Evaluating Medical Radiation Technologists' image interpretation accuracy and clinical practice relative to their postgraduate educational experience in New Zealand.

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A thesis submitted in partial fulfilment of the requirements for the degree of Master[Hons] of Health Science (Medical Radiation Technology), Unitec New Zealand, 2007

ABSTRACT

This study focuses on the effect of postgraduate education on image interpretation of trauma to the appendicular skeleton from a New Zealand (NZ) perspective. It evaluates the changes in the reporting accuracy and the clinical practice of ten Medical Radiation Technologists (MRTs) who underwent the educational intervention. This is in context with the steps taken by the MRT counterparts in the United Kingdom (UK) to extend their role in trauma image interpretation. The study further addresses the issues that the participating MRTs encountered relative to their educational experience.

The research method was a case study conducted longitudinally from September 2006 to June 2007. A mixed method approach that blends the quantitative and the qualitative methods was used for data collection. The ten MRTs in the study submitted 400 reports which were accompanied by reports from radiologists, which were treated as the gold standard. A questionnaire was completed by the MRTs at the onset and again towards the end of the study. In addition, four of the MRTs and four of the radiologists, acting as the MRTs' mentors, were interviewed towards the end of the study.

Findings showed that as the MRTs progressed in their postgraduate educational experience, their clinical practice was enhanced enormously. By the time all the MRTs in the study were half way through their educational intervention; they exhibited accuracy levels of 100 percent and maintained that stable performance till the end of the study. The contribution of both the academic and clinical components of the postgraduate education was evident in playing a vital role in these developments. The ten MRTs' individual circumstances and characteristics as well as their work profiles and their operational demands were further found to have some effect on the changes that were noted.

The conclusion that was drawn from this study was that the wealth of knowledge in image interpretation possessed by MRTs can be improved through appropriate postgraduate education in trauma reporting. This study suggests that, if appropriately implemented, postgraduate education in trauma reporting is effective in enhancing the interpretation accuracy and the clinical practice of MRTs. The research findings provide potential to aid in the facilitation of future developments in possible role extension areas such as image interpretation in emergency departments (EDs) for the MRTs in NZ, especially in remote and rural settings.

Declaration

Name of candidate: Reshmi Devi Kumar

This thesis entitled **Evaluating Medical Radiation Technologists' image interpretation accuracy and clinical practice relative to their postgraduate educational experience in New Zealand** is submitted in partial fulfillment for the requirements for the Unitec degree of Master of Health Science (Medical Radiation Technology).

CANDIDATE'S DECLARATION

I confirm that:

- This thesis represents my own work.
- The contribution of supervisors and others to this work was consistent with the Unitec Regulations and Policies.
- Research for this work has been conducted in accordance with the Unitec Research Ethics Committee Policy and Procedures, and has fulfilled any requirements set for this project by the Unitec Research Ethics Committee.
- Research Ethics Committee Approval Number: **SHREC** 2006.579

Candidate Signature: …….. Date: ……

Student Number: ……..

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List of Abbreviations

Abbreviation	Expansion
A&E	Accident and Emergency
ALARA	As low as reasonably achievable
ARRS	American Roentgen Ray Society
CPD	Continuous professional development
CoR	College of Radiographers
CR	Computed Radiography
RCR	Royal College of Radiologists
CT	Computed tomography
DHB	District Health Board
ED	Emergency Department
FN	False negative
FP	False positive
FTE	Full time equivalent
GP	General Practitioner
MD	Medical Doctor
MO	Medical Officer
MRT	Medical Radiation Technologist
NAD	No abnormality detected
NP	Nurse Practitioner
NZ	New Zealand
NZIMRT	New Zealand Institute of Medical Radiation Technology
OSCE	Objective structured clinical examination
RANZCR	Royal Australia and New Zealand College of Radiologists
RCR	Royal College of Radiologists
RDS	Red Dot System
ROC	Receiver Operating Curve
ROF	Radiographer Opinion Form
RPR	Radiologist to population ratio
RT	Radiologic technologist
THJR	Total hip joint replacement
TN	True negative
TP	True positive
UK	United Kingdom
USA	United States of America

CHAPTER ONE

Introduction

Overview

To aid in arriving at a correct diagnosis of the patients' condition, it is common practice for the medical doctors (MDs) to send the sick or traumatized patients to the medical imaging (MI) department for radiographic examinations. At the MI department, the Medical Radiation Technologists (MRTs) are responsible for interacting with these patients and producing relevant images of the patients' anatomical region that is being evaluated. The images that are produced are then interpreted by radiologists to enable the MDs to diagnose and treat the patient's condition more precisely. However, a worldwide radiologist shortage has affected the timeliness of the availability of reports (Brogdon, 1990; Morin, 2004; Sunshine & Meghea, 2006). As a result of this situation, the quality of care and management provided to the patients has been compromised to some extent (Sunshine, Maynard, Paros & Forman, 2004).

Since the 1990s, countries such as the United Kingdom (UK) have attempted to alleviate the issue of radiologist shortage and its impact by adopting certain strategies. One of the strategies involved the MRTs in the UK being allowed to extend their existing role of producing images to encompass image interpretation activities, especially for emergency departments (EDs). The reason underpinning this venture in the UK was that the MRTs have untapped knowledge in image interpretation as a result of their work. However, it is likely that as a result of the substantial differences between their academic training as well as their clinical skills and knowledge, the MRTs' interpretations may not be up to par with those of radiologists. Hence, to avoid compromising standards, it became imperative that the MRTs interested in performing image interpretation tasks in the UK underwent appropriate postgraduate education in trauma reporting. Therefore, the current study

takes a similar approach to those undertaken in the UK. It focuses on the effect of postgraduate education in image interpretation on MRTs from a New Zealand (NZ) perspective.

Rationale for the study

As part of their professional practice, most MRTs have frequent and direct access to the acquired x-ray images produced for the patients presenting at the MI departments. It is envisaged that such exposure can enable the MRTs to proficiently review and compare normal, normal variants as well as abnormal or negative findings on the obtained images (Manning, Ethell, Donovan, & Crawford, 2006). During this process, the MRTs may "accumulate experience and familiarity with medical images in their daily practice" (ibid. p. 135). As a result, they may acquire interpretative skills and enhance their clinical practice to achieve the desired patient care. However, it has been a common occurrence that these acquired skills remain unrecognized (Smith & Lewis, 2002).

Nevertheless, the MRTs in the UK have initiated change by becoming actively involved in image interpretation. Progressing to such an advanced role has not only increased job satisfaction but has also enabled the effective utilization of their knowledge and skills for better patient care (Nightingale & Hogg, 2003; Hogg & Hogg, 2003). Most of the UK based MRTs embarked on their role extension by interpreting conventional trauma images in emergency departments (Littlefair, 2006). However, these MRTs were required to take an accredited training programme in image interpretation (Brealey, Scally, Hahn, Thomas, Godfrey & Coomarasamy, 2005). Upon completion, they received certification if they demonstrated the recommended accuracy of 90 percent or more (Williams & Berry, 1999). The purpose of doing this was to ensure that the quality of the image interpretation service was not compromised (Loughran, 1994; Robinson, Culpan & Wiggins, 1999).

Considering the initiative taken by the MRTs in the UK, I feel there is a need to gauge whether MRTs in NZ also have similar interpretation skills that they may have gained as a result of their routine clinical practice. Having personally completed a postgraduate diploma in image interpretation, I had noticed that the standard of my clinical practice had improved enormously. I think it is necessary to determine whether a similar impact occurs for other MRTs as well. Therefore, this thesis attempts to evaluate the changes in the image interpretation accuracy and the clinical

practice of MRTs relative to their postgraduate educational experience in interpreting trauma appendicular images in emergency settings in NZ. Trauma appendicular images have been chosen for this study because this is the specific region that will be covered in the postgraduate programme undertaken by the research participants. There is the possibility that this study may act as a milestone for possible role development in trauma image interpretation for MRTs in NZ in future.

Aim and research question for the investigation

The aim of this study is to evaluate the effect of a postgraduate educational intervention in image interpretation of trauma to the appendicular skeleton on the MRTs' reporting accuracy and clinical practice. The research question that drives my interests is: how do the image interpretation accuracy and the clinical practice of MRTs change relative to their postgraduate educational experience in emergency settings in NZ? To add clarity to the research topic and the aim of the study, the following four key questions have been further derived from the research question and will be addressed in this thesis:

1. How does the accuracy of the MRTs' image interpretation of trauma to the adult appendicular skeleton compare with the gold standard of the radiologists' reports as the MRTs progress in their postgraduate education?
2. Is the clinical practice of the MRTs altered in any way by their postgraduate educational experience?
3. Do the individual circumstances and the characteristics of the MRTs and/or the MRTs' workplace profile and its operational demands have any influence on their image interpretation accuracy and clinical practice as they go through their educational experience?
4. What impact do the academic and clinical components of the postgraduate education have on the image interpretation accuracy and the clinical practice of the MRTs?

Outline of the study

This research was conducted from the beginning of September 2006 to the end of June 2007. A longitudinal case study method was utilized to answer the research question and its related key questions. A mixed method consisting of both quantitative and qualitative techniques was used for data collection. The quantitative

component assessed the changes in the interpretative accuracy of the participating MRTs relative to their postgraduate educational experience. The qualitative component involved questionnaires and interviews to determine the contribution of the educational experience to the interpretative accuracy and the clinical practice of the participants. The questionnaires and interviews were further used to provide the MRTs' personal perspectives about the educational intervention as well as the MRTs' interpretation accuracy and clinical practice relative to their progress. Explanations on the data collection methods are given in Chapter 4.

The participants were selected from a cohort of MRTs undergoing postgraduate education in image interpretation of trauma to the appendicular skeleton at a tertiary institution in NZ from the beginning of semester two, 2006, until the end of semester one, 2007. This institution was not named because the participants can be easily identified due to this being the first time for image interpretation courses to be offered to the NZ based MRTs. As part of the educational experience, the participants learnt about adult and pediatric appendicular skeletal anatomy and how to interpret their trauma images. However, for the purpose of this research, the image interpretations of the adult trauma appendicular skeleton images only were used. Data on the pediatric appendicular skeleton image interpretations were excluded to avoid an inflated false positive rate in the study (Smith & Younger, 2002). This is supported by Orames (1997) who emphasized that pediatric trauma image interpretations can be complicated by the epiphyseal growth plates which can be misinterpreted as abnormalities.

Definitions

While the term MRT is used in NZ, Radiologic Technologist (RT) is used in the United States of America (USA) and Radiographer is used in the UK and Australia. For the purpose of the current study, the term MRT was adopted unless literature from these three nations was directly quoted. To avoid any misconception or ambiguity, the key terms used within the context of this research have the following meanings as defined:

- Accuracy corresponded to the likelihood of agreement with an external standard (Kundel & Polansky, 2003).

- Adult patients were as defined by the protocol of the radiology departments participating in this research and the lower age limit for inclusion in this study was 16 years.
- Appendicular skeleton represented the part of the human skeleton from the shoulder joint to the tip of the fingers and from the pelvis to the tip of the toes (Paterson, Price, Thomas & Nuttall, 2004).
- Clinical practice meant the ability of the MRTs to integrate their theoretical, practical and personal knowledge to adapt to each situation encountered in the clinical setting (Price & Paterson, 2002).
- Conventional images included the x-ray images of adult appendicular trauma patients undergoing general radiography examinations. These images were displayed either as x-ray films or digital images for interpretation.
- Postgraduate education represented the two postgraduate courses offered from semester two, 2006, to semester one, 2007, by a tertiary institution in NZ. One of the courses was academically based while its partner course was clinically based at the participating MRTs' workplace. More details about the two courses are available in Chapter two.
- Role expansion meant the modification of the tasks of the MRTs within the boundaries of their own professional group.
- Role extension meant the blurring of existing professional boundaries to provide opportunities for the MRTs to take up tasks from domains of another group within the medical profession (Hardy & Snaith, 2005).
- Trauma characterized any injury caused by a fall, assault or accident.

Meanings for the other terms used in this thesis can be found in the Glossary.

Structure of the thesis

This thesis has ten chapters. Chapter one introduces the study. Chapter two provides a background to set the scene by explaining the focus of the research as well as the content and requirements of the educational aspect of this thesis. Chapter three gives a review of recent literature related to the current study. Chapter four explains the research procedures, the selection of research participants, ethical issues related to this research, the methods of data collection and analysis adapted for this study and evaluates the research procedure in terms of what worked and did not work. Chapter five displays the results which are explained using quantitative

analysis and thematic content analysis in Chapters six to nine. Chapter ten describes the possible limitations and their implications on the study, the conclusions derived from this research and highlights recommendations for the future or further research.

CHAPTER TWO

Background

Overview

MI is an allied health profession that aids in the diagnosis of diseases or injuries through the use of radiation. In the past two decades, the MI profession has been increasingly used not only to diagnose diseases and injuries but to follow up on the progress of patients as well. For example, if a patient has had a fracture, then he or she will be required to have MI examinations within certain time frames to allow the MD to gauge the degree of healing that is occurring. Further, therapeutic techniques and treatment now play a part in MI as well.

When an imaging examination is requested, it indicates that there is a clinical question present that needs additional information in order for it to be answered (Kenny & Pacey, 2005). It is common for the outcome of the examination to impact on the course of action taken by the referring clinician to treat the patient. Therefore, this chapter looks at the MI profession and its key team members. It also focuses on the workflow common to most MI departments and provides information about the postgraduate education in interpretation of trauma to appendicular skeleton that has been offered to the MRTs in NZ for the first time. It further discusses the significance of the present study.

Medical Imaging team

The two main members in the MI team are radiologists and MRTs (Bentley, 2005). Formal education to qualify as a MRT is commonly spread over a span of three years. In NZ, MRTs are taught to interpret images for quality and basic pathology as part of their three-year degree programme and they gain experience in interpreting images during their clinical practice (Pullen, 2005). This experience in image interpretation is

mostly informal. It involves pattern recognition which is at an intuitive rather than a formal level.

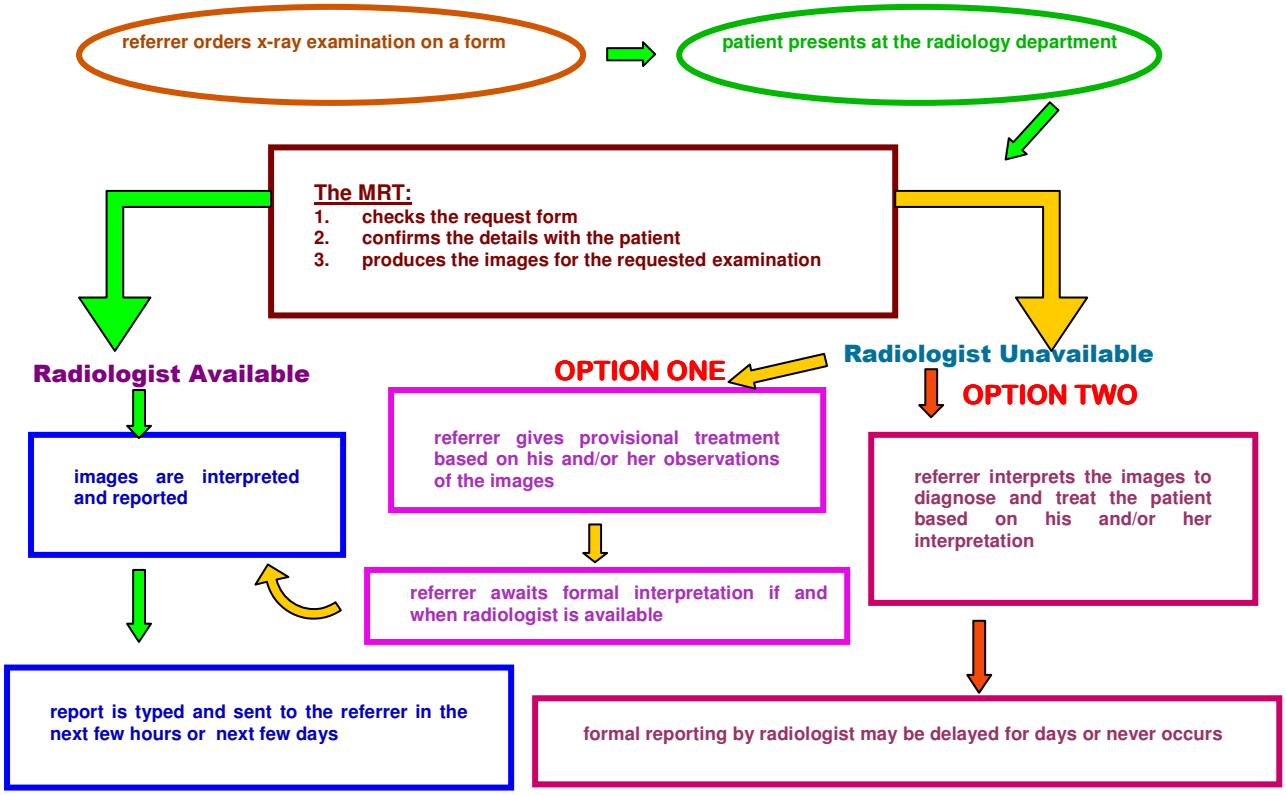
On the other hand, to become a radiologist, the incumbent has to be a qualified doctor and complete at least two years as a junior house surgeon before spending another five years training as a registrar in a radiology department (KiwiCareers, 2004). To practise in NZ, the incumbent has to pass the Royal Australia and New Zealand College of Radiologists (RANZCR) examination or have an overseas qualification (ibid.). Compared to MRTs, radiologists undergo considerably more intensive and comprehensive medical training. The role of the MRT is linked to the operation of MI equipment and the production of images (Smith & Lewis, 2002). It is standard practice for medically trained radiologists to retain the 'ownership' of interpreting images in most MI departments (RANZCR, 2006). They provide a formal radiological report on their observations of the images to the referring clinician, who then decides on the treatment most suitable for the patient. A report contains information such as the clinical details, a description of the findings on the images and a conclusion or interpretation of the findings in the clinical context (Holmes, 2004; Weiner, 2005).

Traditional workflow in MI departments

Despite having someone responsible for providing formal reports for the MI examination, there have been instances when the timeliness of reports has been unacceptable (Hynes, Stevenson & Nahmias, 1997; Swenson & Johnson, 2005). As a result, patient care and management have been affected one way or the other. To explain how the timeliness of reports may be affected, a diagrammatic representation of the workflow common to many MI departments is illustrated in Figure 1. This figure shows that when the radiologist is available, the images are interpreted and the report is sent to the referrer, who is an ED physician or a general practitioner (GP), within a few hours or days. This is in support of the recommendation by the Royal College of Radiologists (cited in McLaughlan, Jones & Guly, 1997) that all x-rays should be reported within three working days. In contrast, McLaughlan et al. (1997) have suggested that all ED images should be reported within 24 hours. This is because the reports will allow the referrer to reassess the condition and provide the best treatment for the diagnosed condition prior to the patient leaving the department (Saketkhoo, Bhargavan, Sunshine & Forman, 2004).

Figure 1 Workflow common to many medical imaging departments

(adapted from Hynes et al., 1997; Swenson & Johnson, 2005)



However, as further illustrated in Figure 1, there can be instances when referrers do not receive the interpretations in a timely manner due to radiologist unavailability (James, Bracegirdle & Yates, 1991; Sunshine, Maynard, Paros & Forman, 2004). Radiologist unavailability can be related to radiologist shortages or no radiologists being on duty over weekends and public holidays (McLaughlan et al., 1997). When such situations occur, the referrer has two options. Option one involves the referrer giving a provisional treatment to the patient and waiting for the formal interpretation from the radiologist if and when it is available. Obtaining a second opinion from the radiologist has been identified as a general approach in EDs by Smith, Temte, Beasley and Mundt (2004) and suggests that the referrer may not be that confident about his/her own interpretations. This implies that when using Option one, there are risks of the referrer having interpretation errors.

On the other hand, option two involves the referrer interpreting the images and treating the patient based on his/her observations. When determining whether adverse patient outcomes might occur if the referrer did not obtain a radiologist's consultation, Smith et al. (2004) found that the concordance rate between the referrer

and the radiologist was 72.5 percent. This finding implies that an error in interpretation of images is prevalent when the interpretations are done by the referrer. Nonetheless, a lack of concordance between the radiologist and the referring doctor could also mean that the radiologist is incorrect. These instances have the potential for drawbacks such as misdiagnosis at the patient's expense (McLaughlan et al., 1997).

There is additional evidence in Figure 1 that hardly any physical contact is made between the patients and the radiologists. It is the MRTs who are in contact with the patients in the MI departments. As part of their work, the MRTs are physically present to check the reason for the x-ray request and produce appropriate images to either confirm or refute the clinical question asked by the referrer. Such routines permit the MRTs to interact with the patients and allow them to obtain mechanism of injury and clinical histories that may be missed by the referrer (Egan & Baird, 2003). As a result of this process, it is likely that the MRTs acquire some skills and attributes in image interpretation.

