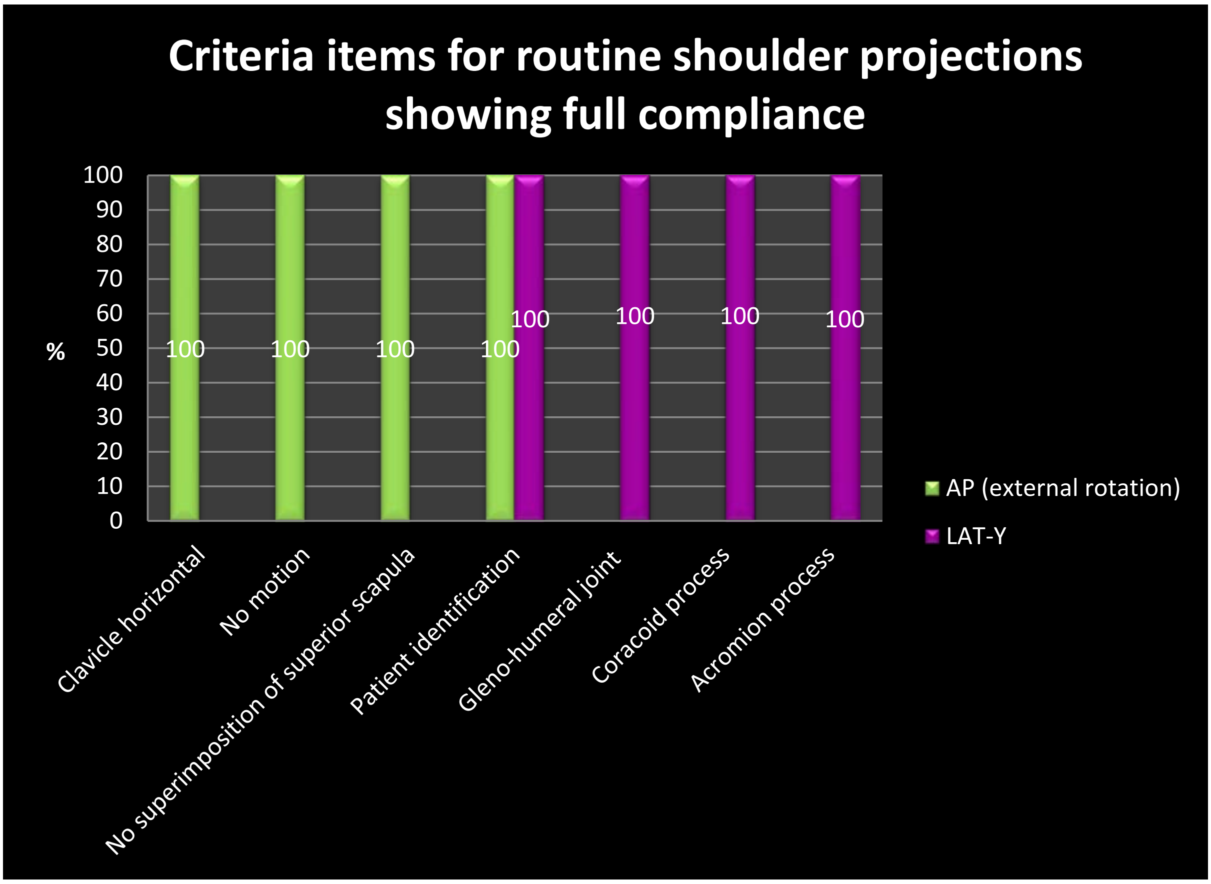

Figure 4.1: Criteria items for routine shoulder projections showing full compliance

4.3.2 Anatomical structures included for routine shoulder projections

Figure 4.2 reveals the anatomical structures included in the AP (external rotation) projection that should not be included. All the images (100%) demonstrate anatomical structures inferior of the superior scapula, which means that more of the superior scapula was included than was required, and 99% of images demonstrate more than two thirds of the clavicle. Only one third of the proximal humerus must be included in the collimation field (see 2.5.5.1), but, as illustrated, 84% of the images included more than one third of the proximal humerus. Figure 4.4 (see 4.3.3) illustrates that an incorrect centring point was utilised for the AP (external rotation) projection and, consequently, unnecessary anatomy was included in the collimation field.

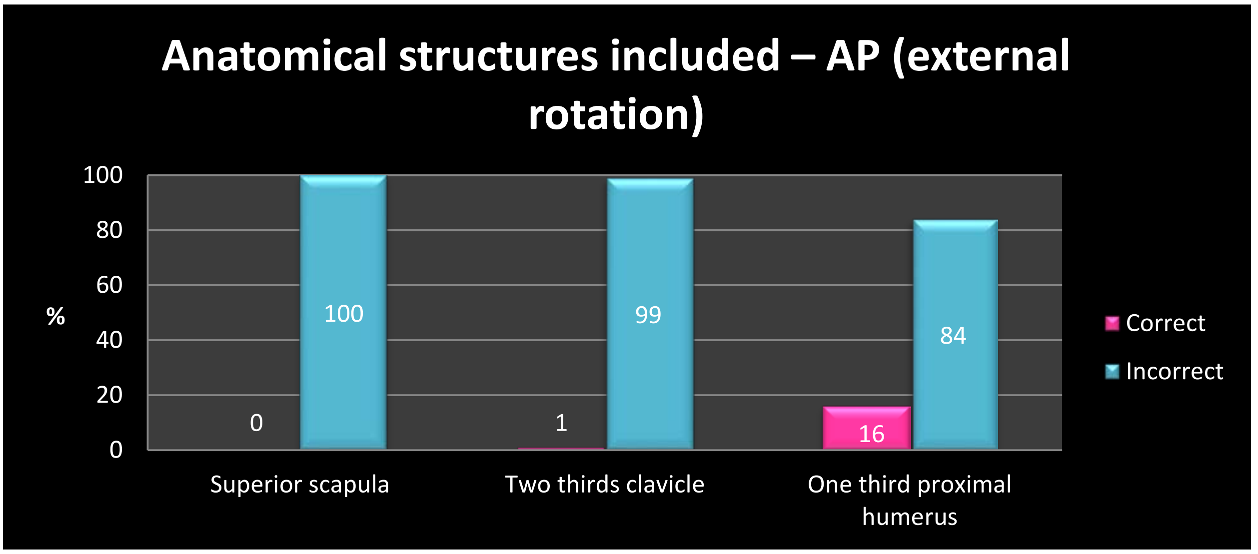

Figure 4.2: Anatomical structures included – AP (external rotation)

Figure 4.3 shows that only 1% of the LAT-Y shoulder projections that were obtained failed to demonstrate the superior and inferior angles of the scapula. Unfortunately, 72% of the images evaluated included not only the proximal humerus, but other anatomical structures too. This could be due to participants centring incorrectly (see Figure 4.5).

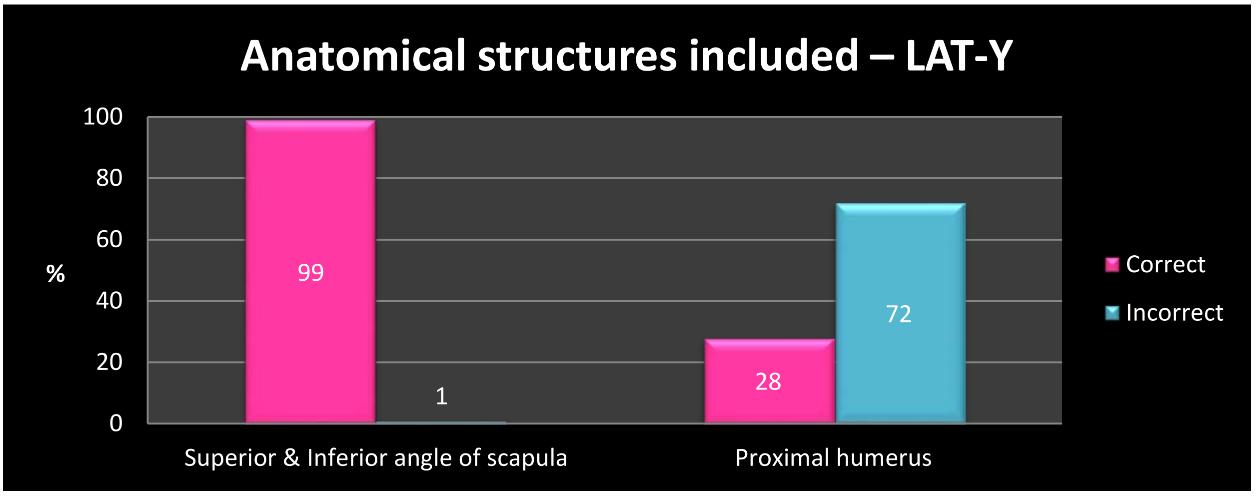

Figure 4.3: Anatomical structures included – LAT-Y

4.3.3 Radiographic technique (positioning factors)

The AP (external rotation) projection had to adhere to specific criteria in relation to positioning (see 2.5.5.1). As can be deduced from Figure 4.4, 89% of the images did not adhere to the correct centring, namely, that the GH joint and coracoid process must be in the centre of the collimation field. Further, 71% of the images did not demonstrate the correct humerus rotation (humeral head slightly overlapping the glenoid cavity). Also evident is that 77% of the images did not demonstrate the correct LT rotation. Correct LT rotation indicates that the LT was positioned between the GT and humeral head, whereas correct GT rotation demonstrates the GT laterally in profile to the proximal humerus (see 2.5.5.1 and Table 2.3). As depicted in Figure 4.4, 76% of the images evaluated did not adhere to the criterion "greater tubercle rotation.

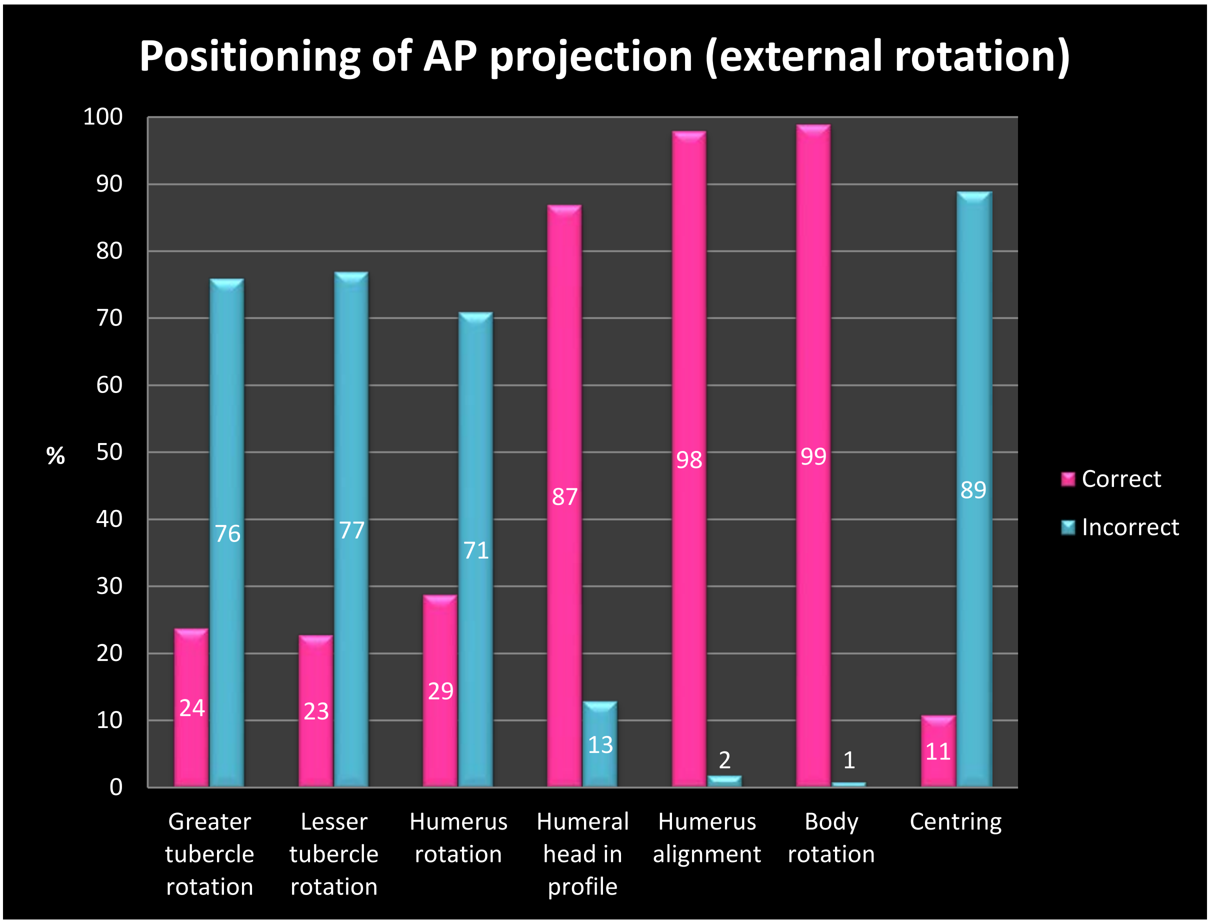

Figure 4.4: Positioning of AP projection (external rotation)

The LAT-Y projection had to adhere to certain criteria in terms of positioning (see 2.5.5.2). Figure 4.5 indicates four main issues of concern, namely, centring, humerus and scapula superimposition, rotation of and Y-formation of the scapula. The correct centring for a LAT-Y shoulder projection is achieved when the mid-scapular body or the humeral head and surgical neck are in the centre of the collimation field. As reported in Figure 4.5, as much as 73% of images did not illustrate the correct centring. Furthermore, 48% of LAT-Y shoulder images did not demonstrate the shaft of the humerus superimposing the scapular body. Y-formation refers to the acromion, coracoid process and scapular body forming a Y, but 30% of the images did not form a Y, indicating a true lateral; therefore, the rotation of the scapula (lateral and vertebral border of scapula superimposed) illustrates that 30% of images did not adhere to this criterion.

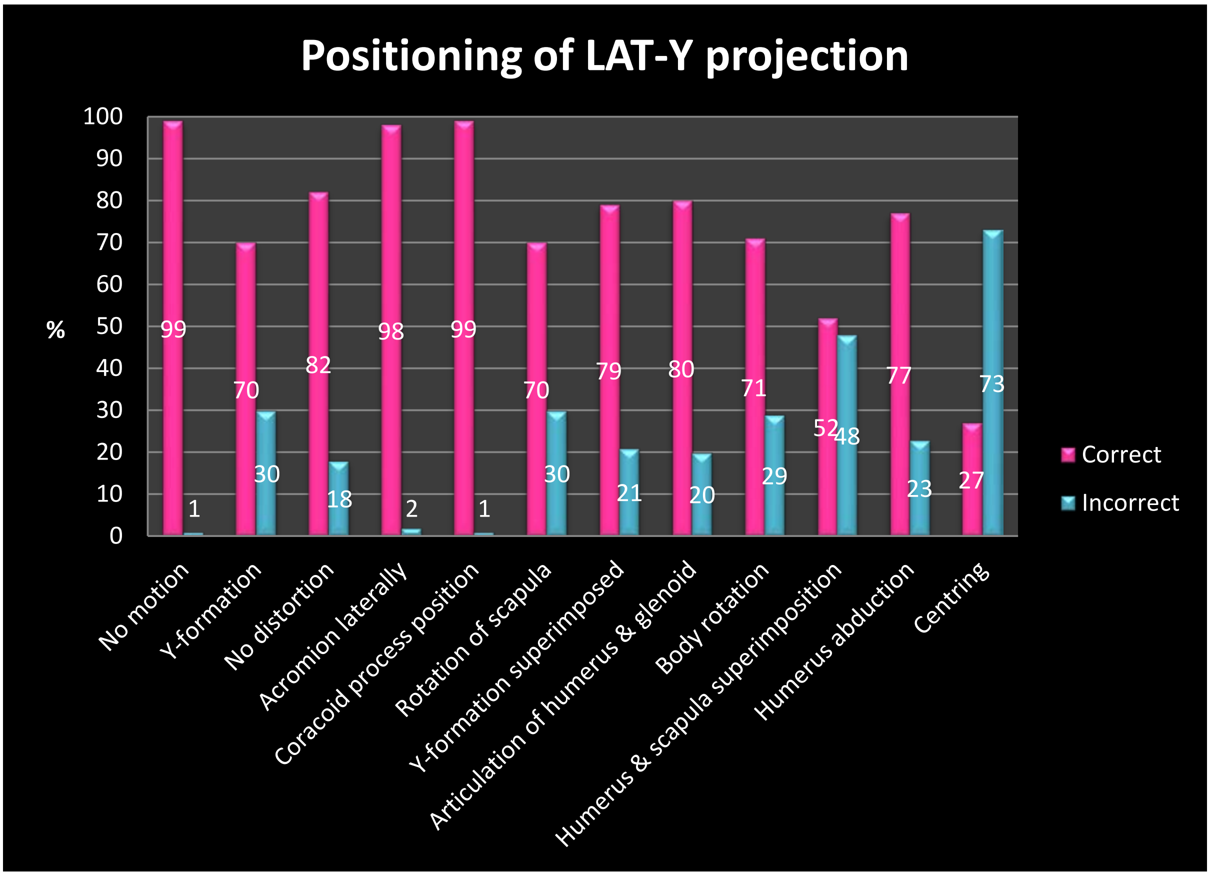

Figure 4.5: Positioning of LAT-Y projection

4.3.4 Technical factors relating to imaging of routine shoulder projections

The findings of the investigation into compliance to criteria relating to the three technical factors, namely, lead markers, artefacts and four-sided collimation, are displayed in Figure 4.6 to Figure 4.8. The results indicate whether a lead marker was visible on the routine shoulder images (correct) or not (incorrect). The lead marker was not visible on 34% of the AP (external rotation) projections and 39% of the LAT-Y projections.

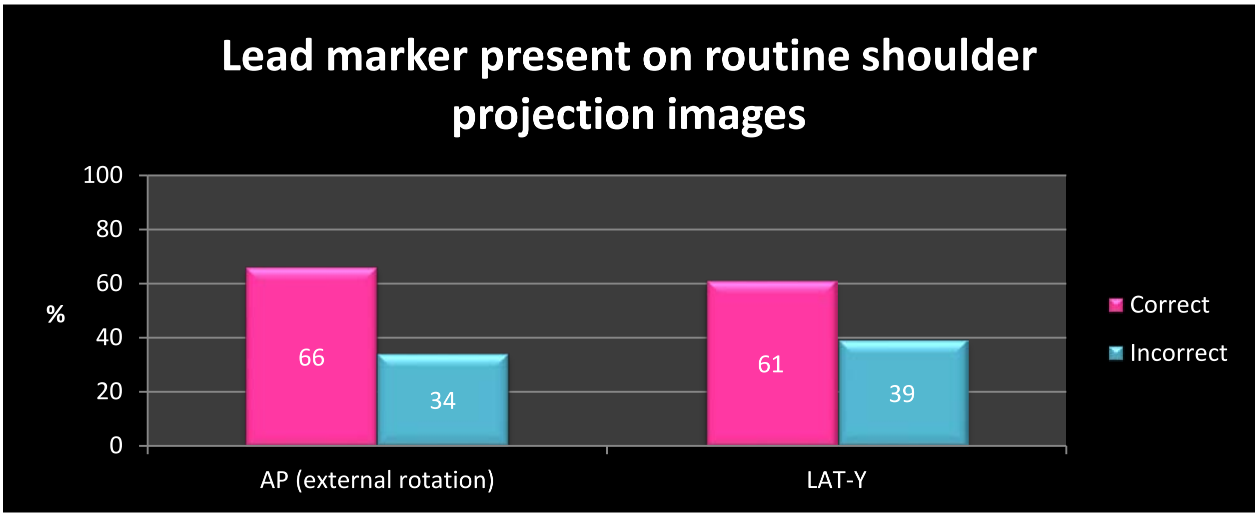

Figure 4.6: Lead marker present on routine shoulder projection images

Artefacts that were visible on the images included clothing, orthopedic equipment, jewellery and quantum mottle (noise). It is evident from Figure 4.7 that 73% of the AP (external rotation) shoulder projections did not have artefacts, whereas 71% of the LAT-Y shoulder projections did not present with artefacts.

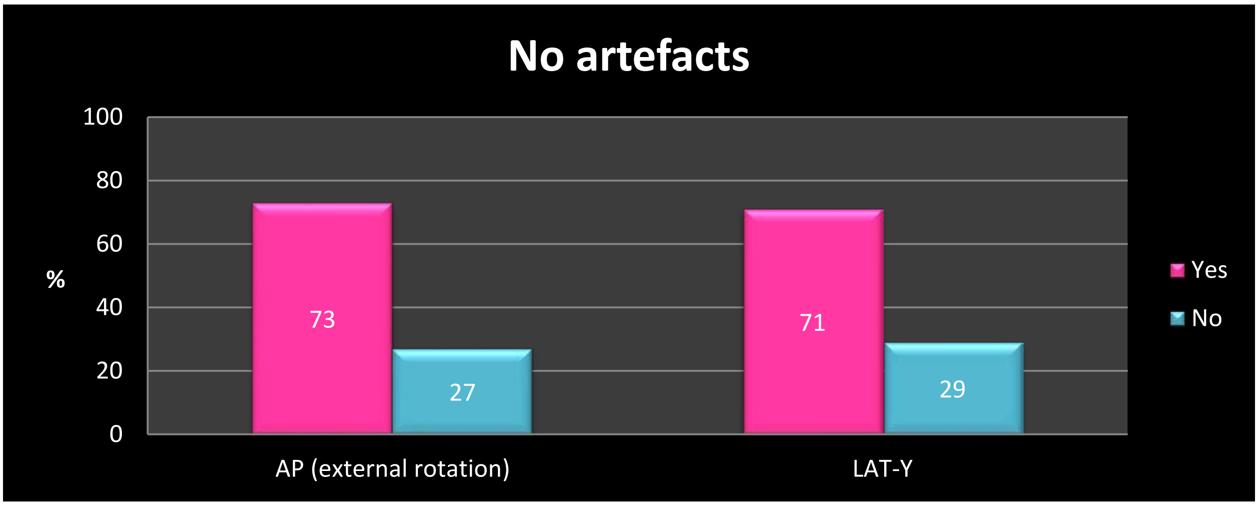

Figure 4.7: No artefacts on AP (external rotation) and LAT-Y projections

Four-sided collimation is visible when the correct centring is utilised and collimation is applied to include only the important anatomical structures. Figure 4.2 and Figure 4.5 show that not all routine shoulder images adhere to the criteria "centring" and "including the correct anatomical structures". Consequently, Figure 4.8 reveals that more than 50% of the routine shoulder images did not demonstrate four-sided collimation.

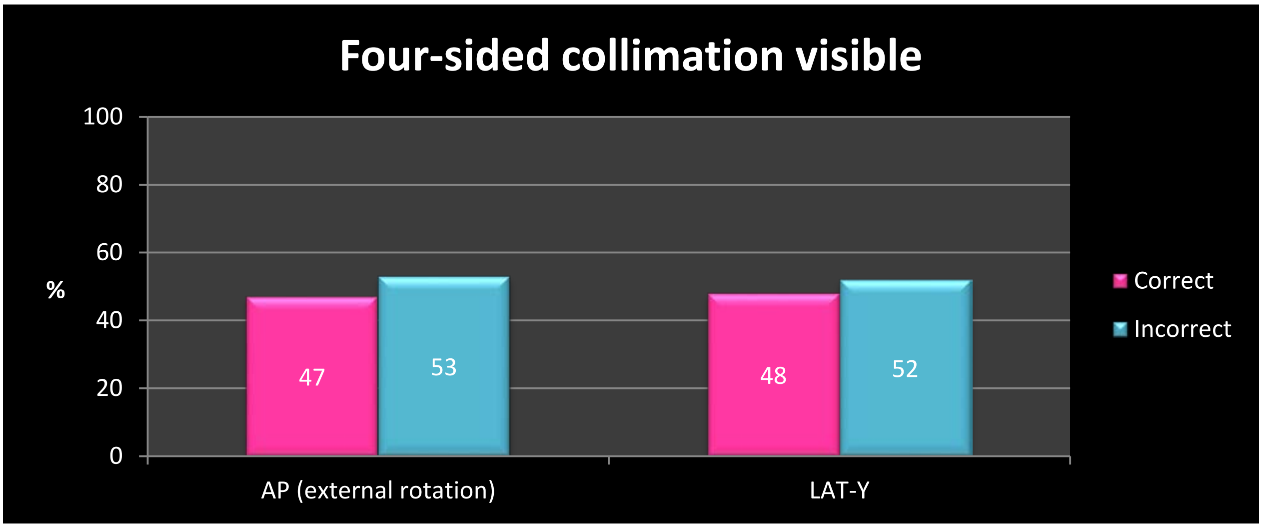

Figure 4.8: Four-sided collimation visible

4.3.5 Exposure factors for imaging of routine shoulder projections

Optimum exposure can be visualised on routine shoulder images if bony trabecular detail, cortical outlines and soft tissue can be visualised. As illustrated in Figure 4.9, more than 90% of the AP (external rotation) shoulder projections that were evaluated demonstrated optimal exposure.

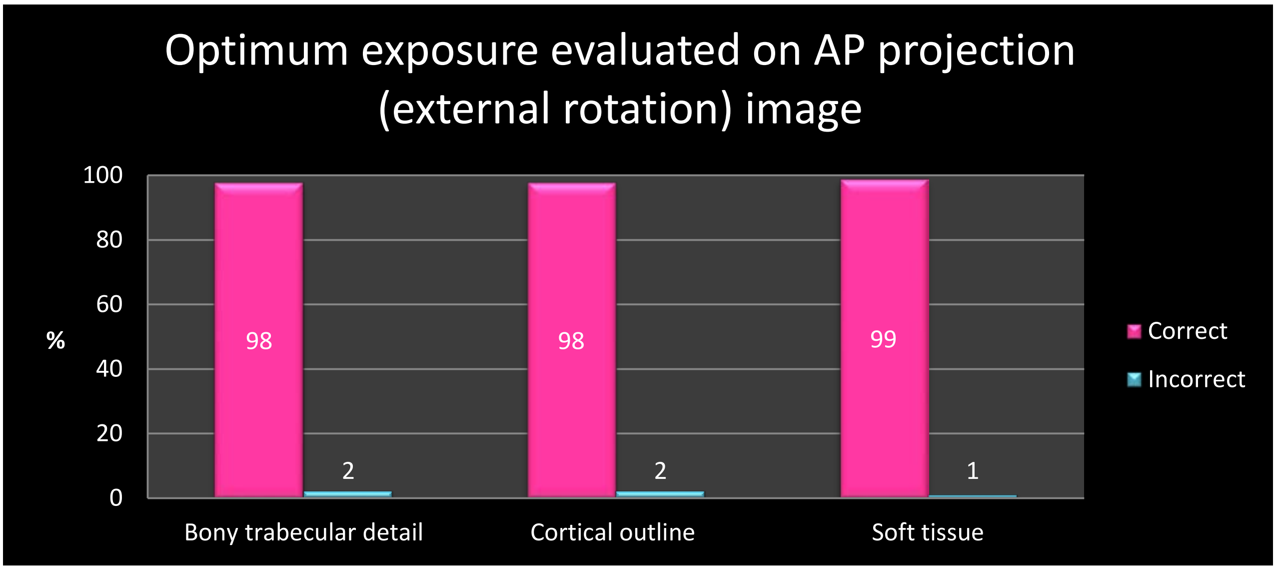

Figure 4.9: Optimum exposure evaluated on AP projection (external rotation) image

Furthermore, for the LAT-Y shoulder projections, 88% showed bony trabecular detail, 93% illustrated cortical outlines, and soft tissue could be seen on 99% of the projections (see Figure 4.10).

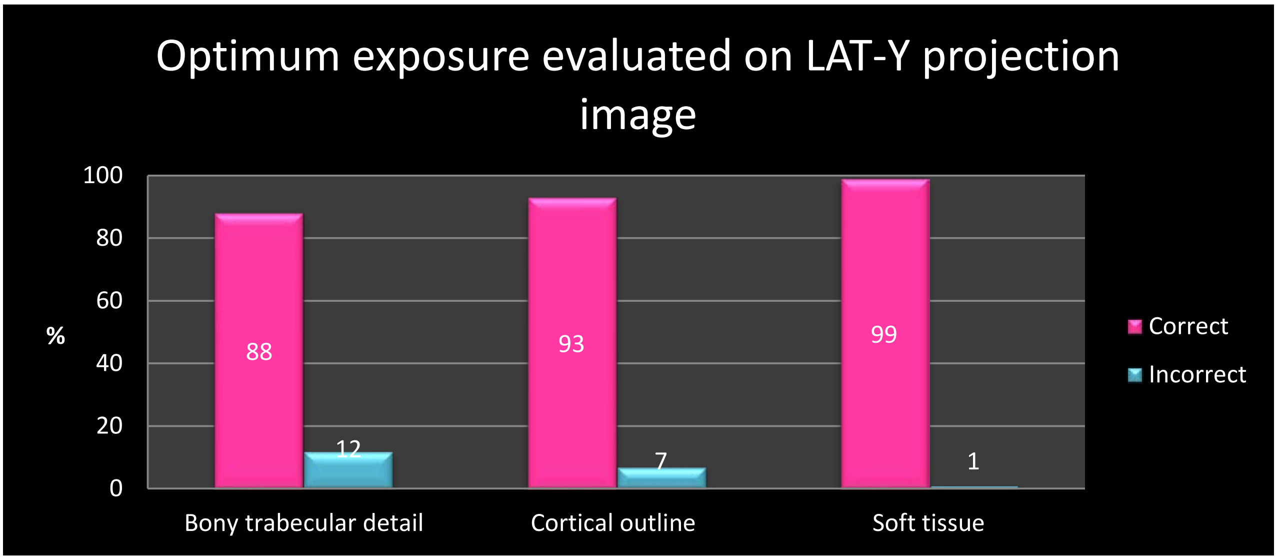

Figure 4.10: Optimum exposure evaluated on LAT-Y projection image

The kVp ranged from 70 to 80 kVp, whereas the mAs ranged from 16 to 25 (see Appendices A1 and A2). Figure 4.11 illustrates that, for the AP (external rotation) and LAT-Y shoulder projections, either the wrong kVp or incorrect mAs, or kVp and mAs were selected for the majority of projections: 91% of the AP (external rotation) projections and 85% of the LAT-Y shoulder projections present with exposure factors beyond the required range (see 2.5.2).

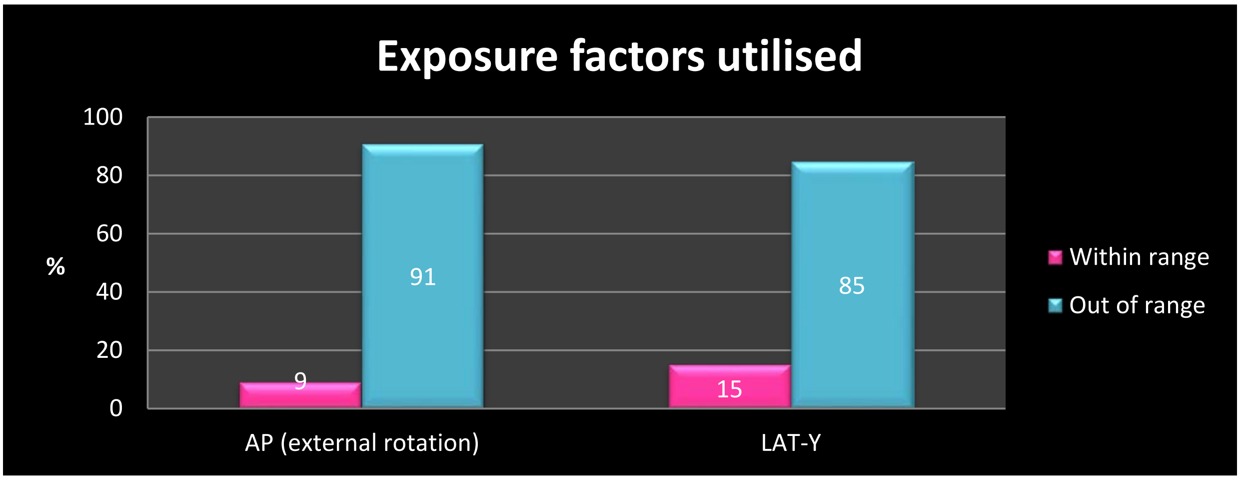

Figure 4.11: Exposure factors utilised

EI values that radiographers should observe are available; these values ensure that the x-ray images obtained are within the set EI value ranges (see 2.5.2.3). The EI value for extremities (upper and lower) in-Bucky examinations ranged from 145 to 344, whereas, for non-Bucky examinations it ranged from 345 to 689 (see Appendices A1 and A2). An acceptable EI value demonstrates an optimal diagnostic shoulder image. At the participating imaging department

67% of the AP (external rotation) shoulder projections were within the range limits, whereas 56% of the LAT-Y shoulder projections were out of range, as shown by Figure 4.12.