Postgraduate courses offered to NZ based MRTs

For the first time, two postgraduate courses in image interpretation leading to a formal qualification have been offered at a tertiary institution in New Zealand. These courses focus on image interpretation of trauma to the appendicular skeleton. The two courses run concurrently and are spread over the duration of one year. One of the courses is academically based whilst the other is clinically based. The academic component uses a mixture of web-based and on-campus teaching and learning experiences such as the Blackboard website and lecture blocks. For the clinical component, the MRTs are required to undertake clinical experience under the supervision of a nominated radiologist at their workplace. The designated radiologist acts as a mentor for the MRT throughout the duration of the two courses.

To ensure that the necessary support and resources are readily available to meet the learning outcomes for the two courses, a shared responsibility has been agreed to between the educators, the individual students and their employers. This agreement ascertains that the students are competent to perform their role and acquire the necessary training and experience in image interpretation of trauma to the appendicular skeleton. Reed (2002) promotes this approach since it encourages the reporting skills to be developed in the workplace. He also believes that such

approaches provide an explicit link between the clinical and academic learning to allow the desired competency levels to be accomplished by the MRTs.

A wide range of theoretical and applied topics is covered in the courses. These topics are related to visual perception, image quality, errors in interpretation, bone osteology, appendicular skeleton anatomy and its anatomic variants, types of trauma related injuries, pathology, strategies of referral for advanced imaging, decision-making models, medico-legal issues, trauma management and alternative imaging methods (Yielder & Murphy, 2006). The postgraduate educational intervention aims to achieve two objectives. The first objective is to enable the MRTs to develop an in-depth appreciation of the trauma appendicular skeleton images. It is anticipated that this in-depth appreciation will enhance the professional practice of the students by allowing them to make informed decisions regarding the radiographic interpretation of conventional images. The second objective is to enable the MRTs to provide a verbal radiographic opinion to the referring clinicians (within the codes of professional practice) and prepare them for an image reporting role where that is appropriate in their workplace. This is accomplished by encouraging the MRTs to integrate their previous and newly acquired knowledge and experience so that their critical thinking, reflective and evaluative skills are developed in relation to their clinical practice (ibid.).

Significance of the study

The pursuit of MRT role extension in NZ is slow-starting in comparison to the progress in the UK. This may be associated with the lack of concrete and substantial evidence to indicate whether there is a radiologist shortage or not in NZ. In addition, it is likely that political reasons linked to role extension of MRTs into the professional boundaries of the radiologists in NZ may have caused further delays in its initiation in NZ. Despite these odds, a tertiary institution in NZ has offered the first formal postgraduate education in trauma appendicular image interpretation to the NZ based MRTs. This postgraduate educational intervention and its components form the groundwork of my thesis.

My view, which I would like to advance with this research, is that MRTs in NZ have the potential to interpret trauma appendicular skeleton images to similar standards as radiologists. This has been exhibited by MRT counterparts in the UK who have been actively involved in their role development as a result of a radiologist shortage since the 1990s. One aspect that many of them have ventured into is image interpretation,

especially in EDs. However, prior to being allowed to undertake their role extension activities in trauma image interpretation, most of the MRTs in UK had to take an accredited image interpretation training programme. When the MRTs completed the programme and demonstrated the recommended competency levels to practise, they received certification. This ensured that the quality of the image interpretation service in the UK was not compromised.

In keeping up with the requirements of postgraduate education and continuing professional development (CPD), I feel this may be a good time for NZ to explore the opportunities that were seen to develop in the UK. Similar thoughts have been expressed by McConnell (2005). I believe that by evaluating the image interpretation accuracy and clinical practice of those MRTs pursuing postgraduate education in trauma image interpretation in NZ, awareness about the wealth of knowledge that the MRTs have will be evident. This awareness may eventually lead to the overt recognition of their clinical expertise. In turn, the current research may be useful in facilitating future developments in potential role extension areas such as interpretation of images in EDs by MRTs in NZ. However, I would like to mention that just because role extension for MRTs happened in the UK, does not mean that it will or can follow the same pattern in NZ. The reasons behind my sentiments are related to the differences between these two countries. First of all, NZ has a higher percentage of private radiology in comparison to the UK. Secondly, there are geographically more remote centres in NZ. Thirdly, the culture, expectations and medico-legal issues for MRTs in NZ are based on the traditional roles of the MRTs. It may therefore be a while before the need for role extension of MRTs in trauma image interpretation activities in NZ is realized and accepted.

CHAPTER THREE

Literature review

Overview

The literature review for this study has two purposes. Firstly, it attempts to obtain a better understanding about trauma image interpretation in EDs and the involvement of MRTs in interpreting trauma images. Secondly, it considers the influence of education in image interpretation on the enhancement of the MRTs' clinical practice. The literature search was very successful and yielded over one hundred articles from the UK over the past two decades and about twenty articles from Australia, the USA and NZ. More than half of these articles generally concentrated on the interpretation of trauma images in emergency settings and how professionals other than radiologists could be involved in this interpretation activity. On the other hand, articles on improving clinical practice through education in image interpretation were very limited. Eight themes emerged during the literature review and are discussed comprehensively in this chapter.

Importance of trauma image interpretation in EDs

Trauma cases comprise the highest workload in any ED with MI playing an important role to aid in their diagnosis (Barron & Branfoot, 2003). It has been common practice for traumatized patients to undergo a MI examination as part of the initial evaluation process (Stimac, 1992) with most of these trauma patients undergoing imaging for a single body region (Kundel et al., 2001). As a result, there may be instances when EDs face extreme congestion due to such workload demands (Oliver, 2002). This can lead to long waiting times for non-priority patients which may eventually produce patient dissatisfaction and frustrations (Overton-Brown & Anthony, 1998). If care is not taken, diagnostic errors can and are made (Guly, 2001). A diagnostic error is "a diagnosis that could have been made in the Accident & Emergency department but was not made until after the patient left A&E" (Guly, 2001, p.263). This definition of

diagnostic error indicates that the value of the MI examination depends on the ability of the clinician to identify and accurately recognize the presence or absence of any abnormality on the image prior to the patient leaving the ED (Hardy & Barrett, 2004).

Using a variety of data collection approaches, Guly (2001) determined the number of diagnostic errors occurring in a busy ED in UK over a four year period. He found a total of 953 diagnostic errors during the study period. Of those 953 errors, 79.9 percent were missed fractures in trauma patients. Misreading of images was found to be the most common reason contributing towards this high rate. Other studies have also confirmed that misreading of images is a source of diagnostic errors during image interpretation (for example, Seltzer, Hessel, Herman, Swennson & Sheriff, 1981; Beggs & Davidson, 1990; James et al., 1991; Smith et al., 2004). In the medical setting, attempts must be made to avoid the diagnostic errors mentioned earlier from occurring, the reason being that no matter how trivial an error might be it will have an impact on the approach adapted for treating the patient (de Lacey, Barker, Harper & Wignall, 1980; Carew-McColl, 1983; Smith & Younger, 2002). Errors can lead to litigation in some instances (Hardy & Barrett, 2004).

To rectify the problem of diagnostic errors, Guly (2001) suggested that trauma images be reported immediately by radiology departments. However, despite sounding so appealing, it is not practical to adopt this proposal if only radiologists are doing the reporting. One reason is that there is a worldwide shortage of radiologists (Decker & Iphofen, 2005). A second reason implies that some of the radiologists consider trauma image reporting a time-consuming and a generally unpopular activity (Fielding, 1990; Benger & Lyburn, 2003). A third reason is linked to the shift in the traditional role of radiologists into interventional procedures such as neurosurgery (Alderson, 2000).

Radiologist shortage

Although interpretation of the images is considered the primary domain of radiologists (Rogers, 2003), recent advances in MI technology have inspired many radiologists to perform more sophisticated tasks such as neurosurgery, endoscopy and so on (Alderson, 2000). The consequence of this progress by radiologists is that most MI departments are unable to report all their examinations in a timely manner. Nightingale and Hogg (2003) have drawn attention to the issue of the formal interpretation being delayed for days or never occurring. Further, Dawood (cited in

Saxton, 1992) has questioned the medicolegal aspect of not reporting the images by pointing out that "without a report no one has made a formal record of the findings and this is just like examining a patient but making no record in the notes" (p. 1). Weiner (2005) also emphasized that patient care can be negatively impacted if a proper report is unavailable.

Usually, the radiologists are available to interpret and provide official reports on the images during routine working hours on weekdays in most MI departments (Tidey, 2005). During the weekends and after hours on weekdays, some of the MI departments, especially those in the rural settings, do not have radiologists available on-site to interpret the images (Jones, O'Donnell & Stuckey, 2000). This can have an impact on the quality of care provided to patients referred for x-ray examinations at those centres (Smith & Lewis, 2002). Chan and Gunderman (2005) have highlighted that a clinically oriented MI department will attempt to shorten the time from initial request for imaging to the transmission of the radiological report to the referrer. This is supported by a longitudinal study which attempted to reduce image interpretation errors by the ED physicians at a hospital in the USA (Epinosa & Nolan, 2000). The researchers introduced a system whereby the radiologists at the hospital in the study were required to interpret the ED images within twelve hours. This encouraged a reduction in the time spent waiting for a formal report and also acted as a quality control in reducing interpretation errors. For similar reasons to Epinosa and Nolan (2000), the Audit Commission (1995) in the UK recommended that basic examinations should be reported prior to the patient leaving the department. However, further exploration of the clinical consequences of absent or delayed reports may be needed through future research in order to make an informed decision on the contribution of the timeliness of reports towards patient management.

When the radiologist shortage and its effects on the timeliness of reports were experienced in the UK in the 1990s, the radiologists in some institutions delegated certain aspects of image reporting to the MRTs (Price, Miller & Mellor, 2002; Nightingale & Hogg, 2003; Price & Le Masurier, 2005). These delegated aspects included ED trauma image interpretation, barium enema, urography and mammography reporting (Palma, 2006). In NZ, there is a paucity of published evidence available to indicate whether or not there is a radiologist shortage. It is interesting to note that the radiologist and the MRT professions have been designated as a long-term skilled shortage by the NZ Visa Bureau (2006). The long-term skilled shortage is defined as a sustained and ongoing shortage of skilled workers (Haig,

personal communication, June 16, 2006). A workforce survey by the RANZCR (2004) revealed that 71.5 percent of the participating radiologists felt that there is a shortage of radiologists in NZ. Further, it has been highlighted that the number of NZ graduate radiologists going overseas is quite high (KiwiCareers, 2006). In its health strategies, NZ First (2006) planned to increase the number of places available for NZ students in areas of need such as radiologists. However, as suggested by Bhargavan, Sunshine and Schepps (2002), more research is needed to assess whether these indications are merely a short-term fluctuation or a long-term imbalance.

There have been press releases as well that focus on the subject of shortage of radiologists and MRTs in NZ (McConnell, 2005). On 1st September, 2006, there was an article about the Hawke's Bay District Health Board (DHB) using teleradiology to have its images reported due to a shortage of radiologists in their hospital (Johnston, 2006). This meant that the radiology services were outsourced to overseas radiologists over the internet. Since most of the radiologists involved in this scheme were actually based in countries such as Lebanon, Pakistan and India, questions were raised about their credentials (Hawke's Bay Today, 2006). Although teleradiology enables the reports to be available almost immediately after the examinations, it has certain disadvantages such as medical registration of the reporting radiologists, liability in cases of misdiagnosis, medical confidentiality of the patient, patient consent since information is transferred via the internet and the impact on local radiology services (Cheng & Ng, 2006). Currently, the Medical Council in NZ has accepted the use of overseas radiologists as a short-term solution (Hawke's Bay Today, 2006). However, to safeguard the patients, it may be imperative for this professional body to consider safer and more economical alternatives that may be available within NZ. A lesson could be learnt from the UK where, due to the radiologist shortage appropriately trained MRTs were delegated the responsibility to report trauma images of ED patients (Hardy & Snaith, 2005).

The radiologist to population ratio (RPR) for the UK where role extension for MRTs originated was 1:32,258 in 1991 and indicated a shortage of radiologists (Donovan & Manning, 2006). In Canada, the recommended RPR is 1:13,000 and a ratio of 1:16,763 in 1998 suggested there was a shortage of radiologists during that year (Sibbald, 1999). According to the 2004 RANZCR workforce report for NZ, 241 radiologists were listed in the RANZCR's database. In the same year, the NZ population was estimated to be 4,084,200 (Statistics New Zealand Te Tari Tatau, 2006). Using the previously mentioned data for 2004, it was revealed that a RPR of

1:16947 existed for NZ in 2004. Although there are no established universal criteria available for the required RPR, the Canadian RPR may be used as a benchmark for NZ to infer that there is probably a radiologist shortage in NZ as well.

Regional analysis has revealed that the radiologist profession in NZ is a floating workforce (Le Claire, personal communication, June 17, 2006). This means that most radiologists work in both private clinics and public hospitals, with many of them travelling within and across the region to fulfil their image interpretation and reporting responsibilities (Christchurch Radiology Group, 2006). It has been acknowledged that the concept of sharing staff radiologists in NZ initiated from the scarcity and resultant competition for radiologists (ibid.). McConnell (2005) has contemplated that such actions may result in the "creation of waiting lists in the public sector in NZ and raise suspicion that the taxpayer may be paying twice for the service that could have been delivered with the correct investment in the public sector" (p.2). In addition, most of the NZ radiologists work an average of 44 hours per week (RANZCR, 2004). Continuation of such trends associated with the pressures of increasing radiologist workloads may result in unbalanced lives and the possibility of burnout (Chan & Gunderman, 2005). Eventually, there is a risk of encountering higher diagnostic error levels during image interpretation (Nightingale & Hogg, 2003). This can result in litigations similar to those mentioned by the American Roentgen Ray Society, ARRS (cited in Jones, 2002). As a solution, Oakley (2001) has suggested the use of MRTs to provide "an experienced and knowledgeable pair of eyes to prevent misdiagnosis" (p.20).

Interpretation of trauma images by non-radiologists

It is often stipulated that a medical background is necessary for appropriate patient care (Cunningham, 1997; Tennant, 2000; Royal College of Radiologists, 2006). It is quite common for the ED physicians to initially interpret the trauma images and make decisions based on their interpretations in the absence of a radiologist (Guly, 2001; Benger & Lyburn, 2003). The accuracy of such interpretations is questionable since many junior doctors have admitted facing embarrassment when interpreting images that they requested, especially when help in interpretation was not readily available (Carew-McColl, 1983). If the physician is either new to the profession or not well-versed in the arena of image interpretation, the likelihood of diagnostic errors is increased (Hardy & Barrett, 2004). This is because the actions of these physicians will be based on trial and error most of the time (ibid.).

Despite many ED physicians finding trauma image interpretation demanding, a limited number of studies have actually tried to assess their accuracy in interpreting trauma images. One aspect of such a study in the USA did compare the interpretations of ED physicians with radiologists (Eng et al., 2000). This study involved eight ED physicians and eight radiologists with experience ranging from two to twenty eight years to interpret a case set of 120 images of the peripheral skeleton, axial skeleton, chest and abdomen. Based on the speciality and level of training, the 16 participants were grouped into two, resulting in eight subgroups. The accuracy of image interpretation for the eight subgroups was measured as the area under the receiver operating curve (ROC). It was observed that the area under the curve was 0.15 times greater for the radiologists than for the ED physicians. This finding indicated that the ED physicians were less accurate in comparison to the radiologists. However, the data analysis adopted for the study was questionable. Though grouping into twos simplified the analysis, it assumed that the two participants that were grouped together had the same level of performance. This might not have been the case since each participant would have had different experiences during their training (Rosen et al., 1999). Thus, there may have been variations in the accuracy with which the images were interpreted by each individual.

Apart from physicians, nurses have also been given the opportunity to interpret trauma images as they triage with ED clinicians to treat the patients (Hardy & Barrett, 2004; RANZCR, 2005). Such professionals are called nurse practitioners (NP). A study at an ED in the UK attempted to assess the accuracy of the initial interpretations of trauma images by four NPs working in that department (Benger, 2002). To determine their interpretation errors, the NPs' interpretations were compared with those of the two ED physicians who had seen the patient and the final report by the radiologist. The results revealed that the NPs had incorrectly interpreted 10.7 percent of the total 300 images that were considered. Analysis of the inaccurate interpretations revealed that there were 26 false positives, four false negatives and two cases where the NPs observed an abnormality but failed to correctly identify it. These findings imply that the interpretative accuracy of NPs is lower than those of ED physicians and radiologists.

Further efforts were made to compare the interpretative abilities of ED physicians and NPs with each other (Overton-Brown & Anthony, 1998). A total of seven NPs and seven ED physicians in a hospital in the UK were recruited to interpret 50

extremity trauma images. Their reports were compared against the gold standard of the radiologists' reports and the study disclosed an accuracy of 79.9 and 75.6 percent for the NPs and ED physicians respectively. From this finding, it was concluded that both the NPs and the ED physicians had similar interpretative abilities. However, the researchers overlooked the fact that in both groups, there was an inaccuracy rate of 20.3 and 24.4 percent respectively. These rates could be attributed to the fact that both professionals are specifically trained in terms of patient care and neither of them have adequate education or training in image interpretation compared to the MRTs (Meek, Kendall, Porter & Freij, 1998; Donovan & Manning, 2006). Simms and Fought (1989) and Guly (2001) have also expressed this opinion.

It has been suggested that "expertise and knowledge can only be gained by direct encounter with an event" (Benner cited in Overton-Brown & Anthony, 1998, p. 895). Researchers such as Pearson (2001) and Sonnex, Tasker and Coulden (2001) had similar sentiments. They articulated that MRTs have adequate experience and potential in image interpretation as a result of their routine work involving the production of images of patients. However, this experience in image interpretation may not be sufficient for MRTs to explicitly verbalise or report the findings on the images. In other words, MRTs may need further education and training in image interpretation to enhance their familiarity in pattern recognition developed relative to their work experience.

The views expressed previously have been confirmed by an internal audit that compared the diagnostic accuracy of the different professionals involved in trauma image interpretation at a UK based hospital (Tidey, personal communication, October 10, 2006). This audit was conducted by Tidey in 2001 (ibid.) on three consultant radiologists, one registrar radiologist, four ED physicians, four MRTs with postgraduate qualifications in reporting, three senior MRTs, six MRTs and four NPs. The 25 participants interpreted a film quiz comprised of fifty appendicular skeleton images. The outcome indicated average accuracy scores of 68 percent for the consultant radiologists and 60 percent for the registrar radiologist. Tidey (ibid.) attributed the low percentage observed in the radiologists to the fact that they see less appendicular trauma since the MRTs took on that workload. Concurrently, an average accuracy score of 77.5, 65.3, 58, 55 and 48 percent were established for the reporting MRTs, the senior MRTs, the MRTs, the NPs and the ED physicians respectively. The conclusion drawn was that the MRTs, particularly "those with appropriate postgraduate training in reporting appendicular trauma, are better

equipped than other professions to offer a more accurate opinion and are the best group to be taking on the work" (p.3).

Notably, the potential of MRTs in pattern recognition was acknowledged over three decades ago by Swinburne (1971), a radiologist in the UK. He proposed that MRTs could be taught to recognize the difference between a normal and an abnormal image. However, many radiologists opposed Swinburne's recommendation because they felt that if radiologists reported the images, the best interests of the patients would be safeguarded (Rudd, 2003). Though opposition was upheld by many radiologists, the pressures related to radiologist shortage acted as an impetus for MRTs in the UK to pursue trauma image interpretation activities in the 1990s (Tilson & Dowd, 1997; Woodford, 2005). As a result, the scope of radiography practice changed considerably and improved the efficiency and quality of patient care in the UK (Hogg & Hogg, 2003). Currently, the College of Radiographers (CoR) has the view that "Reporting by radiographers is not an option for the future, it is a requirement" (cited in Paterson et al., 2004, p. 205).

Involvement and performance of MRTs in image interpretation

Previous work (for example, Bowman, 1991; McConnell & Webster, 2000; MacKay, 2006) has revealed an informal involvement of MRTs in image interpretation known as the Red Dot System (RDS). Two MRTs in the UK initiated this system when an obvious fracture was missed in the ED and the patient was discharged without treatment (Field-Boden, 1997). The RDS is "a system by which the radiographer indicates the presence of a radiological abnormality to the referring clinician in A&E" (Hayes, 2002, p. 17). If there is any abnormality suspected, the radiographer places a red dot sticker on the image (Hall, Kleeman & Egan, 1999). The results of studies by Cheyne, Field-Boden, Wilson and Hall (1987) and Bowman (1991) stress the advantage of such a system in the UK and Australia. Although Tauranga Public Hospital (Tidey, 2005) and other hospitals in NZ (Jesson, 1997; Gould, 2005) have been using this system for trauma images, nothing has been published about its success or failure. It was noted that the introduction of the computed radiography (CR) system at the Middlemore Hospital in NZ subsequently resulted in the discontinuation of the usage of the RDS there (Tunbridge, 2001). The reason given was that any changes made in the CR image will be permanent, therefore raising concerns in the event of a false positive (ibid.).