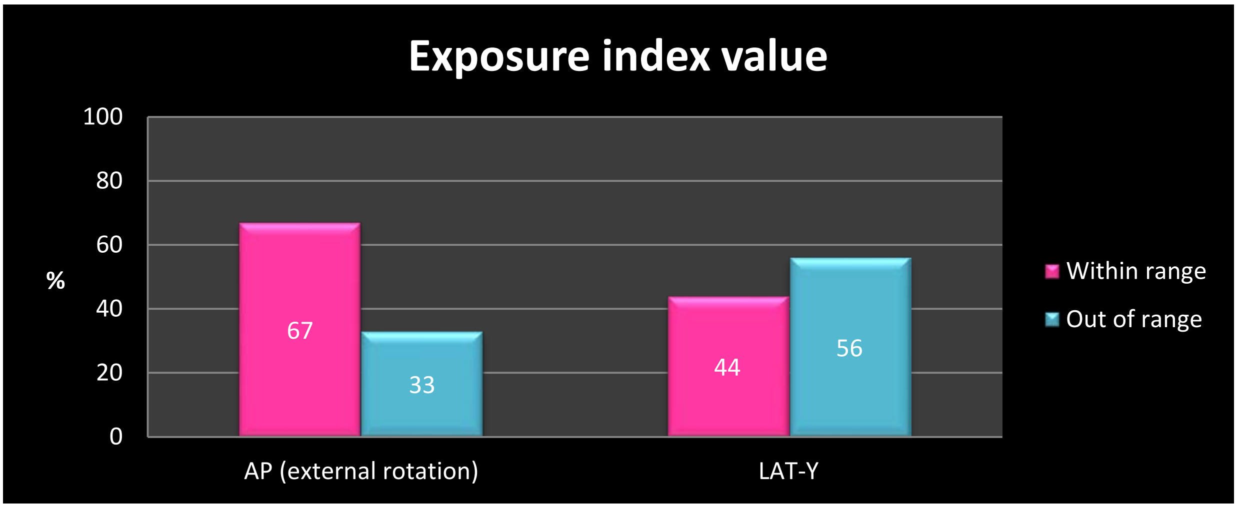

Figure 4.12: Exposure index value

Figure 4.13 reveals that only 14% of the AP (external rotation) shoulder projections were repeated, whereas, 31% of the LAT-Y shoulder projections were repeated.

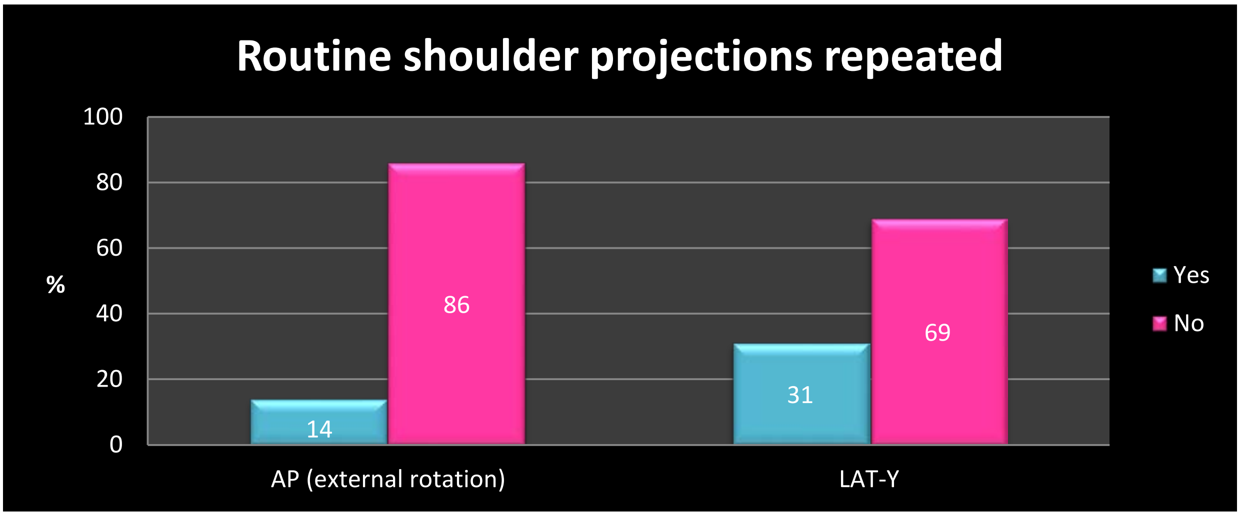

Figure 4.13: Routine shoulder projections repeated

4.4 DISCUSSION OF THE RESULTS

The results of the 578 routine shoulder projections (AP (external rotation) and LAT-Y) that were evaluated by means of the radiographic criteria checklist reveal interesting information in relation to radiographic criteria requirements and the reasons for rejection of shoulder projections at the participating imaging department. Chapter 2 (see 2.5.5.2) emphasised that every one of the criteria listed on the radiographic criteria checklist contributes to good radiation practices. Hence, it is important that radiographers always ensure that the shoulder projections they obtain adhere to all the criteria, so that the projections enable optimal reporting and diagnosis.

4.4.1 Full compliance to criteria

It is evident that all 578 routine shoulder images that were evaluated adhered full to certain criteria, as reported in Figure 4.1 (see 4.3.1). All routine shoulder projections that were examined had patient identification, and motion was not present on any AP (external rotation) shoulder image. Ensuring that patient identification is visible on the x-ray image is part of good radiation practice (see 2.5.5.2); identifying the patient means the x-ray projection will not have to be repeated, thereby reducing unnecessary radiation to the patient. It is commendable that the participants included the GH joint, coracoid process and acromion process structures during imaging of the LAT-Y shoulder projections, and that 100% of AP (external rotation) shoulder projections demonstrated the clavicle horizontally, and not superimposed over the superior scapula (see 2.5.5.2). When the correct positioning technique is applied during imaging the anatomical structures that must be demonstrated for the routine shoulder projections are visualised on the x-ray image.

4.4.2 Radiographic anatomy

It is evident from Figure 4.2 that the participants included more than the necessary anatomy during imaging of the AP (external rotation) shoulder projection (see 4.3.2). None of the projections that were examined demonstrated only the superior scapula, instead, 100% of projections presented the whole scapula. Furthermore, 99% of projections did not include only two thirds of the clavicle, but rather included the whole clavicle. Rather than including one third of the proximal humerus as required, two thirds of the proximal humerus was illustrated on the AP (external rotation) shoulder images.

To determine adherence to the criterion relating to anatomy included in the AP (external rotation) projection, the researcher chose a reference point that represents two thirds of the proximal humerus. The reference point was determined from the middle of the scapula to the inferior angle of the scapula horizontally. Therefore, if the inferior angle of the scapula was included in the collimation field, two thirds of the proximal humerus was included. The AP (external rotation) shoulder projection should include the superior scapula, two thirds of the clavicle and one third of the proximal humerus (see 2.5.5.1).

During the pilot study, two pilot participants suggested that the whole scapula must be included for the AP (external rotation) projection (see 3.2.5.1.6). This suggestion may indicate the reason why the radiographers at the participating imaging department included the whole scapula during imaging of the AP (external rotation) projection. The suggestion made by the pilot study was confirmed when the participants completed the radiographer critique questionnaire (see 5.4.1).

Admirably, most of the LAT-Y shoulder projections showed inclusion of the correct anatomical structures, except in relation to the proximal humerus. As shown in Figure 4.3 (see 4.3.2), 72% of the projections were incorrect, because either two thirds of the proximal humerus or the whole humerus was included in the collimation field (see 2.5.5.2). The whole humerus, from the humeral head to the elbow joint as the reference point, was included. The reference point for determination of two thirds of the proximal humerus was 2 cm and more inferior to the inferior angle of the scapula horizontally, but prior to the elbow joint. According to the researcher the participants centred too inferiorly (see Figure 4.5), therefore more of the proximal humerus was included in the collimation field (see 2.5.3). It could be that the participants try to obtain a single projection that includes two structures (whole humerus and shoulder) to rule out pathologies of the humerus. Noteworthy is that radiographers can be flexible to accommodate the needs of an individual patient; however, doing so does not represent optimal radiation exposure practice. It is not part of the scope of practice of radiographers to decide whether to obtain more anatomical structures, unless they had been instructed by the referring doctor or radiologist to do so.

4.4.3 Radiographic technique

Four positioning criteria are of concern, according to the results demonstrated in Figure 4.4 (see 4.3.3), during imaging of the AP (external rotation) shoulder projection. More than 70% of projections were incorrect regarding the four criteria GT rotation, LT rotation, humerus rotation and centring. GT rotation refers to the GT being in profile, whereas LT rotation refers to the LT being positioned between the GT and the humeral head. Humerus rotation refers to the humeral head slightly overlapping the glenoid cavity, while centring refers to the correct centring point, namely, the GH joint and coracoid process being in the centre of the collimation field (see Appendices A1 and 2.5.5.1). It became evident during data collection that GT, LT and humerus rotations were not always possible, because some patients presented with shoulder dislocations and fractures. When a patient presents with fractures, no arm rotation is advised, because the fractures can injure the arteries and nerves (see 2.2.1.3) situated at the shoulder joint (Bontrager & Lampignano, 2014:194) when the arm is moved.

Overall, the researcher observed that the participants did not rotate a patient's arm externally to demonstrate the GT in profile and the LT between the GT and humeral head (see 2.5.5.1). Furthermore 89% of AP (external rotation) shoulder projections demonstrated an incorrect centring point. Anatomical structures inferior of the correct centring point were at the centre of the collimation field, thereby indicating that the participants centred inferiorly of the GH joint and coracoid process. Structures such as the inferior angle and the middle of the scapula were at the centre of the collimation field. Hence, as illustrated by Figure 4.2, because participants utilised an incorrect centring point, more of the necessary anatomical structures were included in the collimation (see 2.5.3).

The positioning criteria for the LAT-Y shoulder projection were mostly adhered to, as illustrated by Figure 4.5 (see 4.3.3 and 2.5.5.2). The LAT-Y shoulder projections adhered to more than 70% of the various positioning criteria; criteria not adhered to relate to humerus and scapula superimposition and centring. It is pleasing to notice that the participants can mostly apply the correct positioning technique during imaging of the LAT-Y shoulder projection. Only 1-30% of the LAT-Y shoulder projections did not adhere to the criteria requirements for various reasons. The most prominent reasons detected during data collection were under-rotation of the scapula not demonstrating superimposition of the vertebral and medial/lateral borders, shoulder dislocations, and foreshortening of the scapula (see 2.5.5.2). Even though patients present with shoulder dislocations or experienced acute trauma, a true lateral of the scapula can still be obtained because no movement of the arm is required; only body rotation (see

2.4.3). Thus, radiographers cannot use the trauma or pathological indications (see 2.3) of the shoulder to justify why a true lateral of the scapula has not been obtained.

The relationship between the humeral head and the glenoid cavity (articulation of humeral head and glenoid) will not be visible on an LAT-Y shoulder projection if a patient presents with dislocations (see 2.2.1.1 and 2.3.2). Therefore, as shown in Figure 4.3, 20% of the LAT-Y shoulder projections did not demonstrate articulation of the humeral head and glenoid, because patients presented with shoulder dislocations. The criterion "humerus and scapula superimposition" refers to the shaft of the humerus that must superimpose the body of the scapula when the patient's arm is abducted slightly and the patient has been rotated 45-60º (anterior oblique) (see 2.4.3). Humerus and scapula superimposition was not achieved for 48% of LAT-Y shoulder projections, due to some patients presenting with dislocations, therefore the humerus superimposed the chest cavity (ribs) of the patient. The centring as indicated in Figure 4.5 refers to the correct centring point, namely, the mid-scapular body or the humeral head and surgical neck being in the centre of the collimation field (see Table 2.5). Anatomical structures inferior or medial to the correct centring point were at the centre of the collimation field. The incorrect anatomical structures at the centre of the collimation field were the inferior angle, thoracic vertebrae, the middle of the vertebral border and the ribcage. As can be expected, unnecessary anatomical structures will be included in the collimation field because participants utilise the incorrect centring point during imaging of the LAT-Y shoulder projection (see 2.5.3). Unfortunately, if an incorrect centring point is employed unnecessary anatomical structures are exposed to radiation (see 4.4.2,) and the radiographer is not adhering to the ALARA principle (see 2.5).

4.4.4 Technical factors

According to literature (see 2.5.4), an x-ray image with a lead marker is considered a legal document; using a digital/electronic marker is not regarded as good practice as it can be challenged in a court of law. The results relating to the use of <u>anatomical lead markers</u> showed that the participants used anatomical lead markers for more than 60% of routine shoulder projections, as illustrated in Figure 4.6 (see 4.3.4). As stated by Titley and Cosson (2014:46) radiographers place lead markers mostly on AP projections compared to lateral projections which were apparent in this study (see Figure 4.6). Furthermore, as reported by Titley and Cosson (2014:46), it is confirmed with this study that digital markers were added after an exposure was made. It was evident that 34% of the AP (external rotation) shoulder projections and 39% of the LAT-Y shoulder projections presented with digital/electronic markers, thus, indicating that the participants placed digital markers after exposure. Placing the wrong lead marker after an exposure can cause medico-legal complications. Hence, legislation requires that radiographers place a lead marker prior to exposure, and radiologists can refuse to report on an x-ray image that does not display a lead marker that had been placed before an exposure was made (see 2.5 and 2.5.4). The results of this study indicate that the radiographers at the participating imaging department sometimes utilise digital/electronic markers to annotate shoulder images, which is not good practice; furthermore this practice can have medico-legal implications.

The routine shoulder images that were evaluated presented with artefacts (less than 30% of each type of projection), as shown in Figure 4.7 (see 4.3.4). Most of the artefacts that were visible on these images were clothing and orthopaedic equipment. The artefact "clothing" refers to zips, buttons and the metal of underwear. The orthopaedic equipment that was visible included needles, pins, screws, plaster of Paris, plates and wires. The orthopaedic equipment artefacts cannot be controlled by the radiographer, however, the clothing artefacts are under the control of the radiographer. The fact that clothing artefacts presented on the images means that the radiographers do not instruct the patients properly regarding undressing during imaging of the shoulder. When obtaining shoulder projections of female patients, in particular, the radiographers do not properly instruct patients to remove underwear, thus bra metals appear on the image. It is the opinion of the researcher that the radiographers might consider it time-consuming to request that patients undress, that the department is busy or that the participating imaging department does not have enough gowns to provide to patients who undress before shoulder projections are obtained. Nonetheless, it is important that radiographers request patients to undress before shoulder projections are obtained, and radiographers should not consider it a burden. Artefacts, especially artefacts that can be controlled by the radiographer, can superimpose the anatomical structure of interest and can contribute to misdiagnoses (Bushong, 2008:298), and may require repeat projections, leading to more radiation. Hence, the presence of clothing artefacts that were visible on routine shoulder images meant that radiographers at the participating imaging department did not contribute to patient care.

Radiographers must, at all times, demonstrate optimal collimation practices that contribute to the ALARA principle and provide optimal x-ray images (see 2.5 and 2.5.3). Quantum mottle (noise) on an x-ray image is the result of ineffective collimation, caused by scatter radiation reaching the IR and worsening the visibility of the recorded detail (see 2.5.3). More than 50% of the routine shoulder images failed to demonstrate four-sided collimation for the AP (external rotation) and LAT-Y shoulder projections (see Figures 4.8 and 4.3.4). Four-sided collimation is possible when the correct centring is utilised during imaging of the shoulder (see 2.5.3).

Thus, the finding of this study indicates that the participants did not use the correct centring point, as seen in Figure 4.4 and Figure 4.5 (see 4.3.3). As a result, more than half the routine shoulder projections did not present with four-sided collimation borders.

For most AP (external rotation) shoulder projections collimation was applied only superiorly and inferiorly of the ROI, while, for the LAT-Y shoulder projections, collimation was only applied by the radiographers medially and laterally of the ROI. For both routine shoulder projections, the following anatomical structures were included: mostly one-sided anatomy, third cervical vertebra (C3) to sacrum and one-sided anatomy, seventh cervical vertebra (C7) to tenth thoracic vertebra (T10). These anatomical structures were included because the correct centring point was not utilised and collimation was not applied effectively (see Figures 4.2 – 4.5). One-sided anatomy refers to the side of importance (left or right), which was determined by the researcher from the spinous process of the vertebral column up to the lateral end of the clavicle or humerus (side of interest). Due to ineffective collimation practices, sensitive organs, namely, the thyroid, breast and gonads, were unnecessarily exposed to radiation. Figure 4.14 illustrates the anatomical structures that were included due to collimation errors.

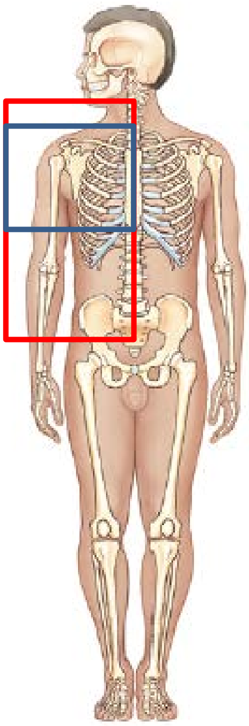

Figure 4.14: Illustration of C7 up to T10 (blue block) and C3 up to sacrum (red block) included in the collimation field (image courtesy Bontrager & Lampignano, 2014:4).

The results show clearly that using a correct centring point has an impact on the anatomical structures that must be included, and on applying collimation effectively (see 2.5 and 2.5.3). Moreover, collimation reduces scatter radiation to the IR and improves the visibility of the recorded detail (see 2.5.3). Since the radiographers at the participating imaging department utilised incorrect centring points, which resulted in collimation errors, optimal shoulder images were not obtained and consequently the presence of collimation errors meant the radiographers did not contribute to patient care.

4.4.5 Exposure factors

The radiographic criteria checklist stipulated specific ranges in relation to exposure factors for imaging of the shoulder. During imaging of the shoulder 70-80 kVp and 16-25 mAs (exposure factors) are utilised for both routine shoulder projections when the AEC is not utilised. It was shocking to find that the exposure factors were out of range for 91% of AP (external rotation) projections and 85% of LAT-Y shoulder projections (see Figures 4.11 and 4.3.5). The finding of out of range refers to both kVp (various shades of grey) and mAs (image density/brightness) selection. If only one of the ranges, either mAs or kVp, was correct, the exposure was considered to be out of range. Both the mAs and kVp selection had to be correct to be defined within range. During data collection it became clear that the kVp selection was generally correct, but the mAs selection was not correct, as required by the checklist (see Appendices A1 and A2). The exposure factors that were utilised for the checklist were based on manual exposures that were set. However, the researcher noted that the radiographers utilise the AEC system when they image the shoulder. The kVp can be adjusted by the radiographer even though the AEC system is utilised (see 2.5.2). This lead to the kVp selection being correct, because the AEC system gives a minimum of 73 kVp for the AP (external rotation) and LAT-Y shoulder projections (see 2.5.2). Nonetheless, more than 80% of routine shoulder projections presented with incorrect mAs as provided by the AEC system. The fact that the radiographers utilised the AEC system during imaging of the shoulder, the mAs differed from the checklist which were based on manual exposures (see 2.5.2), as a result the exposures were considered to be "out of range".

The exposure chart of the participating imaging department indicates that 4 mAs is utilised for routine shoulder projections, whereas the AEC system at the participating imaging department uses 7.4 mAs for an AP projection (external rotation) and 4.3 mAs for a LAT-Y projection. The difference in mAs parameters between the exposure chart of that of the participating imaging department and what the AEC system actually provides can be expected because the exposure chart of the participating imaging department is based on a computed radiography

(CR) system whereas the Phillips x-ray machine is a fully digital system. According to Sandström (2003:129), if an anatomical structure measures 10 cm and a 70 kVp is utilised, then a 16 mAs is recommended to be used in conjunction, whereas, for a 12 cm anatomical structure, a radiographer must use 25 mAs and 70 kVp. These exposures recommended by Sandström are based on manual set exposures by radiographers. The mAs for most of the routine shoulder projections that were evaluated in this study were low in relation to the set mAs range of the checklist, ranging from 0.5 to 12.4 (see Appendices A1 and A2). The difference in mAs parameters is expected because the mAs provided by the AEC system is different to manually set mAs. However, for some of the shoulder images that were evaluated, the mAs provided by the AEC system were low. Some of the AP (external rotation) images ranged from 0.6 to 7.3 and 0.5 to 4.2 for LAT-Y shoulder images. Using a low mAs results in an underexposed image with noise causing diagnostic information being lost (see 2.5.2.1). The radiographers do not understand the impact an AEC system has on the mAs, or how the mAs influences the image. On the contrary, incorrect use of high mAs can lead to an increase in the radiation dose to the patient and producing a dark image (see 2.5.2).

In spite of the inconsistency between the manual set mAs parameters and that of the AEC, Figure 4.9 and Figure 4.10 show that a large percentage of the routine shoulder projections were optimal for diagnosis (see 4.3.5). The routine shoulder images that were non-optimal had either noise or dark areas on the x-ray image. Ionisation chambers were used in conjunction with an AEC system. An over- or underexposed image can be expected during imaging of the shoulder if the correct ionisation chamber has not been selected and if the ROI was not positioned correctly over the active ionisation chamber (see 2.5.2). Since some of the routine images presented with noise, it can be concluded that, either collimation had not been applied correctly (see 2.5.3), or the shoulder had not been positioned correctly over the ionisation chamber, therefore the exposure was terminated before adequate photons reached the IR to provide an optimal image.

A calibrated EI, utilising the correct exposure factors, applying collimation and employing the positioning technique, influence the EI values of shoulder projections (see 2.5.2.3). EI values for non-Bucky examinations (345-689) and Bucky-examinations (145-344) were indicated on the radiographic criteria checklist that was provided by the participating imaging department (see Appendices A1 and A2). The EI values of the routine shoulder projections had to range between these values. However, if a shoulder is measured as being more than 10 cm, shoulder projections are obtained inside the Bucky, whereas, for paediatrics, shoulder projections are obtained outside the Bucky (Bontrager & Lampignano, 2014:41). During data collection it was not possible for the researcher to determine whether the projections had been obtained inside or outside the Bucky, hence, the within-range EI values were for non-Bucky and Bucky examinations. The results illustrated in Figure 4.12 (see 4.3.5) show clearly that 56% of the LAT-Y shoulder projections demonstrated EI values out of range, thus indicating that the EI values where either lower than 145 or higher than 689. Only 33% of the AP (external rotation) shoulder projections presented EI values out of range. Most of the routine shoulder projections with incorrect EI values ranged from 5 to 144. The results presented in Figures 4.2 to 4.5, and Figure 4.8 (see 4.3.2, 4.3.3 and 4.3.4) demonstrate that using an incorrect centring point means that unnecessary anatomical structures are included in the collimation field, and it leads to four-sided collimation not being visible. This information is useful, because ineffective positioning and collimation means the EI value that had been recorded from the display monitor during data collection could possibly have been misrepresented (see 2.5.3). The possibility of a non-calibrated EI contributing to a misrepresentation of the EI value must not be ignored.

Figure 4.13 (see 4.3.5) provides interesting information in relation to repetition of routine shoulder projections. For both routine shoulder projections, one projection was repeated respectively 94% of AP (external rotation) projections and 71% of LAT-Y projections. The most common reasons for repeats were positioning and collimation errors. As reported by Hermann *et al.* (2012:11), it is confirmed with this study that positioning error is one of the most common reasons for repeating projections in digital radiography (see 2.5.1). It is important to realise that a radiographer can repeat a specific projection twice or thrice without rejecting the previous projections, and send all images obtained to the radiologist. Hence, there will be no rejects for the patient. Therefore, the researcher evaluated how many repeats (either rejected or accepted) were obtained of either the AP (external rotation) and LAT-Y projection (see Appendices A1 and A2). The total repeat rate, according to the DoH (South Africa, 2012:8), must not exceed 10% at the three-monthly reject analysis tests. Moreover, the repeat rate may not increase by more than 2% of the previous rate determined (South Africa, 2012:8). Therefore, in order to determine if there was an increase of repeats, specifically for the shoulder, the previous repeat rate must be available. The results of the radiographic criteria checklist made it clear that there are specific areas of concern in relation to imaging of routine shoulder projections. The anatomy that must be included, utilising the correct centring point (positioning), collimation, the correct use of the AEC system and the selection of the correct mAs when manual set exposures are utilised must be addressed at the participating imaging department to enhance overall patient care.

4.5 CONCLUSION

It is evident from the 578 routine shoulder images that were evaluated that many of the criteria were met (more than 60%). As explained in the discussion, all criteria listed on the radiographic criteria checklist contribute to good radiation practices. During the analysis it became clear that the participants did not adhere to all criteria requirements, thus did not comply with the ALARA principle, and therefore increased the radiation dose to the patient (see 2.5).

Chapter 5, entitled ***Results and discussion: Radiographer critique questionnaire,*** will outline the results of the questionnaire and provide more insight into whether the participants utilise the radiographic criteria when evaluating routine shoulder projections.

CHAPTER 5

RESULTS AND DISCUSSIONS: RADIOGRAPHER CRITIQUE QUESTIONNAIRE

5.1 INTRODUCTION

In this chapter the results of the radiographer critique questionnaire will be presented. The radiographer critique questionnaire was designed to determine the knowledge of the participants regarding the anatomy; the criteria for optimal positioning, and the exposure factor selection of the shoulder (see 1.4.2). Student, qualified, community service and supplementary radiographers completed the questionnaire (see 3.2.5.2.2). The results of the radiographer critique questionnaire assisted the researcher to determine whether the participants know the basic anatomy of the shoulder, whether they know how to critique routine shoulder images and if they are familiar with exposure factor selection for acquiring routine shoulder projections.

As outlined in Chapter 1 (see 1.1), patient care in radiography does not only involve communication, but also factors such as obtaining optimal images and having specialised knowledge of anatomy to assist in patient positioning (Brask & Birkelund, 2014:26; Ehrlich & Coakes, 2016:90). This implies that, when radiographers provide optimal images and know how to apply the criteria when evaluating shoulder images, patient care will be enhanced.

5.2 SUMMARY OF THE METHODOLOGY USED FOR THE QUESTIONNAIRE

A quantitative questionnaire was compiled in Microsoft Excel (see Appendix B1) and it consisted of three sections with a total of 28 questions (see 3.2.5.2). Section A aimed at accumulating data about the demographics of the participants, and Sections B and C focused on data relating to the imaging of routine shoulder projections. The researcher utilised the checklist to formulate the questions (see 1.5.3.2 and 2.6.1) to address Objective 3: "to determine by means of a quantitative questionnaire the knowledge of the participants regarding the anatomy of the shoulder and to determine the evaluation of routine shoulder images for optimal positioning and exposure factor selection." The researcher used three of the four main headings of the checklist to formulate the questions of the questionnaire.

5.2.1 Anatomical structures

Questions about anatomy that were included in the questionnaire related to the AP projection (external rotation) and LAT-Y projection. These questions included identifying basic anatomical structures of the shoulder and the important anatomical structures that had to be included for each projection (see Appendix B1, Sections B and C).

5.2.2 Positioning factors

For the various criteria, the researcher compiled questions to determine whether the radiographers understand why certain positioning techniques must be applied during imaging of routine shoulder projections. For example, two questions were formulated for the criterion "no motion visible" (see Appendix B2, Questions 20 and 38). This question provided the researcher with information about whether the participants knew how to reduce motion during imaging and if they were aware of the importance of utilising a breathing technique. Some of the questions focused on the x-ray images, whereby the participant had to discern whether the positioning and centring point were optimal.

5.2.3 Exposure factors

The researcher utilised questions and x-ray images to determine if the participants knew the exposure factors for shoulder imaging, namely, mAs and kVp. In relation to mAs the researcher provided three x-ray images and the participants had to select the x-ray image that demonstrates mAs optimally. Various kVp values were also provided to the participants, and they had to select an average kVp for an adult patient.

The radiographer critique questionnaire was converted into a clicker session that consisted of multiple-choice questions using the TurningPoint program – participants had to select the correct answer using a clicker device. Chapter 3 outlined the researcher's preparation, which ensured the successful execution of the clicker session (see 3.2.5.2). The TurningPoint program integrates with PowerPoint to create an interactive and memorable presentation. This program also provides the options of creating interactive slides, setting up and running a presentation, and generating reports based on the results. The researcher highlighted the correct answer in the TurningPoint program to assist the statistician when the data had to be analysed to determine the number of participants who selected the correct answer. Other TurningPoint features include participant monitoring and reporting tools. The conversion of the questionnaire from Microsoft Excel to the clicker session caused the researcher to convert five questions, namely Questions 6, 8, 18, 20 and 26 (see Appendix B1), into multiple-choice questions, which meant the clicker session had more questions than the hard copy of the questionnaire (see Appendix B2). The participants had to answer 38 questions during the clicker session.

The student radiographers completed the questionnaire during a clicker session on 12 November 2015. The results were saved using TurningPoint. The researcher evaluated the responses of the participants and noticed a technical error. Question 37, "indicate the average kVp range usually utilised for a lateral-Y projection of the shoulder for an adult patient" on the clicker session did not select the correct answer, therefore all the responses were recorded incorrectly. The researcher informed the statistician, who in turn corrected the calculation for all the student radiographers. The researcher had to double check that the correct answers for all the questions were selected using the TurningPoint program during the remaining sessions that still had to be completed (for qualified, community service and supplementary radiographers).

To ensure validity of the results, the statistician analysed the data separately from the data provided by the TurningPoint program and the statistician noticed that the two calculations (determined manually by the statistician and provided electronically by the TurningPoint program) differed for Question 20. The question, "how do you ensure there is no motion when obtaining x-ray projections of the shoulder?" indicated that the student could select more than one answer. For this question there were two correct answers, thus it counted two marks. The results on the clicker system for this question was highlighted in red (indication of wrong answer) if the participant did not choose both answers. However, if the participant did choose one of the answers as correct, the result was still highlighted in red, but the participant obtained only one mark. Therefore, the statistician had to recalculate the results in cases where participants had selected one of the correct answers.

The following sections will display the results of the responses to the questions in the radiographer critique questionnaire (see 5.3); this is followed by a discussion of the results (see 5.4).

5.3 RESULTS OF THE RADIOGRAPHER CRITIQUE QUESTIONNAIRE

5.3.1 Demographic data

Questions 1 to 3 enquired about the demographics of the participants in the study. The sample size (n) of this study was 41 radiographers, made up of 27 student radiographers (66%), one supplementary radiographer (2%), one community service (2%) and 12 qualified radiographers (30%). Figure 5.1 demonstrates the current level of training of the participants.

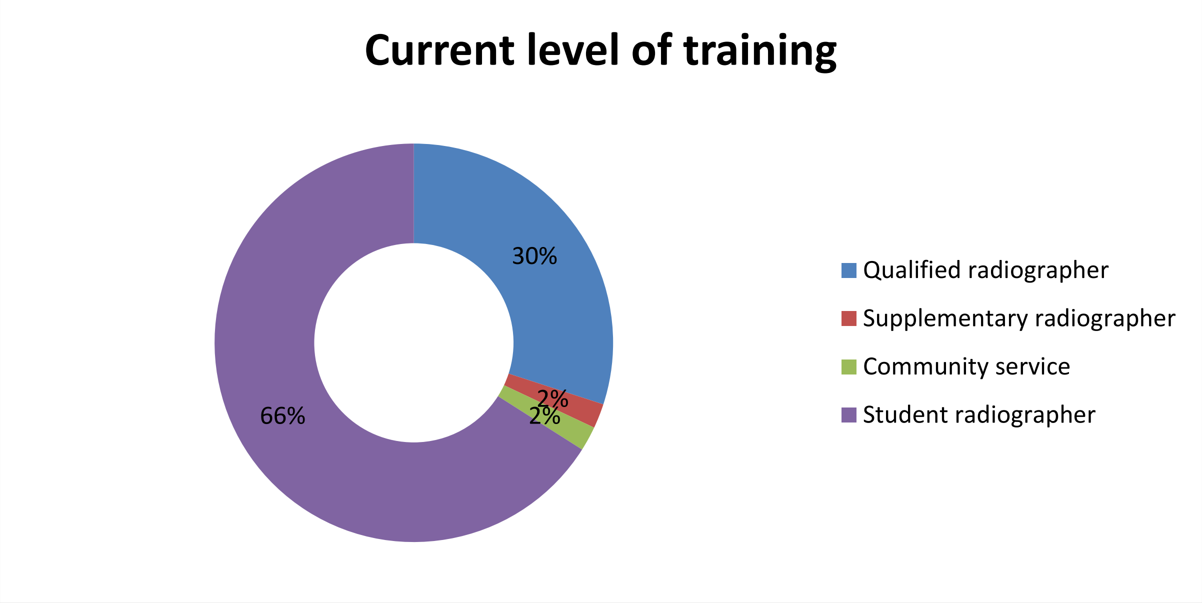

Figure 5.1: Current level of training of the radiographers who completed the radiographer critique questionnaire

The demographic information of the qualified, supplementary and community service radiographers included the years of experience as radiographer. This question was asked as an open-ended question. The minimum level of experience was one year and the maximum was 32 years. Therefore, the mean of the participants' years of experience is 18 years.

Different student groups participated in the study: 15% of the students were second-year students on the National Diploma programme, 44% were second-year students on the Bachelor of Radiography programme, and 41% were third-year students on the National Diploma programme, as shown in Figure 5.2. No first-year students completed the questionnaire (see 3.2.5.2.2).

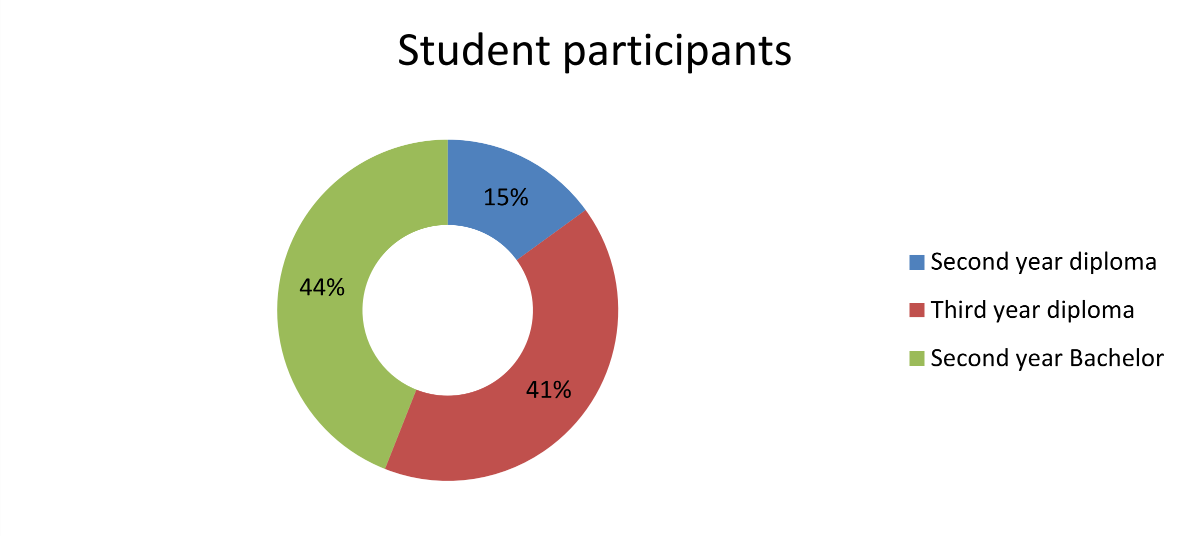

Figure 5.2: Year of study of student participants

5.3.2 The anterioposterior projection (external rotation) of the shoulder

5.3.2.1 *Identification of anatomy*

Question 4 presented the participant with a choice of three shoulder images. The question was, "indicate the x-ray image that includes all the important anatomical structures for a routine AP projection of the shoulder". The correct image, 2, was selected by only 7% of radiographers and 4% of students. As shown in Figure 5.3, the majority of the students (96%) and radiographers (93%) selected incorrect images. There was no significant difference in the percentages between the students and radiographers ($p = 0.8376$).

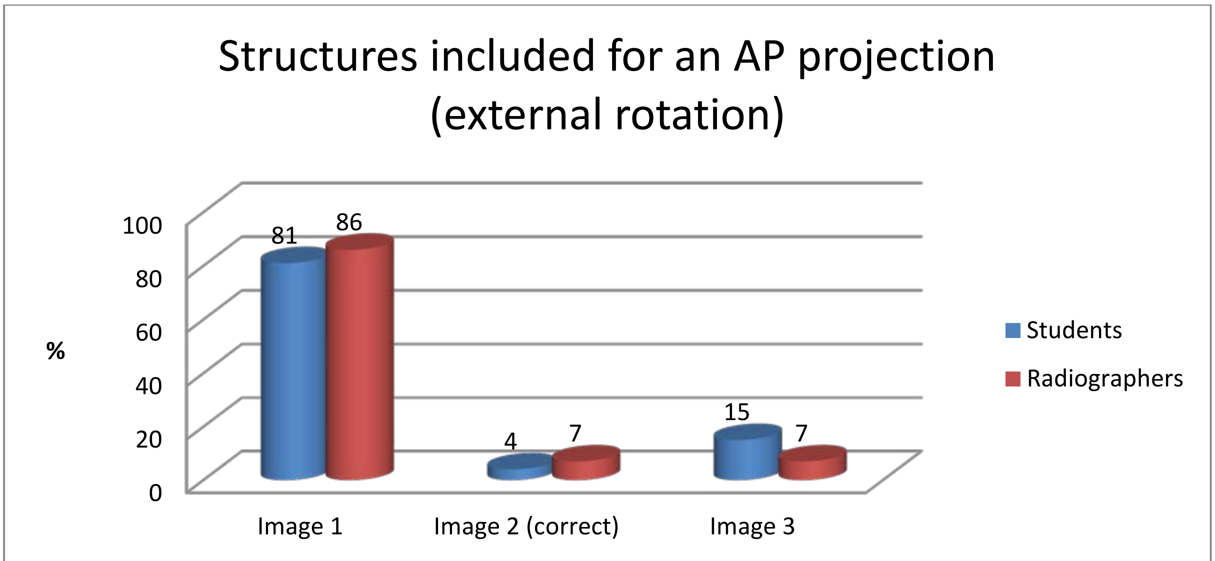

Figure 5.3: Structures included for an AP projection (external rotation)

Question 5 displayed three AP (external rotation) shoulder projection images. The participant had to select Image 3, which demonstrates the GT in profile. Of the students, 11%, and 58% of the radiographers selected the wrong images. This implies that most of the students (89%) and fewer of the radiographers (42%) selected the correct answer, as shown in Figure 5.4. There was a significant difference between the percentages of the students and radiographers (p = 0.0009).

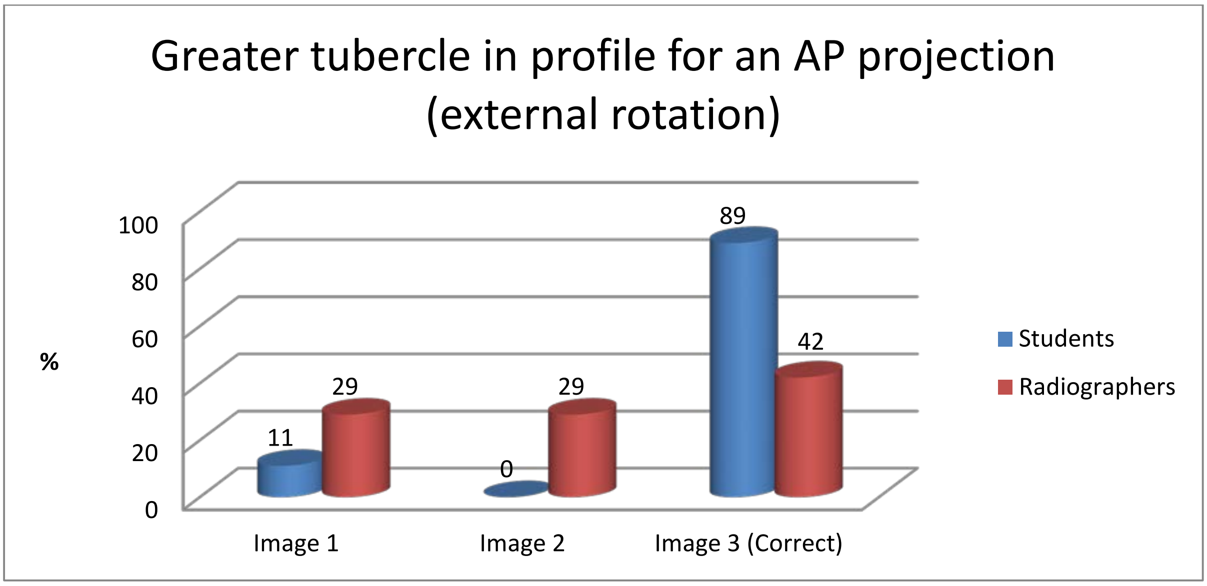

Figure 5.4: Greater tubercle in profile for an AP projection (external rotation)

Questions 6 to 10 displayed an x-ray image of the AP (external rotation) shoulder projection with labels prompting the participants to select the correct anatomical structure. Figures 5.5, 5.6, 5.7, 5.8 and 5.9 illustrate the answers of the participants regarding their identification of the anatomical structures. Figure 5.5 demonstrates that 74% students and half (50%) of the radiographers identified Label A correctly as the acromion. In contrast, 26% of the students and 50% of radiographers selected incorrect answers. No significant difference in percentages were observed (p = 0.1386).

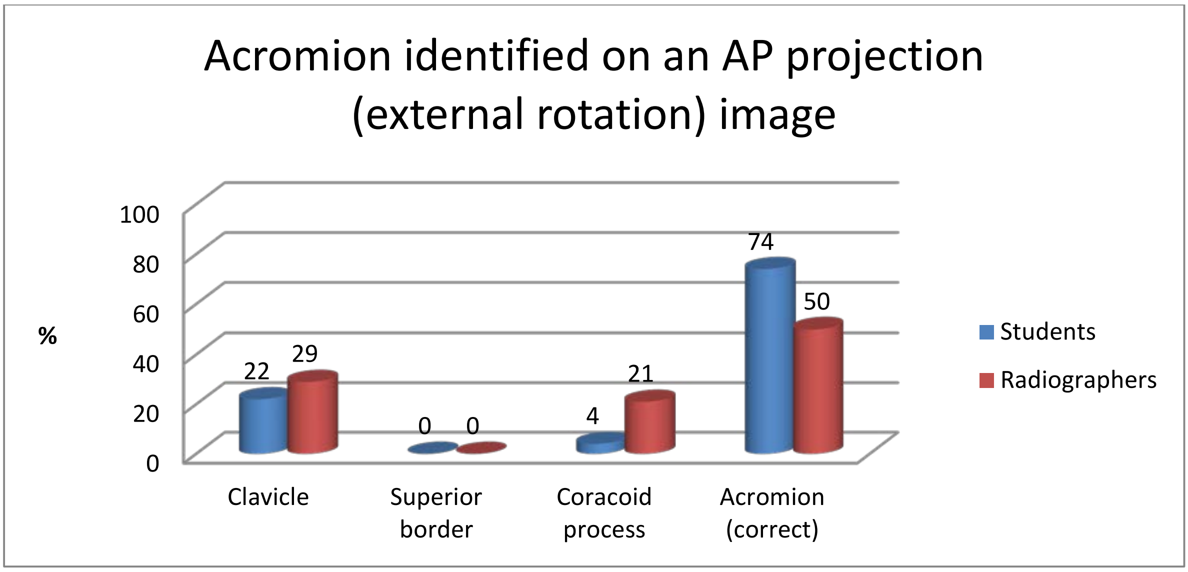

Figure 5.5: Acromion identified on an AP projection (external rotation) image (Label A)

Regarding labelling of the coracoid process, Figure 5.6 displays that only 8% of students selected the wrong answer. Regrettably, 57% of radiographers selected the wrong answer, of whom 7% thought Label B referred to the spine of the scapula and 14% indicated it as the acromion and 36% referred to Label B as the superior angle of the scapula. The correct answer, the coracoid process, was selected by 43% of radiographers which was significantly different from 92% of students ($p = 0.0015$).

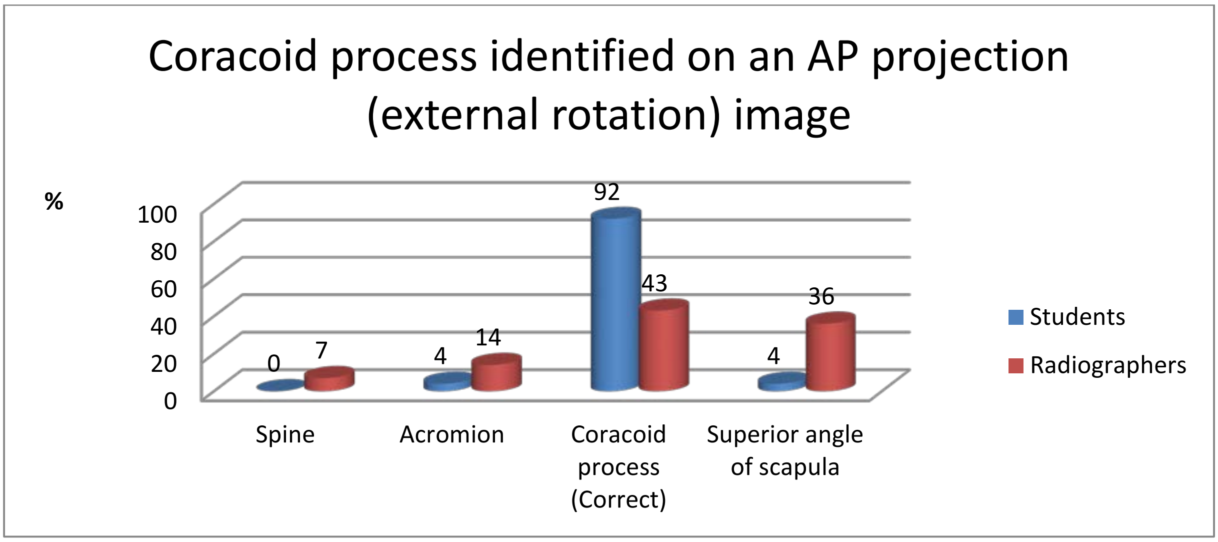

Figure 5.6: Coracoid process identified on an AP projection (external rotation) image (Label B)

When asked to label the GT, 78% of students and 36% of radiographers selected the correct answer. Regrettably, more than 60% of radiographers indicated that Label C refers either to the humeral head or LT, as illustrated in Figure 5.7. Of the students, 22% referred to Label C as referring to either the humeral head, LT or humeral neck. There was a significant difference in percentages between students and radiographers (p = 0.0148).

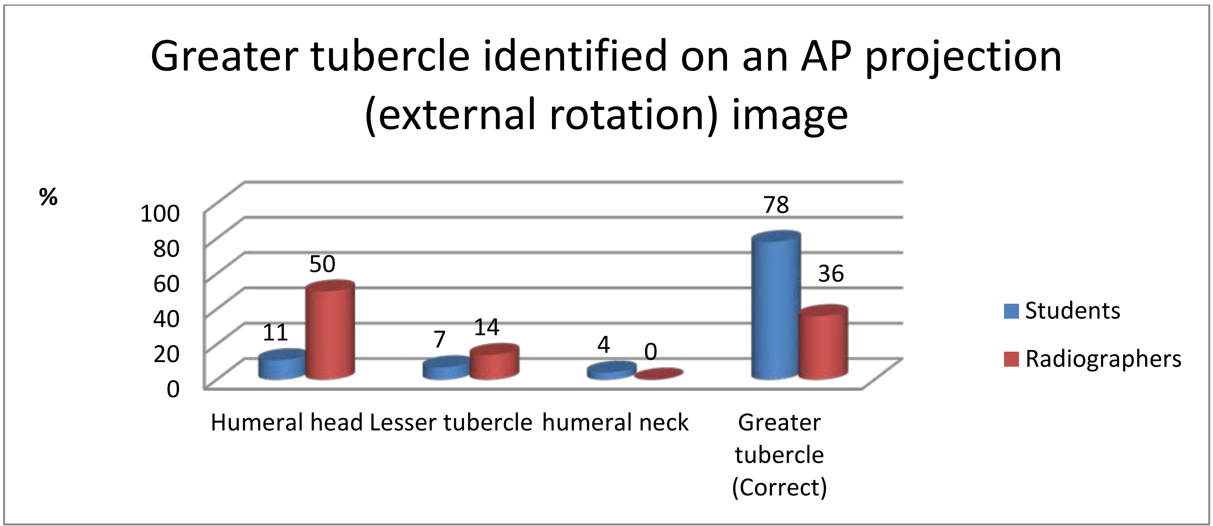

Figure 5.7: Greater tubercle identified on an AP projection (external rotation) image (Label C)

Question 9 required the participants to label the humeral head as the correct answer. Almost 30% of the students and 29% of radiographers referred to Label D as the LT, whereas 11% of students and 14% of radiographers indicated that the glenoid is represented by Label D. Therefore, 41% of students and 50% of radiographers selected the wrong answers, as illustrated in Figure 5.8. No significant difference in percentages were observed (p = 0.6768).

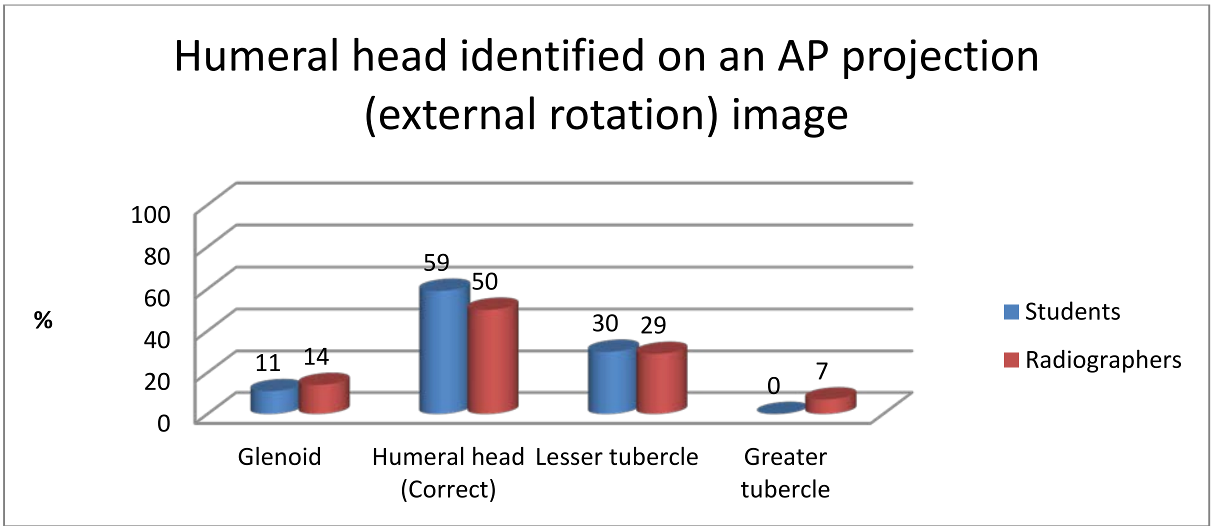

Figure 5.8: Humeral head identified on an AP projection (external rotation) image (Label D)

Question 10 required labelling of the LT. Figure 5.9 illustrates that 37% of students and 57% of radiographers selected the wrong answer. In total 36% of radiographers referred to Label E as the GT and 21% indicated it was the humeral neck. Of the students, 33% assumed that the humeral neck is represented by Label E. There was a significant difference in percentages observed between students and radiographers (p = 0.0090).

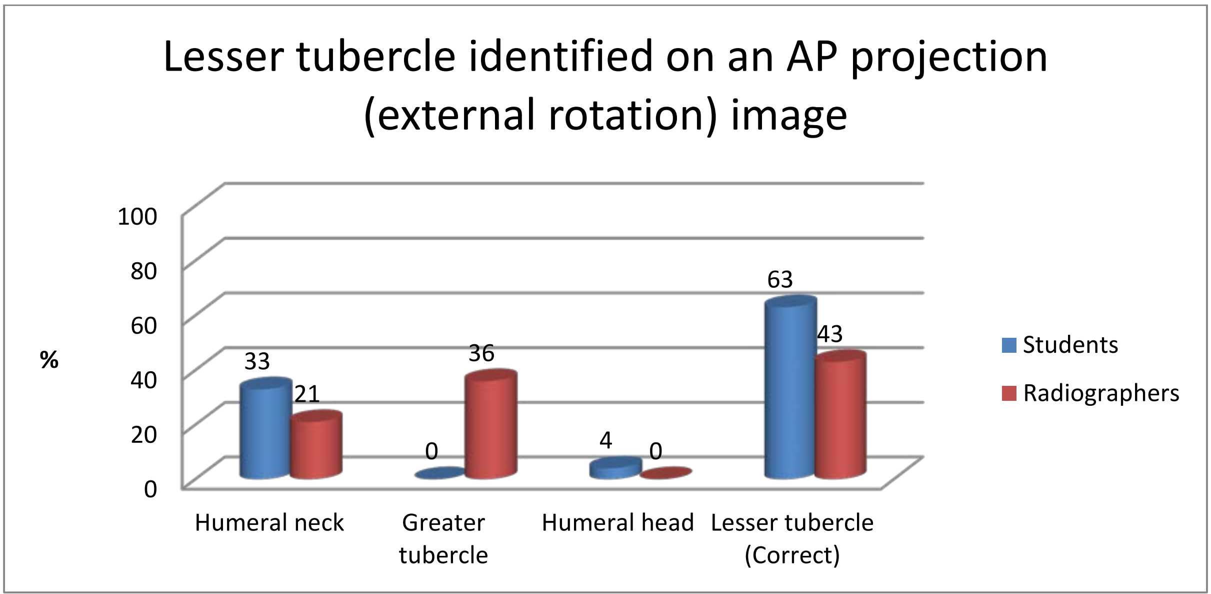

Figure 5.9: Lesser tubercle identified on an AP projection (external rotation) image (Label E)

5.3.2.2 *Selection of exposure*

Question 11 displayed three x-ray images with different exposure factors. The participants had to select the x-ray image that demonstrates the mAs optimally. Of the students and radiographers, 14% and 57% respectively selected the wrong images, as presented in Figure 5.10. There was a significant difference in percentages observed between students and radiographers (p = 0.0076).

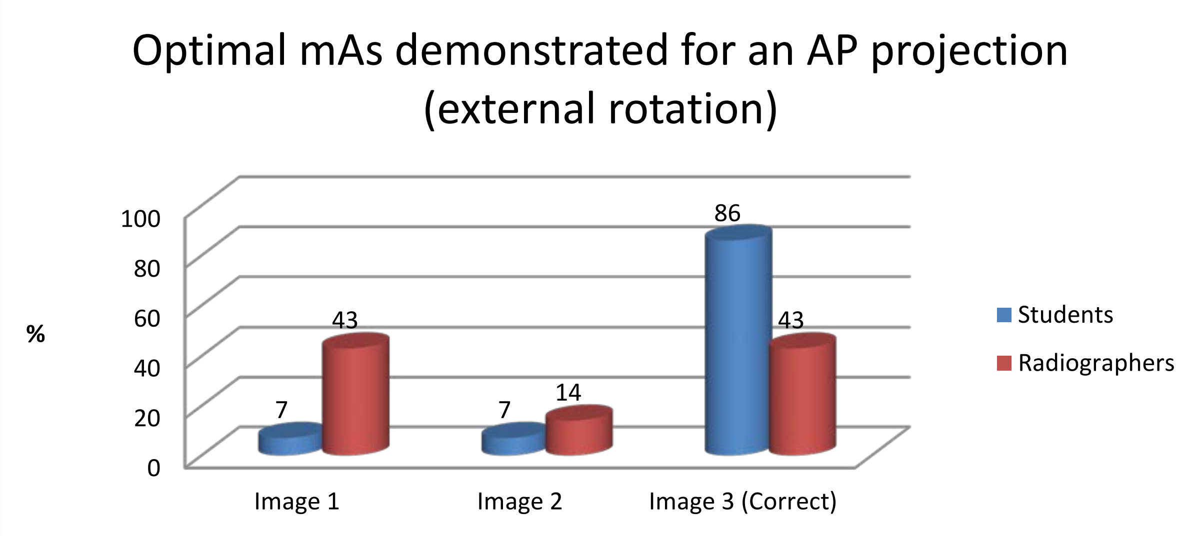

Figure 5.10: Optimal mAs demonstrated for an AP projection (external rotation)

Question 21 required the participants to indicate the average kVp range utilised for an AP projection (external rotation) of the shoulder for an average adult patient. As illustrated in Figure 5.11, 44% of students and 79% of radiographers selected the wrong kVp range to be utilised for an AP projection (external rotation) of the shoulder. No significant difference in percentages were observed (p= 0.0505).

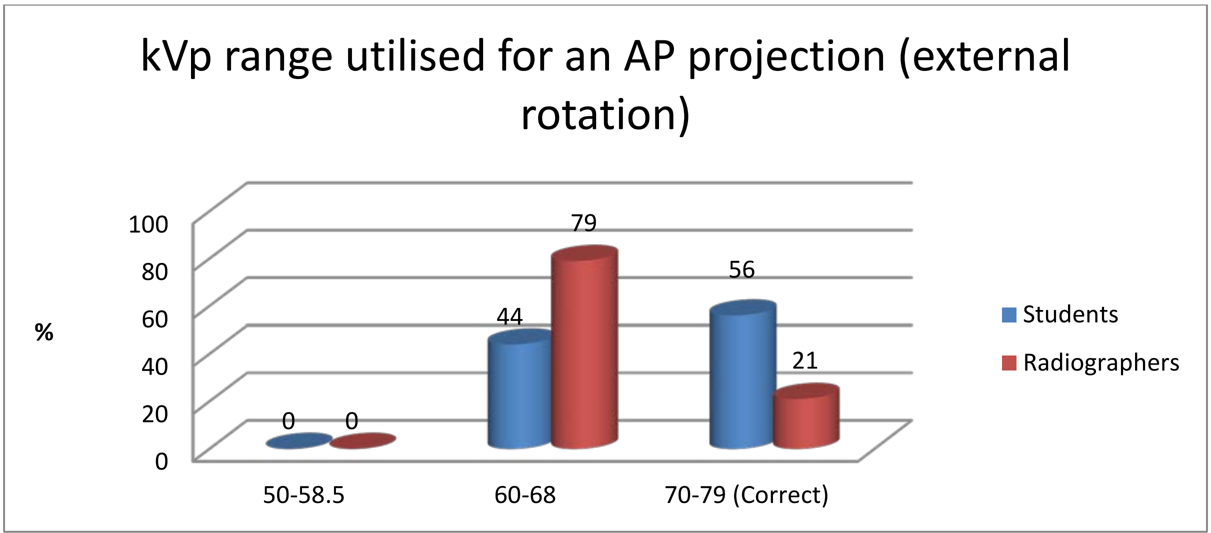

Figure 5.11: kVp range utilised for an AP projection (external rotation)

5.3.2.3 *Radiographic technique*

Question 12 displayed an x-ray image and required participants to indicate whether the positioning was correct or not. Two questions where formulated from the image. Additionally, the researcher provided instructions to the participants in relation to the question. Participants had to remember the answer they had selected in order to motivate the answer in the second question. Figure 5.12 and Figure 5.13 are linked to this x-ray image. The correct answer was selected by 85% of students and 71% of radiographers, who indicated the positioning of the projection as incorrect. No significant difference in percentages were observed (p= 0.4105).

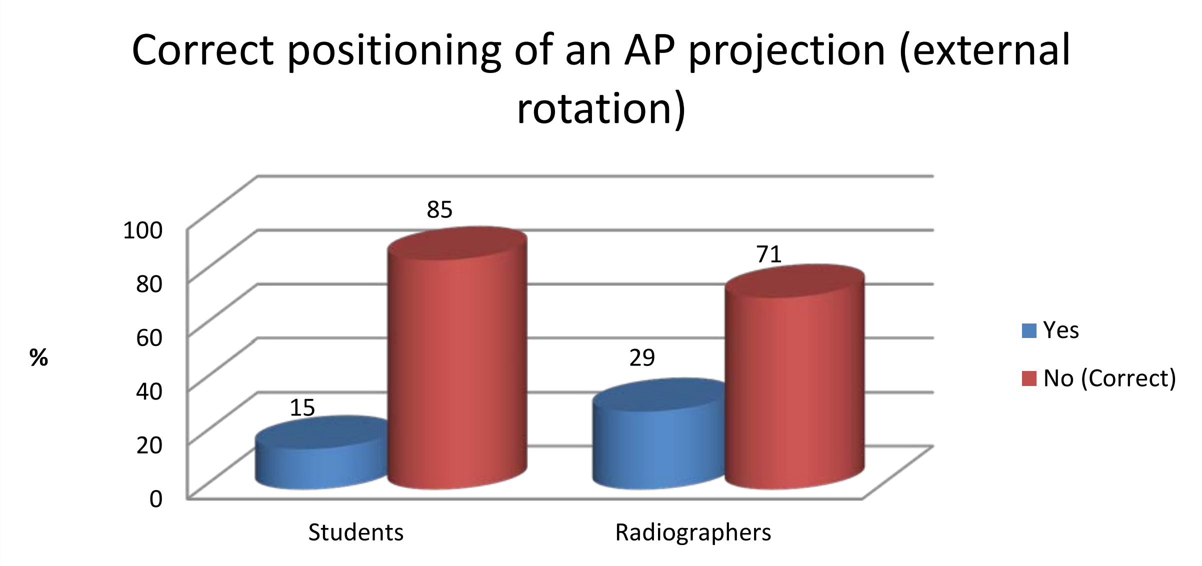

Figure 5.12: Correct positioning of an AP projection (external rotation)

The follow-up question required the participants who had selected "no" (the correct answer, see Figure 5.12) to indicate how to correct the positioning for the x-ray image. The participants who had selected "yes" (the wrong answer, see Figure 5.12) had to select "no correction needed", as shown in Figure 5.13. In this question, 44% of students and 50% of radiographers selected either that no correction was required or that the arm had to be rotated internally, the arm had to be adducted or had to be abducted. The correct answer, that is, to rotate the arm more externally, was selected by 56% of students and half (50%) of the radiographers. Therefore, no significant difference in percentages were observed (p= 0.5800). The responses of the radiographers who had indicated that the positioning was correct (wrong answer in Figure 5.12), and therefore had to select "no correction needed" in the next question, did not correspond with the results reported in Figure 5.13. It is the opinion of the researcher that the radiographers either did not listen to the researcher's instructions, or they did not know how to correct the positioning, or they did not remember the answer they had selected in the previous question.

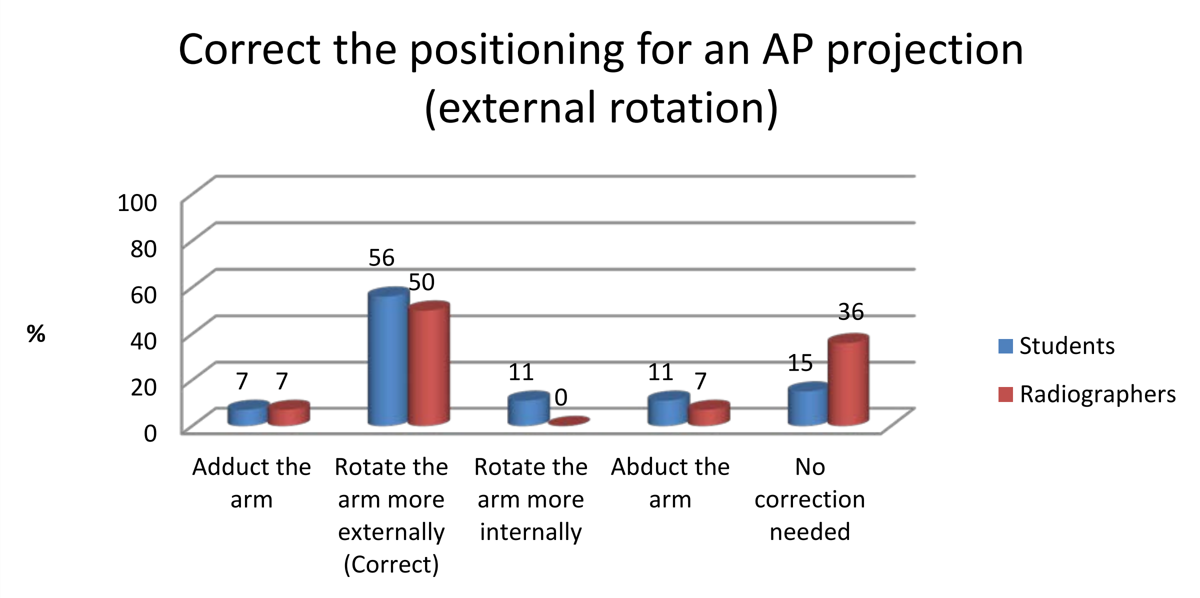

Figure 5.13: Correcting the positioning for an AP projection (external rotation)

In Question 14 the participants had to indicate whether the hand should be positioned in supination or pronation for an AP (external rotation) shoulder projection. As illustrated in Figure 5.14, 22% of students and 29% of radiographers selected the wrong answer (pronation). No significant difference in percentages were observed (p= 0.7989).