Unfortunately, the RDS supports abnormality recognition on images but disallows any formal interpretation by the MRTs, thus, the abnormality indicated by the MRT is merely an opinion and not a definitive diagnosis. This means that there is no medico-legal responsibility on the MRT. In other words, ED is still responsible for medico-legal issues that may arise from the use of the RDS. As pointed out by Robinson, Wilson, Coral, Murphy and Verow (1999), an "opinion admits that doubt exists" (p. 326). Based on this, ED physicians may dismiss the MRTs' informal signal which then leads back to the issue of diagnostic errors. Although the presence of a red dot indicates abnormality, its absence hints at either normality or non-participation by MRTs (Hardy & Culpan, 2005). Hence, it is possible that the latter may send mixed signals to the ED physicians. Once again repercussions such as diagnostic errors may result if the physicians have difficulty interpreting the trauma images.

In consideration of the drawbacks related to the RDS, proposals have been made for the utilization of a commenting system that would encourage the MRTs to interpret images (Snaith, 2005; Tidey, 2005; Hardy, 2005). Such a system would enable the MRTs to identify any abnormality on the image by ticking appropriate boxes on a form and describing its appearance. Smith and Younger (2002) have tested this system in Australia for a period of three months by using a radiographer opinion form as the data collection instrument. They compared the participating MRT's comments against the radiologists' reports to determine the MRT's accuracy, specificity and sensitivity. Their study revealed that the 26 MRTs who had participated had an overall accuracy of 93 percent. These values are significantly higher than those demonstrated by the NPs and ED physicians in the studies mentioned in the earlier sections, thus suggesting that MRTs are better in image interpretation tasks in comparison to these two professional groups.

Despite Smith and Younger (2002) showing that high levels of accuracy can be attained by the MRTs participating in commenting systems, it is arguable that a commenting system is just a modification and progression of the RDS. Due to this feature of the commenting system, the MRT's comments are still considered as an informal signal by the ED physicians (Bowman, 1991). This results in wastage of such a wealth of proficient knowledge that can be usefully tapped to reduce diagnostic errors and to provide appropriate patient care (Pearson, 2001). The best way to overcome this situation is to encourage MRTs to be more formally involved in

image interpretation, especially in ED (Saxton, 1992), which has long been the case for many MRTs in the UK (Chapman, 1997).

Role extension in image interpretation by MRTs

Role extension involves "the carrying out of tasks not included in the normal training for registration so that one professional may take up a role or duty traditionally carried out by another healthcare professional" (White & McKay, 2004, p. 219). Researchers like Yielder (2004) have advocated that MRTs are in a better position than other healthcare professionals to fulfill an extended role such as image interpretation. This is because MRTs "have a much greater experience of viewing radiographs than others" (Hargreaves & Mackay, 2003, p. 284). Such experience is acquired during the MRT's three year training period (ibid.). This experience is also gained during the MRT's routine work where they assess the images for quality and normality (Oakley, 2001). As a result, the MRTs learn to recognize patterns on the images that aid them in making decisions for further views to detect presence of abnormality (ibid.).

Dixon (2006) pointed out that continuing professional development requirements for MI professionals in the UK have resulted in the traditional role of the MRT being redefined to allow for role extension. Pullen (2005) has expressed that similar approaches may need to be taken in the NZ context. However, being a new phenomenon for the radiologists and MRTs in NZ, image interpretation as a potential area of role extension may raise issues of "hostility from some and reservations from many in both professions" (Cunningham, 1997, p. 874). An example is a letter to the editor of the Australasian Journal where a radiologist expressed the view that RANZCR should not let issues related to possible radiologist shortages in Australia and NZ trigger deals to allow non-radiologists to share the radiological workload currently performed by radiologists (Hare, 2003).

According to Williams (1996), role extension is a very challenging issue for three reasons. Firstly, it questions where the boundaries should be. Secondly, it requires a definition of the core skills required to perform the delegated task. Thirdly, it inevitably brings with it the issue of recognition which is partly related to the salary and work conditions. This is supported by Price (2005) who has indicated that when it comes to role delegation, the radiologists will carefully consider the situation in terms of reduction in income for themselves. In addition, those MRTs who intend to pursue

role extension in image interpretation activities may anticipate having some changes to their salary.

To aid the role extension of MRTs in image interpretation in the UK, a four tier system has been adopted. The system is a career development strategy for MRTs and represents grading structures and working incentives for MRTs at the assistant, registered, advanced and consultant practitioner levels (Dixon, 2006). This grading system is used to carefully map the skills of MRTs so that they are rewarded for what they actually do for their clinical practice (Nightingale & Hogg, 2003). The information about the grading structures in the UK suggest that despite being a difficult process, role extension and the changes associated with it can be facilitated if the professions involved share a compelling vision for the future (Swenson & Johnson, 2005). Role extension for MRTs and its implementation is an area that possibly requires further investigation in the NZ context.

Competency levels and accountability issues

Prior to progressively venturing into reporting roles, MRTs in the UK had to exhibit expected competency levels (Parkinson, 1994). There are three plausible justifications for having such requirements. First of all, it ensures that the MRTs are capable of undertaking the delegated task (Brindle, 1996). Secondly, it encourages the MRTs to provide the referrer with the "highest level of opinion, advice and wisdom related to their specialty" (Manning & Bentley, 2003, p. 4). Finally, it allows the MRTs to provide accurate and useful information that will enhance appropriate patient care and management by the referrer (Smith & Younger, 2002).

Competency in image interpretation can be defined as the demonstration of superior performance in a delegated task (Chan & Gunderman, 2005). In previous studies, levels of accuracy attained by the MRTs in comparison to the radiologists have been used as hallmarks to measure the competency of MRTs (for example, Robinson, 1996; Robinson et al., 1999; Hall et al., 1999; Pearson, 2001; Brealey et al., 2005; Littlefair, 2006). Several studies on image interpretation by MRTs have further emphasized that the MRTs need to have accuracy levels of 90 percent or more to allow them to do formal reporting of trauma images (for example, Carter & Manning, 1999; Hardy & Barrett, 2003; Piper, Paterson & Godfrey, 2005; Tidey, 2005; MacKay, 2006). This range of accuracy is considered acceptable because for most of the ED imaging cases, the experts agree approximately 90 percent or more of the time

(Williams & Berry, 1999; Kundel et al., 2001). White and McKay (2004) have concluded that the competency levels accomplished by the MRTs can play an integral part in the transition towards the acceptance of role extension activities for MRTs, especially in trauma reporting.

Williams (1996) wrote that the attitude about proper delegation amongst professional bodies such as the RCR in the UK is that it should be "planned, agreed and monitored" (p. 887). The RCR has also advocated for proper delegation to be medico-legally sound in terms of accountability; which comprises of a 'tripartite nature' of responsibilities and agreements (ibid.). This tripartite nature of accountability revolves around the professional, legal and managerial aspects of delegation (Brindle, 1996). Watt (cited in Williams, 1996) has further explained that the triple characteristics of accountability involve the viewpoint of the reporting MRT, the delegating radiologist and the health board. As discussed by Watt (ibid.), due to being responsible for their actions, the MRTs need to obtain a clarification regarding their delegated responsibilities from their professional bodies. He continued that the medical responsibility lay with the delegating radiologist and the referrer whilst the responsibility related to the risks involved in the delegated task lay with the health board. Similar views have also been communicated by Forsyth and Robertson (2005) from the perspective of radiologists in Scotland.

Impact of appropriate training and education

Evidence suggests that the UK-based MRTs undertaking image interpretation activities have been supported by postgraduate education and their professional body policy to allow them to successfully perform in this role extension activity (McConnell & Thompson, 2006). Likewise, Hardy and Barrett (2004) have ascertained that the "predominant training/education strategy to support radiographers undertaking radiographic image interpretation is postgraduate education" (p. 659). This strategy is also encouraged by researchers such as Hardy (2005), Snaith (2005) and Oakley (2001) who have recommended that MRTs should undergo some form of training prior to engaging in image interpretation. Further, Saxton (1997) and White and McKay (2002) have expressed that MRT reporting can be achieved through carefully designed and controlled educational and training programmes. Adopting this approach improves the performance of the MRTs by familiarizing them with normal variants, search strategies and report writing (Carter & Manning, 1999).

To show that they are competent in their image interpretation skills, there is a recommendation that MRTs undertaking reporting roles in the UK demonstrate an acceptable accuracy of greater than 90 percent (Kundel et al., 2001). This recommendation has been strongly supported by Brealey (2001) who felt that such actions will not only reduce the likelihood of unnecessary investigations and treatments but also avoid extra costs to the patient and the healthcare system. However, Cowell (2002) has expressed that the extent to which the image interpretation skills are developed by the MRTs depends on their level of competence, depth of experience, degree of responsibility and type of workplace.

In consideration of all the points mentioned previously, the curriculum content of six institutions in the UK offering higher education in radiographic reporting was analyzed by Prime et al. (1999). Assessment of competence emerged as a vital component in all of the six programmes that were reviewed. The analysis also revealed that by focusing on experiential learning and explicitly linking the clinical and the academic learning to each other, it was possible to attain the desired competency levels. It further suggested that experiential learning can be supported at the workplace if the fundamental importance of the inter-relationship of the roles of radiologists and MRTs was demonstrated. Prime et al. (1999) concluded that development of reporting courses should involve collaboration between the academic and the clinical sites with an emphasis placed on teamwork.

Another study in the UK concluded that by monitoring procedures, the effect of training and experience over time can be demonstrated and the activities that raise competency levels can be highlighted (Carter & Manning, 1999). It involved a case study of a MRT undergoing a postgraduate reporting course. The study revealed that the MRT's sensitivity improved during the training period, although the 100 percent sensitivity rate was not fully maintained. It further showed that the MRT's specificity improved from 88 to 100 percent from week one to week three and accuracy changed from 88.7 to 100 percent from week one to week four. In comparison, Loughran (1994) determined the influence of a six-month period of tutorials on the image interpretation of three MRTs at an ED in the UK. His study revealed that the specificity improved from 94.4 to 96.6 percent. Moreover, the sensitivity for fracture detection improved from 81 percent at the beginning of the trial to 95.9 percent at the end of the trial. These findings indicate that the performance of

MRTs in trauma image interpretation can improve significantly if they undergo a period of appropriate training and supervision.

A further study assessed the impact of training on the image interpretation of 28 MRTs (Piper et al., 2005). These MRTs were selected from three cohorts who had successfully completed a postgraduate qualification in clinical reporting of the appendicular and the axial skeleton from 1995 to 1997 at a university in the UK. The MRTs reported a bank of 6,796 cases and described the appearance and suggested pathology where applicable in a free text hand-written report. The mean sensitivity, specificity and accuracy scores attained by the participants were 92.9, 93.1 and 92.3 percent respectively. This led the researchers to conclude that with appropriate training, MRTs can provide accurate reports on trauma examinations that are comparable to radiologists.

The significance of undergoing postgraduate education in image interpretation was acknowledged by a MRT in Canada (Murray, 2005). Murray (2005) who learnt image interpretation through distance-learning expressed that despite working in a trauma centre for 18 years, his educational experience made him realize that he did not know as much as he had thought he knew about looking at images initially. Murray continued that his postgraduate educational experience in reporting images had provided him with a new perspective on observing the images and he was able to understand the images in a manner that he had not done so previously. Likewise, Reeves (2004), a MRT in the UK, found that her formal education in trauma reporting made her aware of how her FP scores were influenced by her inability to recognize the extent of normal anatomy. She further acknowledged that her error rates reduced greatly due to her educational intervention. However, no published literature on postgraduate education in image interpretation in NZ is available since it has not been taught in this country before.

A study investigating the need for reporting MRTs in EDs in NZ did note that 59 percent of the participants were interested in doing an image reporting postgraduate diploma (Hewitt, 2004). This finding is indicative that there is interest by many of the MRTs in NZ to pursue further education in image interpretation. In addition, McConnell and Thompson (2006) established the benefit of the introduction of a two-day course on conventional image pattern recognition and abnormality detection for the MRTs in NZ. They found that at the end of the course when the participants re-attempted an image highlighting test that they had sat at the onset of the course,

many of them searched for patterns that they had not looked for previously. Upon returning to their workplace, the majority of the participants indicated that their level of confidence in image interpretation had increased as a result of what they had learnt during the course. This particular course justifies the recommendation by Pullen (2005) that with appropriate education and training, MRTs in NZ have the potential to interpret conventional images. As suggested by McConnell (2005), this is most probably a good time for NZ "to explore the opportunities that were seen to develop in the UK" (p. 2). This suggestion supports Price (2005) who contemplated that if MRTs in the UK had not shown potential then developments in image interpretation would never have been adopted and progressed to the extent they have in the UK.

Clinical practice of MRTs

Within the MI profession, the primary role of the MRT is to "produce high quality diagnostic images with due consideration of the needs of the patient" (Williams & Berry, 1999, p. 231). This role places MRTs at an interface between patients and technology during their clinical practice (ibid.). These insights point out that during their clinical practice, the MRTs undertaking the examinations formally or informally contribute towards the images and their final reports (Booth & Mannion, 2005). Since it is the images that convey messages regarding the suspected condition of the patient (Rogers, 2003), it becomes imperative that the MRTs enhance their clinical practice (Casanas & Coello, 2005). Clinical practice refers to the ability of the MRTs to integrate their theoretical, practical and personal knowledge to adapt to each situation encountered in the clinical setting (Price & Paterson, 2002).

In research regarding radiographic practice, Egan and Baird (2003) found that the MRTs' opinion on what it is they do crucially shapes the final image they produce. As a result, they attributed the use of appropriate radiographic techniques, confidence to perform extra projections and ability to determine the patient's cooperation capability as paramount characteristics of clinical practice. They have even suggested that clinical practice traits which enable the MRTs to obtain good quality images can be enhanced with appropriate formal education. This is supported by White and McKay (2002) who have talked about the "need to align clinical skills and achievements with more theoretical endeavours" (p. 224). Read (cited in Hardy & Snaith, 2005) has defended the idea of enhancing clinical practice through professional academic progression by explaining that the clinical practice of MRTs is strongly related to a

high level of clinical decision making for a distinct patient caseload instead of the performance of highly technical procedures. There is also agreement by Smith and Lewis (2002) who have expressed the necessity for MRTs to improve their decision making skills during their clinical practice. Such attempts by the MRTs will make them more aware of the importance of answering the clinical question rather than merely taking an image of the anatomical region under examination (Smith & Younger, 2002).

Attention has also been drawn to the relationship between educational interventions and their influence on those who undertake these interventions. Chan and Gunderman (2005) have announced that the "success of an educational intervention is related to the change in knowledge, attitudes, and behavior inculcated in the learners" (p. 432). Equally, Hardy and Snaith (2005) have questioned the focus of many postgraduate courses offering advanced clinical practice for MRTs in the UK. They have pointed out that the courses offered mostly "teach the acquisition of skills that support role extension but do not explore the innovative development and application of these skills" during the MRTs' clinical practice (p. 4). The sentiment of Hardy and Snaith (2005) is supported by many of the studies that have evaluated the interpretation accuracy of MRTs (for example, Loughran, 1994; Robinson, 1996; Robinson et al., 1999; Piper et al., 2005; Mackay, 2006). These studies have provided quantitative values for the MRTs' image interpretation accuracy relative to appropriate education and training, but this approach has often left unanswered the effect of such educational experiences on the clinical practice of the MRTs. Clearly, this is a matter that requires further consideration through appropriate research.

Summary

This review revealed that although a lot of literature exists related to trauma image interpretation in EDs, there is very little when it comes to literature related to change in the clinical practice of MRTs relative to their education in trauma reporting. Nonetheless, the literature that was available has indicated that appropriate education can influence the clinical practice of MRTs one way or the other. In addition, it was stated that accurate interpretation of ED trauma images is needed prior to the patient leaving the ED. By doing so, the chances that the patient will be correctly managed and treated by the referrer will be enhanced. However, as a result of the radiologist shortage, many MI departments have not been able to provide reports in a timely manner. This has resulted in other healthcare professionals such as ED doctors,

nurses and MRTs analyzing and interpreting the ED images. Evidence from the literature has indicated that the image interpretation performance of the ED physicians and NPs is outweighed by the MRTs. This is mainly because the MRTs' routine work places them in a better position to identify normal and abnormal appearances on most of the images that they produce.

There was further indication in the literature that the involvement of MRTs in image interpretation has undergone dynamic changes. Commencing as a RDS, it has developed into commenting systems in some places such as the UK and even NZ. Due to voluntary participation by the MRTs and the informal nature of the RDS as well as the commenting system, there has been a tendency for many ED physicians to disregard the MRTs' signals. To combat this drawback and to alleviate issues related to the radiologist shortage, formal interpretation of images by MRTs has been successfully adopted by the MRT counterparts in the UK. However, prior to being allowed to undertake their role extension activities in trauma image interpretation, most of the MRTs in the UK had to enroll in accredited image interpretation training programmes. When these MRTs completed the programme and demonstrated the recommended competency levels to practise, they received certification. This ensured that the quality of the image interpretation service in the UK was not compromised. In addition to appropriate training and education, the transition of the MRT counterparts in the UK to interpret images was facilitated through support from their professional bodies.

Most of the literature that was reviewed confirmed that appropriately trained and educated MRTs have image interpretation competencies that are on par with those of the radiologists. Some of this literature further suggested that such interventions may have the possibility to enhance the clinical practice of the MRTs as well. However, no proven data was available to reveal how this could be achieved. Thus, to build upon the knowledge gathered by previous studies in the UK, Australia and the USA and to gauge its applicability in the NZ context, this thesis will attempt to evaluate the changes that occur in the image interpretation accuracy and the clinical practice of MRTs relative to their postgraduate educational experience in emergency settings in NZ.

CHAPTER FOUR

Research Procedures

Overview

This chapter provides a description of the different aspects of the research process for this thesis. This has been done to enable me to attend to issues and concerns related to the research procedures so that any expected obstacles can be overcome and the study can attain its full potential (Bell, 1999). To accomplish this, the chapter considers the research method that has been adopted to conduct this study. In addition, it describes the methods of data collection that have been utilized to obtain information to provide answers to the research question and its derived key questions that were discussed in an earlier chapter. This chapter also includes an explanation about the selection method that has been used to determine the sample size and considers the ethical issues that may probably be encountered as well as acknowledges ways of addressing them. Further, it enlightens about the approach that has been taken to analyze the data and the chapter finalizes with an evaluation of the research procedures.

Research methods

Since the research method is a strategy that provides specific direction for the actual research plan to guide the research procedures (Beyea & Nicoll, 1997; Creswell cited in Jones, Torres & Arminio, 2006), the case study approach was used as the research method for this thesis. The case study method was relevant to this study for the two reasons given by Yin (2002). Firstly, this investigation involved a 'how' question to answer a phenomenon in a real-life situation. Secondly, as a result of being the principal researcher, I had minimal control over the activities that were being evaluated. The 'how' question in this case was the research question which was discussed earlier in Chapter One. The phenomenon involved the interpretation of trauma images of appendicular skeleton by a group of MRTs relative to their

educational experience. The real-life situation was that these MRTs interpreted the trauma images at their various workplaces during their clinical practice.

The case study was conducted longitudinally, that is, over a ten month period as illustrated in Figure 2, page 32. This was done to allow the comparison of data amongst the participants at intervals during the study so that any inter-individual and intra-individual changes that may have occurred in the participants relative to their educational intervention could be assessed. However, the longitudinal approach presented as a time and resource consuming task (King, 2001). As the principal researcher, I was actively involved in the implementation of the case study method and the collection as well as analysis of the data. This approach allowed me to focus on the process rather than the outcome by using the explanatory nature of the case study method to trace the operational links over time (Burns, 1997). Through this approach, I hoped to gain "in-depth understanding replete with meaning for the subject" (ibid. p. 365). Furthermore, this method allowed me to use a range of different kinds of evidence to answer the specific research question (Gillham, 2001) and enabled me to extend the experience and add strength to what is already known through previous research (Soy, 1997) on the topic. When using the case study method, I encountered other benefits and limitations as well. Those specific to this research are given in Table 1 below.