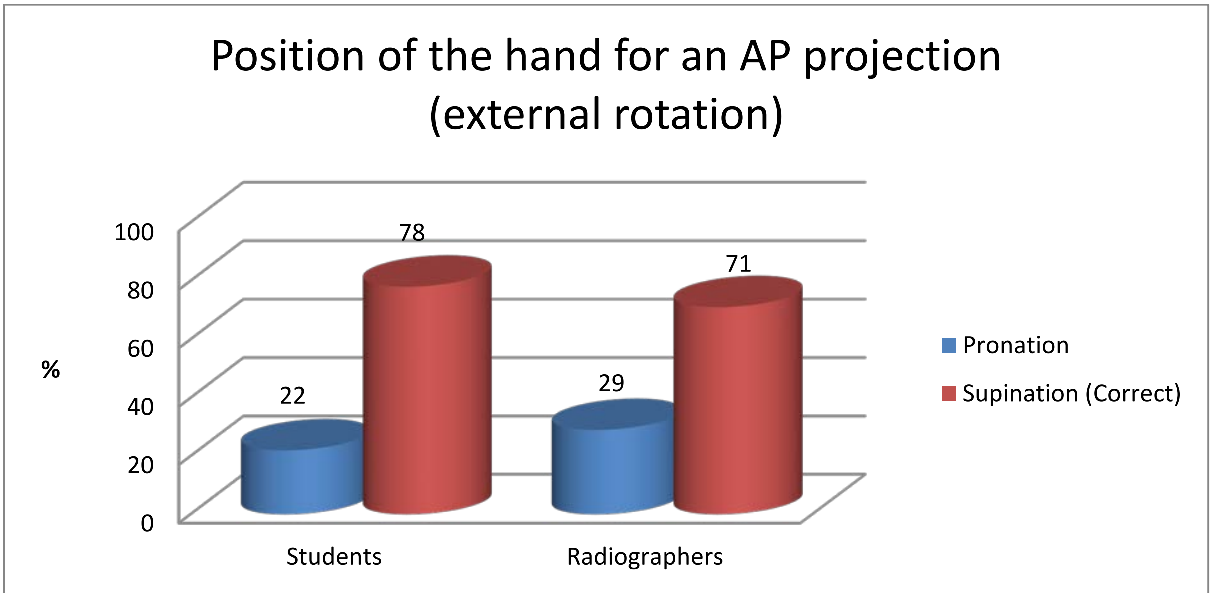

Figure 5.14: Position of the hand for an AP projection (external rotation)

Question 15 required the participants to evaluate two AP (external rotation) shoulder x-ray images and indicate which image demonstrated the hand in supination. Figure 5.15 demonstrates that only 7% of students and 36% of radiographers selected the wrong image.

There was a significant difference in percentages observed between students and radiographers (p = 0.0350).

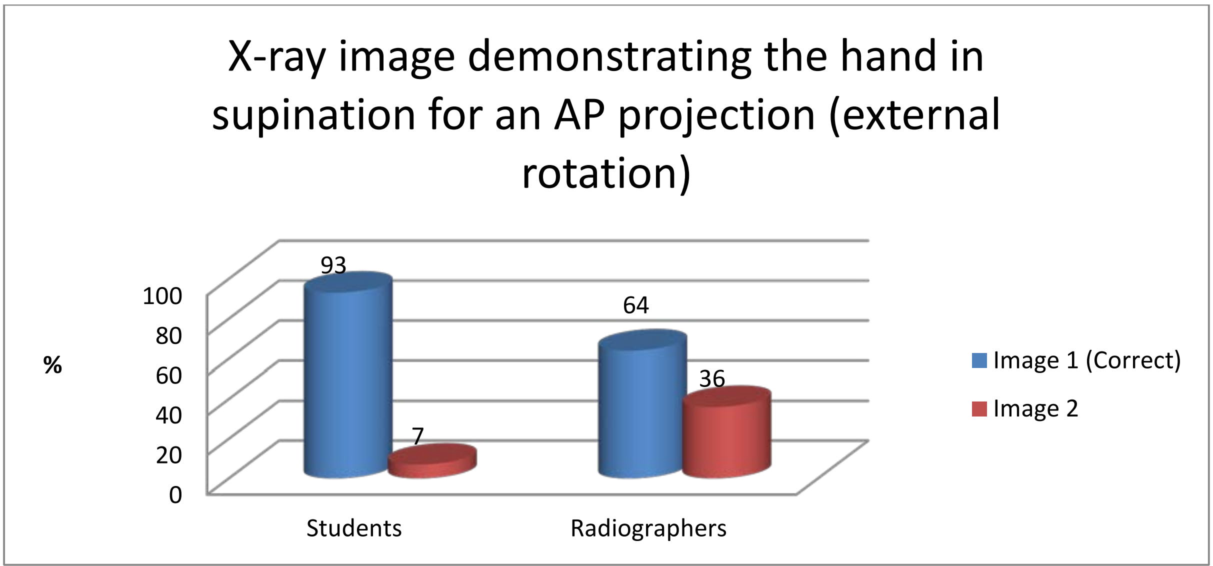

Figure 5.15: X-ray image demonstrating the hand in supination for an AP projection (external rotation)

Question 16 required the participants to indicate whether they rotate the affected shoulder of the patient towards the Bucky for an AP external shoulder projection. Most of the students (74%) and radiographers (79%) indicated that they rotate towards the patient's affected side for positioning (see Figure 5.16). No significant difference in percentages were observed between students and radiographers (p = 1.0000).

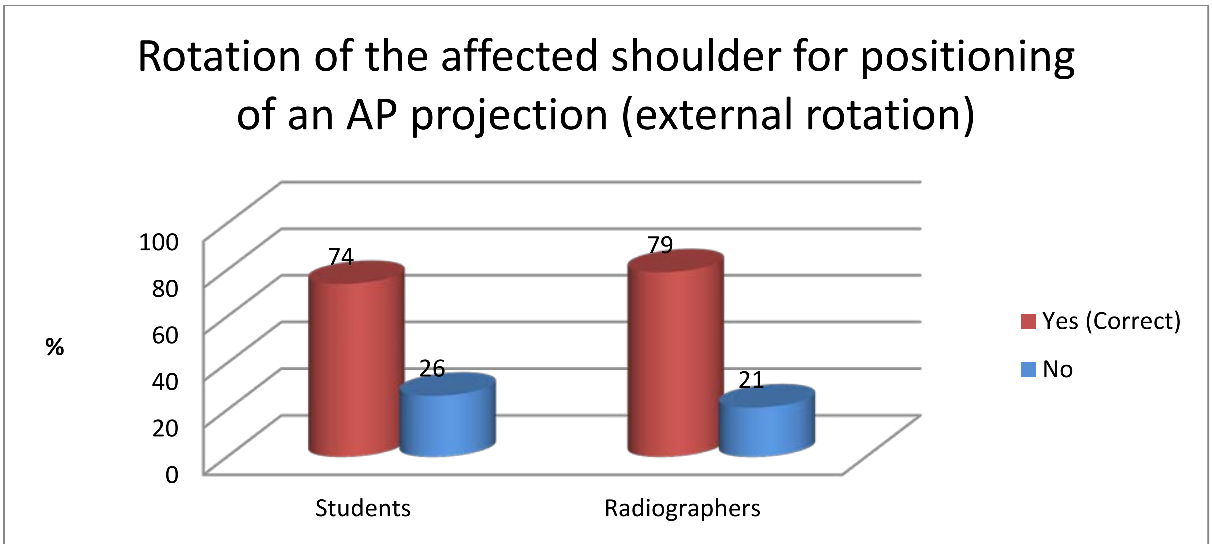

Figure 5.16: Rotation of the affected shoulder for positioning of an AP projection (external rotation)

In Question 17 various factors were listed, and the participants had to indicate what is important for ensuring that the AP external shoulder projection is demonstrated optimally. Most of the students (93%) and radiographers (71%) selected the correct answer, namely, that all the indicated factors are required to ensure optimal positioning of this projection. As a result, there was a significant difference in percentages observed between students and radiographers ($p = 0.0099$). However, 29% of radiographers indicated only that the hand must be supination, and 7% of students indicated that only the humeral epicondyles must be parallel to the IR.

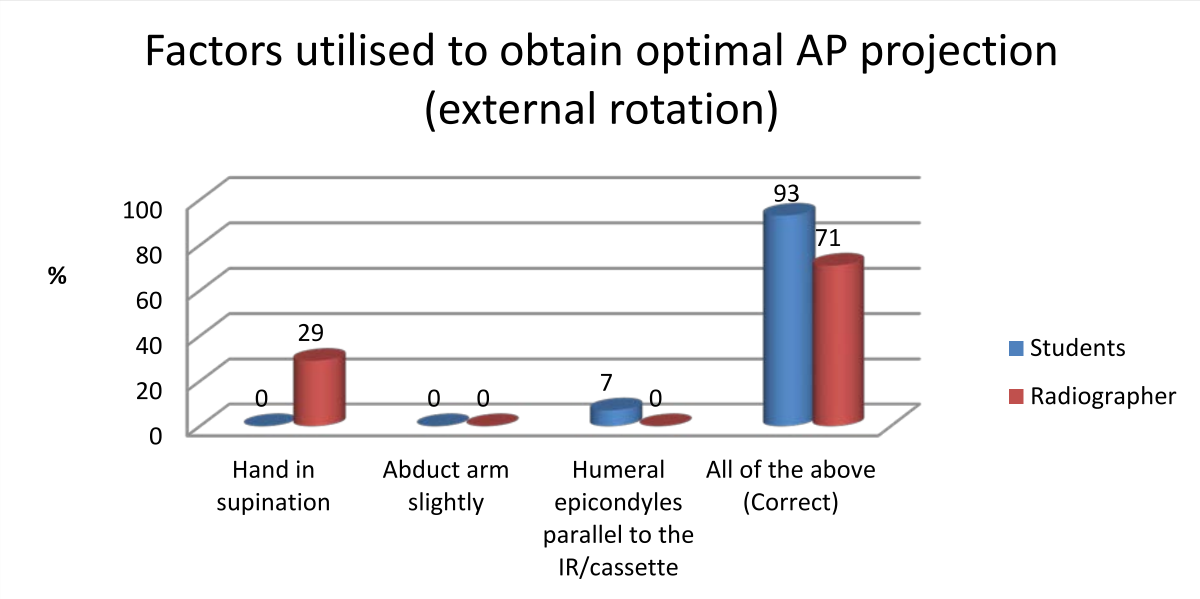

Figure 5.17: Factors utilised to obtain optimal AP projection (external rotation)

Question 18 labelled an AP (external rotation) shoulder projection as A, B, C or D. The participant had to select the label they would utilise as the centring point for the AP external shoulder projection. Of the students, 7% selected Label B (humeral head) as the centring point, while 28% of radiographers selected Label B or Label C (1 cm laterally of humeral head), as demonstrated in Figure 5.18. The majority of the participants indicated correctly that Label D (coracoid process) is the centring point for the AP projection (external rotation) of the shoulder. No significant difference in percentages were observed between students and radiographers ($p = 0.0728$).

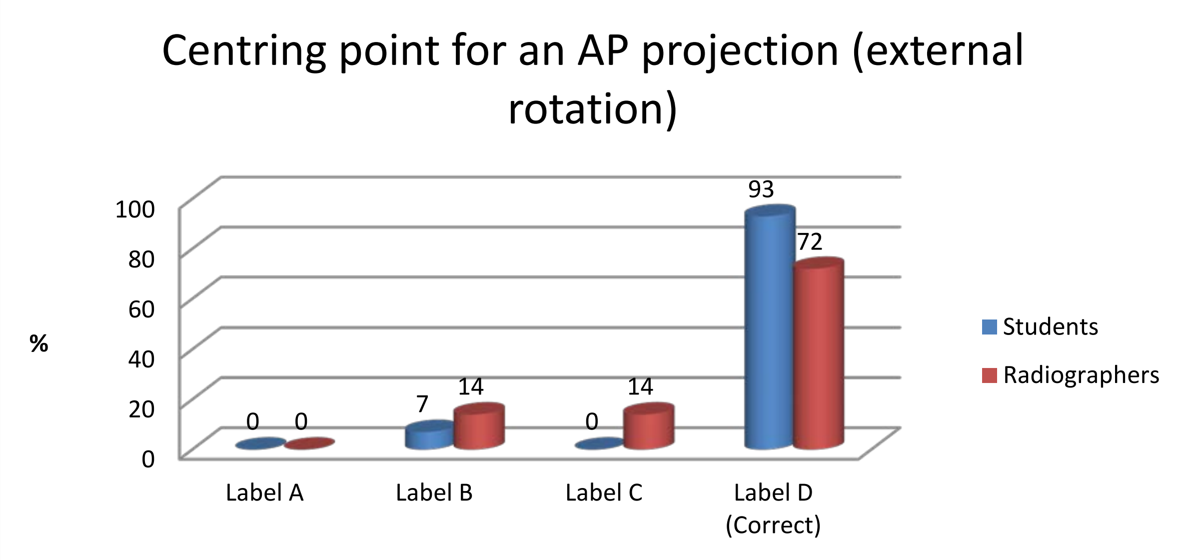

Figure 5.18: Centring point for an AP projection (external rotation)

Question 19 instructed the participants to evaluate three AP (external rotation) shoulder x-ray images and indicate which image demonstrates the x-ray image with optimal centring. Incorrect answers, that is, Images 1 and 3, were selected by 70% of students and 93% of radiographers (see Figure 5.19). No significant difference in percentages were observed between students and radiographers ($p = 0.3313$).

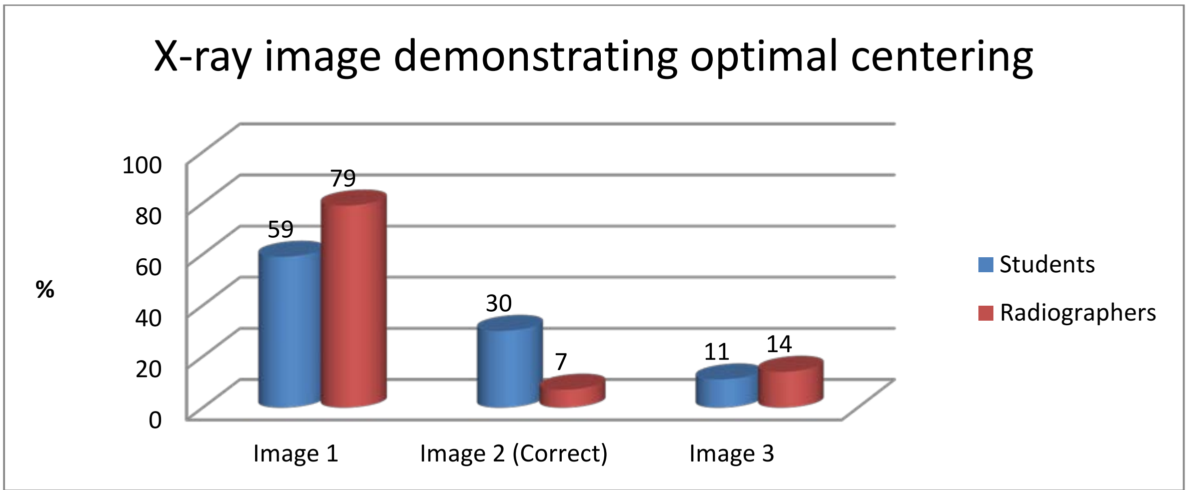

Figure 5.19: X-ray image demonstrating optimal centring

Question 20 required the participants to select the factors that can be applied to ensure that there is no motion when obtaining x-ray projections of the shoulder. The participants could select more than one answer (see Appendix B2, Question 20). This question had two correct answers, namely, applying a breathing technique **and** using a short exposure time. Figure 5.20 demonstrates the results as correct, partially correct and incorrect. Corrected was recorded when the participant selected both answers. Partially correct meant that the participant had selected one of the correct answers. Incorrect indicated that the participant selected none of the correct answers -- 11% of students and 21% of radiographers selected the incorrect answers. No significant difference in percentages were observed between students and radiographers (p = 0.5157).

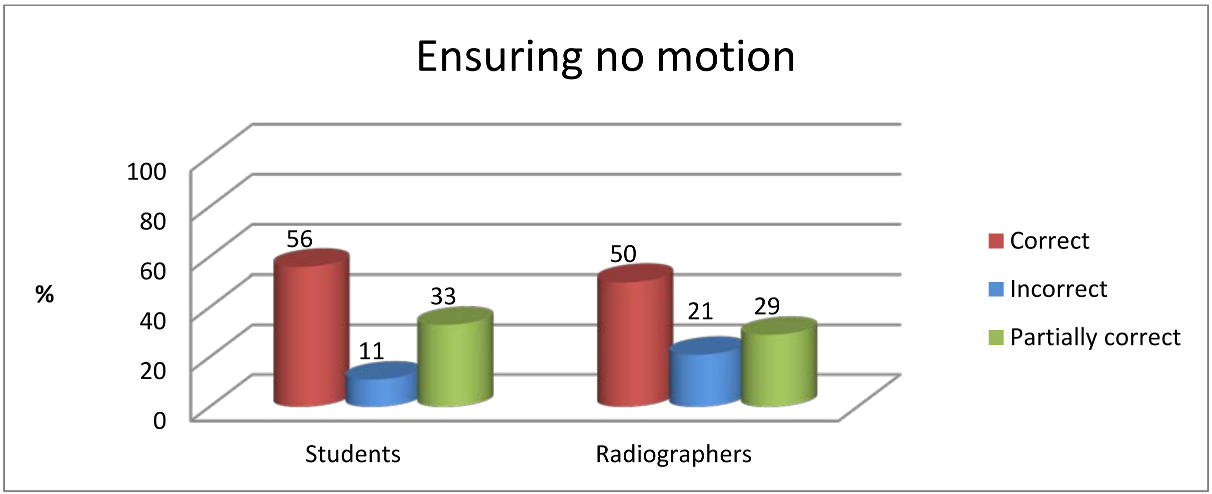

Figure 5.20: Ensuring no motion

Question 22 required participants to indicate whether they abduct the patient's affected arm to obtain an AP projection (external rotation) of the shoulder. The correct answer was selected by 41% of students and 21% of radiographers, as shown in Figure 5.21. No significant difference in percentages were observed between students and radiographers (p = 0.5496).

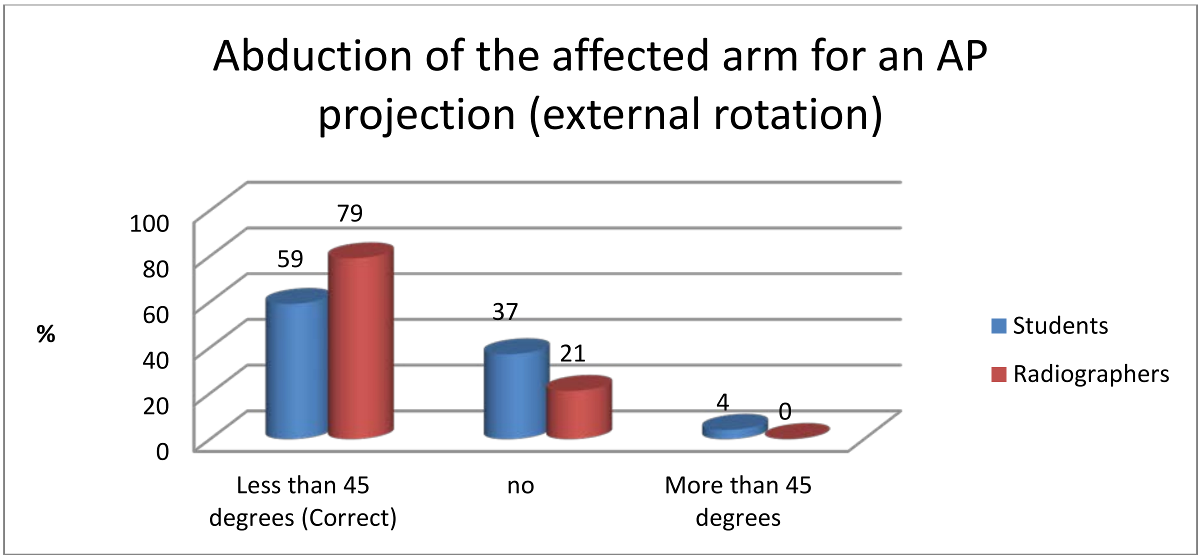

Figure 5.21: Abduction of the affected arm for an AP projection (external rotation)

5.3.3 The lateral-Y projection of the shoulder

5.3.3.1 *Identification of anatomy*

Question 23 displayed a lateral (LAT-Y) shoulder image with labels and the participants had to select the correct anatomical structure demonstrated by the label. Figures 5.23 to 5.26 illustrate the answers of the participants regarding selection of the anatomical structures. As illustrated in Figure 5.22 incorrect answers were given by 30% of students and 50% of radiographers, who indicated that Label A refers to either the spine of the scapula, the coracoid process or clavicle. No significant difference in percentages were observed between students and radiographers (p = 0.2472).

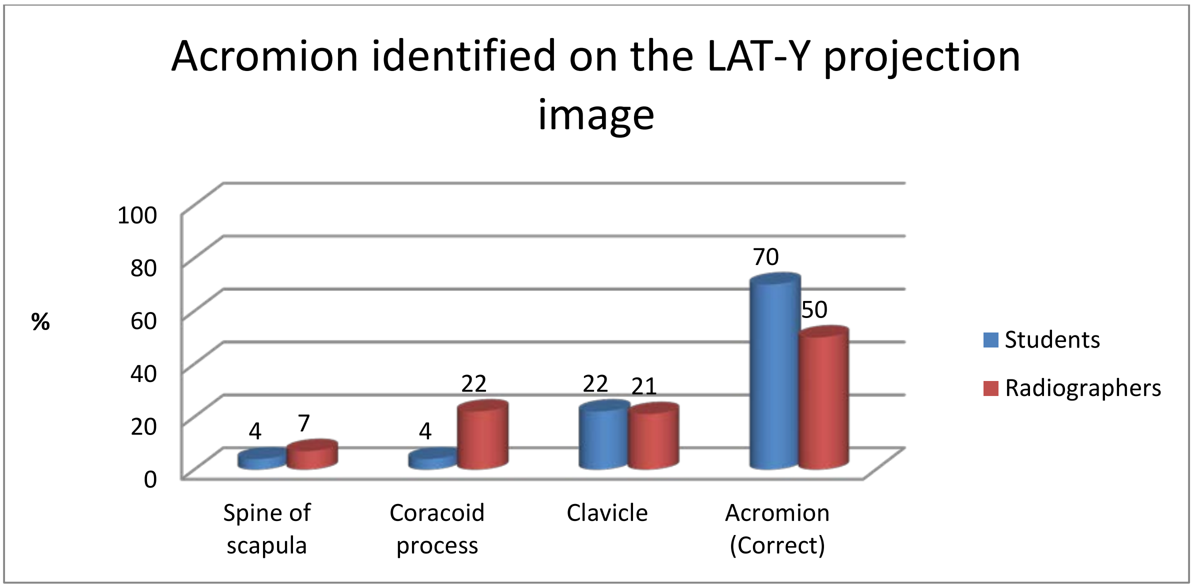

Figure 5.22: Acromion identified on the LAT-Y projection image (Label A)

Question 24 required the participants to tag Label B correctly as the coracoid process. Figure 5.23 demonstrates the answers given for the anatomical structure labelled B, namely, 37% of students and 43% of radiographers selected either the acromion or superior angle of the scapula, which are incorrect answers. No significant difference in percentages were observed between students and radiographers (p = 1.0000).

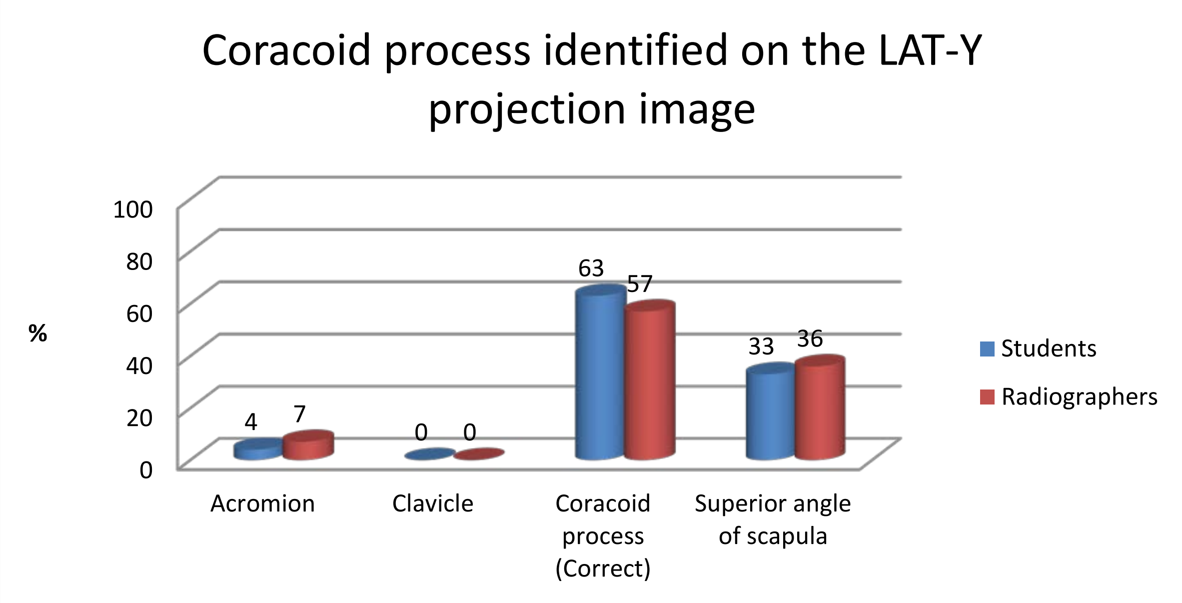

Figure 5.23: Coracoid process identified on the LAT-Y projection image (Label B)

For Question 25 the participants had to identify the body of the scapula as Label C. Figure 5.24 demonstrates that 74% of students and 86% of radiographers selected the correct answer, and 26% of students identified Label C as the spine of the scapula (see Figure 5.24). In contrast, 7% of radiographers respectively identified either the inferior angle of the scapula, or the superior angle of the scapula as Label C. There was a significant difference in percentages observed between students and radiographers (p = 0.0247).

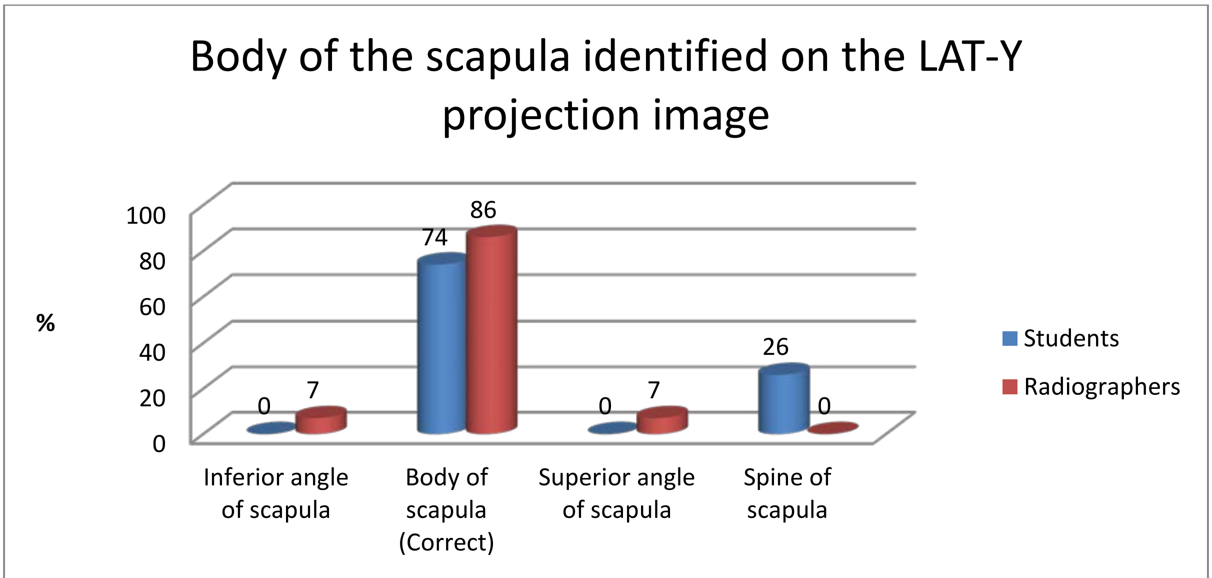

Figure 5.24: Body of the scapula on the LAT-Y projection image (Label C)

Question 26 required the participants to select the inferior angle of the scapula as Label D. All students and radiographers identified Label D as the correct answer, as illustrated in Figure 5.25.

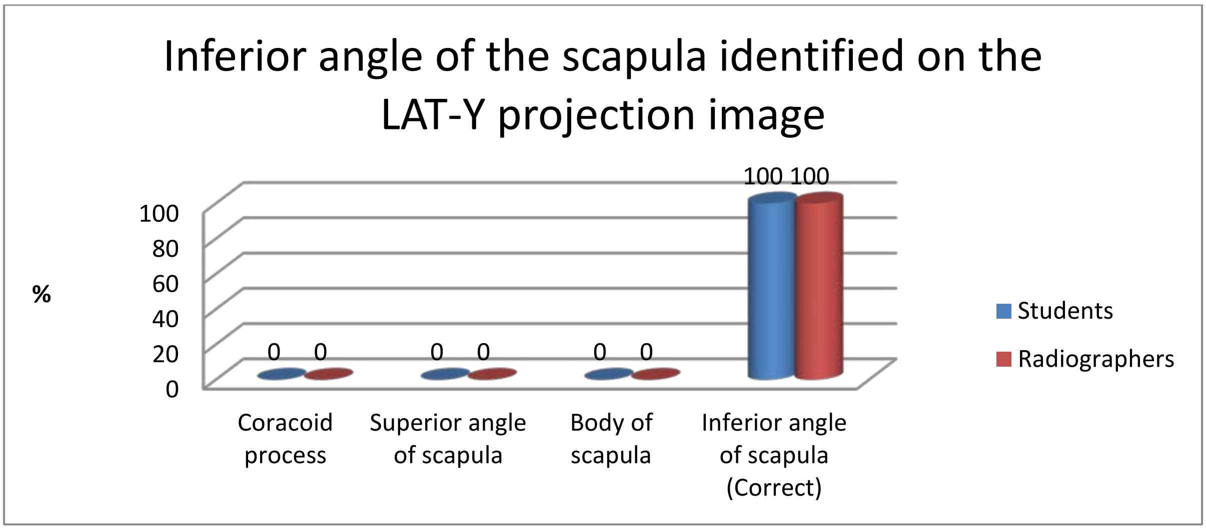

Figure 5.25: Inferior angle of the scapula identified on the LAT-Y projection image (Label D)

5.3.3.2 *Selection of exposure*

Question 29 displayed three LAT-Y shoulder projection images and required participants to select the image that demonstrates the mAs optimally. Figure 5.26 shows that 48% of students and 86% of radiographers selected the incorrect answer. Image 3 was the correct choice, because bony trabecular detail, cortical outlines and soft tissue around the lateral and superior region of the shoulder could be visualised. No significant difference in percentages were observed between students and radiographers ($p = 0.0558$).