Table 1 Benefits and limitations of the case study method

(adapted from Soy, 1997; Burns, 1997; Gillham, 2001; Yin, 2002)

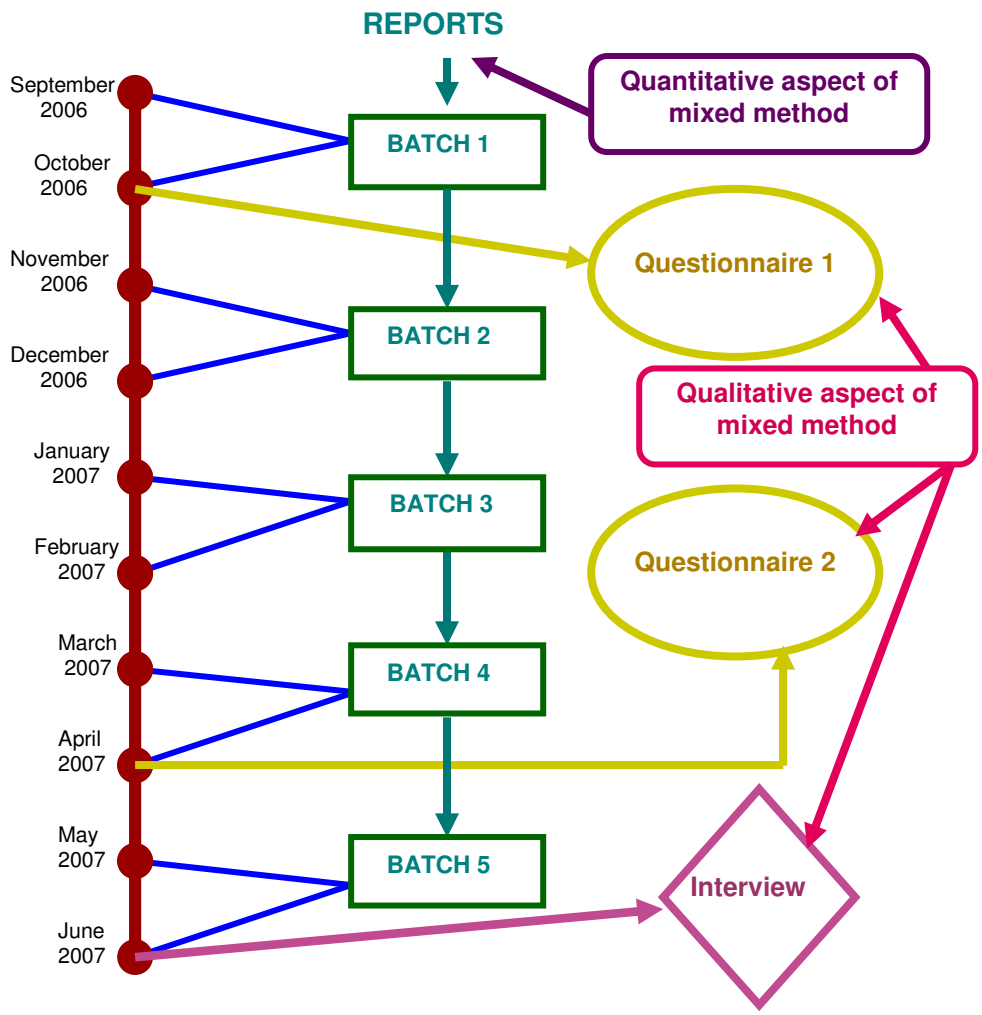
Benefits	Limitations
• the researcher was able to retain the holistic and meaningful characteristics of real-life events	• the researcher's personal interpretation of data and inferences may have introduced chances of inherent subjectivity
• opportunity was provided to use many different sources of evidence to gather data	• complexity of the materials may have easily caused a loss of study focus
• flexibility was allowed	• time consuming
• emphasis on the context was encouraged	• difficult to establish reliability
• the researcher was allowed to work inductively from what was available in the research setting and developed theories as the evidences emerge	• the researcher was unable to generalize the results to others i.e. conclusions were drawn only about the participant or group in the specific context being investigated

Methods of data collection

From Chapter Three, it was evident that most of the studies that were reviewed had utilized a quantitative approach for data collection. Despite providing values for the phenomena being tested, this approach often failed to provide in-depth understanding of the particular event being investigated or account for the factors contributing to the obtained values (Smith & Younger, 2002). In consideration of these drawbacks, the quantitative and qualitative methods were merged for the purpose of this research, an approach that is commonly known as the mixed method approach. The required combination for the mixed approach was achieved by adopting a sequential explanatory strategy, which involved using the qualitative data to support the quantitative findings of the study (Sorenson, 2006). By using this strategy, information from multiple sources to explain the same fact or phenomenon was collected resulting in data triangulation (Miles & Huberman, 1994; Gillham, 2001; Yin, 2002). Using the mixed method approach allowed a more comprehensive understanding of the phenomena being evaluated to be gained (Johnson & Christenson, 2007). Words, illustrations and narratives from the qualitative data were used to add meaning to the numbers acquired through the quantitative data (Sydenstricker-Neto, 2006). Such a blending of quantitative and qualitative approaches allowed their strengths to be complemented and their weaknesses to be overcome (Pope & Mays, 1995). In addition, the reliability and validity of the research was enhanced through the convergence of data obtained in this study (Burns, 1997).

As illustrated in Figure 2, the current study was spread over a ten month period from September 2006 to June 2007 and used three data collection tools to collect the required data. These three tools were the image interpretation reports by the MRTs, the questionnaires and the interviews. The first tool formed the quantitative aspect whilst the latter two contributed to the qualitative aspect of the mixed approach. During the study period, the reports by the MRTs were collected in five batches distributed over a two month period. In October 2006, which was the second month of the study, a questionnaire was given to the MRTs. Later in April 2007, another questionnaire was distributed to the participants. Then in the final month, interviews were conducted.

Figure 2 Methods of data collection



Quantitative aspects

The quantitative approach involved a set number of image interpretations to be performed by a group of MRTs undergoing formal postgraduate education in trauma appendicular skeleton image interpretation. Each research participant interpreted a total of 40 different images spread over five batches as illustrated in Figure 2. Each batch comprised eight images and the interpretations were in the form of free text hand-written reports. To have a consistent reporting format, a reporting form similar to the one used by radiologists was adopted (an exemplar reporting form is available in Appendix Two). The five batches were used to compare any changes in the participants' image interpretation in terms of specificity, sensitivity and accuracy as they progressed in their postgraduate education during the research period. Details of these test results and data analysis are discussed later.

The calculation of the test results were facilitated by collecting the reports by the MRTs together with a copy of the actual report written by radiologists for the same patients. The radiologists were used as the reference standard based on the fact that in any radiology department, the final and formal report is provided by radiologists (Cook, Oliver & Ramsey, 2004). While treating radiologists' reports as the gold standard in the study, it was assumed that they are 100 percent correct in their reports so that a constant is available for the study (Orames, 1997). However, this assumption about radiologists contributed as a limitation of this research, which is supported by three studies that have provided evidence that radiologists are not 100 percent correct all the time. Loughran (1994) found that the radiologists who participated in his study had sensitivity of 96.8 percent and specificity of 99.6 percent for fracture detection. Likewise, Siegle, Baram, Reuter, Clarke, Lancaster and McMahan (1998) found a mean interpretation disagreement rate of 4.4 percent amongst the 35 radiologists who reviewed over 11,000 images in their study. Similarly, Robinson et al. (1998) found an error rate of three to six percent while comparing the interpretations of three UK radiologists.

Qualitative aspects

As illustrated in Figure 2, the qualitative aspects comprised three data collection tools (two sets of questionnaires and interviews) to describe in detail the impressions and feelings the participants had about any changes noticed in the MRTs' reporting accuracy and clinical practice relative to their educational experience at their respective workplaces. This situation was observed from a combination of emic and etic perspectives, which are also known as the 'insider's perspective' and 'outsider's framework' respectively (Morse, 1994). The emic approach involved presenting the observed changes in the research participants through their perspective (Bouma & Ling, 2004) while the etic approach involved the researcher to provide meanings to what was going on in reality (Gillham, 2001). The two viewpoints were combined such that events and their consequences were identified and fruitful explanations for the research findings were derived.

Questionnaires

The questionnaires were purposefully designed documents for obtaining specific information from the participating MRTs (Boynton & Greenhalgh, 2004). They are included in Appendix two. Questionnaire One assessed how the MRTs foresaw their educational experience impacting on their image interpretation accuracy and clinical

practice during the study. It also acted as a platform for comparing the outcomes of Questionnaire Two. Questionnaire One had 11 questions altogether and a number was assigned to each of the question. Instructions were provided to inform the respondents where they were required to tick the appropriate answers in the boxes provided and where they were required to explain or make a comment. A commenting section was included at the end of the questionnaire so that the respondents were able to comment on any other relevant observations that they made in relation to their education and clinical practice at the beginning of the study. In addition, a footnote with information on who to contact regarding any issue about the conduct of the research was included.

This questionnaire was piloted on five of the principal researcher's colleagues having either some or no background knowledge in image interpretation. This mixture of colleagues was purposefully used in an attempt to obtain balanced feedback on the questionnaire content. The pilot acted as a guide for rephrasing most of the questions (Kletzenbauer, 1996) and checked the reliability and validity of the questionnaire (Marshall, 2005). This questionnaire was distributed to the MRTs on their first day of block lectures in October 2006. The MRTs were required to complete the questionnaire in my presence and return it on the same day. This approach ensured that the intended respondents completed the questionnaire and that I was present to clarify any unclear questions that the respondents had (Williams, 2003). However, my presence may have intimidated some of the respondents and possibly hindered them from sharing their true personal opinions (ibid.). To avoid this limitation, I interacted with the participants only if they have any doubts or questions that needed to be clarified.

On the other hand, Questionnaire Two was used to identify any changes that occurred in the participating MRTs' image interpretation accuracy and clinical practice relative to their educational experience and establish how these changes actually took place. The changes were determined by comparing the responses in this questionnaire with those of Questionnaire One. There were two parts to the second questionnaire. The first part had eight questions that obtained background information about the participants' workplace and determine any influence they may have had on the MRTs' progress relative to their educational experience. The second part had 17 questions focusing on the postgraduate educational experience, the image interpretation skill acquisition by the MRTs and their clinical practice. This questionnaire ended in a similar manner to that of Questionnaire One (see Appendix

Two) and was also piloted for the same reasons given earlier for the piloting of Questionnaire One. However, due to availability, only four colleagues were engaged. The pilot revealed that the majority of the questions were acceptable and only minor amendments were required in relation to the wording of the rest of the questions.

As illustrated in Figure 2, the second questionnaire was distributed to the participants in April 2007. To ensure that all the participants received the questionnaire, an electronic attachment was sent via e-mail and a hardcopy also posted around the same time. A postage paid return envelope was provided to the respondents to encourage them to return the questionnaire on time. As recommended by Marshall (2005), the hardcopy was accompanied with a covering letter giving information about the research, return instructions including to whom and where it was to be returned, e-mail address and telephone number for any queries and the permitted date for return. The covering letter is available in Appendix One. By using the mentioned method of distribution, the chances of the questionnaire being answered at the respondents' convenience were increased and anonymity was offered (Neuman, 2000; Polgar & Thomas, 2000).

Interviews

The interviews in this research were for a period of one hour and took the form of a conversation between the informant and me. These interviews provided me the best opportunity to find out about the thoughts and feelings of the participants and offered a 'window' on reality from the viewpoint of the participants (Bouma & Ling, 2004). I selected the 'key informants' so that the required insights into the situation or issue under study was provided (Polgar & Thomas, 2000). To accomplish that, eight interviewees were interviewed in June 2007 as illustrated in Figure 2. To enable me to select the eight interviewees, the MRTs were located at four demographic locations (Region One, Region Two, Region Three and Region Four) at the onset of the study. I based the grouping on the location of the MRTs and the DHBs. Details about the grouping are presented in Table 2.

Table 2 Details about the MRTs' locations during the study

Location	Region One	Region Two	Region Three	Region Four
Group members	MRT1 MRT2 MRT3	MRT4 MRT5 MRT6	MRT7 MRT8	MRT9 MRT10

The participating MRTs were requested to select a representative in accordance to their locations at the beginning of the study so that one MRT from each of the four locations was interviewed. Through the interviews with the four MRTs, I hoped to obtain in-depth insight about aspects of the postgraduate educational intervention and how these features impacted on the MRTs' image interpretation accuracy and clinical practice. In addition, radiologists acting as the MRT's mentors from these four locations were invited to be interviewed and one mentor from each location was selected for the actual interview. By interviewing four mentors, I intended to share their observations on the mentoring process, the performance of the MRTs and any other aspects of the educational experience that they encountered during the research period.

I conducted a semi-structured interview, that is, I asked each interviewee the same number of questions but rephrased the questions and reorganized the order of the questions where needed. This approach enabled me to elicit certain information from the interviewees and allowed me to probe for more information concerning the interviewee's answer to an earlier question (Crowl, 1996). To accomplish this, I used two interview schedules, that is, one for the MRTs and the other for the mentors (refer to Appendix Two for details). Both schedules had open-ended questions that allowed the interviewees to express what was really on their minds without being influenced by me (Denzin & Lincoln, 1998). The interview schedules were adhered to avoid idle talk and to redirect the discussion back to the research topic (Bouma & Ling, 2004; Burns, 1997). Considering the geographical location and workload of the interviewees, I conducted the interviews at the interviewees' workplaces where possible.

I documented the eight interviews by tape recording them and creating transcriptions based on the four reasons given by Gillham (2001). Firstly, it was impossible for me to get a complete account any other way. Secondly, writing down during the interview had the potential of interrupting the flow and distracting me from listening and reflecting on what the interviewee was saying. Thirdly, the inhibiting nature of writing would make me selective in what to include in the notes. Lastly, tape-recording allowed me to listen to the interview several times and recognize more information each time. The transcriptions took the form of a verbatim written version of the conversation that takes place between the interviewee and me (Tolich & Davidson, 1999). I transcribed the interviews as soon as possible so that my memory aided in recalling what was on the tape (Gillham, 2001). Once completed, I

let those interviewed read a copy of their transcripts in an attempt to vet the materials based on the interview, double-check the accuracy of the transcripts and enhance the research transparency and reliability (Mays & Pope, 1995; Polgar & Thomas, 2000). Once these steps were taken, the content of the transcripts was analysed as discussed later in this chapter.

Research participants

Jones et al. (2006) highlighted that when using the case study method, it is common practice to purposefully select participants who will provide significant information during the investigation. Therefore, the participants in this research were selected based on their relevance to the research topic rather than their representativeness (Flick cited in Neuman, 2000; Polgar & Thomas, 2000). I adopted convenience sampling method, which is an example of a non-probability or a non-random sampling approach (Burns, 1997; Cohen et al., 2000). The choice of convenience sampling approach was based on the student numbers involved in image interpretation courses as a result of the intensive nature of the courses and the large commitment expected from both the students and the clinical departments. I used 10 MRTs for the current research. The participants were the cohort of MRTs who commenced formal postgraduate education in image interpretation of trauma to the appendicular skeleton from semester two, 2006, at a tertiary institution in NZ. Notably, this was the first time that formal postgraduate education in image interpretation was offered in NZ. Thus, this cohort of ten MRTs undertaking the education in trauma reporting was pioneers for the MRTs in NZ.

Ethical considerations

This thesis involved evaluating the competency of people, asking them questions and collecting information about them in relation to their work. It entailed the ten MRTs in this study to interpret the images of trauma to the appendicular skeleton of ED patients during the MRTs' clinical practice, which was part of the course requirement. In addition, there were face-to-face interviews conducted with four of the participating MRTs and with four of the radiologists acting as mentors. As a result of all of these factors, I needed to obtain informed consent from the research participants. Informed consent is described as "the procedures in which individuals choose whether to participate in an investigation after being informed of facts that would be

likely to influence their decisions" (Diener & Crandall cited in Cohen et al., 2000, p. 51).

To ensure that the prospective participants had enough information and time to make informed decisions about their participation in my study, I sent an information sheet to all the MRT participants at least one month prior to the commencement of the research. The information sheet met all the requirements highlighted by Neuman (2002). The MRTs who agreed to participate signed a consent form after understanding the ethical issues and the measures that I would take to deal with them. In the case of the four MRTs who represented their colleagues for an interview, written consent was taken prior to their being interviewed. The information sheet and the consent forms are available in Appendix One.

Another ethical issue was the subject of confidentiality and anonymity. Confidentiality means that although I will know who the participants are, I will not divulge their names or any information that may identify them (Tolich & Davidson, 1999). On the other hand, anonymity suggests that I will not disclose any information that may make the true identity of the participant known to the public (Jones et al., 2006). To maintain confidentiality and anonymity during the data collection phases, I adhered to the suggestion by Crowl (1996) and assigned code numbers to the research participants. I accomplished this by giving an alphanumeric code such as MRT1, MRT2 and so on to each participant in this study. However, to give a more realistic approach to the thesis, the codes were substituted by pseudo-names when the data was discussed.

A third ethical issue was the privacy of the participants and the places, such as the institutions, from where the data was collected (Crowl, 1996). Diener and Crandall (cited in Cohen et al., 2000) highlighted for privacy to be considered from the perspectives of the sensitivity of the information, the setting being observed and the dissemination of information. Keeping this in mind, I considered the privacy of the tertiary institution, the participating radiology departments, patients whose images were interpreted by the participants, the participating MRTs and the radiologists acting as the mentors for the participating MRTs.

Firstly, I did not name the tertiary institution providing the image interpretation courses, as recommended by the Unitec Research Ethics Committee (approval number: SHREC 2006.79). The tertiary institution had already obtained permission

and support from the radiologists and the clinical managers to allow the MRTs to undergo the postgraduate educational experience at their radiology departments in NZ. I also wrote letters to the clinical managers to seek their approval to use patient reports from their departments to conduct this study. I further reassured the radiology departments that all the information obtained would be treated with utmost confidence and anonymity (the letter is available in Appendix One). To ensure patient confidentiality, I asked the participating MRTs to erase the personal details of the patients from the reports collected in the five batches over the study period. I further advised these MRTs to only provide details such as the age, sex and clinical indication for which the patient presented at the radiology department.

Secondly, I sent an advance letter to the radiologists acting as mentors and invited them to be interviewed in June 2007. The letter contained information such as description of the study, an explanation of what was involved in the interview, the likely duration of the study and an assurance of confidentiality (Britten, 1995). I followed this correspondence with repeat communication through letters and e-mails to confirm an appointment. I also allocated alphanumeric codes such as Mentor1, Mentor2, Mentor3 and Mentor4 to the four mentors who were interviewed so that their privacy was safeguarded. Details of the letter for approval and the consent to be interviewed are available in Appendix One.

I used pseudonyms for the ten MRTs and the four mentors instead of the alphanumeric codes that were assigned to them during the data collection stage when discussing the obtained data and disseminating the information. I would like the reader to note that the names used were not a true reflection of the gender distribution of the present study. This approach was taken so that anonymity of the participants was maintained and the findings did not give away any of the participants' true identity. In addition, the use of names instead of numbers gave a more personal approach to the thesis.

Data analysis

I used the interpretative paradigm to analyze the data collected during the research period by systematically arranging and presenting information so that comparisons, contrasts and insights were made and demonstrated. This was achieved by integrating the qualitative data with the quantitative data. By doing so, I hoped to use the qualitative data to explain and add to the quantitative data, that is, give the

findings more depth than statistics alone could achieve. To analyze the quantitative data, the MRTs' interpretations were compared with those of radiologists. This allowed me to allocate the MRTs' interpretations into either true positive (TP), true negative (TN), false positive (FP) or false negative (FN) scores. These scores were also been used by researchers such as Mackay (2006), Piper et al. (2005) and Carter and Manning (1999) in their studies assessing interpretation accuracies of MRTs. A description of the four scores and the approach that I used to allocate them in this study are given in Table 3.

Table 3 Description and allocation of the test scores for analysing the quantitative data (adapted from Piper, Ryan & Paterson, 1999)

Test Score	Description and allocation in current study
TP	• The image has an abnormality and both the MRT and the gold standard agree on the presence and the description of the abnormality in terms of its site and nature.
TN	• The image does not have an abnormality and both the MRT and the radiologist agree on the absence of abnormal appearances. • A normal variant is clearly identified as such by the MRT and verified by the gold standard's report.
FP	• The image does not have an abnormality and the MRT has commented on an appearance as abnormal whilst the gold standard's report disagrees and considers the image to be normal.
FN	• The MRT has identified the image as normal whilst the gold standard's report indicates the presence, site and nature of an abnormality. • The MRT has described the site and nature of appearances incorrectly and/or used inaccurate terminology. • A number of abnormalities are present and one or more are missed by the MRT according to the gold standard's report.

Further analysis of the TP, TN, FP and FN scores were performed to calculate the MRTs' image interpretation competency in terms of sensitivity, specificity and accuracy as they progressed in their educational experience. The sensitivity, specificity and accuracy scores were analyzed according to the five batches illustrated in Figure 2, page 32, to show any changes that may have taken place during the study. A description of the sensitivity, specificity and accuracy as well as the accepted formulae for calculating them in this study is given in Table 4.

Table 4 Description and acceptable formulae for calculating sensitivity, specificity and accuracy values (adapted from Bowman & Johnson, 2001)

Factors	Description	Formulae
Sensitivity	The proportion of true positives that were correctly identified by the MRTs	$\frac{TP}{(TP + FN)} \times 100\%$
Specificity	The proportion of true negatives that were correctly identified by the MRTs	$\frac{TN}{(TN + FP)} \times 100\%$
Accuracy	The sum of the true positive and true negative findings as a proportion of the total cases interpreted by the MRTs	$\frac{(TP + TN)}{(TP + TN + FP + FN)} \times 100\%$

Since the sensitivity and specificity values address the validity of a test, the kappa value was also calculated for the projected 400 interpretations (Viera & Garrette, 2005). This was done to determine whether the agreement between the gold standard and the MRTs in the study was merely through guesswork or perfect agreement (ibid.). To enable the calculation of the kappa value, the 400 interpretations were organized into the two-by-two contingency table as illustrated in Table 5 below.

Table 5 Contingency table showing notations for calculating kappa value
(modified from Sim & Wright, 2005)

		MRTs		*Total*
		Abnormal	*Normal*	
Gold standard	*Abnormal*	a TP scores	b FN scores	g_1 (a + b)
	Normal	c FP scores	d TN scores	g_2 (c + d)
	Total	f_1 (a + c)	f_2 (b + d)	n (a + b + c + d)

Once the TP, TN, FP and FN scores were allocated into the appropriate sections in Table 5, I used the formula described by Sim and Wright (2005) to calculate the kappa value. The formula and its components are given in Table 6.