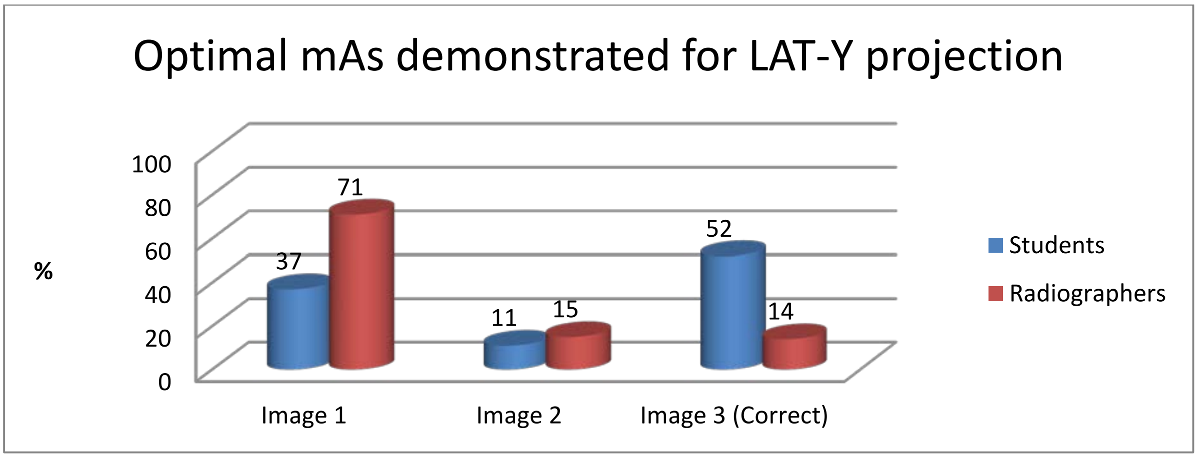

Figure 5.26: Optimal mAs demonstrated for LAT-Y projection

The average kVp range utilised for a LAT-Y projection of the shoulder of an adult patient had to be indicated by the participants in Question 37. As illustrated in Figure 5.27, 81% of students and 71% of radiographers selected the correct kVp range. No significant difference in percentages were observed between students and radiographers (p = 0.6156).

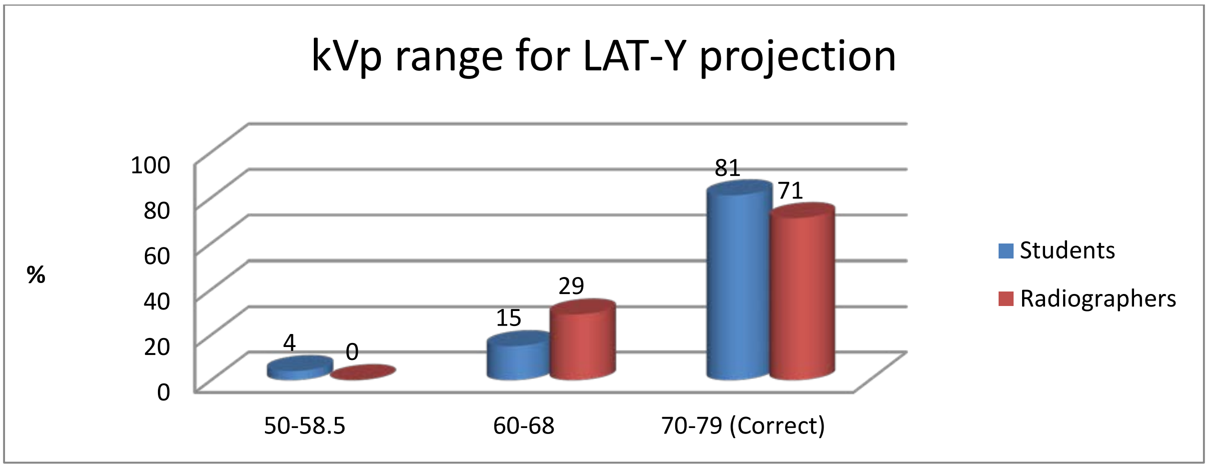

Figure 5.27: kVp range for LAT-Y projection

5.3.3.3 *Radiographic technique*

Question 27 required the participants to select the landmark, whether A (humeral head), B (mid-scapular body) or C (2 cm inferior of mid-scapular body), that must be utilised as a centring point for a LAT-Y projection of the shoulder. Figure 5.28 demonstrates that 70% of students and 21% of radiographers selected the incorrect landmark for centring. The mid-scapular body (Label B) was indicated as the correct landmark for centring. There was a significant difference in percentages observed between students and radiographers (p = 0.0001).

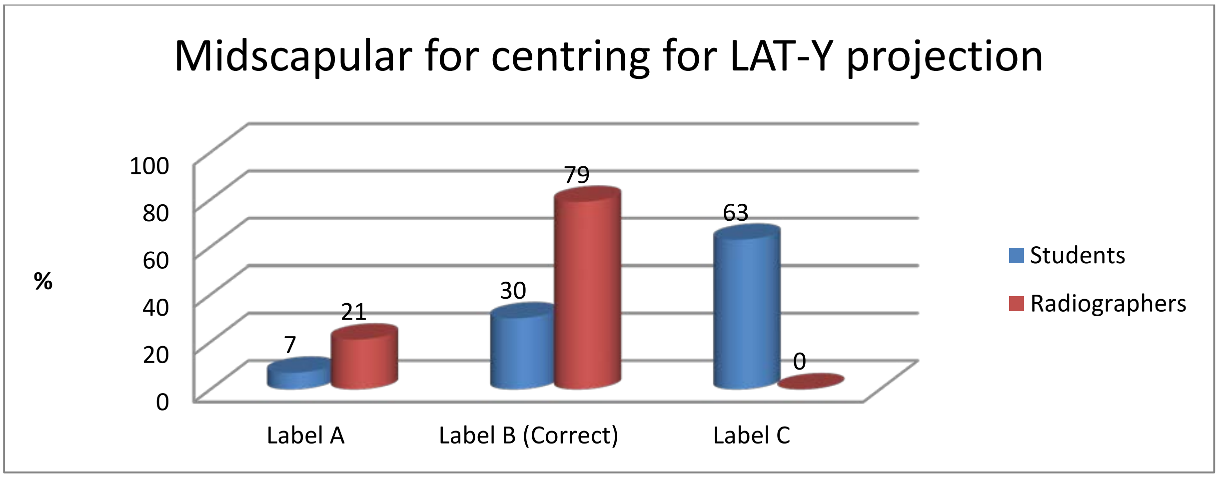

Figure 5.28: Mid-scapular for centring for LAT-Y projection (Label B)

For Question 28 the participants had to select from three LAT-Y shoulder images the image that optimally demonstrates the anatomical structures that must be at the centre of the collimation field. Image 1 demonstrates the mid-scapular body was at the centre of the collimation field, whereas Image 2 and 3 demonstrated the base of the "Y" in the centre of the image. Image 1 was the correct image. Figure 5.29 illustrates that 52% of students and 43% of radiographers selected the incorrect answer. No significant difference in percentages were observed between students and radiographers (p = 0.8943).

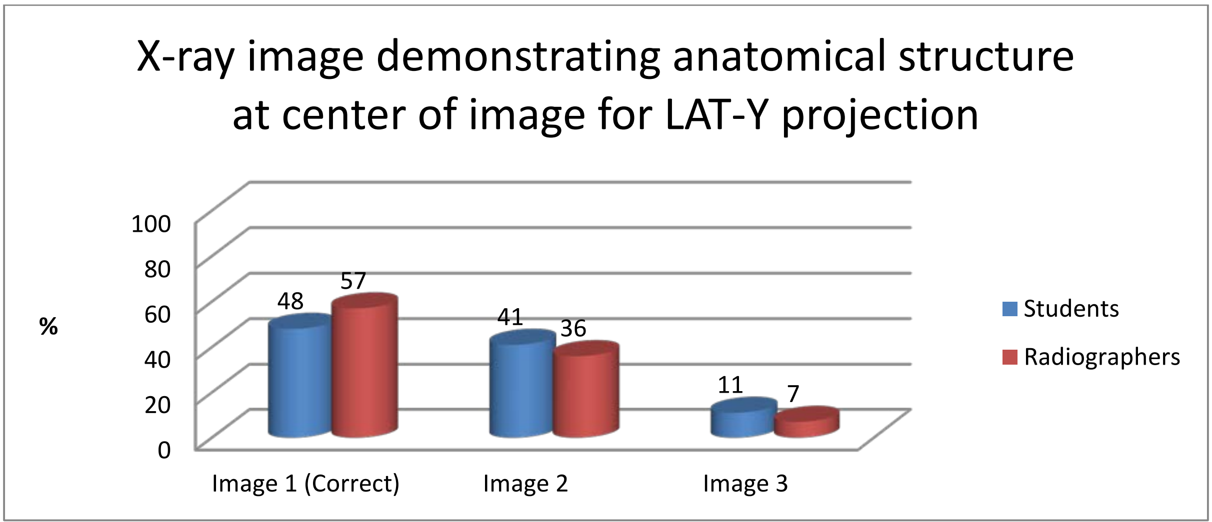

Figure 5.29: X-ray image demonstrating anatomical structure at centre of image for LAT-Y projection

The correct position of the arm for a LAT shoulder projection had to be identified by the participants in Question 30. As illustrated in Figure 5.30, 81% of students and 79% radiographers selected correctly that the patient's arm must be abducted slightly as part of positioning for a LAT-Y shoulder projection. No significant difference in percentages were observed between students and radiographers (p = 1.0000).

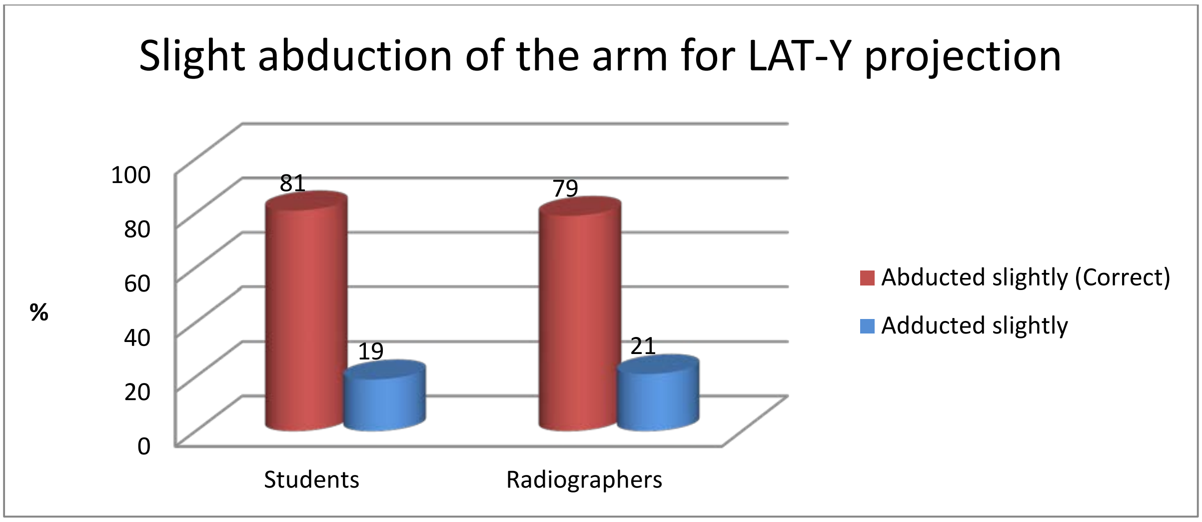

Figure 5.30: Slight abduction of the arm for LAT-Y projection

For Question 31 the participants had to indicate the degree of rotation of the patient from the posterioanterior position for a LAT-Y shoulder projection. More than 50% of the participants indicated correctly that the patient's body is rotated less than 45°. On the other hand, 37% of students and 43% radiographers selected the incorrect answer as shown in Figure 5.31. No significant difference in percentages were observed between students and radiographers (p = 0.7468).

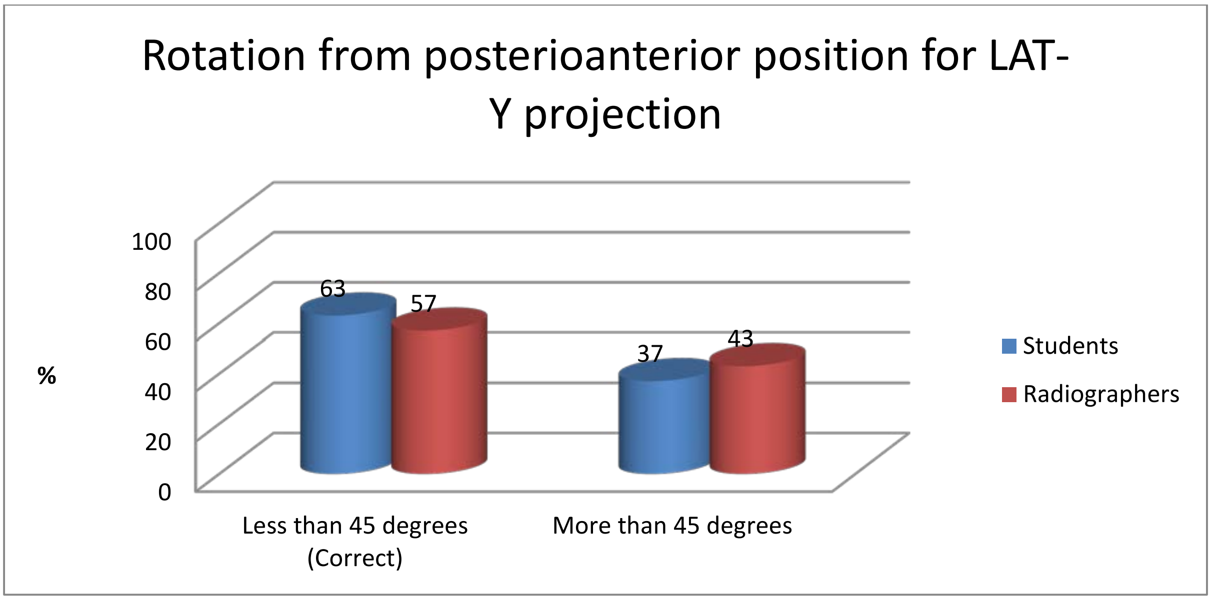

Figure 5.31: Rotation from posterioanterior position for LAT-Y projection

If the patient's arm is extended due to an extended elbow, the participants had to select how many degrees the patient must be rotated for a LAT-Y shoulder projection. Figure 5.32 illustrates that 70% of students and 71% of radiographers failed to select the correct answer of 45° rotation. No significant difference in percentages were observed between students and radiographers ($p = 0.1317$).

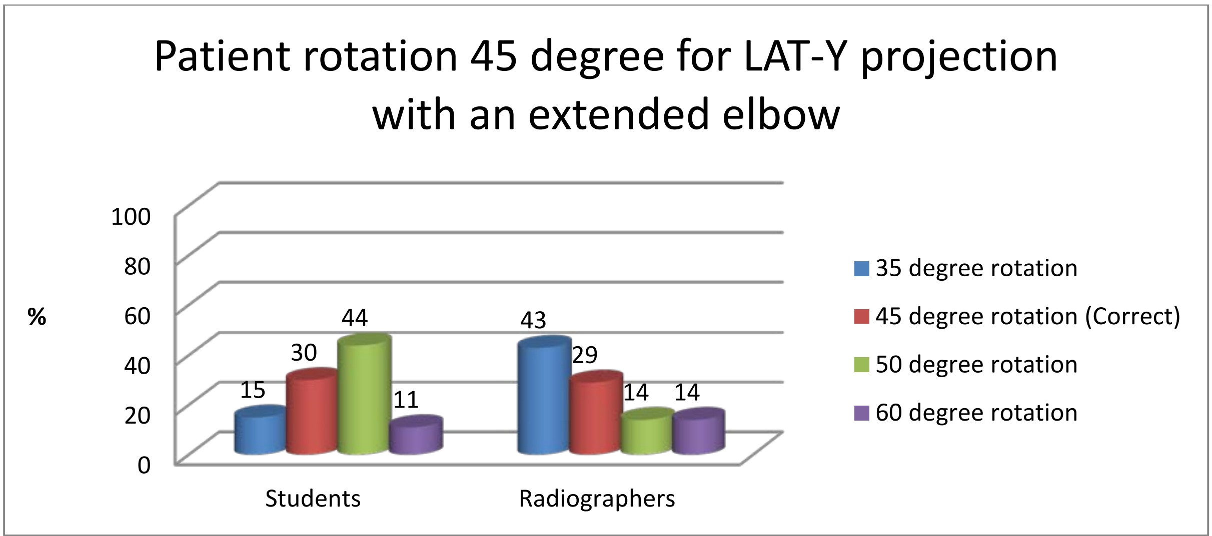

Figure 5.32: Patient rotation 45º for LAT-Y projection with an extended elbow

The participants had to indicate in Question 33 the degree of rotation of the patient's body for a LAT-Y shoulder projection when the patient's arm is abducted and placed on the crest. In total 81% of students and 93% of radiographers selected the wrong answers. Most of the participants indicated that a 45° body rotation is required for this projection instead of a 60° rotation (see Figure 5.33). No significant difference in percentages were observed between students and radiographers ($p = 0.9564$).

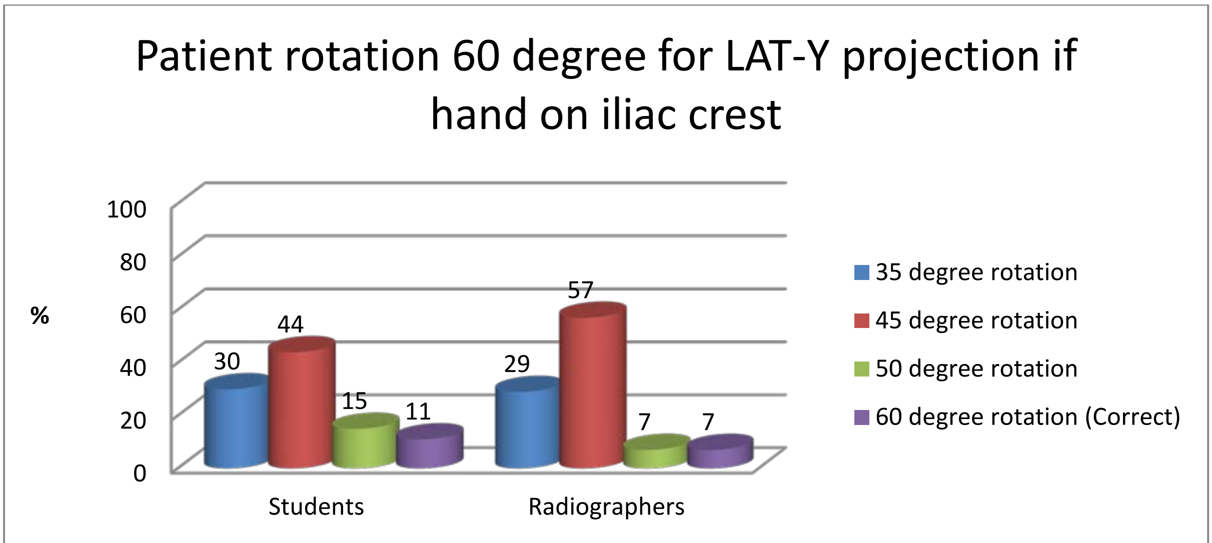

Figure 5.33: Patient rotation 60 º for LAT-Y projection if hand is on iliac crest

Three LAT-Y shoulder images were displayed in Question 34 and the participants had to identify the optimal shoulder image (Image 2) based on positioning and the exposure factors. More than 70% of the students and the radiographers selected the correct image, as illustrated in Figure 5.34. No significant difference in percentages were observed between students and radiographers (p = 1.0000).

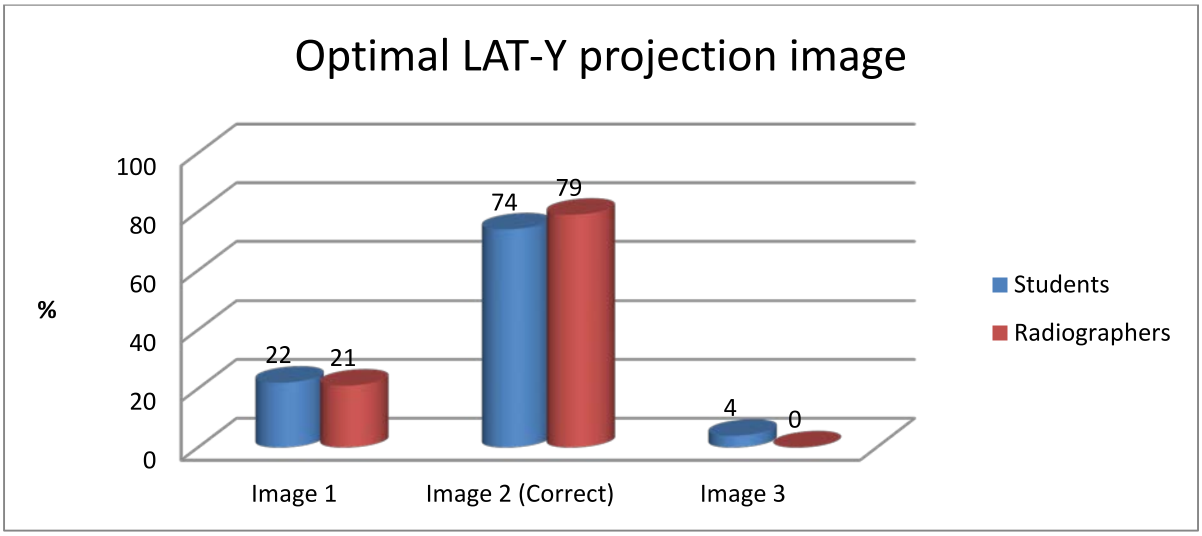

Figure 5.34: Optimal LAT-Y projection image

In Question 35 the participants had to evaluate an x-ray image and indicate whether the positioning of the LAT-Y shoulder projection is correct or not. Two questions where formulated from the image. Therefore, the participants had to remember the answer they had selected for the first question in order to answer the second question. Figure 5.35 and Figure 5.36 are linked to this x-ray image. Figure 5.35 shows that 74% of students and 86% of radiographers selected the correct answer by indicating that the positioning of the projection is incorrect. No significant difference in percentages were observed between students and radiographers (p = 0.6925).

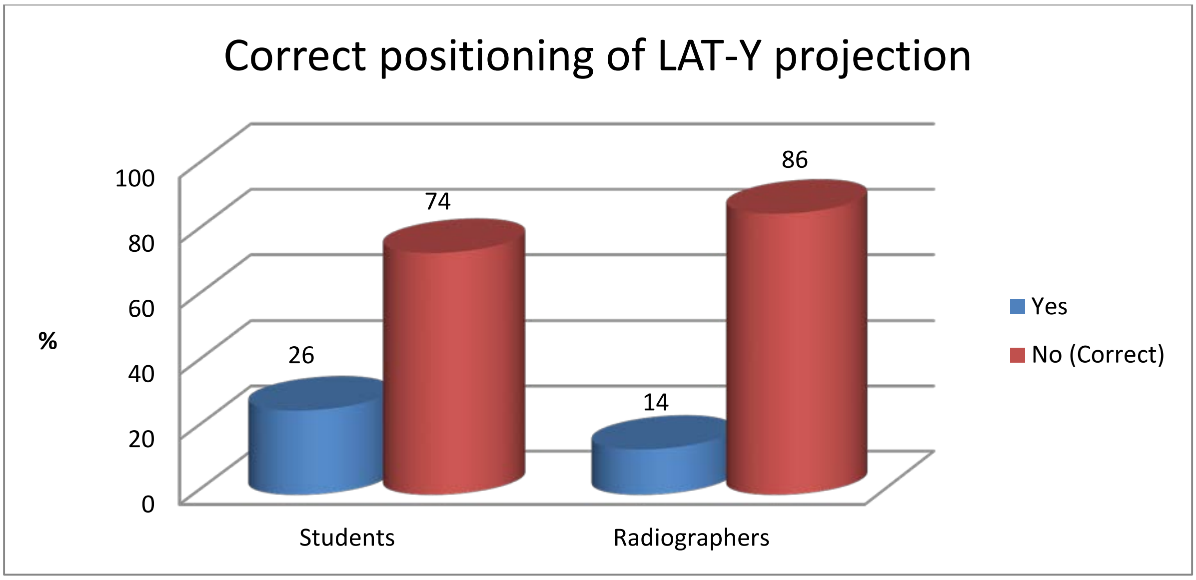

Figure 5.35: Correct positioning of LAT-Y projection

The participants that selected "no" (see Figure 5.35) had to select how to correct the positioning for the x-ray image. Therefore, the participants had to remember what they had answered in the previous question in order to answer the succeeding question. The participants that selected "yes" as demonstrated in Figure 5.36 had to select "no correction needed" as seen in Figure 5.36. The two answers correlate, because 55% of students and 57% of radiographers could not indicate how to correct the positioning. They either selected "no correction" was required, or that "the arm must be adducted", or that "the patient must be rotated away from the affected side", as illustrated in Figure 5.36. No significant difference in percentages were observed between students and radiographers (p = 0.7839).

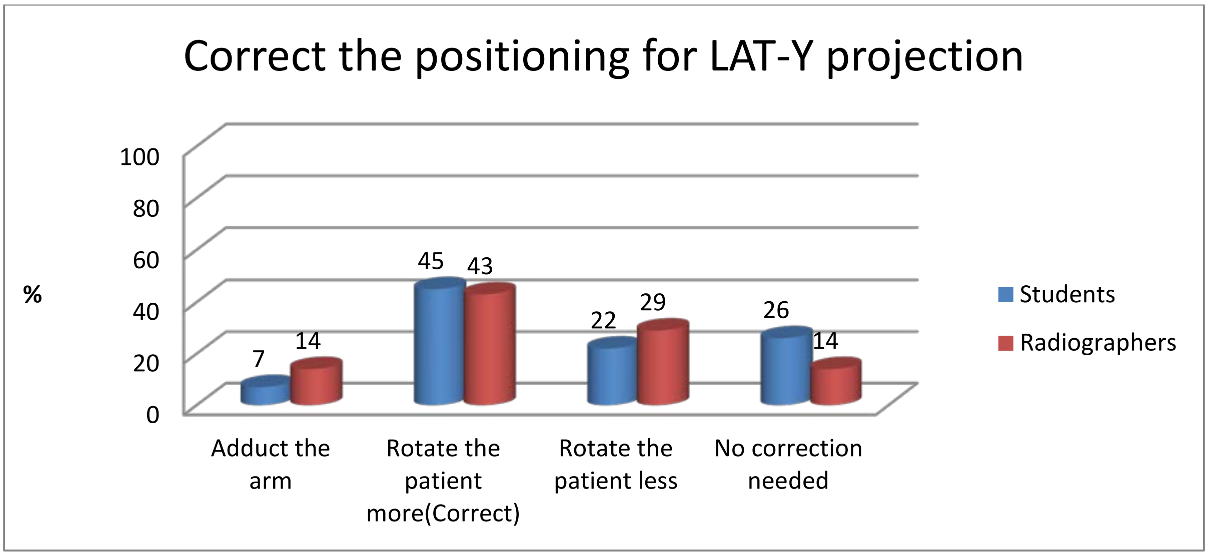

Figure 5.36: Correct the positioning for LAT-Y projection

In Question 38 the participants had to indicate whether breathing instructions must be given to the patient during imaging of the routine shoulder projections. Figure 5.37 shows that 70% of students and 43% radiographers selected the incorrect answer and did not indicate that the patient should be instructed to hold his/her breath after inspiration. No significant difference in percentages were observed between students and radiographers (p = 0.3530).

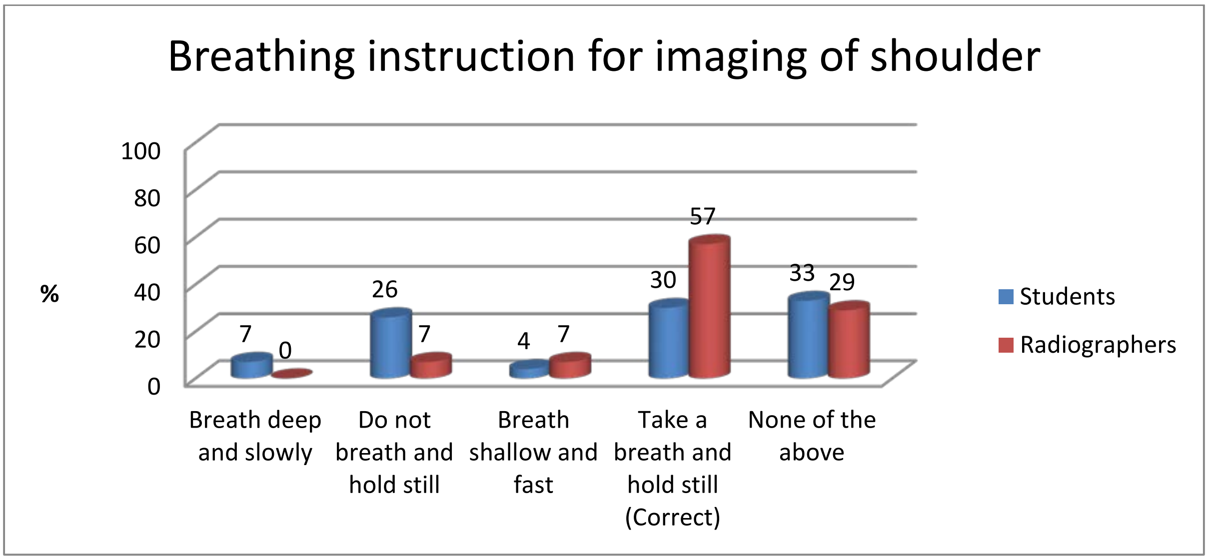

Figure 5.37: Breathing instruction for imaging of shoulder

5.4 DISCUSSION OF THE RESULTS

A large portion of the population of this study constitutes student radiographers (66%) (see Figure 5.1). Interesting details were highlighted through the questionnaire.

5.4.1 Radiographic anatomy

The results displayed in Figure 5.3 confirm that most of the students and radiographers do not know what anatomical structures must be included for an AP projection (external rotation) (see 5.3.2.1). The students and radiographers indicated that the whole clavicle, whole scapula and more than one third of the proximal shoulder must be included for an AP projection (external rotation). What is interesting is that only 4% of students and 7% of radiographers realise that the proximal humerus (one third of the humerus), two thirds of the clavicle and the upper scapula (superior scapula) are the anatomical structures that must be included for an AP projection (external rotation) of the shoulder (see 2.5.5.1). Thus, when x-ray images for an AP projection (external rotation) are obtained by the participants at the participating imaging department, more than the necessary anatomical structures are included for this projection.

The radiographic criteria checklist revealed that the participants include the whole scapula and whole clavicle for imaging of the AP (external rotation) shoulder projection. It is the opinion of the researcher that it is required by the participating imaging department that the radiographers include the whole scapula and whole clavicle in the collimation field, or the radiographers do not want to exclude other pathologies of the shoulder, hence they include more than the necessary anatomy (see 4.4.2).

Figures 5.5 to 5.9 show the results for identification of the important anatomical structures on an AP projection (external rotation) image of the shoulder. The results confirm that, in some instances, less than 50% of radiographers could identify the correct anatomical structures (see Figure 5.6, 5.7, 5.9 & 5.3.2.1). The radiographers could, for instance, not identify the coracoid process and indicated it on the image as the superior angle of the scapula; acromion and spine of the scapula (see Figure 5.6 & 2.2.1.1). The superior angle of the scapula, acromion, spine of the scapula and coracoid process differ vastly from one another in relation to anatomical appearance. The results also confirmed that some of the radiographers cannot differentiate between the various anatomical structures of the humerus (see Figures 5.7, 5.8, 5.9 & 2.2.1.1), therefore, they confused the humeral head with either the GT or the LT, and they also confused the LT with the GT and humeral neck. The student radiographers did particularly well in identifying the anatomical structures, but what was worrying is that only 59% of students identified the humeral head correctly. Many students confused it for the LT and the glenoid cavity (see Figure 5.8 & 5.3.2.1). Furthermore, 63% of the students could identify the LT, but 37% of students either confused the LT for the humeral neck and humeral head. Some students also struggled to identify the various anatomical structures of the humerus. Therefore, the students' knowledge on the important anatomy visible on the AP (external rotation) shoulder image, compared to the knowledge of the radiographers, was better based on the significant differences in percentages that were present (see Figures 5.6, 5.7 and 5.9).

The results of questions relating to identification of the important anatomical structures on the LAT-Y projection image of the shoulder was equally worrisome (see Figures 5.22 to 5.25 & 5.3.3.1), as the radiographers answered certain sections poorly. Some of the students and radiographers confused the coracoid process with the superior angle of the scapula (see Figure 5.23 & 2.2.1.1), although these are two anatomical structures that differ in appearance and location on a LAT-Y shoulder image. Only 50% of radiographers knew the important anatomical structure, the acromion (see Figure 5.22). However, both the students and the radiographers should improve their knowledge of anatomy.

5.4.2 Exposure factors

Milliamperage per second (mAs) is an important exposure factor that produces an x-ray image on which the bony structures and also soft tissue can be visualised well (see 2.5.2). In digital radiography, brightness/image density of an image on a display monitor is controlled by the window level, and not the mAs (see 2.5.2.1). Fewer than 50% of radiographers identified the correct x-ray image demonstrating an optimal mAs (see Figure 5.10 & 5.3.2.2) for an AP projection (external rotation) of the shoulder, whereas 14% of radiographers selected the correct LAT-Y shoulder image demonstrating optimal mAs (see Figure 5.26 & 5.3.3.2). Only 52% of students identified the correct LAT-Y shoulder image demonstrating optimal mAs. It seems that the students and, specifically, radiographers cannot identify optimal mAs on an x-ray image. They do not realise that mAs refers to the brightness/image density and that kVp refers to the grey scale that is present on an x-ray image (see 2.5.2). Hence, the radiographers struggle to assess brightness/image density on an image displayed on the monitor.

The exposure factor kVp is responsible for providing various shades of grey on an x-ray image (see 2.5.2). It is important to note that the kVp range differs from imaging department to imaging department, but in relation to the research study only one imaging department participated in the radiographer critique questionnaire. It was evident during data collection, when the researcher evaluated the shoulder images by means of the radiographic criteria checklist, that the radiographers do no select exposure factors themselves, but rather use automatic exposure. Therefore, a 70-79 kVp range was utilised for imaging of the routine shoulder projections (AP and LAT-Y) at the participating imaging department (see Appendices A1 & A2). More than 70% of participants selected the correct kVp for the LAT-Y shoulder projection (see Figure 5.27 & 5.3.3.2), however 79% of radiographers utilised a 60-68 kVp for an AP projection (external rotation) (see Figure 5.11 & 5.3.2.2). Only 56% of students and 21% of radiographers selected the correct kVp (70-79) for the AP projection (external rotation) (see Figure 5.11). The exposure chart of the participating imaging department indicates that a 60 kVp must be utilised for an AP projection (external rotation), whereas a 70 kVp must be utilised for a LAT-Y projection. However, when radiographers use the AEC system, 73 kVp is utilised for both routine shoulder projections (see 2.5.2). The kVp selected by the radiographers during the radiographer critique questionnaire indicates that they (1) are aware of the kVp they should utilise for imaging of the routine shoulder projections as stated on the exposure chart, (2) do not realise what kVp the AEC system provides, and (3) do not understand the effect of a low kVp on the quality of the image and patient dose, specifically in relation to the AP projection (external rotation) of the shoulder (see 2.5.2). Utilising a 60 kVp may lead to less x-rays penetrating through the body tissue, and the patient's body absorbing the dose (see 2.5.2). The x-ray image might be optimal, depending on the mAs utilised together with the low kVp, but the dose to the patient will increase.

5.4.3 Radiographic technique

Correct positioning of the AP projection (external rotation) is evident when the GT is in profile. Regrettably, fewer than 50% of the radiographers could identify the x-ray image that demonstrates the GT in profile (see Figure 5.4, 5.3.2.1, 2.5.5.1 & 4.4.3). There was a significant difference in percentages (p= 0.0009) that the students answered the question correctly compared to the radiographers (see Figure 5.4). It is the opinion of the researcher that these radiographers do not know where the GT is situated. The opinion of the researcher was confirmed when the preceding questions (6 – 10) prompted identification of the important anatomical structures visible on an AP image (external rotation) of the shoulder (see Figure 5.5 - 5.9). The results shown in Figure 5.7 indicate that only 36% of radiographers identified the GT correctly, whereas 50% identified it as the humeral head. *The radiographic criteria checklist demonstrated that 24% of AP (external rotation) shoulder images demonstrated the GT in profile, thereby confirming the observation of the researcher during the evaluation of the routine shoulder projections and answers provided for the questionnaire at the participating imaging department that the radiographers do not know the where the GT is situated.*

Radiographic criteria are supposed to assist students and radiographers to evaluate shoulder images they obtain, but also to correct the image to ensure it is of diagnostic value. Fifteen per cent (15%) of students and 29% of radiographers evaluated the supplied AP image (external rotation) of the shoulder and indicated the image is optimal (see 2.5.5.1). However, most of the students and radiographers realised that the image is not optimal and indicated that external rotation of the affected arm is required to achieve optimisation (see Figure 5.12, Figure 5.13, 5.3.2.3 & 2.4.2). Unfortunately, only 50% of radiographers and 56% of students selected the correct answer for correcting the patient to provide an optimal AP projection (external rotation) of the shoulder. Therefore, it is evident that the participants can determine if an image is positioned correctly or not, but they struggle to decide how to correct the wrong positioning. A relatively high percentage indicated that the x-ray image was not optimal (see Figure 5.12), however, a lower percentage selected the correct answer to correct the positioning error (see Figure 5.13).

This uncertainty about the identification of important anatomical structures (see 2.2.1.1) also became evident when 29% of radiographers indicated that the image of an AP projection (external rotation) of the shoulder is optimal (see Figure 5.12), but the results in Figure 5.13

show that 36% of radiographers indicated that no correction was needed. It suggests that 7% of radiographers who previously specified that the x-ray image was not optimal decided in the preceding question that no correction in relation to positioning was required for this image. It is the opinion of the researcher that the radiographers who indicated that the x-ray image was not optimal changed their minds, either because they do not know how to correct the positioning because their knowledge of anatomy is lacking (see 2.5.1), or they could not decide if the image was optimal or not.

Two facts can be highlighted from the results for the positioning of the patient's hand for imaging of an AP projection (external rotation) of the shoulder. The first is that 71% of radiographers realise that the patient's hand must be in supination (see Figure 5.14 & 5.3.2.3, 2.4.2), however, as demonstrated in Figure 5.15, only 64% could identify an x-ray image that demonstrates that patient's hand in supination. It seems that the radiographers know the positioning, but struggle to identify the related anatomical structures on an x-ray image. In contrast, the students know how the projection should appear, but their theoretical knowledge is not on the same level as the practical/application part. This is evident because 93% of students could identify the x-ray image that demonstrates the patient's hand in supination (see Figure 5.15), whereas only 78% of students (see Figure 5.14) remembered the theory stating that the hand must be in supination to project the GT in profile, which indicates the positioning for the AP projection (external rotation) is correct.

The majority of radiographers and students know the theory of the centring point for an AP projection (external rotation) (see Figure 5.18) of the shoulder, but find it difficult to identify an x-ray image that demonstrates optimal centring (see Figure 5.19, & 5.3.2.3). The centring point for imaging of the AP projection (external rotation) is 2.5 cm inferior of the coracoid process, which will demonstrate the GH joint and coracoid process in the middle of the image (see 2.5.5.1). Unfortunately, of the 93% of students who know the centring point, only 30% could identify the x-ray image with optimal centring. To the contrary, only 7% of the 72% of radiographers who could identify the centring point, selected the correct x-ray image demonstrating optimal centring. This information confirms the gap that exists between the application of theory and practice.

This gap is also evident for the LAT-Y shoulder projection, as 79% of radiographers know the centring point for a LAT-Y projection of the shoulder (see Figure 5.28 & 5.3.3.3), but only 57% of radiographers could identify the correct x-ray image that demonstrates optimal centring. In relation to the students, 48% knew the x-ray image demonstrating optimal centring, yet only 30% knew the theoretical centring point for the LAT-Y shoulder projection (see Figures 5.28, 5.29, & 5.3.3.3, 2.5.5.2). As outlined in Chapter 2 (see 2.5.3), the way to determine the centring point of an x-ray image is for the radiographer to draw an imaginary line from the four corners of the x-ray image, which will indicate the anatomical structure in the middle of the x-ray. Utilising the imaginary line can assist students and radiographers to determine if the correct centring point has been utilised.

Concerning the LAT-Y projection, incorrect positioning was easily identified by both the students and radiographers, however, suggesting how to correct the positioning seems to be problematic for both students and radiographers (see Figures 5.35, 5.36 & 5.3.3.3). Of the 74% of students who indicated that the positioning of the LAT-Y shoulder projection is incorrect (see 2.5.5.2 and Figure 5.35), only 45% knew how to correct the positioning error (see Figure 5.36). Furthermore, only 43% of the 86% of radiographers who identified the LAT-Y shoulder image as incorrect knew how to correct the positioning. Thus, there is a gap between identifying incorrect positioning and suggesting or applying corrective measures to adjust the positioning, among both the students and radiographers. *The participants know the theory of correct centring, as evidenced by the radiographer critique questionnaire, however, they cannot apply the theory to practice. This was evident from the radiographer critique questionnaire and the results revealed by the radiographic criteria checklist, and this lack, resulted in routine shoulder projections that included more than the necessary anatomical structures (see 4.4.3).*

Students and radiographers alike need more guidance on the appearance of the body of the scapula (see 2.2.1.1) in relation to the vertebrae when the patient's body is rotated for a LAT-Y projection of the shoulder. The results reveal that the radiographers and students realise that the patient's body must be rotated from a posterioanterior position to obtain a LAT-Y projection of the shoulder (see Figure 5.31 & 2.4.3), but do not understand the concept of how much body rotation is required if the patient's elbow is extended and if the hand is placed on the iliac crest – this is evident in Figures 5.32 and 5.33, which show how few students and radiographers selected the correct body rotation. A 45° body rotation is required if the patient's elbow is extended, whereas, if the hand is placed on the iliac crest, a 60° body rotation is necessary (see 2.4.3). At most 30% of students and radiographers understand the body rotation if the elbow is extended, and merely 11% of students and 7% of radiographers apprehend the amount of body rotation needed if the hand is placed on the iliac crest.
Concerning knowledge about the correct breathing technique to apply when imaging the shoulder, 50% and more of radiographers and students comprehend that applying a breathing technique and utilising a short exposure time will ensure that there is no motion (see Tables 2.2 & 2.4) during imaging of the shoulder. What is interesting is that 29% of radiographers and

33% of students indicated that only a short exposure time is of importance to ensure absence of motion, making no reference to the suspension of breathing (see Figure 5.20). It is important to note that when the AEC system is utilised, the radiographer cannot select the exposure time, but only has control over the kVp and mA (see 2.5.2), therefore a breathing technique will contribute to reduce motion during imaging. Comparing these results with the last question about whether a breathing technique is utilised, it is noteworthy that 33% of students and 29% of radiographers (see Figure 5.37) do not give breathing instructions to patients during imaging of the shoulder. Thus, for some of the students and radiographers, a breathing technique is not of importance.

5.5 CONCLUDING SUMMARY

The results for identification of anatomical structures on an AP projection (external rotation) and LAT-Y projection of the shoulder confirms that radiographers' knowledge about the anatomy of the shoulder does not compare well with the knowledge of the students. There were significant differences in percentages among students and radiographers specifically in relation to identifying anatomical structures of the shoulder (see Figures 5.6, 5.7, 5.9 and 5.24). Sadly, it is evident that radiographers do not know the basic anatomy of the shoulder, although they have to supervise student radiographers at the participating institution. Students and radiographers are expected to know the anatomy of the body part that is being imaged well, because this knowledge will assist them to identify the pathology and determine how it impacts the x-ray image (see 2.2.1 & 2.3), and will also assist radiographers to critique shoulder images for optimal positioning (see 2.5.1 & 2.5.5).

The radiographers at the participating imaging department have to indicate to students whether the images they have obtained are optimal or not, however a small percentage of radiographers selected the correct images for both the AP (external rotation) and the LAT-Y projections. However, no significant differences in percentages were observed regarding the selection of optimal images between the students and radiographers (see Figures 5.12, 5.13, 5.35 and 5.36).

The results presented and subsequent discussion made it clear to the researcher that there is a gap between the theory of routine shoulder projections and its application in critiquing this complex joint on an x-ray image. Neither the students nor the radiographers utilise the radiographic criteria to evaluate the images they obtain to ensure that the images are of optimal quality, and radiographers and students do not know the anatomy of the shoulder. Unnecessary elements, such as more than the necessary anatomy, are included, and the participants do not know how to correct patient position for either the AP projection (external rotation) or LAT-Y projection of the shoulder.

The results clearly highlight specific gaps in relation to imaging of the shoulder, in areas such as anatomy, positioning, evaluation criteria and exposure factors – these aspects need to be addressed at the participating imaging department. Addressing these gaps will enhance imaging of the shoulder and, consequently, patient care in the imaging department.

Chapter 6, entitled, ***Conclusion, recommendations and limitations,*** will supply a summative conclusion of the research study and outline the limitations of the research study. The recommendations for this research study will also be discussed in Chapter 6.

CHAPTER 6
CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

6.1 INTRODUCTION

A research study was conducted with the intention of enhancing patient care at the participating imaging department in relation to imaging of the shoulder. Patient care involves all aspects of radiography, therefore, includes adhering to radiographic criteria requirements for shoulder imaging.

Student, qualified, community service and supplementary radiographers are under obligation to provide care to all patients and to have the best interests of patients at heart, as outlined by the South African Health Professions Act 56 (1974:2). Hence, ensuring that routine shoulder projections; the AP projection (external rotation) of the shoulder and LAT-Y projection are optimal for diagnosis. Radiographers must be familiar with the anatomical structures that must be included, how to position the shoulder to demonstrate the anatomical structures of importance, utilise lead markers, remove artefacts, reduce repeat projections of the shoulder, utilise the AEC system correctly, and correct kVp and mAs combination (manual set exposures) with the aim of reducing radiation dose to the patient. Therefore, the research investigated whether radiographers utilised radiographic criteria when evaluating routine shoulder images and obtaining reasons for repeat shoulder projections at the participating imaging department.

The aim of this chapter is to provide a brief overview of the study, followed by the conclusions drawn and a short discussion of the limitations of the study. The chapter concludes with recommendations on the way forward, and the contribution of the research.

6.2 OVERVIEW OF THE RESEARCH STUDY

Chapter 1 (see 1.3) outlined the research question that contributed to the outcome of the study. The research question was deliberated in Chapters 4 and 5. The findings of the research study assisted the researcher to determine the factors contributing to non-optimal shoulder images and reasons for repeat shoulder projections. The findings were provided by means of two research instruments, namely, the radiographic criteria checklist and radiographer critique questionnaire.

6.2.1 Research question and objectives

The following objectives were pursued:

1. To benchmark, from literature, the radiographic criteria for the routine AP projection (external rotation) and LAT-Y projection of the shoulder. The information from literature assisted in compiling the radiographic criteria checklist and quantitative questionnaire;
2. To identify, by means of the radiographic criteria checklist, the causes contributing to images not meeting the requirements; and
3. To determine, by means of a quantitative questionnaire, the knowledge possessed by participants regarding the anatomy of the shoulder and the evaluation for optimal positioning and exposure factor selection.

The above-mentioned objectives addressed the research question by means of two research instruments in the following manner: (1) the researcher obtained content on the radiographic criteria for the routine AP projection (external rotation) and LAT-Y projection of the shoulder, (2) determined whether the radiographers utilise the radiographic criteria to evaluate shoulder images, and (3) determined the factors contributing to non-optimal routine shoulder images and therefore the reasons for repeat shoulder projections.

Objective 1 was met in Chapter 2, by a description of the content of the radiographic criteria checklist and radiographer critique questionnaire. Four sources were utilised to obtain the various criteria that the AP projection (external rotation) and LAT-Y projection of the shoulder must adhere to (see 2.5.5). The criteria focused on the following main aspects (1) <u>anatomy included</u>, (2) <u>positioning</u>, (3) <u>technical factors</u> and (4) <u>exposure factors</u>. Possessing thorough knowledge on these aspects and the application of this knowledge will lead to optimal diagnostic shoulder images (see 2.5). Shoulder images that adhere to the criteria requirements contribute to good radiation practice (see 2.5.5.2). A diagrammatic overview of Chapter 2 is provided in Figure 2.1.

Objective 2 was met by compiling a <u>radiographic criteria checklist</u> and determining whether the radiographers apply the radiographic criteria to critique routine shoulder images. The findings of the radiographic criteria checklist were described according to the four main criteria in Chapter 4 (see Appendices A1 and A2). The routine shoulder projections that were evaluated demonstrated whether the images that were obtained adhered to the criteria requirements. The findings were demonstrated as graphs that showed the percentages of the routine shoulder images that adhered to criteria and those that did not adhere to the criteria.

Objective 3 was achieved by determining the knowledge of the participants about the various criteria applicable to the routine shoulder projections, and whether these criteria can be applied by means of the radiographer critique questionnaire. Chapter 5 described the findings of the radiographer critique questionnaire. The radiographer critique questionnaire focused mainly on anatomical structures, positioning factors and exposure factors by referring to routine shoulder x-ray images (see Appendices B1 and B2). The radiographer critique questionnaire was able to determine the knowledge of the participants in relation to imaging of the routine shoulder projections. The results of the radiographer critique questionnaire were presented as graphs, which illustrated the percentages of the correct and incorrect answers to the various questions.

The two research questions that address the problem statement are:

Do the routine images of the shoulder adhere to the radiographic criteria?

Will a radiographic criteria checklist assist to determine the reasons for repeat shoulder routine projections at the specific imaging department?

The research questions were answered during the research study by means of the two research instruments. The radiographer critique questionnaire revealed that student, qualified, community service and supplementary radiographers struggled to apply the radiographic criteria to the shoulder images that were presented to them. The theoretical knowledge of routine shoulder projections of the radiographers is optimal, however, the radiographers struggle to apply the theoretical knowledge to practice. It became evident during data collection with the radiographic criteria checklist that the routine shoulder images obtained by the radiographers did not adhere to all the radiographic criteria, therefore, the radiographers do not apply the radiographic criteria before shoulder images are sent to the PACS. Furthermore, the radiographic criteria checklist assisted the researcher to determine the number of repeats of routine shoulder projections and the reasons for repeats. The shoulder images were repeated mostly due to positioning and collimation errors.

The research tools complemented each other and can thus be utilised to enhance the radiographic technique of radiographers, which will contribute to patient care in the imaging department (see 2.6). Chapter 3 outlined the methodology of the radiographic criteria checklist and radiographer critique questionnaire (see 3.2.5.1 & 3.2.5.2). Necessary changes to the research instruments were made after the pilot study had been completed (see 3.2.5.1.6 & 3.2.5.2.1), to ensure validity, reliability and trustworthiness of the research study.

A discussion of the radiographic criteria checklist (see 4.4) and the radiographer critique questionnaire (see 5.4) was outlined.

6.3 CONCLUSION

The research study focused on determining if radiographers utilise radiographic criteria to critique routine shoulder images; to do this a radiographic criteria checklist and radiographer critique questionnaire was used. The research study found that certain criteria were not applied by the radiographers and students at the participating imaging department. The following concerns were identified by both research instruments:

- More anatomy than was necessary was included during imaging of the AP (external rotation) shoulder projection. The participants indicated that an image including the whole scapula and clavicle is optimal for AP (external rotation) shoulder projection. This practice was evident in the AP (external rotation) shoulder images evaluated by the researcher. It is clear that the participants do not know what anatomical structures should preferably be included for an AP (external rotation) shoulder projection; alternatively it may be the protocol of the participating imaging department to include the whole scapula and clavicle.
- External arm rotation was not applied correctly to demonstrate the GT in profile on an AP (external rotation) shoulder image. A contributing factor to this finding was that the radiographers could not identify the anatomical structures, namely the GT and LT, on an x-ray image, hence the radiographers cannot identify an image demonstrating the GT in profile. The radiographers (64%) and students (93%) could identify an x-ray image where the patient's hand is in supination, indicating that the GT is in profile, however, the theoretical knowledge of the participants did not correspond with the application part. Only 78% of students (and 71% radiographers) indicated the correct theory, namely, in order to project the GT in profile the hand must be in supination.
- An incorrect centring point was utilised for imaging the routine shoulder projections. The participants possessed the theoretical knowledge of the correct centring point to utilise during imaging of the routine shoulder projections. However, it became evident that the participants centre too inferiorly for AP (external rotation) shoulder projections and either inferiorly or medially of the correct centring point for LAT-Y shoulder projections. Because they used an incorrect centring point, ineffective collimation practices were evident, and consequently, exposing unnecessary

anatomical structures, such as the thyroid, breast and abdomen, to radiation. Therefore, a gap between application and theoretical knowledge has been identified.

- The inadequate knowledge of participants regarding mAs parameters during imaging of the routine shoulder projections became evident. A high percentage of radiographers could not pinpoint routine shoulder images that demonstrate mAs optimally, whereas a small percentage of students could not pinpoint routine shoulder images that demonstrate mAs optimally. The radiographers at the participating imaging department utilise the AEC system during imaging of the shoulder, hence, the AEC system provides the mAs. Some of the routine shoulder images had a very low mAs respectively for AP (external rotation) (0.6 to 7.3) and LAT-Y (0.5 to 4.2) images, which could have been caused by the anatomical structure under investigation not being positioned correctly over the active ionisation chamber, causing the exposure to be terminated early, resulting in a low mAs being produced. The low mAs had a negative influence on routine shoulder images, because these images presented with quantum mottle (noise). Therefore, it can be concluded that the participants do not understand the impact an AEC system has on the mAs and the recorded detail on the x-ray image.

A gap between the application and theoretical knowledge relating to the positioning criteria applied by the participants was identified from responses to the radiographer critique questionnaire. The participants are able to apply the theory of the positioning criteria to determine if an image is optimal, but they cannot necessarily correct the wrong positioning. This was evident for both the AP (external rotation) and the LAT-Y shoulder projections.

The results of the research study highlighted the factors contributing to non-optimal routine shoulder projections. If the factors are addressed at the participating imaging department, it could make a significant contribution to the enhancement of the radiographic technique of the radiographers. Hence, radiographers will comply with legislation relating to providing and improving optimal patient care.

6.4 LIMITATIONS OF THE RESEARCH STUDY

A few limitations of this study are acknowledged.

- Firstly, no specific research study could be traced on the topic at hand, therefore the researcher relied mostly on the radiographic criteria quoted in textbooks.

- Secondly, the researcher was the only person who evaluated the 578 routine shoulder images by means of the radiographic criteria checklist at the participating imaging department. This could have led to errors in the evaluation of the shoulder images.
- The third limitation was technical errors during the clicker session (radiographer critique questionnaire). These technical errors were due to the researcher failing to ensure that the correct answers were selected. After the student radiographers had completed the clicker session the researcher realised that Question 37 (see Appendix B2) did not select the correct answer in order for the TurningPoint program to work out the percentages. This error was corrected by the researcher for the remaining clicker sessions and the statistician manually calculated the percentages of the answers for this question as answered by the student radiographers. Another technical error with Question 34 (see Appendix B2) was noticed after the clicker sessions. The incorrect answer was selected as the correct answer. This error was noted by the researcher when the dissertation was being compiled. Fortunately, the clicker session provided all the answers that were given for the specific question. Hence, the researcher could indicate, for Figure 5.33, the correct answer for the question.
- Fourthly, the arrow utilised to demonstrate the correct centring point on the image for Question 18 and Question 27 did not illustrate the principle of utilising an imaginary X to determine the centring point (see Appendix B2). However, the principle of using the imaginary X to demonstrate the anatomical structure at the centre was evident for Question 19 and Question 28.
- The fifth limitation was that the researcher was too rigid in her approach with regard to the pilot study and the inclusion of anatomical structures for the AP projection (external rotation). Two pilot participants indicated that the whole scapula should be included for this projection (see 3.2.5.1.6) and it became evident that it is required by the participating imaging department to include the whole scapula, but the researcher did not amend the checklist accordingly.
- The original plan to complete the checklist and thereafter execute the questionnaire did not work out as planned. This is considered a limitation of the study. The number of images that the researcher evaluated forced the researcher to complete the questionnaire before all the 578 shoulder images were evaluated. From November 2015 the researcher still had to evaluate 177 (31%) routine shoulder images when the questionnaire was completed by the participants. The researcher takes cognisance that it could have influenced the results.

- The seventh limitation is that the AEC option was not included on the checklist under exposure factors therefore the exposure ranges (exposures set manually) on the checklist did not correspond with the exposure ranges provided by the AEC system especially in relation to mAs. As a result, most of the shoulder images were considered out of range. The participating imaging department uses a CR exposure chart for a fully digital radiography system.
- The eight limitation was that the results of the radiographic criteria checklist were comprehensive, and large amounts of data were generated. The quantitative data was presented in full and discussed extensively, however, the qualitative data was not presented in Chapter 4. Nevertheless, the discussion of the quantitative data was complemented by some aspects of the qualitative data (see 4.4). The qualitative data that was not presented in full will be discussed in future publications.

6.5 CONTRIBUTION OF THE RESEARCH

The value of this study was recognised when the factors contributing to non-optimal shoulder images and repeat shoulder projections at the participating imaging department became evident. The research questions were answered in that it was confirmed that the radiographers and students find it challenging to apply some of the radiographic criteria. The radiographic criteria checklist did assist the researcher to determine reasons for repeats for routine shoulder projections.

The findings of the study will benefit radiographers if the findings are applied to enhance practice. The patients also benefit, since radiographers will provide optimal shoulder images for diagnosis and will apply optimal radiation protection to honour the ALARA principle. The topic at hand can be researched further and combined with in-service training, which has the potential to contribute to the improvement of radiographic technique by radiographers.

6.6 RECOMMENDATIONS

The findings of the research study compel the researcher to recommend and pursue the following:

i. To publish articles on the research results in accredited journals.
ii. To present the results at the participating imaging department, conferences and seminars.
iii. To propose to the participating imaging department that an in-service training session be presented to enhance radiographic technique in relation to routine shoulder

projections. The in-service training session should focus mainly on (1) the anatomical structures that must be included for AP shoulder projections (external rotation), (2) identifying important anatomical structures that indicate whether the correct arm positioning was utilised for the AP shoulder projection (external rotation), (3) applying theoretical knowledge to centre correctly for routine shoulder projections, (4) how to critique routine shoulder images based on centring, (5) how to correct wrong positioning for routine shoulder images, (6) the importance of correct positioning when utilising the AEC system and the impact this system has on mAs, and (7) determining what mAs to utilise when a high or low kVp is selected when manual exposures are set.

iv. To advise radiographers to continue to utilising the AEC system during adult imaging, but not during paediatric radiography (Herman *et al*., 2012:8,9)

v. To propose that the research tools be utilised for enhancing skills and learning in relation to the evaluation of routine shoulder images.

vi. To propose a simplified radiographic criteria checklist for utilisation during critique of routine shoulder images at imaging departments.

vii. To recommend that a pre- and post-research study be executed on the topic at hand to determine if presenting an in-service training session will enhance and change the practice of the radiographers.

6.7 CONCLUSIVE REMARKS

Radiographers are obliged to provide good patient care and apply the ALARA principle during imaging. The study showed clearly that patient care in radiography does not refer only to the way the radiographer interacts with the patient, but also to the x-ray projections that are obtained (optimal or non-optimal). Applying the radiographic criteria during imaging of routine shoulder projections will enhance the radiographic technique of radiographers, with the result being production of optimal images for diagnosis. The prevention of unnecessary repeat projections and reduction of the radiation dose to patients will honour the obligation of patient care.

Enhancing patient care is a continuous process. Radiographers must often reflect on their radiographic technique to determine whether they still abide by their scope of practice. Areas of concern that radiographers notice that need to be improved on, must be adjusted accordingly by the radiographer. Ensuring that patient care is of optimal quality and working towards improvement will show that radiographers have the best interests of patients in South Africa at heart.

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Study title: Radiographers utilisation of radiographic critique

APPENDIX A1: RADIOGRAPHIC CRITERIA CHECKLIST FOR THE ROUTINE AP PROJECTION OF THE SHOULDER (EXTERNAL ROTATION)

Checklist unique nr:

CRITERIA 1: ANATOMICAL STRUCTURES INCLUDED IN THE PROJECTION				For office use only:
	YES	NO	COMMENT	
1.1. Superior scapula				
1.2. 2/3 of clavicle				
1.3. 1/3 Proximal humerus				
CRITERIA 2: POSITIONING FACTORS				
2.1. No visible motion on projection				
2.2. Greater tubercle in profile (on lateral aspects of proximal humerus)				
2.3. Lesser tubercle positioned between the greater tubercle and the humeral head (lesser tubercle superimposing the humeral head)				
2.4. No superimposition of superolateral border of scapula over ribs				
2.5. Humeral head slightly overlap glenoid cavity				
2.6. Humeral head is in profile				
2.7. Humerus aligned parallel with the body				
2.8. Clavicle demonstrated horizontally				
2.9. Superior scapula angle superimposed by midclavicle				
2.10. Glenohumeral joint and coracoid process in center of collimation				
CRITERIA 3: TECHNICAL FACTORS				**For office use only**
3.1. Identification visible				
3.2. Lead marker is visible				
3.3. No artifacts visible				
3.4. Four sided collimation margins visible before post processing				

Central University of Technology, Free State **Study title:** Radiographers utilisation of radiographic critique

CRITERIA 4: EXPOSURE FACTORS				
	YES	**NO**	**COMMENT**	
4.1. Bony trabecular detail sharply defined				
4.2. Cortical outlines of the shoulder demonstrated sharply				
4.3. Soft-tissue seen around proximal humerus				
4.4. Average exposure factors (70-80 kvp 16-25 mAs)				
4.5. Exposure index (EI) for shoulder imaging is Non-bucky=345-689, Bucky= 145-344 (Philips & Agfa)				
4.6. Amount of repeats				

5. Additional comments:

Department of Clinical Sciences • Private Bag X20539 • Bloemfontein • SOUTH AFRICA • 9300 •
Tel: +27 051 507 3267 • **Fax:** +27 051 507 3354 • **E-mail:** isebelego@cut.ac.za • **Website:** www.cut.ac.za

Study title: Radiographers utilisation of radiographic critique

APPENDIX A2: RADIOGRAPHIC CRITERIA CHECKLIST FOR THE ROUTINE LATERAL PROJECTION OF THE SHOULDER (Y-VIEW)

Checklist unique nr:

CRITERIA 1: ANATOMICAL STRUCTURES INCLUDED IN THE PROJECTION				**For office use only:**
	YES	**NO**	**COMMENT**	
1.1. Superior and inferior angle of the scapula				
1.2. Glenohumeral joint				
1.3. Proximal humerus				
1.4. Coracoid processes				
1.5. Acromion processes				
CRITERIA 2: POSITIONING FACTORS				
2.1. No motion visible on projection x-ray				
2.2. Acromion, coracoid processes and scapular body form a Y (true lateral)				
2.3. Scapula not magnified				
2.4. Acromion projected lateral				
2.5. Coracoid processes superimpose the clavicle or projected below the clavicle				
2.6. Lateral and vertebral border of scapula is superimposed				
2.7. Humeral head superimpose the base of the Y				
2.8. Relationship between the humeral head and glenoid cavity is seen clearly				
2.9. Scapular body seen on end without superimposition of ribs				
2.10. Shaft of humerus superimpose body of scapula				
2.11. Shaft of the humerus not superimposed by ribs				
2.12. Midscapular body/ humeral head and surgical neck is at center of the projection				

Study title: Radiographers utilisation of radiographic critique

CRITERIA 3: TECHNICAL FACTORS				For office use only:
	YES	**NO**	**COMMENT**	
3.1. Identification visible				
3.2. Lead marker is visible				
3.3. No artifacts visible				
3.4. Four collimation margins visible before post processing				
CRITERIA 4: EXPOSURE FACTORS				
4.1. Bony trabecular detail is sharply defined				
4.2. Cortical outlines of the shoulder is sharply demonstrated				
4.3. Soft-tissue seen around shoulder (Lateral and superior region of the shoulder)				
4.4. Average exposure factors (70-80 kvp 16-25 mAs)				
4.5. Exposure index (EI) of for shoulder imaging Non-bucky=345-689, Bucky= 145-344 (Philips & Agfa)				
4.6. Amount of repeats				

5. Additional comments:

APPENDIX B1: RADIOGRAPHER CRITIQUE QUESTIONNAIRE (MICROSOFT EXCEL)

RADIOGRAPHERS UTILISATION OF RADIOGRAPHIC CRITIQUE OF ROUTINE SHOULDER PROJECTIONS

Instructions:
- *Mark the appropriate answer with an 'X' or*
- *Selecting the correct answer by encircling it*

For office use only

Questionnaire unique number ☐☐ 1-2

SECTION A: DEMOGRAPHIC INFORMATION

1. Kindly indicate your current level of training: ☐ 3
   - ☐ Qualified radiographer
   - ☐ Supplementary radiographer
   - ☐ Community service radiographer
   - ☐ Student radiographer