Table 6 Formula and related components for calculating the kappa value

(adapted from Sim & Wright, 2005)

$$K = \frac{P_0 - P_C}{1 - P_C}$$

where:

K = kappa value P_0 = observed agreement P_C = chance agreement

P_0 and P_C will be derived as shown below and substituted in the above formula.

$$P_0 = \frac{(a + d)}{n}$$

$$P_C = \frac{\left(\frac{f_1 X g_1}{n}\right) + \left(\frac{f_2 X g_2}{n}\right)}{n}$$

A kappa score of zero indicates guesswork whilst a kappa score of one indicates perfect agreement (Dhingsa, Finlay, Robinson & Liddicoat, 2002). More details on the allocation of kappa scores are available in Table 7.

Table 7 Guidelines for kappa scores

(Dhingsa et al., 2002, p.136)

Value of kappa	Strength of agreement
<0.20	Poor
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81 – 1.00	Very good

I determined the response rate for the two questionnaires prior to analysing the data obtained from them. This was done to identify the percentage of questionnaires that were completed and returned by the respondents (Data Analysis Australia, 2007). Once the response rate was established, I used thematic content analysis as described by Burnard (1991) to inductively analyze the qualitative data obtained through the two sets of questionnaires and the eight interviews. I used this method of analysis to encourage me to discover features in the content of large amounts of material that might otherwise go unnoticed (Neuman, 2000). I accomplished this by searching for patterns that occurred within the context of the study from the point of

view of the participants. This approach allowed me to sort the data in such a manner that underlying meanings in the text were uncovered and the central and peripheral referents were brought to my attention (Morse, 1994). In other words, I was able to relive the obtained data to the participants' meanings.

To do thematic content analysis, I first coded the responses to the questions in the questionnaires and the interviews by converting the responses into meaningful categories (Williams, 2003). I then grouped the categories into similar or contrasting themes that emerged from the qualitative data (Tolick & Davidson, 1999). These categories and themes were focused on the research question and its derived key questions. As proposed by Boynton (2004), I used appropriate quotations from the interview transcripts and the questionnaires where necessary to construct suitable explanations for the research findings.

Evaluation of the research procedures

The piloting stage of the two sets of questionnaires proved to be very productive. It enabled factors such as language, wording, sequencing and questionnaire length to be checked as well as removing any flaws present (Marshall, 2005). As a result, two sets of questionnaires that encouraged worthwhile data to be collected were devised. However, some difficulties were encountered initially regarding the participant number for the research. At first, when the information sheet was sent out to the prospective participants, not everyone responded. The reason contributing to this was because there was some confusion amongst the prospective participants regarding the number of trauma images they were supposed to interpret. To alleviate the problem of not having the projected sample size of 10, the researcher met with the prospective participants to discuss and clarify any doubts they had with regard to the research. However, at no particular point in time was there any attempt of coercion made by me. The sole purpose of the meeting was to clarify any doubts that the participants had and to let them make informed decisions regarding their willingness to participate or not to participate in this study. After the meeting, ten MRTs voluntarily gave their consent to participate.

Summary

This thesis involved case study research that was conducted longitudinally on a cohort of MRTs undergoing the first formal postgraduate education in image

interpretation of trauma appendicular skeleton in NZ. The participants were selected using convenience sampling approach and they were allocated to one of four locations at the onset of the research to aid in the collection of part of the qualitative data. Possible ethical issues that were encountered in this study and ways to alleviate them have been acknowledged in this chapter. The mixed method approach, which involved the blending of the quantitative and qualitative approaches, was used for data collection. The combination was achieved through the use of 400 image interpretation reports, two sets of questionnaires and interviews.

The reports, which formed the quantitative aspect of the mixed approach, were used to calculate the image interpretation sensitivity, specificity and accuracy of the MRTs. An evaluation of the research procedures revealed that although there were some drawbacks initially, the research procedures were successfully implemented during the study period. The qualitative data was analyzed using thematic content analysis and appropriate quotations were used from the questionnaires and the interviews where needed to support the conclusions emerging from the analysis. The relevant tables and graphs from the analyzed data have been displayed in the results section in Chapter Five while the themes that emerged have been discussed in Chapters Six to Nine of this thesis.

CHAPTER FIVE

Results

Overview

This chapter displays the research findings that were obtained using mixed methods approach. The data collection tools that were adopted were the image interpretation reports, two sets of questionnaires and eight interviews. The displayed graphs and tables, which will be discussed in detail in the next few chapters, are for the image interpretation reports and the two sets of questionnaires. A response rate of 100 percent was noted for the two sets of questionnaires and may be attributed to the limited number of participants. As mentioned by Williams (2003), such a response rate is extremely good because it has a likelihood of being representative of the study findings. In addition, the response rate of 100 percent offers validity and reliability to the findings (Frary, 2001). This chapter also has a summary of the themes generated by thematic analysis of the interview data and the open comments from the questionnaires. Information from these two sets of qualitative data and any relevant quotations from them will be integrated in the discussion chapters.

Figure 3 Comparison of the MRTs' personal ratings of their image interpretation skills

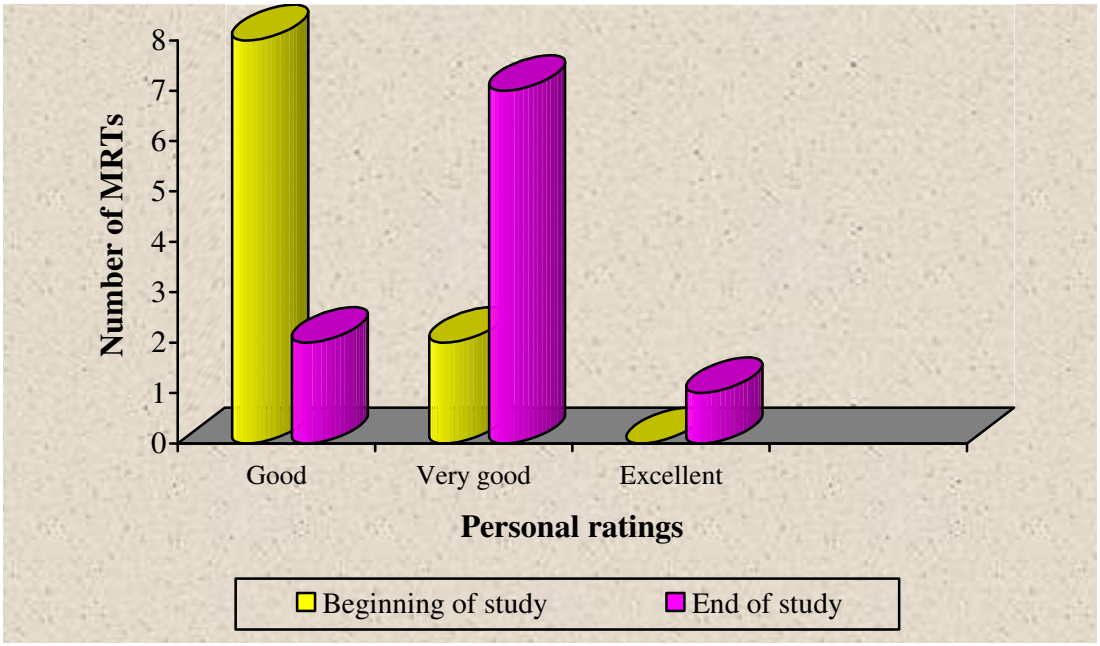


Figure 4 Comparison of the sensitivity values attained by the MRTs

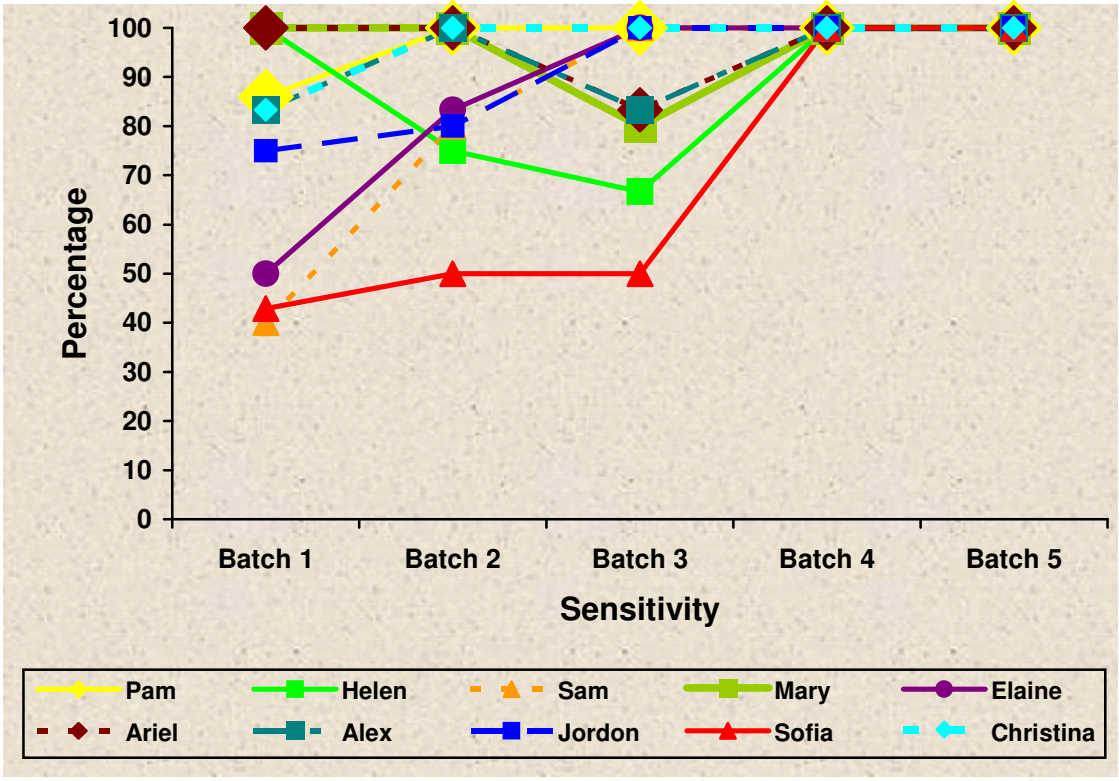


Figure 5 Comparison of the specificity values attained by the MRTs

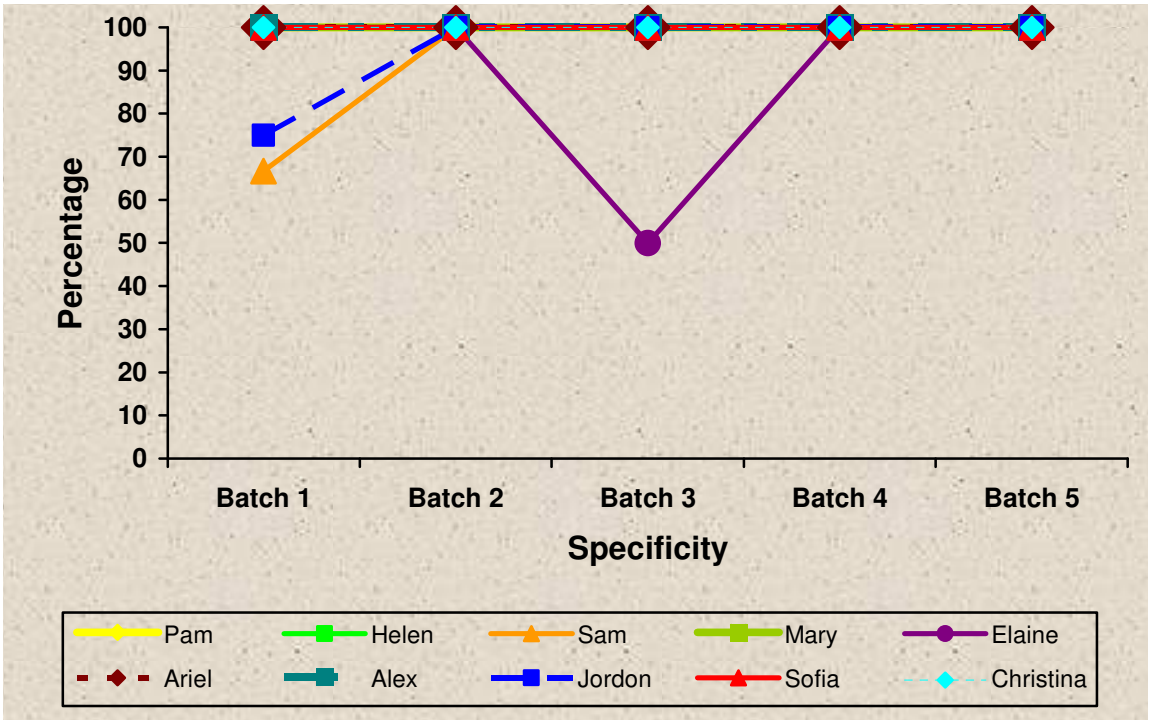


Table 8 Breakdown of the anatomical regions interpreted by the MRTs

	Anatomical regions						
	Group 1 Finger/ hand/ wrist	**Group 2** Forearm/ elbow/ humerus	**Group 3** Shoulder/ clavicle	**Group 4** Toes/ foot/ calcaneus	**Group 5** Ankle/ leg	**Group 6** Knee/ femur	**Group 7** Hip/ pelvis
MRT1	8	7	7	2	6	5	5
MRT2	6	5	5	7	8	3	6
MRT3	13	3	7	2	8	5	2
MRT4	10	7	4	4	10	3	2
MRT5	10	9	4	2	9	3	3
MRT6	14	4	9	2	4	5	2
MRT7	5	7	8	4	9	4	3
MRT8	6	6	5	5	13	3	2
MRT9	12	4	2	7	10	3	2
MRT10	14	3	7	9	5	2	0
Total	**98**	**55**	**58**	**44**	**82**	**36**	**27**

Figure 6 Types of image selection criteria adapted by the MRTs

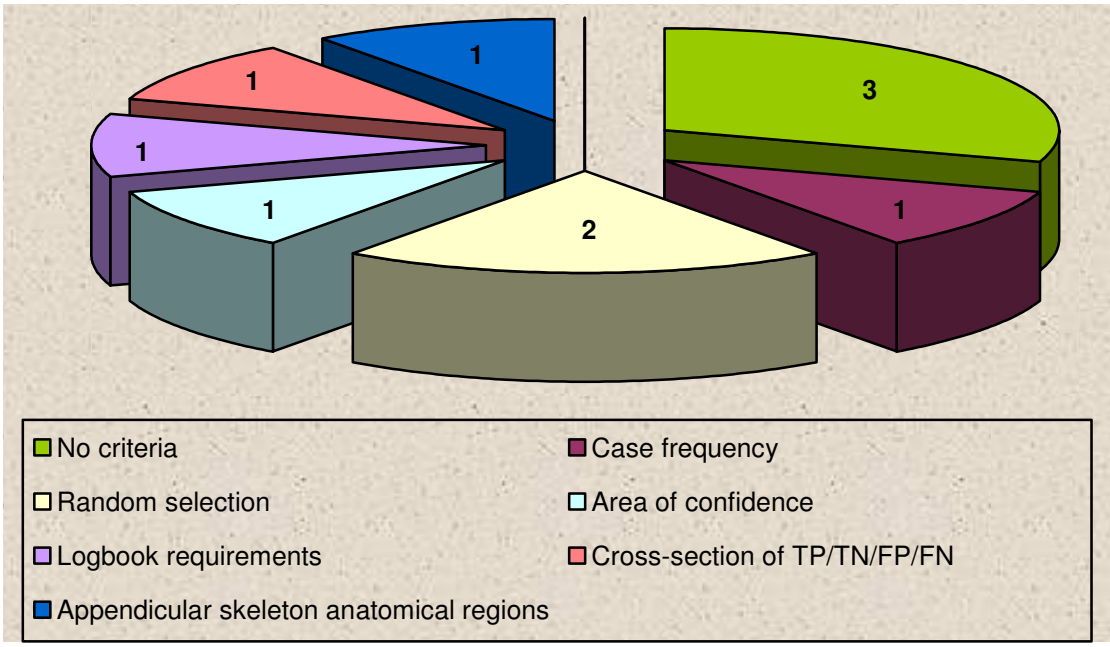


Table 9 Interpretation outcomes of the individual MRTs

	Batch 1				Batch 2				Batch 3				Batch 4				Batch 5			
Participants	TP	TN	FP	FN	TP	TN	FP	FN	TP	TN	FP	FN	TP	TN	FP	FN	TP	TN	FP	FN
Pam	6	1	0	1	4	4	0	0	4	4	0	0	6	2	0	0	6	2	0	0
Helen	3	5	0	0	3	4	0	0	2	5	0	1	5	3	0	0	6	2	0	0
Sam	2	2	1	3	4	3	0	1	5	3	0	0	4	4	0	0	4	4	0	0
Mary	5	3	0	0	5	3	0	0	4	3	0	1	4	3	1	0	5	3	0	0
Elaine	1	6	0	1	5	2	0	1	4	2	2	0	6	2	0	0	5	3	0	0
Ariel	7	1	0	0	6	2	0	0	5	2	0	1	7	1	0	0	7	1	0	0
Alex	5	2	0	1	6	2	0	0	5	2	0	1	5	2	0	0	3	5	0	0
Jordon	3	3	1	1	4	3	0	1	1	7	0	0	5	3	0	0	5	3	0	0
Sofia	3	1	0	4	1	6	0	1	1	6	0	1	5	3	0	0	4	4	0	0
Christina	5	2	0	1	7	1	0	0	7	1	0	0	7	1	0	0	6	2	0	0

Figure 7 Overall percentages of TP, TN, FP and FN scores by the MRTs

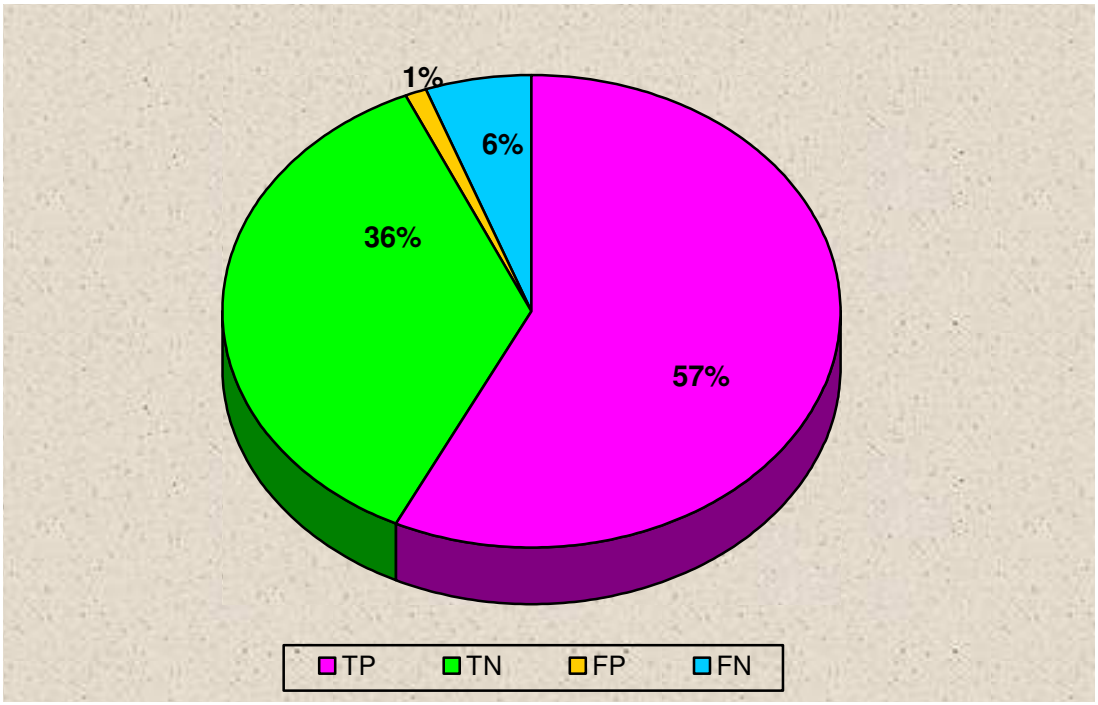


Table 10 Contingency table for calculating kappa value in the study

		MRTs		
		Abnormal	*Normal*	*Total*
Gold standard	*Abnormal*	a 229	b 22	g_1 251
	Normal	c 5	d 144	g_2 149
	Total	f_1 234	f_2 166	n 400

Table 11 Calculation of the kappa value for degree of agreement

$$P_0 = \frac{(a + d)}{n} = \frac{(229 + 144)}{400} = \frac{373}{400} = \mathbf{0.9325}$$

$$P_C = \frac{\left[\frac{f_1 X g_1}{n}\right] + \left[\frac{f_2 X g_2}{n}\right]}{n} = \frac{\left[\frac{234 X 251}{400}\right] + \left[\frac{166 X 149}{400}\right]}{400}$$

$$= \frac{[\,146.835 + 61.835\,]}{400}$$

$$= \frac{208.67}{400}$$

$$= 0.521675$$

$$= \mathbf{0.5217}$$

$$K = \frac{P_0 - P_C}{1 - P_C} = \frac{0.9325 - 0.5217}{1 - 0.5217} = \frac{0.4108}{0.4783} = 0.8588 = \mathbf{0.86}$$

Figure 8 Comparison of the accuracy values attained by the MRTs

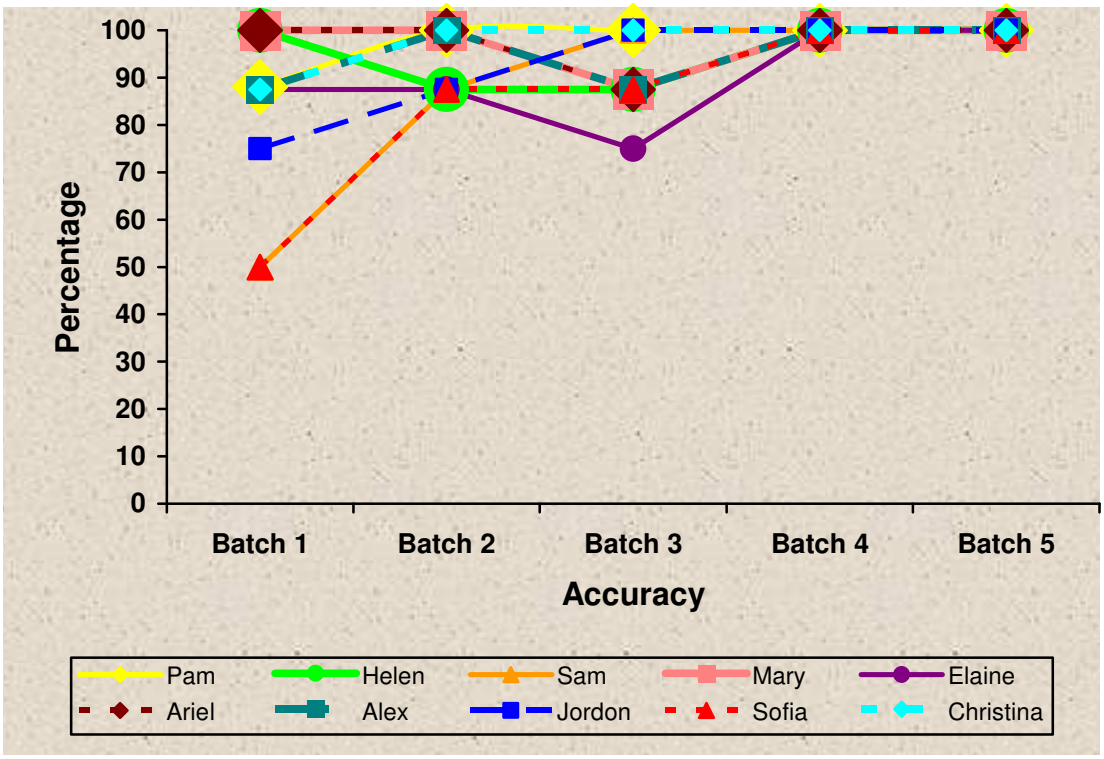


Figure 9 Number of MRTs who foresaw that their clinical practice will alter

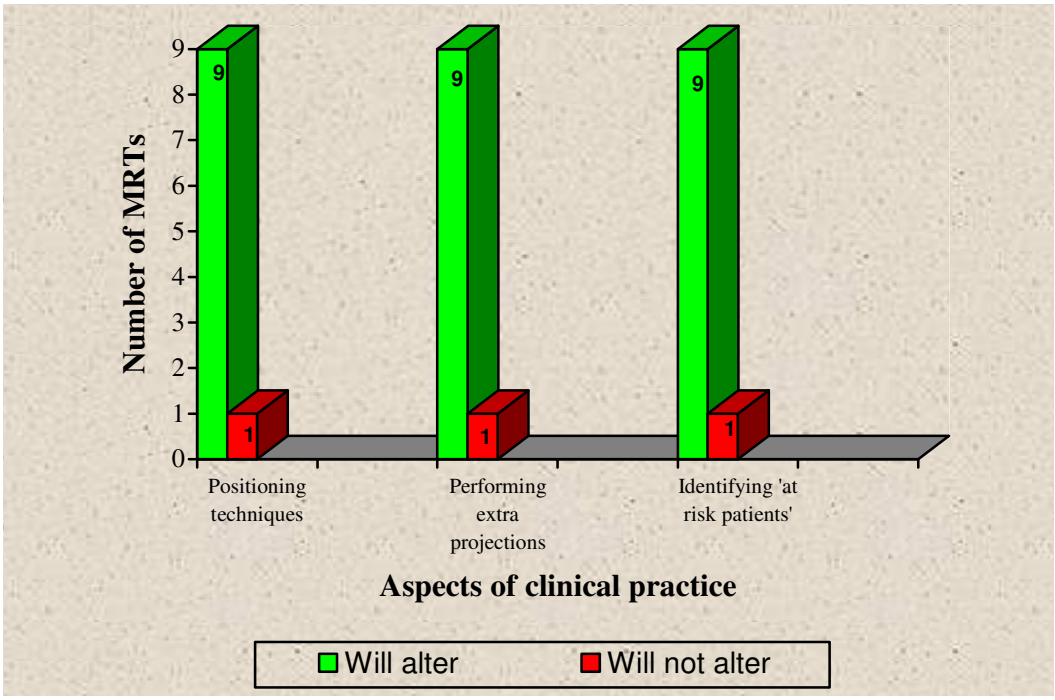


Figure 10 MRT's personal ratings of their clinical practice at the onset of the study