2. For how long have you been practicing in the radiography profession as a qualified radiographer?

   ________ years ☐☐ 4-5

3. If you are a student, please indicate your year of study: ☐ 6
   - ☐ First year diploma
   - ☐ Second year diploma
   - ☐ Third year diploma
   - ☐ Second year bachelor

SECTION B: RADIOGRAPHIC PRACTICE OF THE AP PROJECTION OF THE SHOULDER (EXTERNAL ROTATION)

4. Indicate the x-ray projection that includes all the important anatomical structures for a routine AP of the shoulder. 7

Image 1

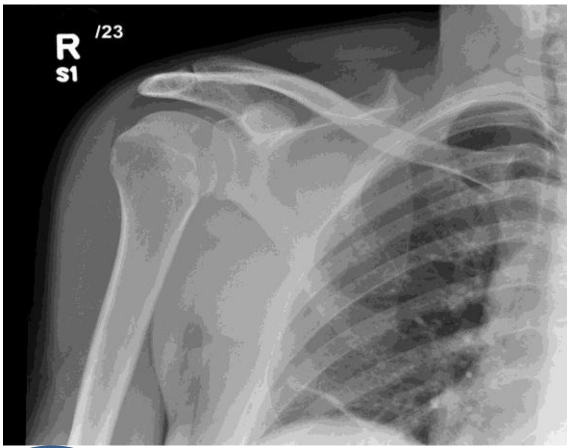
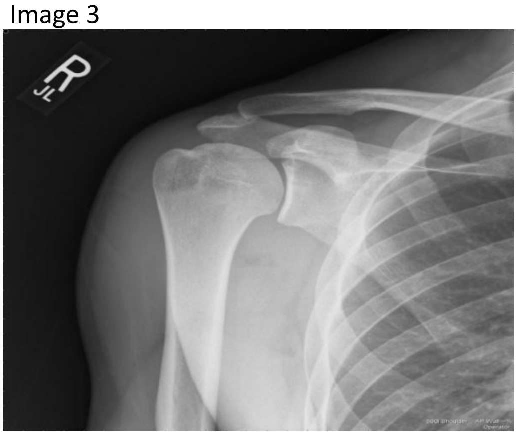


Image 2

Image 3



5. Indicate which of the x-ray projections below, optimally demonstrate the greater tubercle in profile. 8

Image 1

Image 2

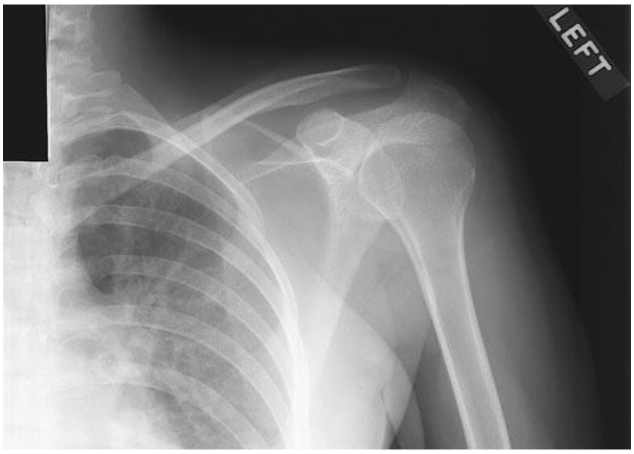
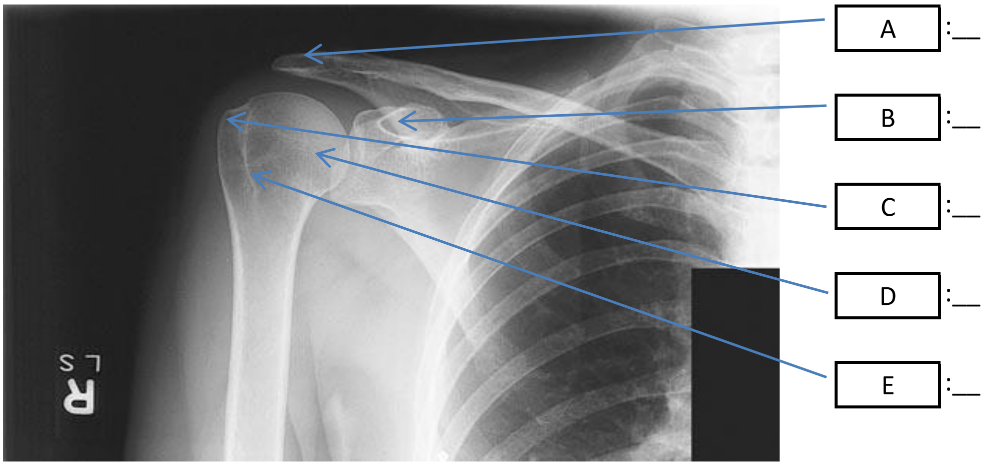


Image 3

6. Identify the anatomical structures labeled A, B, C, D and E.



9
10
11
12
13

7. Select the x-ray projection that demonstrates the mAs optimally. 14

Image 1

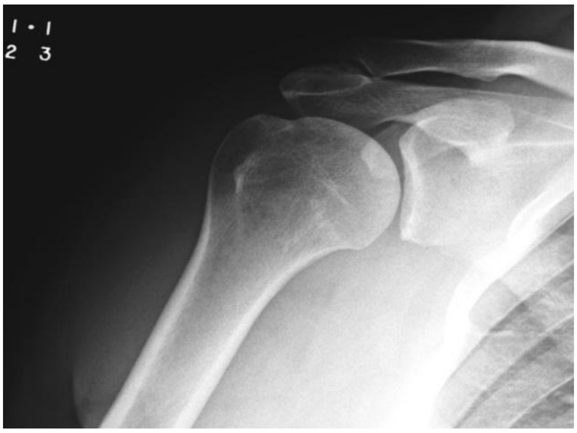


Image 2

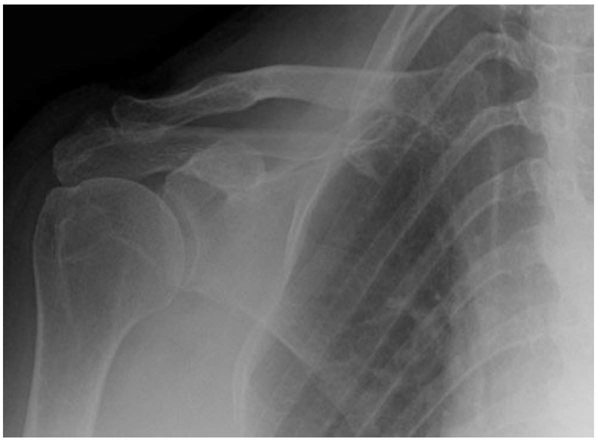
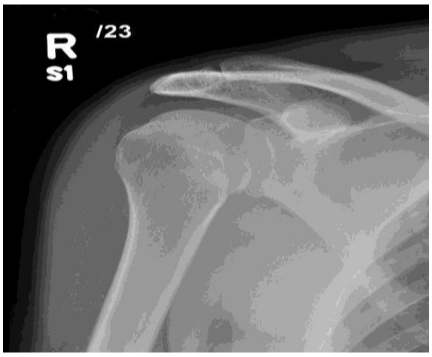


Image 3

8. Please answer the following questions in relation to the image below. 15



8.1 Do you think the positioning for the AP external shoulder projection is correct? 16

	YES
	NO

8.2 If no, indicate how you will correct the positioning error. If yes, select E. 17

A= adduct the arm

B= rotate the arm more externally

C= rotate the arm more internally

D= abduct the arm

E= no correction needed

9. Identify the position of the hand for an AP external shoulder projection. 18

A= Pronation

B= Supination

10. Select the x-ray projection where the hand was in supination. 19

Image 1

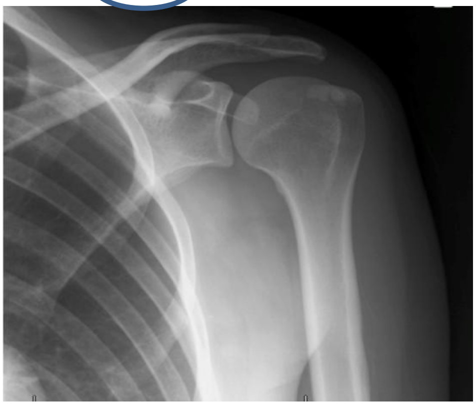
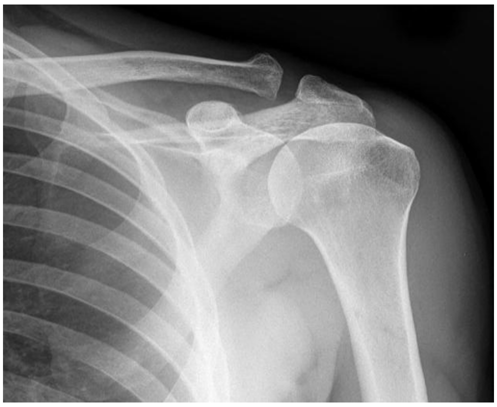


Image 2



11. Do you usually rotate the affected side of the patient towards the bucky for an AP external shoulder projection? 20

☐ YES

☐ NO

12. Which of the following is important to ensure that the AP shoulder projection is done with external rotation? 21

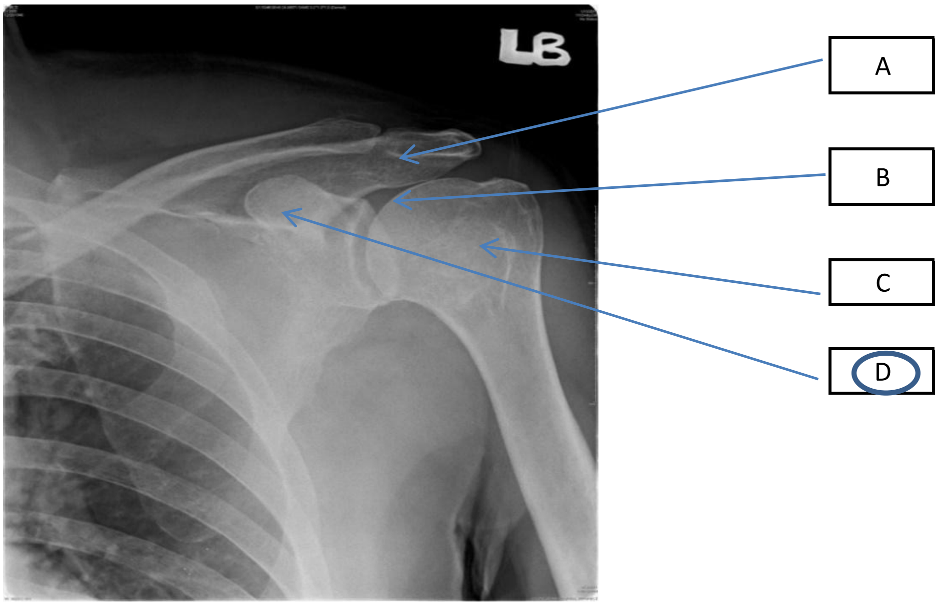
A= hand in supination

B= abduct arm slightly

C= humeral epicondyles parallel to the imaging receptor/cassette

D= All of the above

13. Select if you will utilise A, B, C or D for centering of the AP external shoulder projection. 22



14. Identify the x-ray projection below with optimal centering. Encircle either A, B or C. 23

Image 1

Image 2

Image 3

15. How do you ensure there is no motion when obtaining x-ray projections of the shoulder? You may select more than one answer. 24

A= Applying the breathing technique for the shoulder

B= using short exposure time

C= using high kVp

D= None of the above

16. Indicate the average kVp range you usually utilise for AP imaging of the average shoulder for an adult patient. 25

A= 50-58.5

B= 60-68

C= 70-79

17. Do you abduct the affected arm to obtain an AP x-ray projection of the shoulder? 26

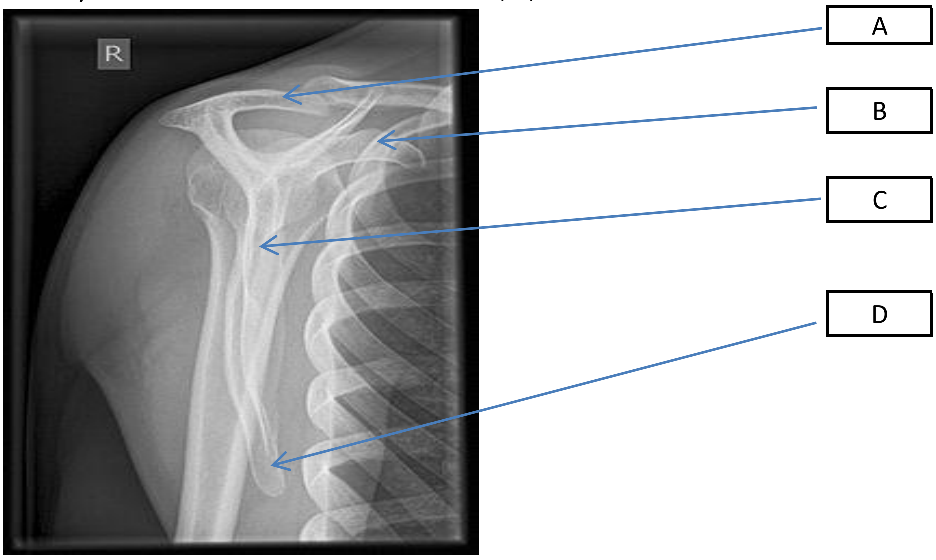
A= Less than 45 degrees

B= No

C= More than 45 degrees

SECTION C - RADIOGRAPHIC PRACTICE OF THE LATERAL PROJECTION OF THE SHOULDER (Y-VIEW)

18. Identify the anatomical structures labeled A, B, C and D.



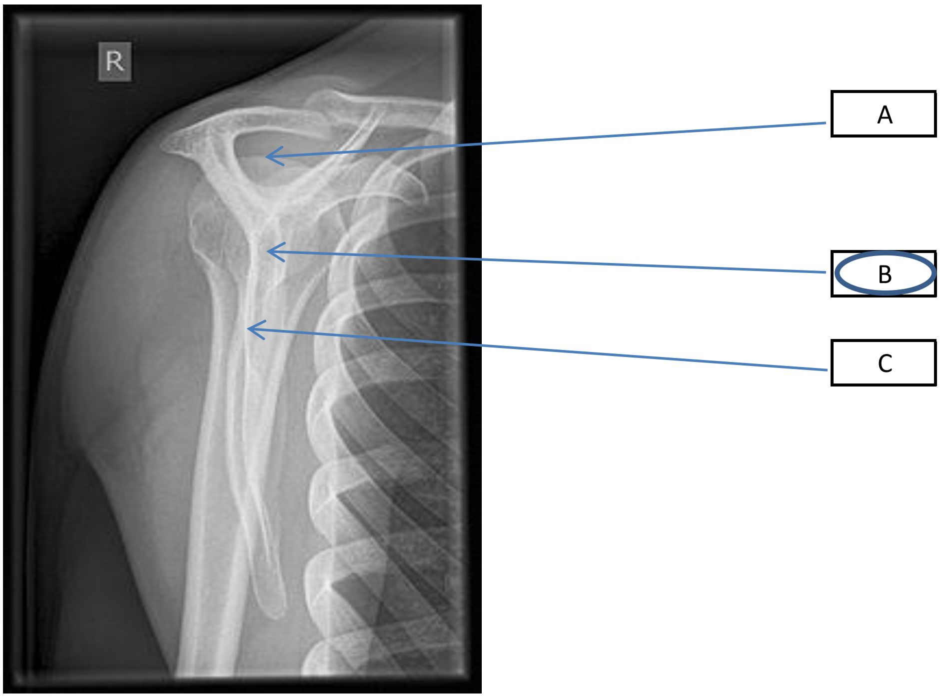
A :________________ 27

B :________________ 28

C :________________ 29

D :________________ 30

19. Select which landmark A, B or C you will utilise as a centering point for a lateral projection (Y-view) of the shoulder. 31



20. Please answer the following questions in relation to image A, B and C. 32

Image 1

Image 2

Image 3

20.1 Indicate which projection (A, B or C) demonstrates the anatomical structures that must be at the center of the collimation field. 33

Image A

Image B

Image C

20.2 Indicate which projection (A, B or C) demonstrates the mAs optimally. 34

Image A

Image B

Image C

21. Identify the correct position of the arm for a lateral shoulder projection. 35

A= abducted slightly

B= adducted slightly

22. How many degrees do you rotate the patient from the PA postion for a lateral shoulder projection (Y-view)? 36

A= Less than 45 degrees

B= More than 45 degrees

23. If the patients arm is extended due to an extended elbow, how many degrees do you rotate the patient for a lateral shoulder projection (Y-view)? 37

A= 35

B= 45

C= 50

D= 60

24. If the patient's arm is abducted with the hand placed on the crest, how many degrees do you rotate the patient patient for a lateral shoulder projection (Y-view)? 38

A= 35

B= 45

C= 50

D= 60

25. Identify the optimal lateral (Y-view) shoulder projection below (adequate to send back to the referring doctor). 39

Image 1

Image 2

Image 3

26. Please answer the following questions in relation to the image below. 40

26.1 Do you think the positioning for the lateral (Y-view) is correct? 41

YES

NO

26.2 If no, indicate how you will correct the positioning error in the picture. If yes, select D. 42

A= Adduct the arm

B= Rotate the patient more

C= Rotate the patient less

D= No correction needed

27. Indicate the average kVp range you usually utilise for a lateral (Y-view) projection of the shoulder for an adult patient. 43

A= 50-58.5

B= 60-68

C= 70-79

28 Select the correct answer. During imaging of the shoulder, do you tell the patient? 44

A= Breathe deep and slowly

B= Do not breathe and hold still

C= Breathe shallow and fast

D= Take a breathe and hold still

E= None of the above

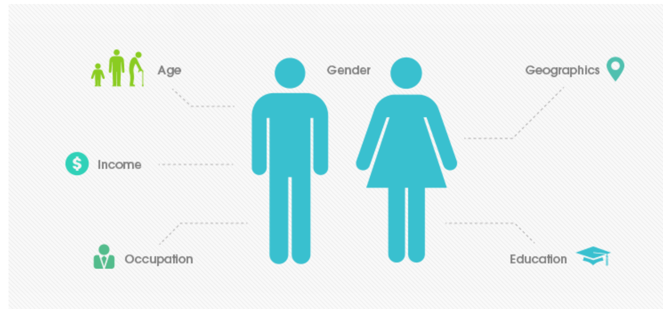
The due date for return of this questionnaire is September 2015.

Thank you for taking the time to complete the questionnaire.

APPENDIX B2- RADIOGRAPHERS CRITIQUE QUESTIONNAIRE (CLICKER)

RADIOGRAPHERS UTILISATION OF RADIOGRAPHIC CRITIQUE OF ROUTINE SHOULDER PROJECTIONS

Questionnaire
Pelonomi Imaging department
Researcher: Ida-Keshia Sebelego
Contact details: 051 507 3267
isebelego@cut.ac.za

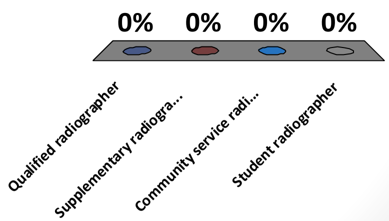


Demographic information

APPENDIX B2- RADIOGRAPHERS CRITIQUE QUESTIONNAIRE (CLICKER)

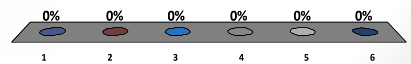
1. Kindly indicate your current level of training

1. Qualified radiographer
2. Supplementary radiographer
3. Community service radiographer
4. Student radiographer



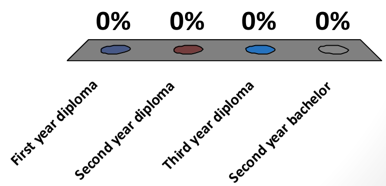
2. For how long have you been practicing in the radiography profession as a qualified radiographer.

Rank	Responses
1	
2	
3	
4	
5	
6	Other



3. If you are a student, please indicate your year of study.

1. First year diploma
2. Second year diploma
3. Third year diploma
4. Second year bachelor



AP Shoulder projection (external rotation)

APPENDIX B2- RADIOGRAPHERS CRITIQUE QUESTIONNAIRE (CLICKER)

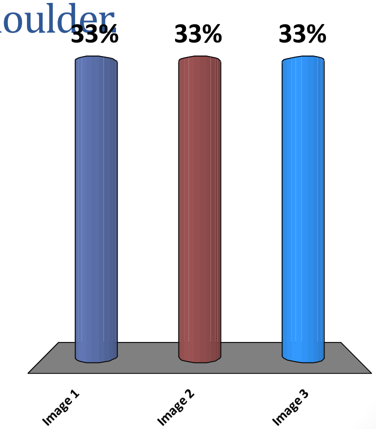
Image 1

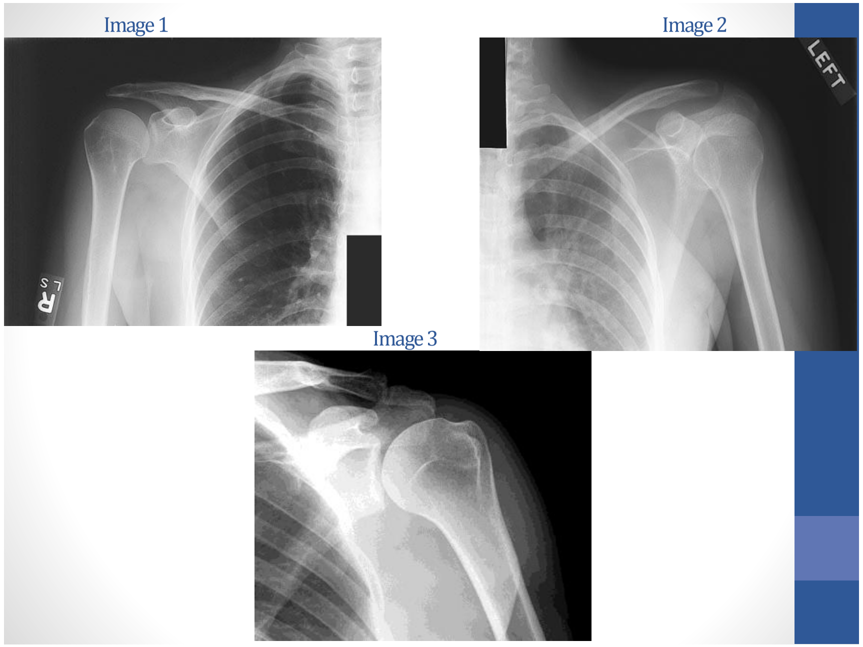
Image 2

Image 3

4. Indicate the x-ray projection that includes all the important anatomical structures for a routine AP of the shoulder

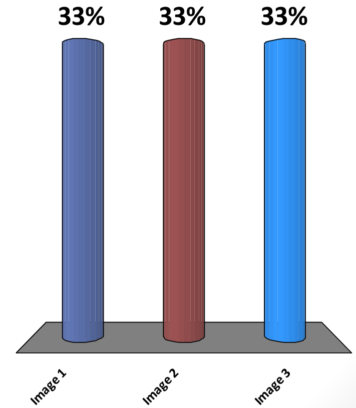
1. Image 1
2. Image 2
3. Image 3



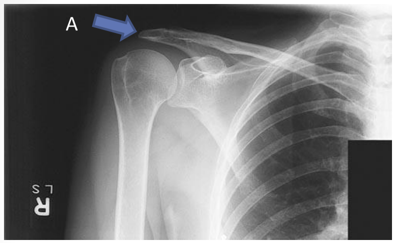


5. Indicate which of the x-ray projections below, optimally demonstrate the greater tubercle in profile

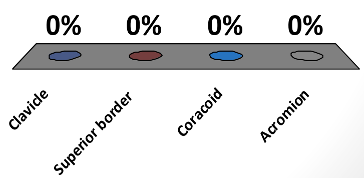
1. Image 1
2. Image 2
3. Image 3



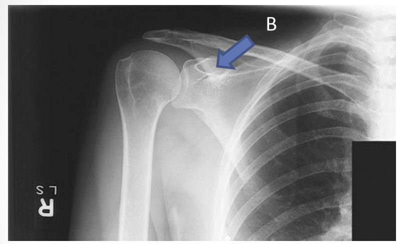
6. Identify the anatomical structure labelled A.



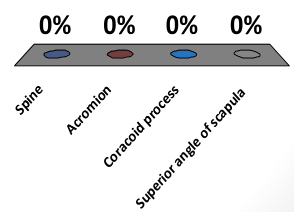
1. Clavicle
2. Superior border
3. Coracoid
4. Acromion



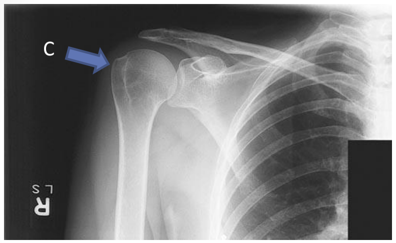
7. Identify the anatomical structure labelled B.



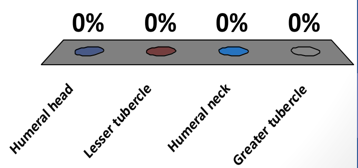
1. Spine
2. Acromion
3. Coracoid process
4. Superior angle of scapula



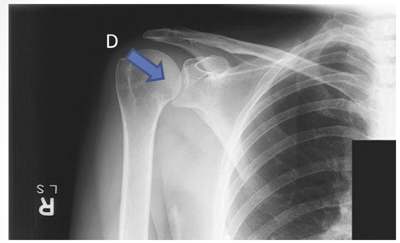
8. Identify the anatomical structure labelled C.



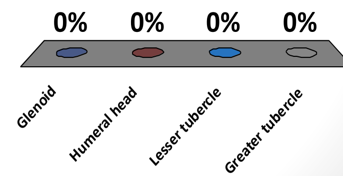
1. Humeral head
2. Lesser tubercle
3. Humeral neck
4. Greater tubercle



9. Identify the anatomical structure labelled D.

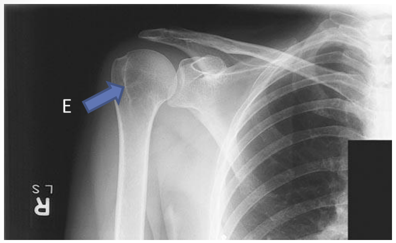


1. Glenoid
2. Humeral head
3. Lesser tubercle
4. Greater tubercle



APPENDIX B2- RADIOGRAPHERS CRITIQUE QUESTIONNAIRE (CLICKER)

10. Identify the anatomical structure labelled E.



1. Humeral neck
2. Greater tubercle
3. Humeral head
4. Lesser tubercle

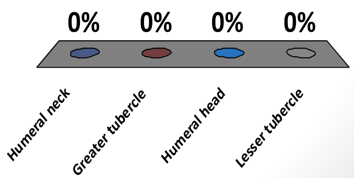


Image 1

Image 2

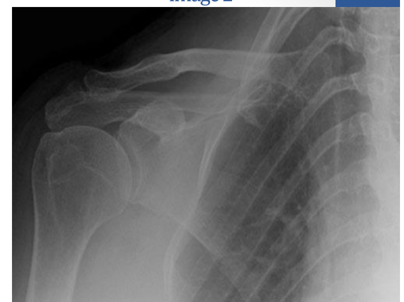
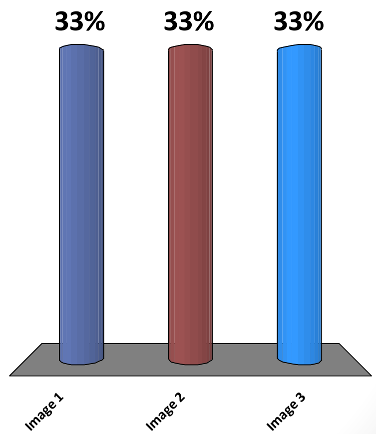


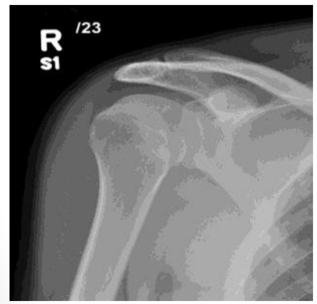
Image 3

11. Select the x-ray projection that demonstrate the mAs optimally

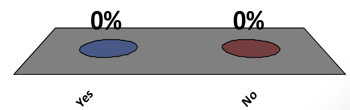
1. Image 1
2. Image 2
3. Image 3



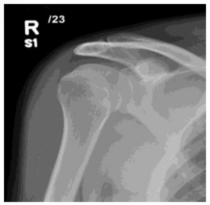
12. Are you of the opinion that the positioning for the AP external shoulder projection is correct.



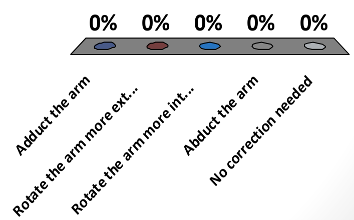
1. Yes
2. No



13. If no, indicate how you will correct the positioning, if yes, select 5



1. Adduct the arm
2. Rotate the arm more externally
3. Rotate the arm more internally
4. Abduct the arm
5. No correction needed



14. Identify the position of the hand for an AP external shoulder projection.

1. Pronation
2. Supination

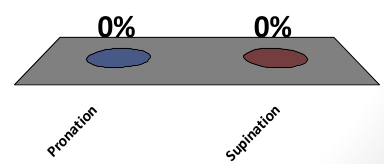


Image 1

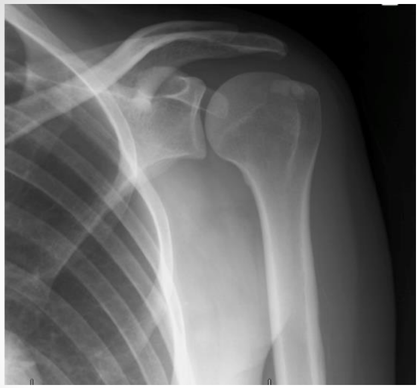
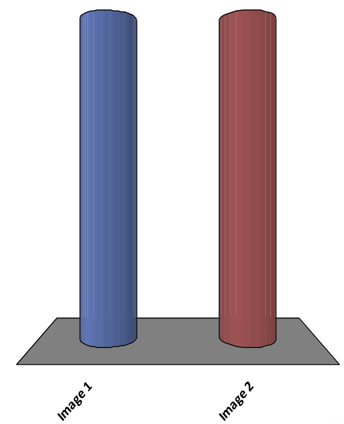


Image 2

15. Select the x-ray projection where the hand was in supination.

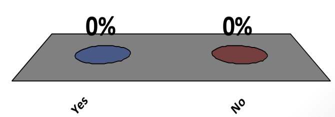
1. Image 1
2. Image 2



APPENDIX B2- RADIOGRAPHERS CRITIQUE QUESTIONNAIRE (CLICKER)

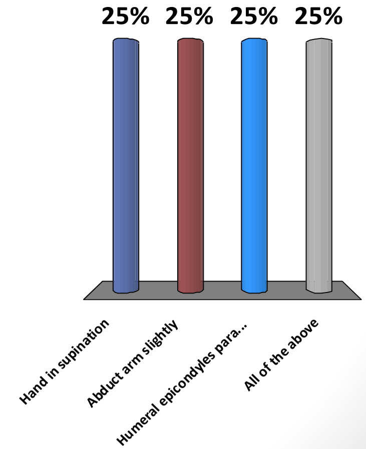
16. Do you usually rotate the affected side of the patient towards the bucky for an AP external shoulder projection?