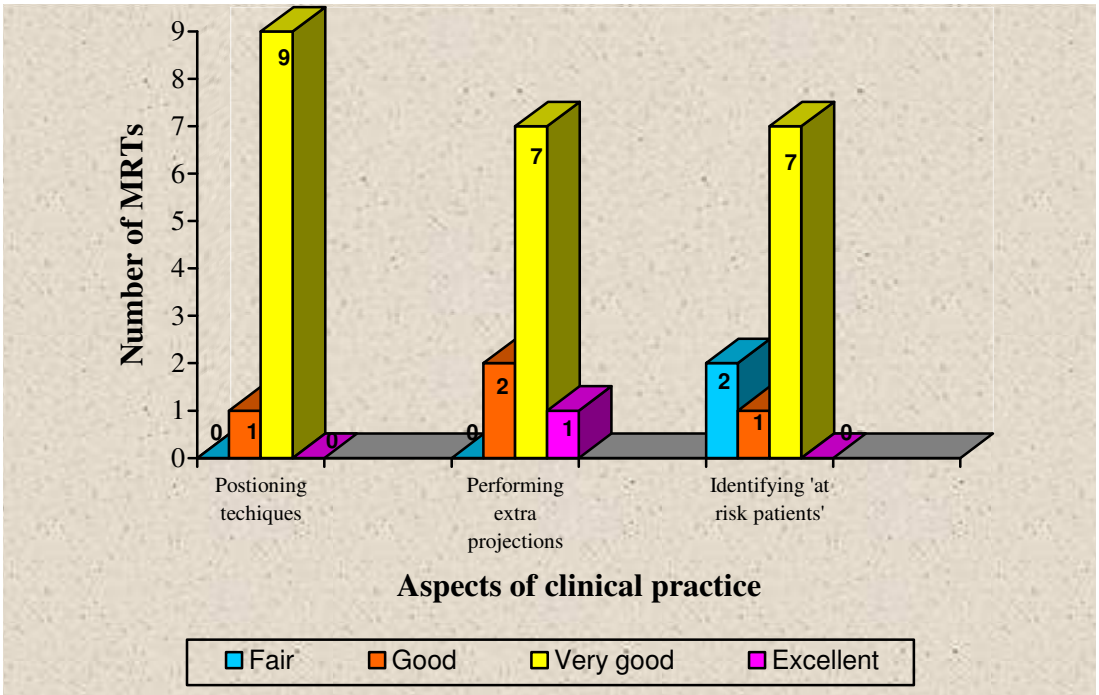


Figure 11 Alterations in other aspects of MRTs' clinical practice

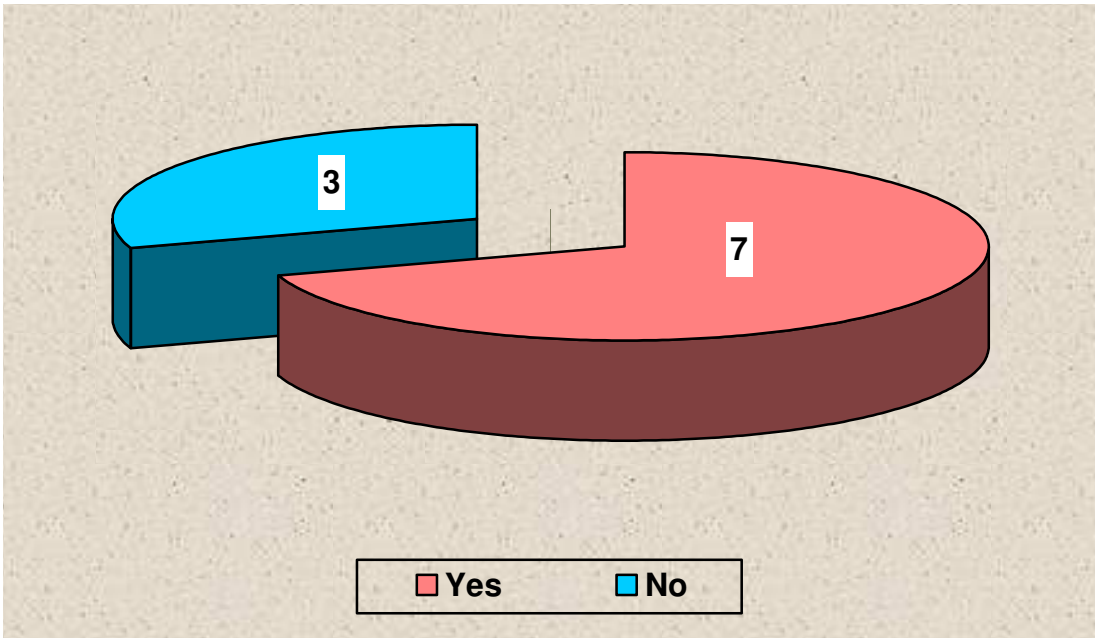


Figure 12 Prior training in image interpretation

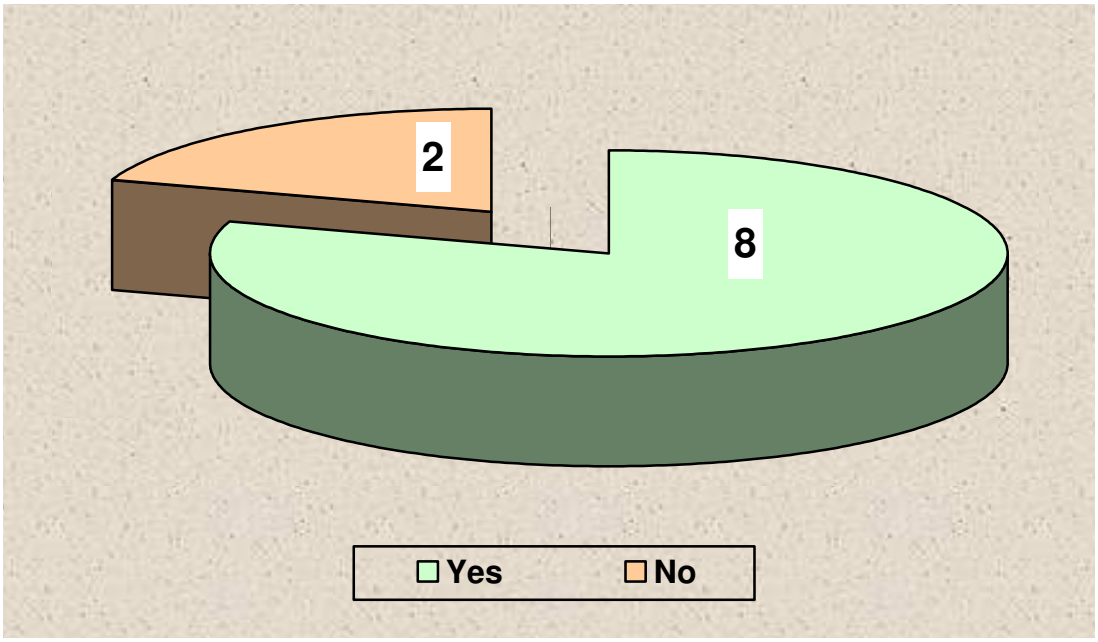


Figure 13 Types of prior training in image interpretation

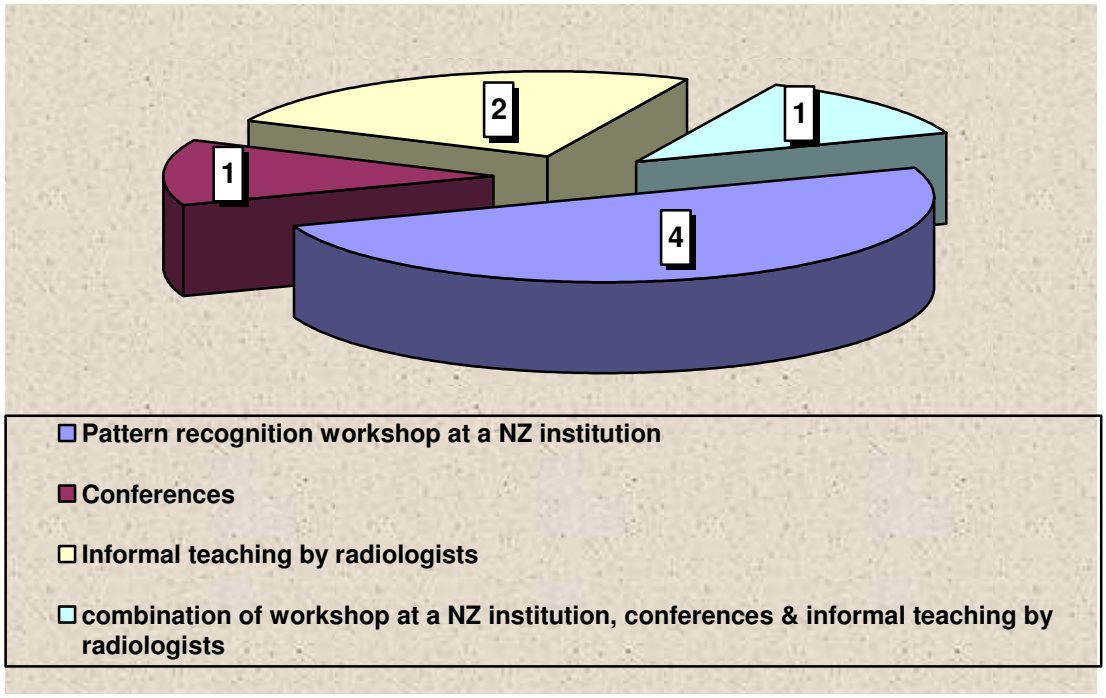


Figure 14 Work experience as a MRT

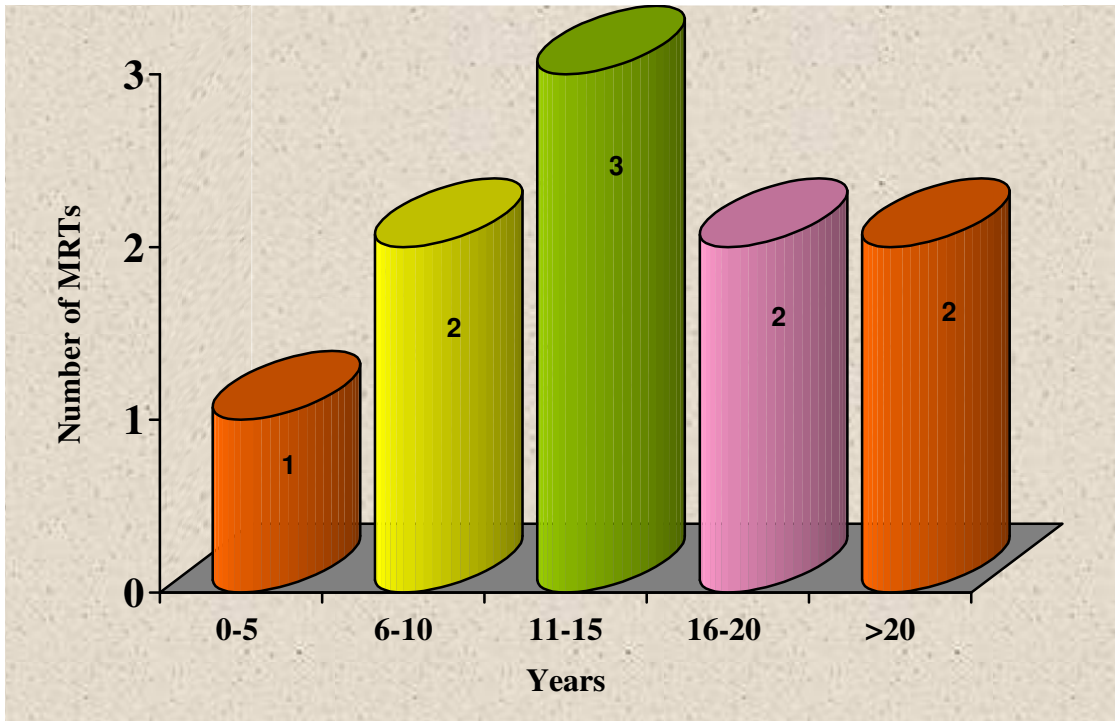


Figure 15 Type of practice where the MRTs worked

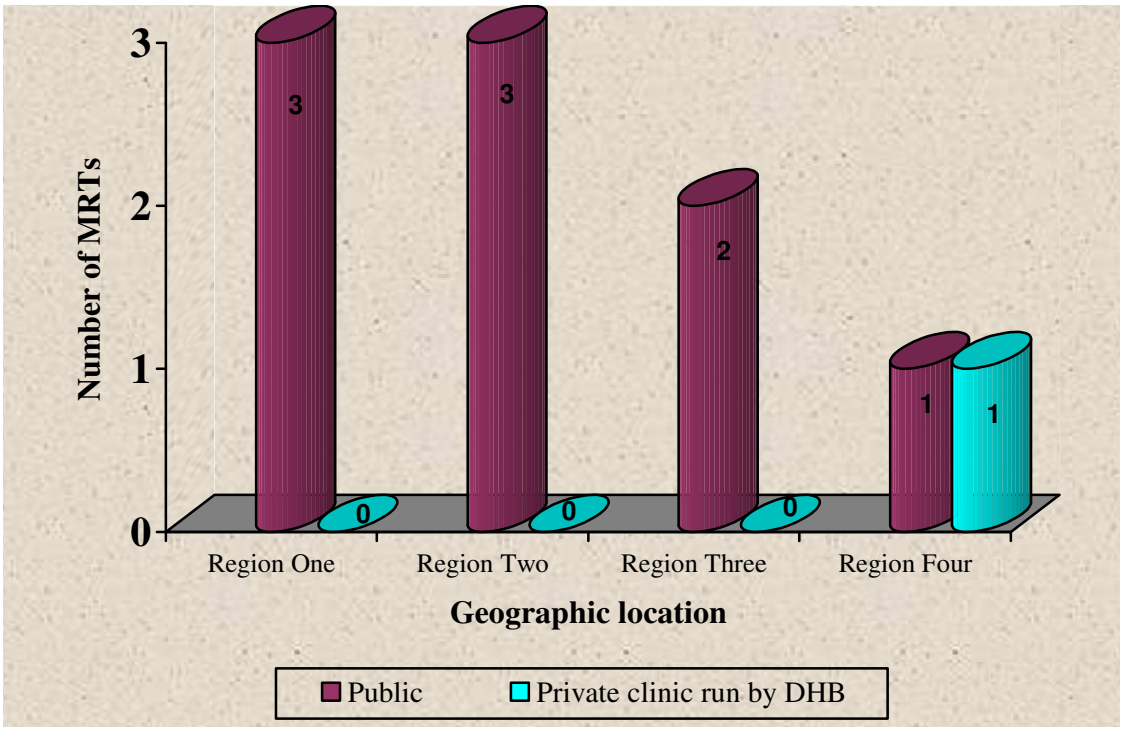


Figure 16 Location of MRT's workplace

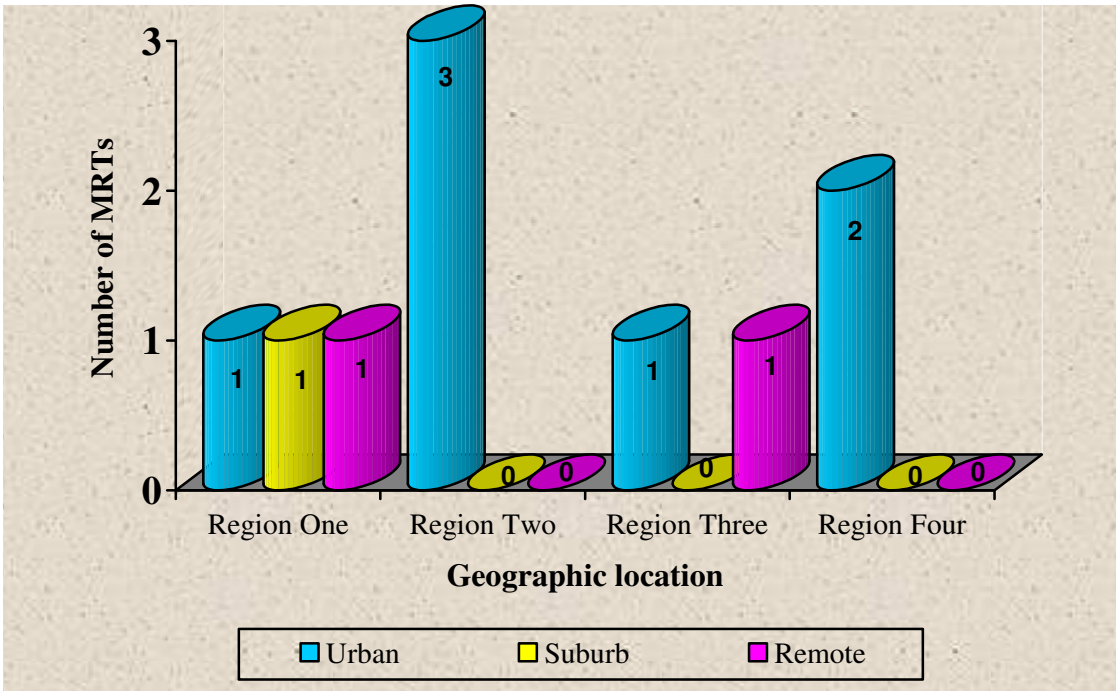


Figure 17 Frequency of encountering appendicular skeleton cases

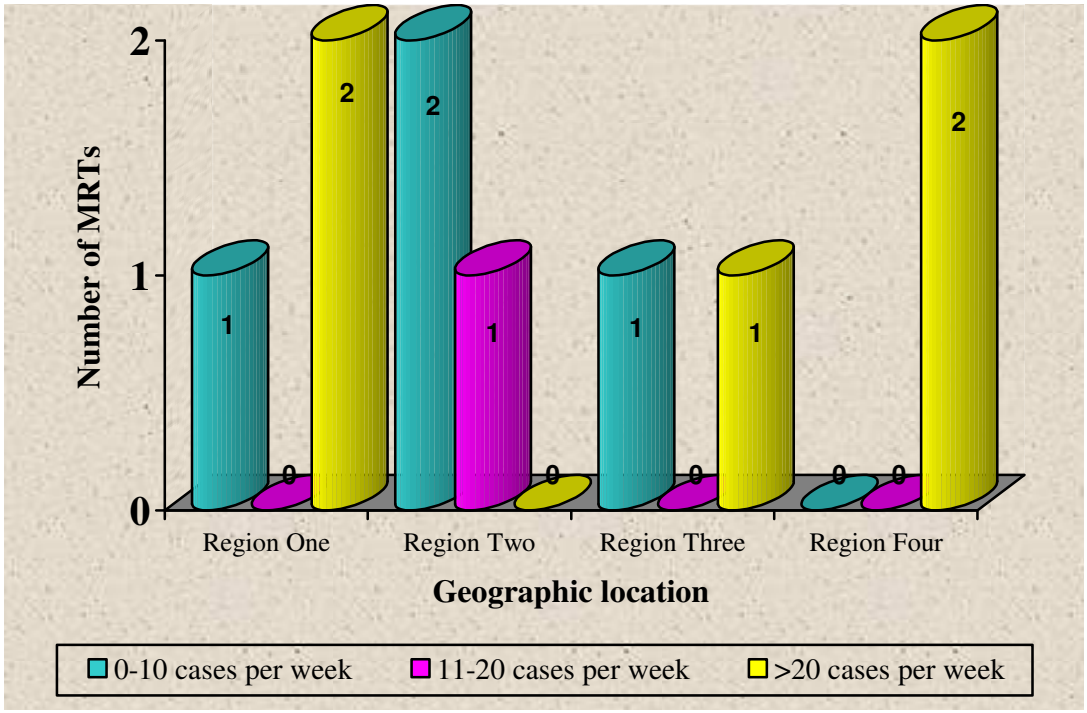


Figure 18 Workmates' opinions influencing MRT's image interpretations

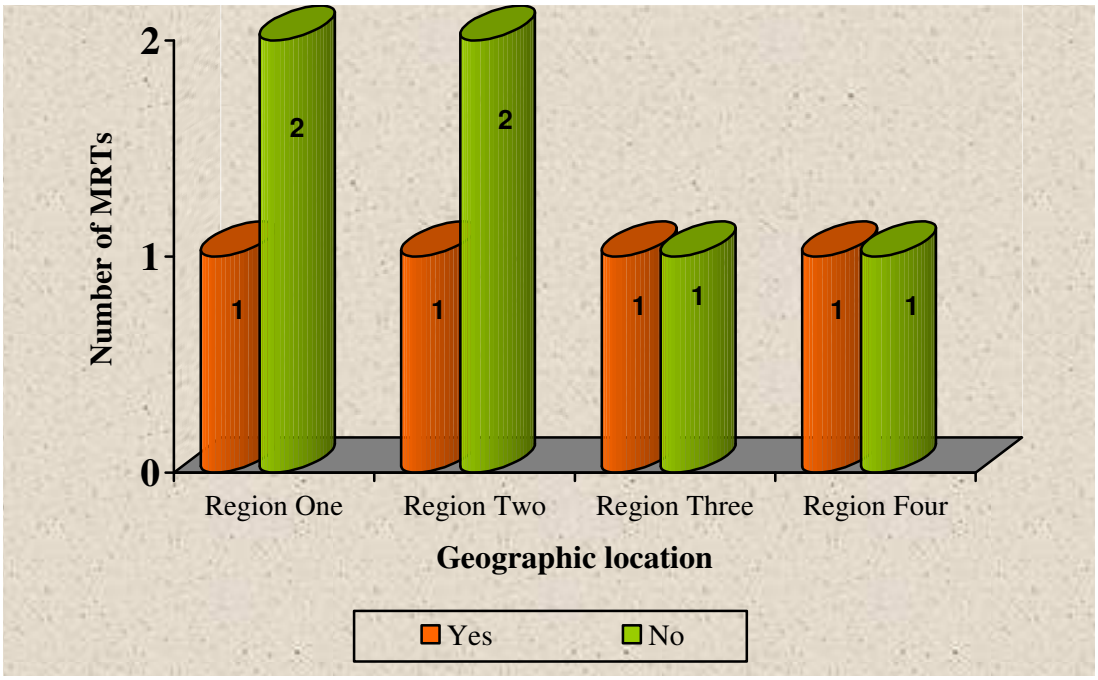


Figure 19 Involvement of MRT in ongoing image interpretation activities at workplace

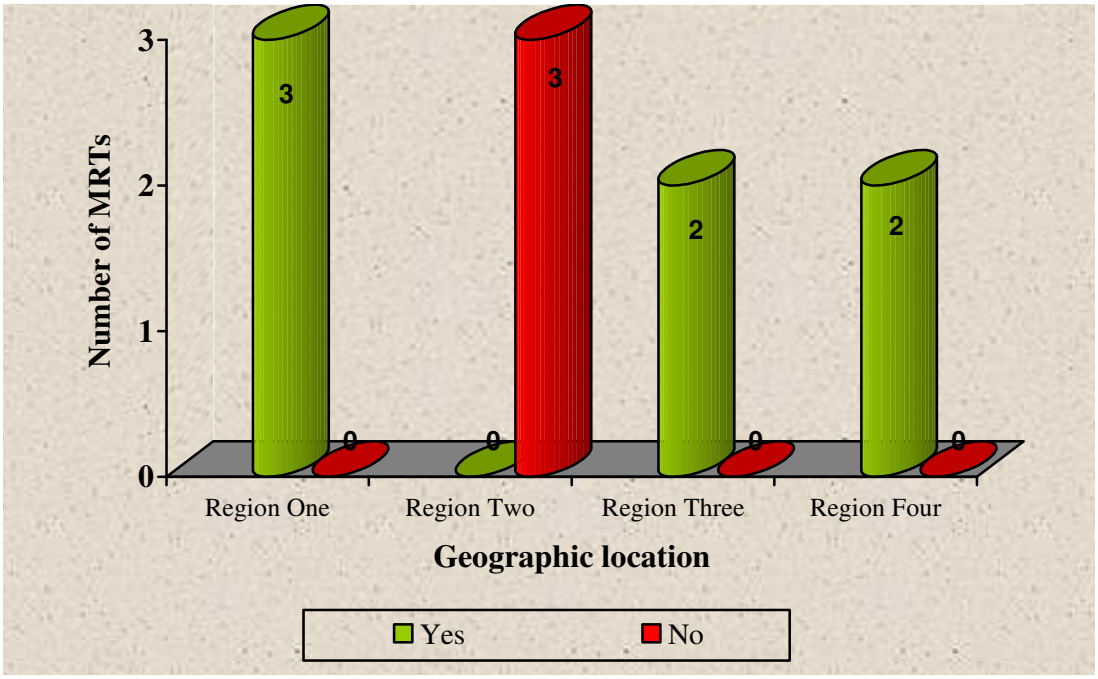


Figure 20 Forms of ongoing trauma image interpretation activities at workplace

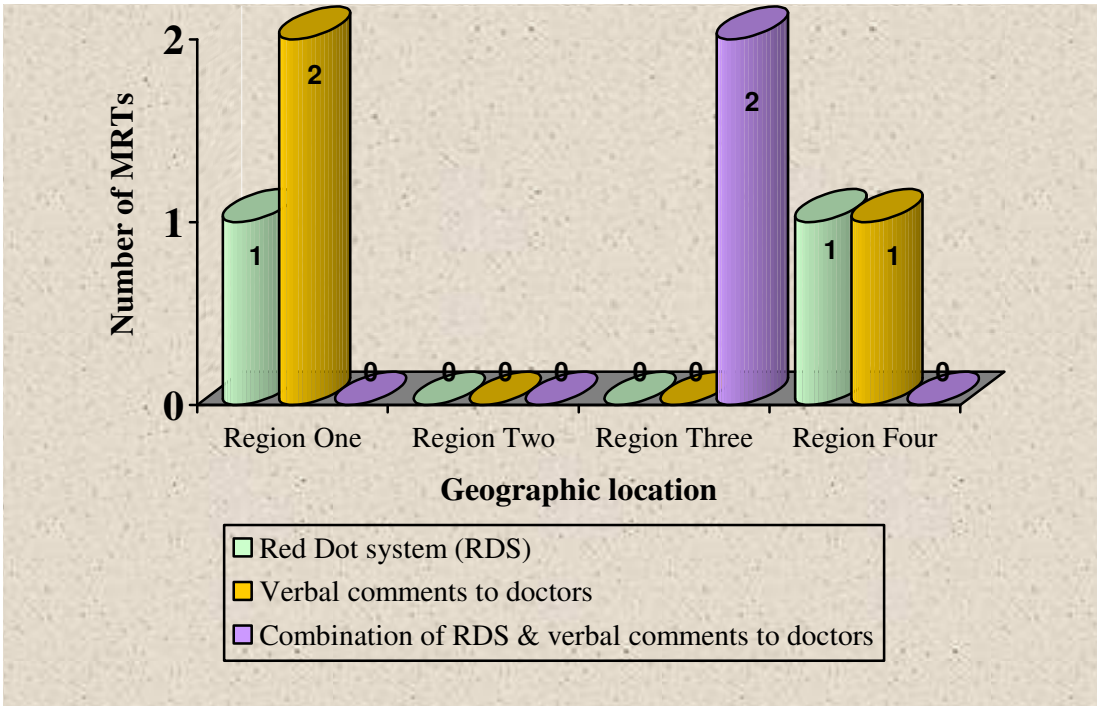


Figure 21 Percentage of interpretations undertaken during normal working hours

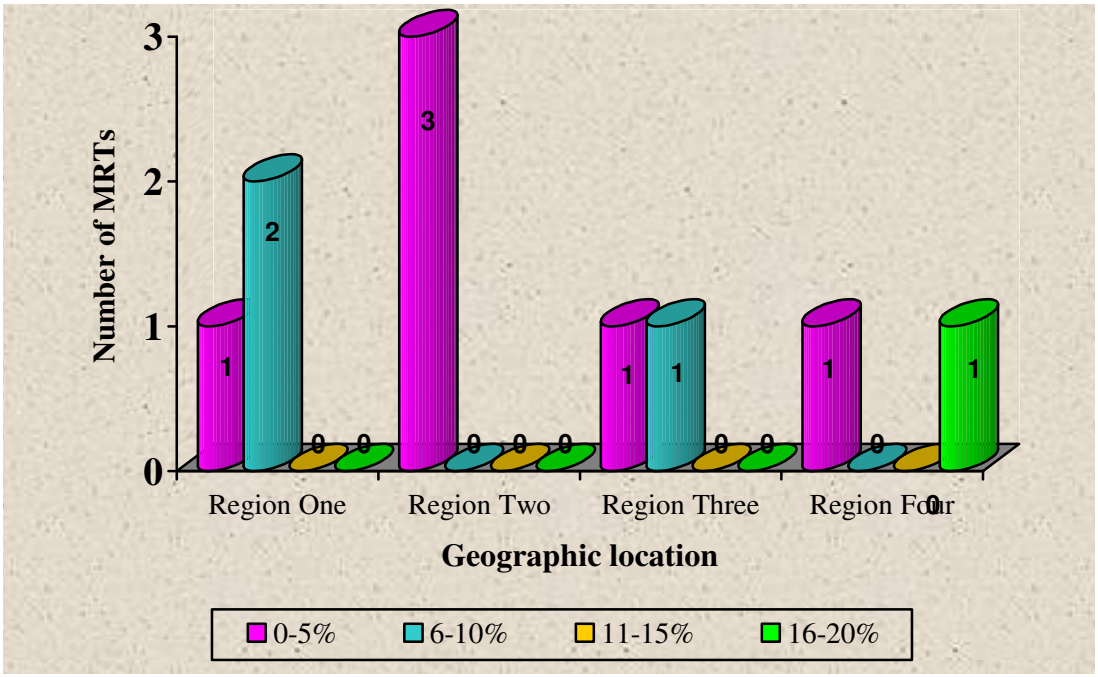


Figure 22 Location where the MRTs interpreted the images

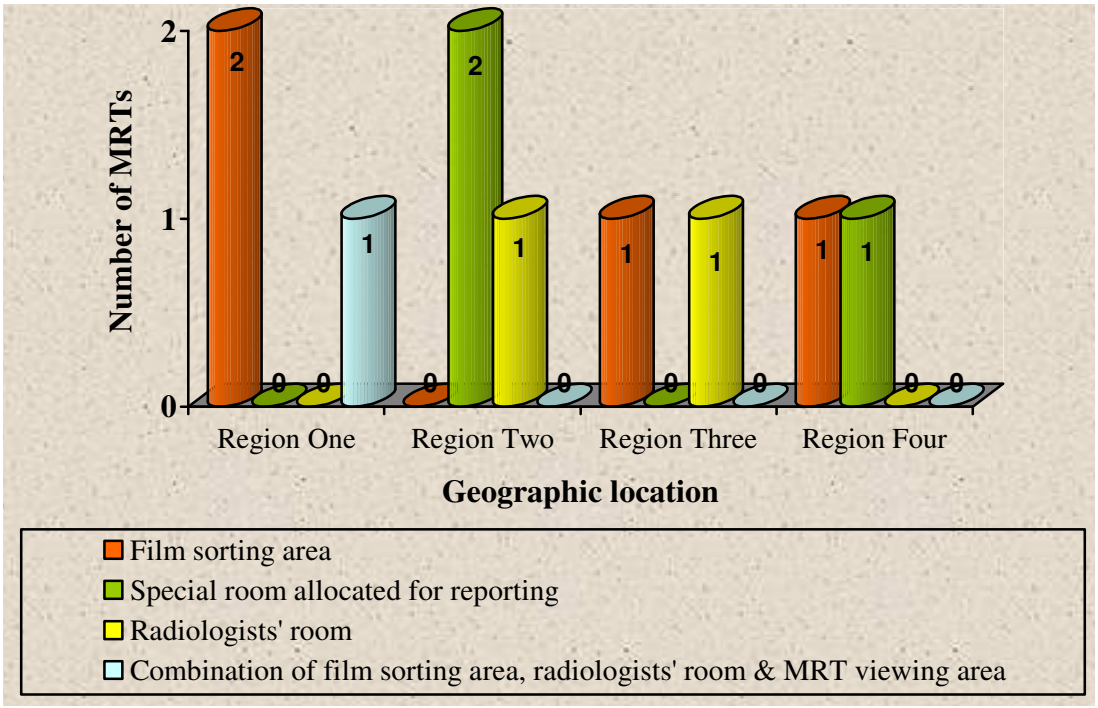


Figure 23 MRTs' personal ratings of the effectiveness of the mentoring arrangement

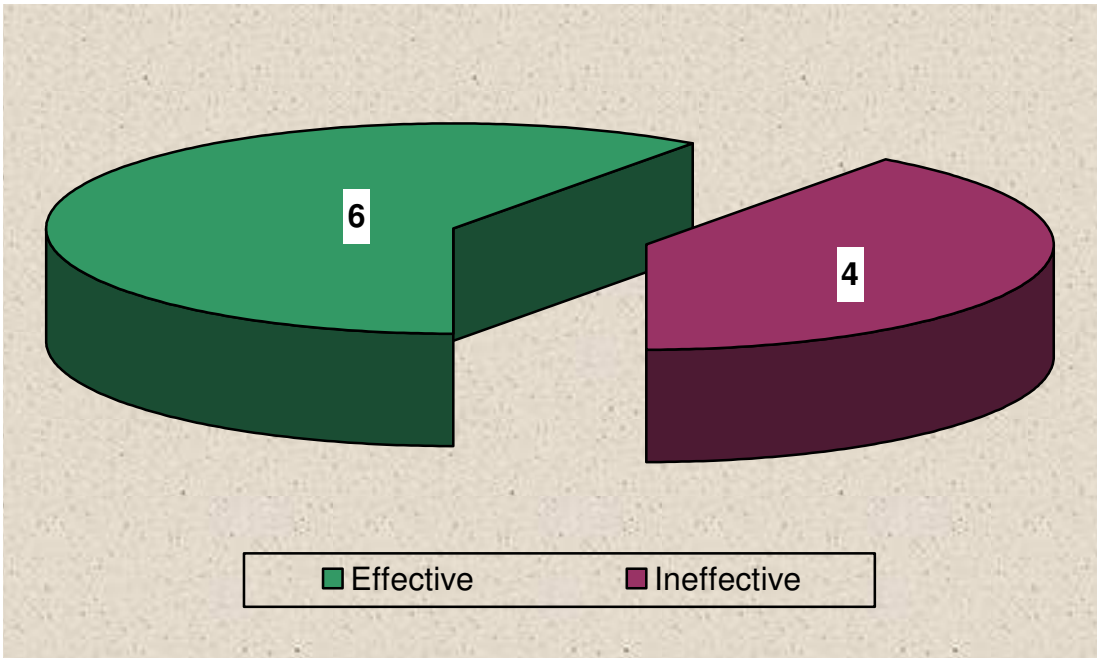


Figure 24 Prevalence of disagreement between the MRTs and their mentors

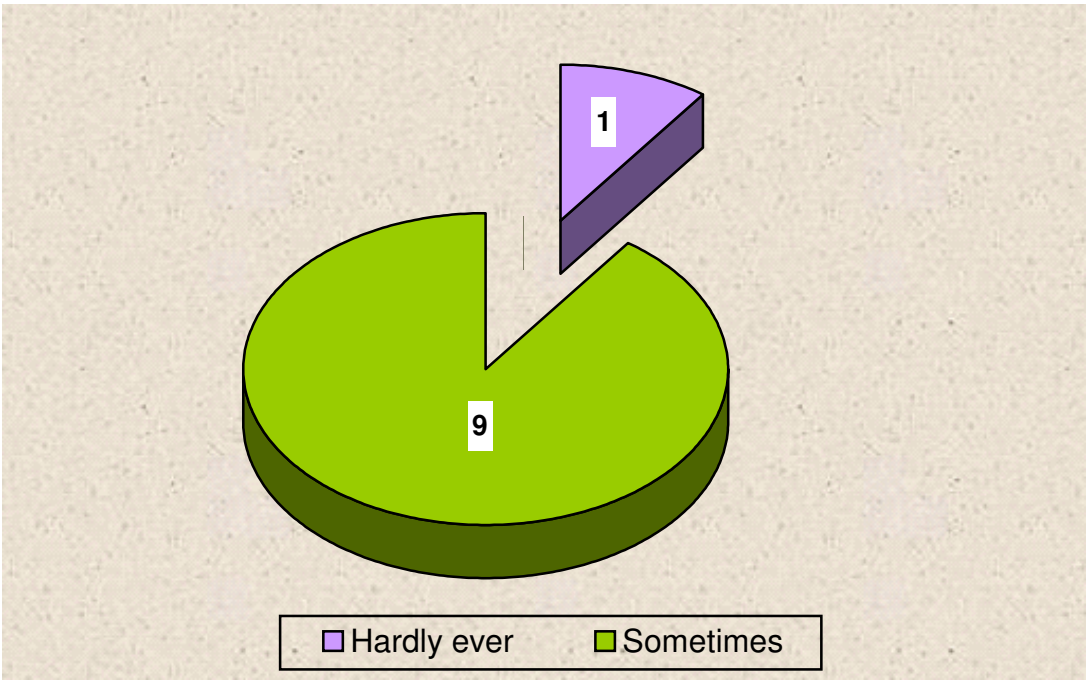


Figure 25 MRT's attitude if asked to interpret images without any formal education in trauma reporting