1. Yes
2. No

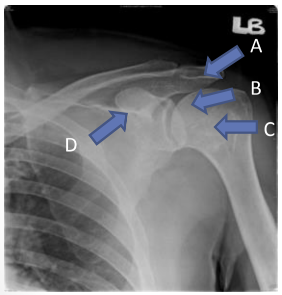


17. Which of the following is important to ensure that the AP external shoulder projection is projected optimally?

1. Hand in supination
2. Abduct arm slightly
3. Humeral epicondyles parallel to the imaging receptor/cassette
4. All of the above



18. Select if you will utilise A, B, C or D for centering of the AP external shoulder projection.



1. A
2. B
3. C
4. D

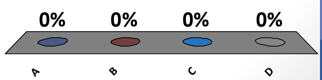


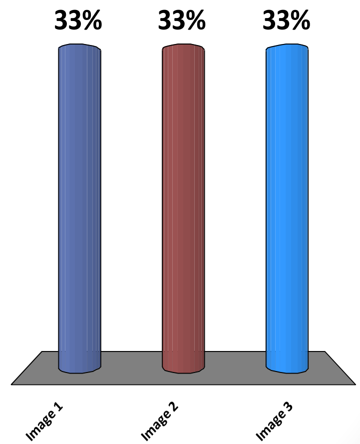
Image 1

Image 2

Image 3

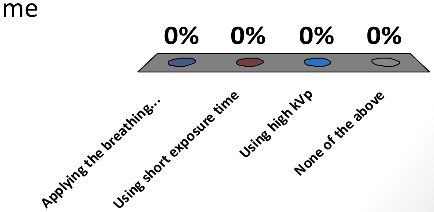
19. Identify the x-ray projection with optimal centering

1. Image 1
2. Image 2
3. Image 3



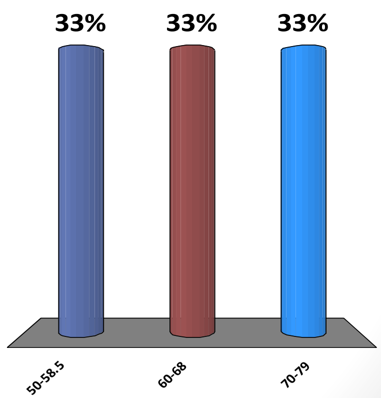
20. How do you ensure there is no motion when obtaining x-ray projections of the shoulder? You may select more than one answer.

1. Applying the breathing technique for the shoulder
2. Using short exposure time
3. Using high kVp
4. None of the above



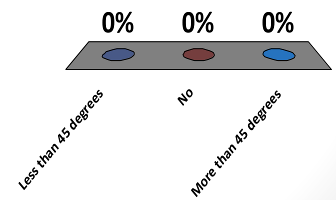
21. Indicate the average kVp range you usually utilise for AP imaging of the average shoulder for an adult patient.

1. 50-58.5
2. 60-68
3. 70-79



22. Do you abduct the affected arm to obtain an AP x-ray projection of the shoulder

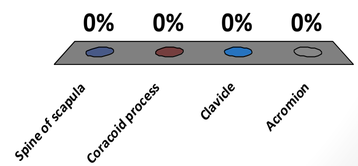
1. Less than 45 degrees
2. No
3. More than 45 degrees



Lateral Shoulder projection (Y-view)

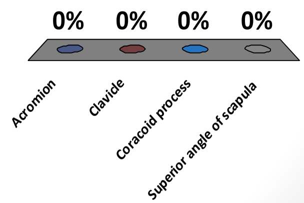
23. Identity the anatomical structure labelled A.

1. Spine of scapula
2. Coracoid process
3. Clavicle
4. Acromion



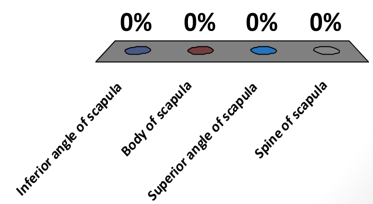
24. Identity the anatomical structure labelled B.

1. Acromion
2. Clavicle
3. Coracoid process
4. Superior angle of scapula



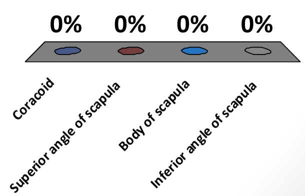
25. Identity the anatomical structure labelled C.

1. Inferior angle of scapula
2. Body of scapula
3. Superior angle of scapula
4. Spine of scapula

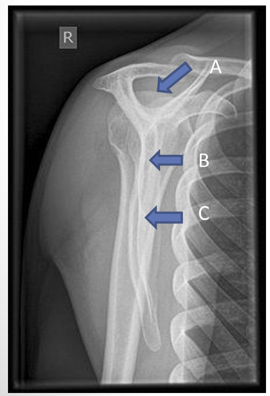


26. Identity the anatomical structure labelled D.

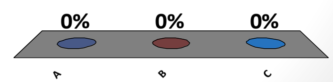
1. Coracoid
2. Superior angle of scapula
3. Body of scapula
4. Inferior angle of scapula



27. Select which landmark A, B or C you will utilise as a centering point for a lateral projection (Y-view) of the shoulder.



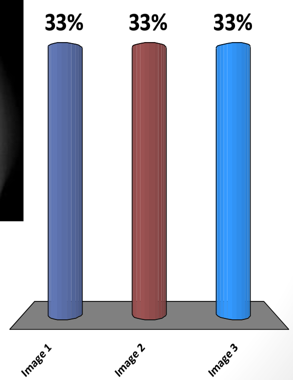
1. A
2. B
3. C



28. Indicate which projection demonstrates the anatomical structures that must be at the center of the collimation field.

Image 1 Image 2 Image 3

1. Image 1
2. Image 2
3. Image 3



29. Indicate which projection demonstrates the mAs optimally.

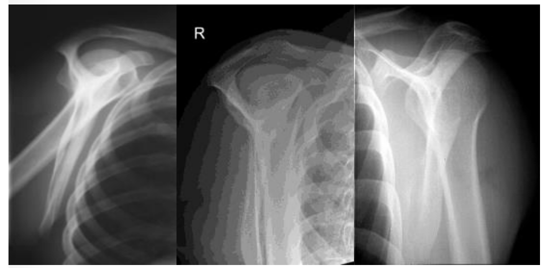
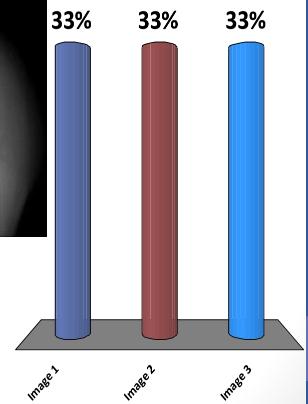


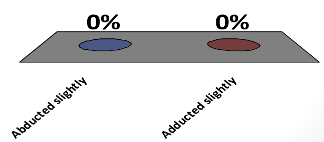
Image 1 Image 2 Image 3

1. Image 1
2. Image 2
3. Image 3



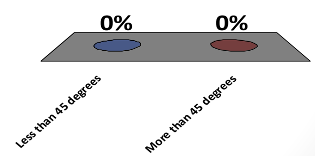
30. Identify the correct position of the arm for a lateral shoulder projection

1. Abducted slightly
2. Adducted slightly



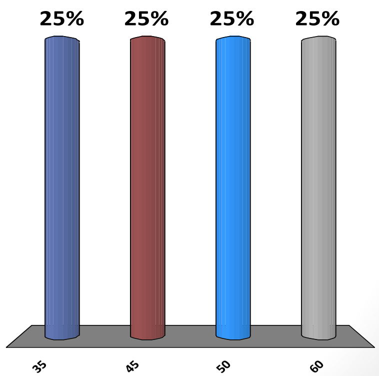
31. How many degrees do you rotate the patient from the PA position for a lateral shoulder projection (Y-view)?

1. Less than 45 degrees
2. More than 45 degrees



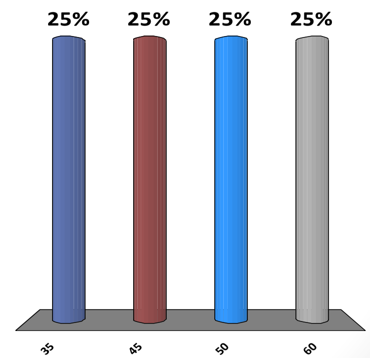
32. If the patients arm is extended due to an extended elbow, how many degrees do you rotate the patient for a lateral shoulder projection (Y-view)?

1. 35
2. 45
3. 50
4. 60



33. If the patients arm is abducted with the hand placed on the crest, how many degrees do you rotate the patient for a lateral shoulder projection (Y-view)?

1. 35
2. 45
3. 50
4. 60



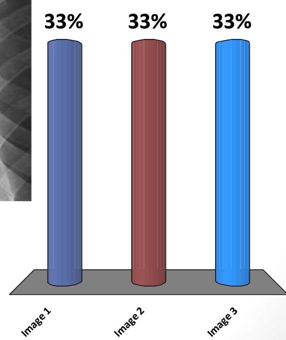
34. Identify the optimal lateral (Y-view) shoulder projection below (adequate to send back to the doctor).


Image 1


Image 2

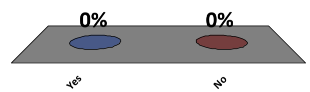

Image 3

1. Image 1
2. Image 2
3. Image 3



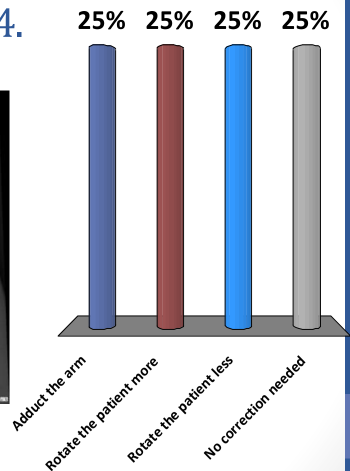
35. Do you think the positioning for the lateral (Y-view) is correct.

1. Yes
2. No



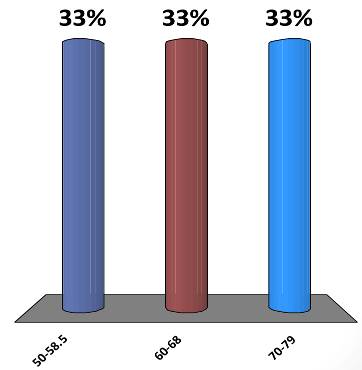
36. If no, indicate how you will correct the positioning error in the picture. If yes select 4.

1. Adduct the arm
2. Rotate the patient more
3. Rotate the patient less
4. No correction needed



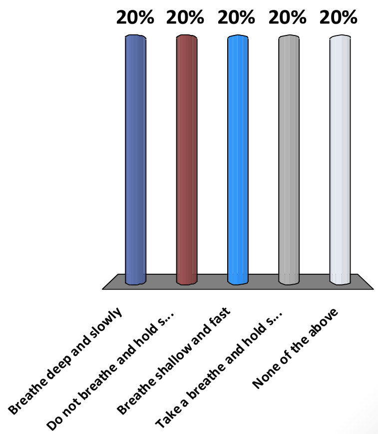
37. Indicate the average kVp range you usually utilise for a lateral (Y-view) projection of the shoulder for an adult patient.

1. 50-58.5
2. 60-68
3. 70-79



38. Select the correct answer. During imaging of the shoulder, do you tell the patient?

1. Breathe deep and slowly
2. Do not breathe and hold still
3. Breathe shallow and fast
4. Take a breathe and hold still
5. None of the above



Central University of Technology, Free State **Study title:** Radiographers utilisation of radiographic critique

APPENDIX C1: INFORMATION DOCUMENT FOR RADIOGRAPHERS

Information document

Study Title: Radiographers utilisation of radiographic critique of routine shoulder projections.

My name is Ida-Keshia Sebelego. I am currently working at Central University of Technology (CUT) as a junior lecturer in Radiography. I am enrolled for a Magister Technologiae (M-Tech) in Radiography (Diagnostic) to investigate radiographers' utilisation of critique of routine shoulder projections by means of a checklist and questionnaire.

Dear healthcare professional your participation in this study is requested.

You are invited to participate in this research study by completing the questionnaire attached to this letter. The aim of this questionnaire is to establish how you critique shoulder images. The research study has the potential to sensitise radiographers to optimally utilise the radiographic criteria requirements to enhance optimal diagnostic imaging and thereby striving to enhance patient care and patient management.

The completion of the questionnaire will take approximately 40 minutes. It contains only close-ended questions. Please answer all the questions honestly in order for the researcher to make constructive conclusions. Please do not discuss the questionnaire with colleagues. **Please answer all the questions.**

If you are willing to participate in this study, please sign Appendix C2 below. Take note that this is an anonymous questionnaire. None of your personal information is needed and any information shared will be handled confidentially. No names will be mentioned in my study. You will receive no remuneration and you can withdraw from the study at any given time. The results of the study may be published. The outcome of the study will be made available to all participants. Should you have any specific questions, my contact details are as follows:

Department of Clinical Sciences • Private Bag X20539 • Bloemfontein • SOUTH AFRICA • 9300 •
Tel: +27 051 507 3267 • **Fax:** +27 051 507 3354 • **E-mail:** isebelego@cut.ac.za • **Website:** www.cut.ac.za

Study title: Radiographers utilisation of radiographic critique

Telephone number: 051 507 3267

Cellular phone: 076 588 8029

E-mail address: isebelego@cut.ac.za

Contact details of Secretariat and Chair

Ethics Committee of the Faculty of Health Sciences

University of the Free State

Telephone number: 051 401 7795

E-mail address: EthicsFHS@ufs.ac.za

Thanking you in advance

Ida-Keshia Sebelego (Researcher)

Department Clinical Sciences

Central University of Technology, Free State

Bloemfontein

9301

Study title: Radiographers utilisation of radiographic critique

APPENDIX C2: CONSENT DOCUMENT FOR RADIOGRAPHERS

Consent document

Study Title: Radiographers' utilisation of radiographic critique of routine shoulder projections.

I, ____ (Name and surname), agree to participate (radiographer critique questionnaire) in this study entitled**:** 'Radiographers' utilisation of radiographic critique of routine shoulder projections'. I understand that participation is voluntary, that I will receive no remuneration and that I can withdraw from the study at any given time.

__________________________________ ____________________

Participant signature Date

Please submit this page separately to the researcher.

My contact details are as follows:

Telephone number: 051 507 3267

Cellular phone: 076 588 8029

E-mail address: isebelego@cut.ac.za

Yours faithfully

Department of Clinical Sciences • Private Bag X20539 • Bloemfontein • SOUTH AFRICA • 9300 •
Tel: +27 051 507 3267 • **Fax:** +27 051 507 3354 • **E-mail:** isebelego@cut.ac.za • **Website:** www.cut.ac.za

APPENDIX D: APPROVAL FROM ETHICS COMMITTEE

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS·UV
HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

IRB nr 00006240
REC Reference nr 230408-011
IORG0005187
FWA00012784

22 July 2015

Ms IK Sebelego
Department of Clinical Sciences
CUT

Dear Ms IK Sebelego

ECUFS 100/2015
PROJECT TITLE: RADIOGRAPHERS UTILISATION OF RADIOGRAPHIC CRITIQUE

1. You are hereby kindly informed that, at the meeting held on 21 July 2015, the Ethics Committee approved the above project after all conditions were met.

2. Any amendment, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

3. A progress report should be submitted within one year of approval of long term studies and a final report at completion of both short term and long term studies.

4. Kindly use the ECUFS NR as reference in correspondence to the Ethics Committee Secretariat.

5. The Ethics Committee functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the Ethics Committee of the Faculty of Health Sciences.

Yours faithfully

....
DR SM LE GRANGE
CHAIR: ETHICS COMMITTEE

Ethics Committee
Office of the Dean: Health Sciences
T: +27 (0)51 401 7795/7794 | F: +27 (0)51 444 4359 | E: ethicsfhs@ufs.ac.za
Block D, Dean's Division, Room D104 | P.O. Box/Posbus 339 (Internal Post Box G40) | Bloemfontein 9300 | South Africa
www.ufs.ac.za

APPENDIX E: PERMISSION FROM DEPARTMENT OF HEALTH

health
Department of Health
FREE STATE PROVINCE

23 June 2015

Ms IK Sebelego
Department of Clinical Science
CUT
Bloemfontein

Dear Ms. IK Sebelego

Subject: Radiographers utilization of radiographic critique.

- Permission is hereby granted for the above – mentioned research on the following conditions:
- Participation in the study must be voluntary.
- A written consent by each participants must be obtained.
- Serious adverse events to be reported and/or termination of the study.
- Ascertain that your data collection exercise neither interferes with the day to day running of ; nor the performance of duties by the respondents or health care workers.
- Confidentiality of information will be ensured and no names will be used.
- Research results and a complete report should be made available to the Free State Department of Health on completion of the study (a hard copy plus a soft copy).
- Progress report must be presented not later than one year after approval of the project to the Ethics Committee of the University of the Free State and to Free State Department of Health.
- Any amendments, extension or other modifications to the protocol or investigators must be submitted to the Ethics Committee of the University of the Free State and to Free State Department of Health.
- Conditions stated in your Ethical Approval letter should be adhered to and a final copy of the Ethics Clearance Certificate should be submitted to khusemj@fshealth.gov.za or sebeelats@fshealth.gov.za before you commence with the study
- No financial liability will be placed on the Free State Department of Health
- Please discuss your study with the institution managers/CEOs on commencement for logistical arrangements
- Department of Health to be fully indemnified from any harm that participants and staff experiences in the study
- Researchers will be required to enter in to a formal agreement with the Free State department of health regulating and formalizing the research relationship (document will follow)
- You are encouraged to present your study findings/results at the Free State Provincial health research day
- Future research will only be granted permission if correct procedures are followed see http://nhrd.hst.org.za

Trust you find the above in order.

Kind Regards

Dr D Motau
HEAD: HEALTH
Date: 29/06/2015

Head : Health
PO Box 227, Bloemfotein, 9300
4th Floor, Executive Suite, Bophelo House, cnr Maitland and, Harvey Road, Bloemfotein
Tel: (051) 408 1646 Fax: (051) 408 1556 e-mail:khusemj@fshealth.gov.za@fshealth.gov.za/chikobvup@fshealth.gov.za

www.fs.gov.za

APPENDIX F1- PERMISSION FROM HEAD OF CLINICAL SERVICES OF PARTICIPATING HEALTH INSTITUTION

Junior Lecturer Radiography (Diagnostic)

Central University of Technology, Free State

25 March 2015

The Head of Clinical Services

Free State

Dear

Re: PERMISSION TO INCLUDE HEALTHCARE PROFESSIONALS AND TO EVALUATE SHOULDER PROJECTIONS FOR MTECH STUDY PURPOSES

My name is Ida-Keshia Sebelego. I am currently working at Central University of Technology (CUT) as a junior lecturer in Radiography. I am enrolled for the Magister Technologiae in Radiography with the title: "Radiographers' utilisation of radiographic critique for routine shoulder projections".

My study leader is:

Ms. B. van der Merwe

Faculty of Health and Environmental Sciences

Department Clinical Sciences

Central University of Technology, Free State

Study title: Radiographers utilisation of radiographic critique

The **aim of the study** is to determine the utilisation of the radiographic criteria checklist during critique of routine shoulder projections.

I need your permission to (1) approach the healthcare professionals at the hospital namely; radiographers to participate in a questionnaire survey that will take approximately 40 minutes and (2) obtain access to evaluate retrospectively 578 x-ray projections of the shoulder acquired in the imaging department. I also require (3) the medical physicist of the imaging department to assist to obtain specific information related to the images from the various display monitors.

The research study is for educational purposes and the results will be published in an article and dissertation. I assure you that the information accumulated from the investigation will be treated with confidentiality. No names of patients, participants or hospitals will be mentioned in the report or the educational materials that will be published.

Thanking you in anticipation

Yours faithfully

Mrs. I-K Sebelego

Junior Lecturer

Department Clinical Sciences

Central University of Technology, Free State

Tel: 0765888029/ 051 507 3267

E-mail address: isebelego@cut.ac.za

Sign of approval

Head of Clinical Service

30 06 2015

DEPARTMENT OF HEALTH

Date

30/06/2015

APPENDIX F2- PERMISSION FROM DEPUTY DIRECTOR OF PARTICIPATING IMAGING DEPARTMENT

Junior Lecturer Radiography (Diagnostic)

Central University of Technology, Free State

25 March 2015

The Deputy Director

Imaging Department

Free State

Dear

Re: PERMISSION TO INCLUDE HEALTHCARE PROFESSIONALS AND TO EVALUATE SHOULDER PROJECTIONS FOR MTECH STUDY PURPOSES

My name is Ida-Keshia Sebelego. I am currently working at Central University of Technology (CUT) as a junior lecturer in Radiography. I am enrolled for a Magister Technologiae in Radiography. The title of my investigation is: "Radiographers' utilisation of radiographic critique for routine shoulder projections".

My study leader is:

Ms. B. van der Merwe

Faculty of Health and Environmental Sciences

Department Clinical Sciences

Central University of Technology, Free State

Study title: Radiographers utilisation of radiographic critique

The **aim of the study** is to determine the utilisation of a radiographic criteria checklist during critique of routine shoulder projections. I need your permission to (1) approach the healthcare professionals at the hospital namely; the radiographers (qualified, supplementary, community service and student) to participate in a questionnaire survey that will take approximately 40 minutes and (2) obtain access to evaluate retrospectively 578 x-ray projections of the shoulder acquired in the imaging department over five months. I also require (3) the medical physicist of the imaging department to assist to obtain specific information related to the images from the various display monitors.

The research study is for educational purposes and the results will be published in an article and dissertation. I assure you that the information accumulated from the investigation will be treated with confidentiality. No names of patients, participants or hospitals will be mentioned in the report or the educational materials that will be published.

Thanking you in anticipation

Yours faithfully

...gn of approval

11 MAY 2015

SIG... MANAGE.

Mrs. I-K Sebelego

Junior Lecturer

Department Clinical Sciences

Central University of Technology, Free State

Tel: 0765888029/ 051 507 3267

E-mail address: isebelego@cut.ac.za

Date

APPENDIX G1- PERMISSION FROM HEAD OF CLINICAL SCIENCES DEPARTMENT AT THE CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE

Study title: Radiographers utilisation of radiographic critique

PERMISSION LETTER TO THE HEAD OF DEPARTMENT OF CLINICAL SCIENCES, CENTRAL UNIVERSITY OF TECHNOLOGY

Junior Lecturer Radiography (Diagnostic)

Central University of Technology, Free State

23 June 2015

The Head of Department

Department of Clinical Sciences

Central University of Technology

Free State

Dear Prof. H. Friedrich-Nel

Re: PERMISSION TO INCLUDE RADIOGRAPHY STUDENTS FOR MTECH STUDY PURPOSES

My name is Ida-Keshia Sebelego. I am currently employed as a junior lecturer in Radiography in the Department of Clinical Sciences at Central University of Technology (CUT). I am enrolled for a Magister Technologiae in Radiography. The title of my investigation is: "Radiographers' utilisation of radiographic critique for routine shoulder projections".

My study leader is:

Ms. B. van der Merwe

Faculty of Health and Environmental Sciences

Department Clinical Sciences

Central University of Technology, Free State

Study title: Radiographers utilisation of radiographic critique

The **aim of the study** is to determine the utilisation of a radiographic criteria checklist during critique of routine shoulder projections. I need your permission to approach the radiography students placed for work place learning at imaging department to participate in a questionnaire survey. The duration of the survey is approximately 40 minutes. Most of the students will complete the questionnaire at imaging department, but it may be necessary for some students to complete the questionnaire during contact sessions at the Central University of Technology due to the block system of the radiography programme.

The research study is for educational purposes and the results will be published in an article and dissertation. I assure you that the information accumulated from the investigation will be treated with confidentiality. No names of the participants or hospital will be mentioned in the report or in the educational materials that will be published.

Thanking you in anticipation

Yours faithfully

Mrs. I-K Sebelego

Junior Lecturer

Department Clinical Sciences

Central University of Technology, Free State

Tel: 0765888029/ 051 507 3267

E-mail address: isebelego@cut.ac.za

Sign of approval

Prof. H. Friedrich-Nel

approved by programme pending institutional approval (received 20 July 2015)

Date

2015-06-30

APPENDIX G2: PERMISSION FROM ACADEMIC PLANNING AT CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE

Central University of Technology, Free State

ACADEMIC PLANNING

Mrs I-K Sebelego

Junior Lecturer

Department Clinical Sciences

isebelego@cut.ac.za

PERMISSION TO CONDUCT SURVEY "RADIOGRAPHERS' UTILISATION OF RADIOGRAPHIC CRITIQUE FOR ROUTINE SHOULDER PROJECTIONS" AT CUT BLOEMFONTEIN CAMPUS

Dear Mrs Sebelego

This is to confirm that you have been granted permission to conduct survey for the MTech project entitled: **"Radiographer's utilisation of radiographic critique for routine shoulder projections"** at the CUT Bloemfontein Campus.

The conditions of the permission are:

- The survey will not interrupt any of the official activities at the CUT;
- You will supply us with the copy of your report;
- The cost of all related activities will be covered by yourself;
- Recruitment of participants is the sole responsibility of yourself;
- Voluntary nature of the potential participant's decision to consent to participate should be strictly observed;
- You should not disclose a potential participant's decision to participate or otherwise to any other party;
- Permission does not compel, in any sense, participation of staff members or students in your survey.

DIRECTOR: ACADEMIC PLANNING

DR DM BALIA

20 JULY 2015

APPENDIX H- EXAMPLE OF A PAGE IN THE LOGBOOK

13 humerus = inf angle horizontal c humerus (Level) AP

3 humerus = 2cm below inf angle (LAT)

			Okt-312 Short = 264 (31/10)	Nov = 399 Short = 177	Dec = 446 Short = 129
10/15 Motheri 16h32 Nekopi 16h45 None None -ibcke 17h17	6/11/15 A1 - Khampin 15h55 A4 - None B6 - Davids 16h49 B5 - None B4 - Mofokeng 16h45	23/11/15 A1 - Nthebe 15h51 A4 - Machine off B6 - None B5 - None B4 - Mali 18h27	07/12/15 A1 - Mokoena 17h00 A4 - Machine off B6 - Machine off B5 - None B4 - Selong 18h30	06/01/16 A1 - Simmons 16h04 A4 - Machine off B4 - Johnson 15h44 B5 - Machine off B6 - None	22/01/16 A1 - Mampe 16h47 A4 - None B6 - Sekotome 16h13 B5 - None B4 - Mogorosie 16h08
10/15 Not done (weather) None 17h50 None 17h54 None 17h52 Not done (weather)	9/11/15 A1 - Kok 18h26 A4 - None B6 - Mokoena 17h36 B5 - None B4 - Leeto 17h54	25/11/15 A1 - Makakela 17h57 A4 - None B6 - Monnane 18h07 B5 - None B4 - Maletlatsana 18h15	10/12/15 A1 - Serame 18h55 A4 - Machine off B6 - Mkhize 9h09 B5 - None B4 - Lawu 9h37	08/01/16 A1 - Jones 14h46 A4 - Machine off B6 - None B5 - None B4 - Mahlangu 15h07	25/01/16 A1 - Raffie 16h20 A4 - None B6 - Taku 16h42 B5 - None B4 - Rans 17h04
10/15 Pelotsi 18h00 None 16h50 Thunzi 17h07 Machine off None 16h57	12/11/15 A1 - Pampiri 18h21 A4 - Motlhanke B6 - None 19h27 B5 - Machine off B4 - Knight 19h24	27/11/15 A1 - Mekwe 16h09 A4 - None B6 - Machine off B5 - None B4 - Radebe 15h51	11/12/15 A1 - Mocho 14h26 A4 - Machine off B6 - None B5 - None B4 - Maharee 14h56	11/01/16 A1 - Sehloho 16h30 A4 - Machine off B6 - Ratshidi 16h10 B5 - None B4 - Mondsiwa 17h00	27/01/16 A1 - Ndsomai 16h05 A4 - None B6 - None B5 - None B4 - Kate 16h25
10/15 Nkosi 20h54 None Nyamusi 21h23 Machine off Smith 20h38	13/11/15 A1 - Henning 15h40 A4 - None B6 - None B5 - Machine off B4 - Mnembe 15h	30/11/15 A1 - Busy A4 - None B6 - Phephong 17h29 B5 - None B4 - Moleleki 17h35	20/12/15 A1 - Motsokobi A4 - Machine off B6 - Ngcobo 15h58 B5 - None B4 - Mdingle 16h36	13/01/16 A1 - Madi 15h40 A4 - None B6 - Shelebo 15h50 B5 - Machine pictures B4 - Dase 16h11	29/01/16 A1 - None A4 - None B6 - None B5 - None B4 - Nkunyana 15h40
10/15 Maka 15h59 None Leetimo 17h14 None Mosenyegi 17h22	16/11/15 A1 Rakotseane 18h44 A4 - None B6 - Motaung 15h29 B5 - Machine off B4 - Khabanyane 16h44	01/12/15 A1 - Nkoane 15h05 A4 - None B6 - Motlakoe 14h11 B5 - None B4 - Tshesi 15h27	01/01/16 A1 - None 14h24 A4 - Machine off B6 - None B5 - None B4 - Swarts 14h13	15/01/16 A1 - Ndebuka 5h19 A4 - Machine off B6 - None B5 - Machine off B4 - Dinaledi (lateral)	30/02/16 A1 - Mosuoe 11h47 A4 - None B6 - None B5 - None B4 - None
11/15 Songome 21h18 None Maile 16h12 None Phakathe 17h12	18/11/15 A1 - Mathebula A4 - Ramosoeu B6 - Moroenga B5 - Machine off B4 - Thathe 9h30	02/12/15 A1 - Seleke 16h06 A4 - None B6 - Nau 15h36 B5 - None B4 - None	04/01/16 A1 - Dafane (3h01) 16h29 A4 - Machine off B6 - Kau 16h19 B5 - None B4 - Moeketsi 16h00	18/01/16 A1 - Nkuatipo 16h16 A4 - None B6 - Khotle 15h44 B5 - Machine off B4 - Moloko 16h36	03/02/16 A1 - A4 - B6 - B5 - B4 - Done
11/15 Phadi 17h10 None None None None	20/11/15 A1 - Mkhize 15h44 A4 - Floor flooding c H2O coming from wash machine B6 - None B5 - Machine off B4 - Griele 16h26	04/12/15 A1 - Khaleng 16h57 A4 - None B6 - None B5 - None B4 - Khoabane	05/01/16 A1 - Khalema 12h00 A4 - Machine off B6 - None B5 - None B4 - None	20/01/16 A1 - Laboka 15h49 A4 - None B6 - Maiyane 16h31 B5 - None B4 - Thatopoli 16h49	05/02/16 A1 A4 B6 B5 B4 Done Radi - Check B3

APPENDIX I: TITLE OF DISSERTATION LANGUAGE EDITED

2 June 2015

DECLARATION

I hereby declare that I am a qualified and professional language practitioner with the following qualifications:

- Bachelor of Arts (Linguistics)(1995)(UNISA)
- Honours Bachelor of Arts (Linguistics: Translation Studies)(1999)(UNISA)
- MA (Higher Education Studies)(UFS)(2014)

In this capacity, I have linguistically revised (in English) the following title of an MTech dissertation:

TITLE: **Radiographers' utilisation of radiographic critique of routine shoulder projections**

(NOTE: TITLE REMAINED UNCHANGED)

STUDENT: **IK Sebelego (student number 210032901)**

DEGREE: **Magister Technologiae (Radiography)**

INSTITUTION: **Central University of Technology, Free State**
Faculty of Health and Environmental Sciences

Signed:

LAURIKA VAN STRAATEN
MANAGER: LANGUAGE SERVICES
CENTRAL UNIVERSITY OF TECHNOLOGY, FREE STATE

APPENDIX J: LANGUAGE EDIT OF DISSERTATION

Declaration

25 November 2016

Hester Sophia Human
18 C Ben Tindall Street
Heuwelsig
Bloemfontein
Hettie.human@gmail.com
072 137 8991

Student: Ida-Keshia Sebelego

I confirm that I edited and checked the references of this student's M.Rad thesis for a study entitled, *Radiographers' utilisation of radiographic critique of routine shoulder projections.*

I cannot guarantee that all recommendations for changes were accepted.

HS Human

HS Human
BA Hons (Language Practice)

Hettie Human
WRITER | EDITOR | TRANSLATOR | PROOFREADER

072 137 8991 | hettie.human@gmail.com

APPENDIX K: LETTER FROM BIOSTATISTICIAN

Maryn Viljoen
Statistics Consulting Services

maryn.viljoen@vodamail.co.za
082 823 5731

Protocol and research methodology consultation • Ethical consultation • Database construction and capturing of data
Analyzing data using statistical software packages (SAS Version 9.1.3) • Statistics consultation services to analyze and interpret data
Conveys results with statistical tables and figures where needed

24 October 2016

Title: "RADIOGRAPHERS' UTILISATION OF RADIOGRAPHIC CRITIQUE FOR ROUTINE SHOULDER PROJECTIONS"

Researcher: Mrs. Ida-Keshia Sebelego (Student number: 210032901)
Magister Technologiae Radiography (Diagnostic)
The Faculty of Health and Environmental Sciences
Department of Clinical Sciences (Programme Radiography)
Central University of Technology (Free State)

I was the biostatistician responsible for the analysis of the data for this research project.

Maryn Viljoen
M.Sc. Risk Analysis (UFS)
maryn.viljoen@vodamail.co.za
082 82 35 731