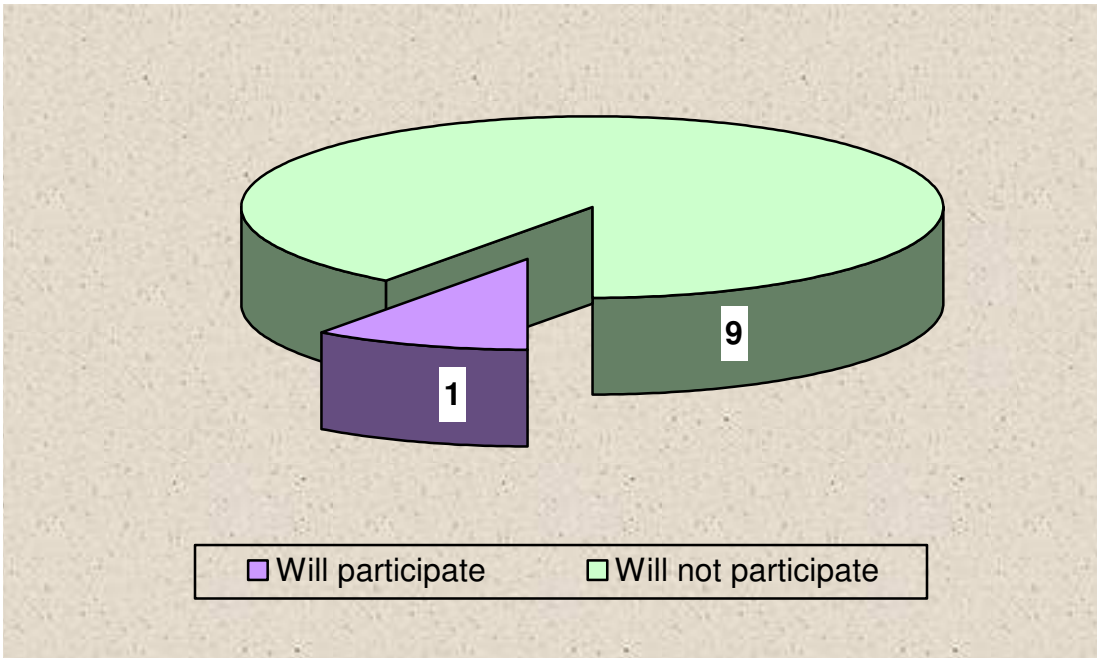


Figure 26 MRT's level of confidence as they interpreted the images

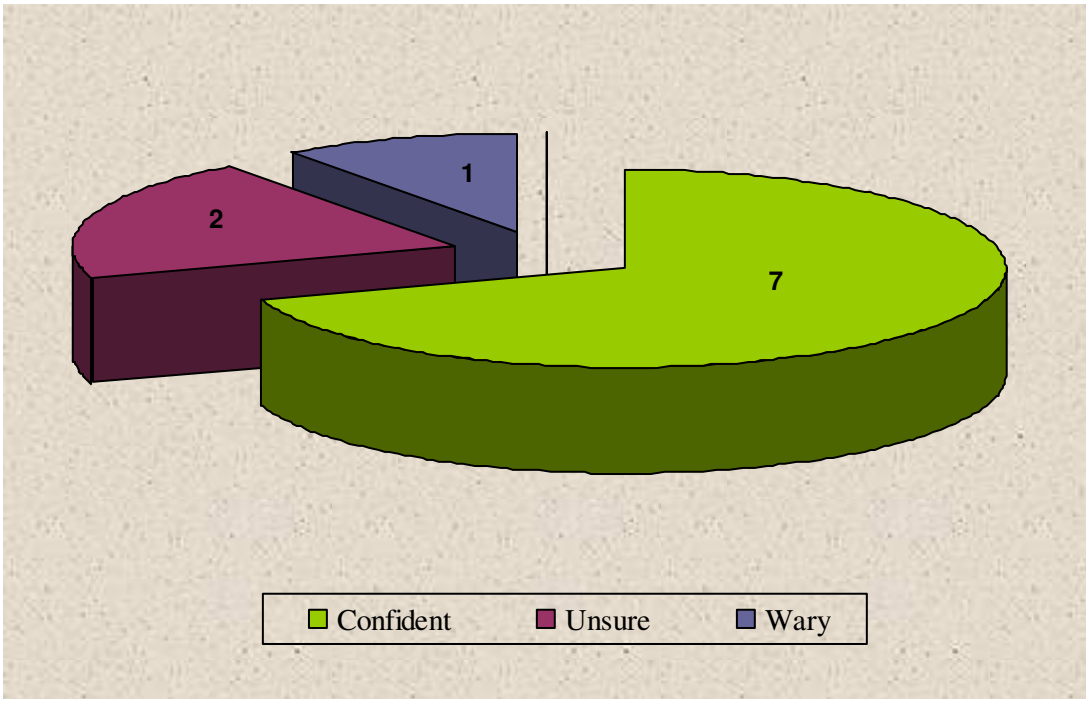


Table 12 Summary of categories and themes generated by the analysis of questionnaires and interviews

Categories	Themes
• Previous training in pattern recognition • Returning to study as a mature student	Individual circumstances of MRTs
• Personal learning objectives and motivations • Work experience as a MRT • Participant interactions	Characteristics of MRTs
• Workplace setting • Work colleagues and their influence • Radiologists at the workplace	MRTs' work profile
• Ongoing image interpretation activities • Time allocated to interpret images at work • Location at work where images were interpreted	Operational demands of MRTs' workplace
• Lecture notes and readings • Assignments • Block lectures • Objective structured clinical examinations	Theoretical component of educational intervention
• Logbooks • Mentoring of MRTs	Clinical component of educational intervention

CHAPTER SIX

MRTs' detection rates and clinical practice

Overview

This chapter involves a thematic content analysis of the data obtained from the interviews and the open comments from the questionnaires in an attempt to provide an insight into the MRTs' detection rates and clinical practice relative to their educational intervention. Further, appropriate quotations from the data have been incorporated to support the discussions in this chapter. This chapter gauges the changes that the ten MRTs expected in their image interpretation skills and clinical practice and analyzes the actual changes that took place relative to their postgraduate educational experience in image interpretation of trauma to the appendicular skeleton of adult patients in emergency settings.

MRTs' perceptions of their image interpretation skills

Image interpretation skills involve the recognition of patterns to determine whether there is any presence or absence of abnormality on the images being observed (Bowman, 1991). The ten MRTs who participated in this study had the perception that their image interpretation skills were either good or very good at the onset of the study. This finding is reflected in Figure 3 which indicates that the MRTs had very high opinions about their current image interpretation skills when they commenced their educational intervention. This high rating may be linked to the MRTs' routine work of producing images and making decisions as to whether the examination needs to be terminated or further views are needed to aid in the diagnosis:

> As a radiographer, I'm already making decisions about which views will be the most useful to provide the information required to make an accurate diagnosis. **Helen**

Figure 3 further showed that there was an increase noted in the interpretation skills ratings of six of the MRTs. These were Pam, Helen, Sam, Elaine, Ariel and Sofia. For Helen, the rating changed from good to excellent while the rating improved from good to very good for the other five MRTs. These changes imply that the manner in which the MRTs viewed the images was different from when they commenced their education, which is further supported by one of the mentors:

> When you're just looking at something a colleague showed casually, that's quite different to the mind set you have when you're reporting something, it's fully inclusive and fully exclusive and you weigh up all the possible factors but when you're looking at something, it's more casual…I think the mentees now will look at it from an interpretative perspective…it's the radiographic factors but a little bit more… **Ian** *[mentor]*

As a result of their becoming more conscientious about the interpretative aspect in combination with the technical aspect of the images, it is likely that improvements may have occurred in the six MRTs' image interpretation skills. Due to this transformation, these MRTs may have therefore given a higher rating to their image interpretation skills at the end of the study. However, as further shown in Figure 3, there was no change noted in the personal ratings of four of the MRTs (Mary, Alex, Jordon and Christina) at the end of the study. Since these ratings were given by the MRTs themselves, it is possible that they were overly self-critical and were therefore unable to accurately assess the actual changes that may have taken place. For that reason, an analysis of the sensitivity, specificity, test scores such as TP, TN, FN and FP and the accuracy of the MRTs relative to their educational experience was undertaken to gauge the actual changes that occurred. In addition, the changes that the MRTs observed in their clinical practice as they progressed in their educational experience were determined as well.

Sensitivity and specificity

As reflected in Figure 4, the initial values for sensitivity (definition given in Table 4) that were demonstrated ranged from 40 to 100 percent. As the ten MRTs progressed in their educational experience, there were six patterns of changes noted in the sensitivity values amongst them. The first pattern involved an increase from the original value in batch one to 100 percent in batch two with this value being maintained in the rest of the batches. This pattern was characteristic of Pam and

Christina. The second pattern involved the maintaining of the 100 percent value from batch one to batch two, with this value reducing in batch three and then improving to 100 percent from batch four onwards. Mary and Ariel demonstrated this pattern of change. The third pattern involved an increase in the subsequent batches with 100 percent achieved from batch three onwards. Sam, Elaine and Jordon had shown this format of change. The fourth pattern involved the initial sensitivity value increasing in batch two, remaining at that value in batch three and then increasing to 100 percent from batch four onwards. Sofia displayed this particular pattern. The fifth pattern involved a fluctuating pattern, where the initial sensitivity value increased from batch one to batch two but reduced to the initial value in batch three. However, the sensitivity became 100 percent from batch four onwards. Alex exhibited this pattern. The sixth pattern entailed the sensitivity value of 100 percent, reducing gradually till batch three and then improving to 100 percent from batch four onwards. This pattern was shown by Helen.

Despite there being six different patterns of progress in sensitivity as shown in Figure 4, all the MRTs improved their sensitivity to a value of 100 percent at some stage in the study and maintained that until the end. Pam and Christina demonstrated a value of 100 percent from batch two; Sam, Elaine and Jordon showed it from batch three, whilst the rest of the MRTs exhibited it from batch four. This finding strongly confirms that as the ten MRTs progressed in their postgraduate education, their sensitivities improved. The improvement in sensitivity implies that the ten MRTs got better in correctly identifying whether the image was abnormal or normal (Hardy & Culpan, 2005). This finding further supports the correlation made by Smith and Baird (2007) between reduced error rates and a competent observer who correctly identifies the presence or absence of an abnormality. Thus, there is evidence that the educational intervention can make a difference to the MRTs' ability to correctly identify abnormalities and also encourage reduction in the likelihood of encountering diagnostic errors.

Observations of the values for specificity (defined in Table 4, page 42) represented in Figure 5 revealed that seven out of the ten MRTs had a specificity of 100 percent from the onset to the end of the study. Those seven MRTs were Pam, Helen, Mary, Ariel, Alex, Sofia and Christina. This finding supports the suggestion by Hargreaves and MacKay (2003) that the MRTs' basic level of training in image interpretation along with their practical experience is already sufficient to enable them to correctly detect normal images.

However, different patterns of change were seen in the specificity values of Sam, Jordon and Elaine. For Sam and Jordon, the specificity value increased from a particular value at the beginning of the study to 100 percent in batch two and remained 100 percent thereafter. Their initial specificity values were 66.7 and 75 percent respectively. Sam explained that "…some of the problems we have here is that with severe trauma we get to x-ray them, see the trauma but when it gets sent to the main hospital, the films very often never get reported so I can never compare my reports to the official reports sometimes." Jordon's mentor also confirmed that this was the case for Jordon.

It can be assumed that the issue of unavailability of official reports may have hindered the two MRTs from cross-checking their performance in correctly identifying abnormalities, especially at the onset of the study. As a result, they both may have ended up having a lower initial specificity in comparison to their other colleagues. It is also possible that this limitation may have influenced which images these MRTs selected for the five batches allocated in the study. Conversely, it is possible that as they compared their interpretations with their mentors, Sam and Alex may have been able to assimilate the information provided by their mentors, thereby improving their future interpretations. This may be a plausible reason for the patterns observed for their specificity during the study period:

> …doing the reporting and comparing with the mentor's report and then being able to get the forms afterwards as well to check where you went wrong or just compare their words with yours - that is actually a good learning tool really. **Sam**

In contrast, Elaine had a specificity value of 100 percent in batches one and two; which reduced to 50 percent in batch three. This specificity value of 50 percent observed for Elaine was extremely low in comparison to the 90 percent or more specificity levels that have been found in previous studies on MRT reporting (for example, Orames, 1997; Smith & Younger, 2002; Brealey et al., 2005). Elaine explained that "I feel my experience as a radiographer is still limited and this may hinder my confidence and possibly how seriously my opinion will be taken". It may have been likely that as a result of being novice to the profession and image interpretation related tasks, Elaine's confidence to correctly describe abnormalities was affected. Work by Lesgold et al. (1988) on developing expertise in reporting has made a similar comparison between novices and experts within a group. According

to them, novices are seen to perform poorly mainly because they have not yet fully mastered their skill in understanding the features present on the images in comparison to their more experienced colleagues. In spite of having the mentioned shortfall, Elaine managed to improve her specificity value of 50 percent to 100 percent from batch four and maintain that until the end of the study. This finding indicates that, as Elaine progressed in her educational experience, she was able to correctly describe the abnormality present on the images just like her colleagues in the study. Hence, the observations made in relation to Elaine advocate that the educational intervention was valuable in developing the ability of the MRTs to correctly describe the abnormalities present on the images that they interpreted for the study.

Nonetheless, Brealey and Scally (2001) have identified that the sample of films that is reported in a study can have implications on the sensitivity and the specificity of those involved in the interpretation of those images. This is because the selection method used to choose the images for interpretation may introduce spectrum bias in the study. Spectrum bias is the ability of the observer to comment on a range of appearances and it has the likelihood of limiting the trauma types, their severity or demographic presentation thus biasing the performance of the observer (Brealey & Scally, 2001). As shown in Table 8, images of the fingers, hand and wrist were interpreted most frequently while the hip and pelvic images were interpreted the least by the research participants. This configuration of the anatomical regions was also confirmed by the four MRTs interviewed. It may be possible that the anatomical regions most commonly interpreted were influenced by the selection criteria used by each MRT to choose the images for the five batches allocated in the existing study (details on the five batches are available in Figure 2, page 32).

The assumption about the selection criteria and the type of images that were interpreted for the study is supported by Figure 6 which shows that six different image selection criteria had been adapted. Sam and Mary had chosen random selection while Ariel had picked cases based on area of confidence. In contrast, Alex had selected images that represented the logbook requirements of the postgraduate courses, while Jordon had selected images that provided a cross-section of his true and false positives and negatives. In comparison, Christina had selected images that represented the different anatomical areas of the appendicular skeleton. Helen, Elaine and Sam had not used any selection criteria at all while Pam had used case frequency to select the images because she was facing “limits on

what examinations were available to interpret due to unknown A&E department patient presentation". The finding that the MRTs adapted different selection criteria to choose images for the present study reiterates the implications discussed previously by Brealey and Scally (2001). It even implies that the initial specificity and sensitivity scores in the current study could have been skewed as a result. Thus, it is likely that the suspected skew could have influenced the patterns that were observed in the sensitivity and specificity throughout the rest of the study.

Further comparison of the sensitivity and the specificity values in Figures 4 and 5 revealed that the initial specificity scores were significantly higher than the initial sensitivity scores. Such findings were also prominent in a study by Brealey et al. (2005) in the UK. The specificity being higher than the sensitivity indicates that the MRTs in the existing study were under-reporting the presence of abnormalities on the images that they had interpreted for the study. In other words, it seemed that the MRTs were still missing some abnormalities that were present in the images that were interpreted for this study. In Chapter Four of this thesis, it was indicated that any deviation of the MRT from the reference standard will be allocated a FN score. It is possible that this strict method of allocating scores for FN responses could have impacted on the research results by artificially improving the specificity and reducing the sensitivity.

Despite under-reporting in the initial stages of the study, the MRTs were found to improve and maintain a steady performance of 100 percent in their sensitivity and specificity as they progressed in their educational intervention. This means that the MRTs were not only able to correctly identify the presence or absence of an abnormality but were also able to correctly describe the true abnormality on the images they interpreted. This finding demonstrates the value of the educational intervention which is further supported by Sam who commented "…to actually do the reporting and to have the logbook is great - well tailored to the needs of a reporter." Likewise, Alex expressed that "I actually think it's a very good course when you look at it…just reviewing even the simplest thing, it's quite amazing that you knew so little about it or just learning tools that you could apply to every film to make a better diagnosis and that kind of thing…" In the literature review, similar sentiments were expressed by a MRT in Canada, who had undergone postgraduate education in image interpretation through distance-learning (Murray, 2005). It is possible that the MRTs in this study may have had similar experiences to Murray (ibid.) therefore

demonstrating the patterns of changes in their sensitivity and specificity that was discussed earlier.

TP, TN, FP and FN scores and the overall kappa value

A study by Goddard, Leslie, Jones, Wakeley and Kabala (2001) has acknowledged that discrepancy between observers is inevitable due to the overlapping nature of the normal and abnormal images that were interpreted. This acknowledgement supports the difficulties that were faced by the radiologists and the MRTs when it came to allocating TN, TP, FP and FN scores in this study:

> …there will be cases hard to score as TP, TN etc…a typical one is 'suspicious of…' where it's not a true positive or a true negative but an equivocal…or incidental findings where you get collateral pathology say a twisted ankle and no fracture but well marked OA changes at the mortise joint so it's a true negative since no fracture but people with significant OA change get more pain and it's a pathologically significant comment but there is no way of scoring it on the current method… **Ian** *[mentor]*

> …sometimes it was very hard for both of us to work out whether if things that you have mentioned, if let's say, you have mentioned four out of the five fractures and you've missed one and it's not going to change patient management do you still say that's a false because you didn't pick up the five fractures or is it still right… **Alex**

The explanations given by Ian and Alex point out how situations such as suspicious abnormalities, incidental findings of pathological abnormalities and multiple abnormalities may have caused dilemmas in allocating appropriate test scores to the ten MRTs' interpretations. As suggested by Brealey et al. (2005), it is possible that the individual measures that were taken by the mentors to score the MRTs' interpretations in the circumstances mentioned earlier may have been subjective. These measures may have therefore had some influence on the MRTs' progress. On the other hand, the allocation of TP, TN, FP and FN scores to the MRTs' interpretations have been acknowledged as decisive elements in the MRTs' progress. One of the mentors, Peter, reflected that "…I think from the mentee's point of view it's obviously a very useful exercise…" Peter's reflection was supported by Sam who commented that "I found it effective…it's actually a really good learning experience to get the false positives and false negatives - they help you learn." Ariel

further explained that “It’s good because you know where exactly you are going and you can see where your faults are.”

Observations of the TP, TN, FP and FN scores in Table 9 have pointed out that six of the MRTs had no FP scores from the onset to the end of the study. They were Pam, Helen, Ariel, Alex, Sofia and Christina. Although FP scores were present in batch four for Mary, in batch three for Elaine and only in batch one for Pam as well as Sam, no FP scores were encountered by the time they all reached batch five. This finding suggests that as Mary, Elaine, Pam and Sam progressed in their postgraduate educational experience, they were all able to correctly say that there was no abnormality present on the images that they interpreted. Table 9 further showed that although FN scores were encountered up to batch three, they were quite low in number. In addition, no FN scores were encountered from batch four onwards, therefore implying that all the MRTs were able to correctly identify abnormal images as they progressed in their educational intervention. These observations may have resulted from the MRTs reflecting on why they were missing the presence of abnormalities on the images and learning from their previous mistakes:

> We looked back and reflected on them basically and tried to find out what it is that we were missing and it’s often the subtle things more than anything that we were missing; obviously, the blatant fractures are easier for us to see.
>
> **Ariel**

From Ariel’s insight, it is clear that the errors were mostly linked to the MRTs missing subtle abnormalities. Obvious or blatant abnormalities are easily picked up because they capture visual attention easily (Samuel, Kundel, Nodine & Toto, 1995). Subtle abnormalities, which are irregularities that are not immediately obvious or understandable in the image, can be difficult to perceive on the image. However, the fact that the MRTs’ FN scores reduced relative to their educational intervention supports the sentiments of Benger (2002) that subtle abnormality detection rates can be expected to improve over time with appropriate training. This suggests that the education in trauma reporting plays a crucial role in developing the MRTs’ ability to pick up subtle fractures.

Upon further comparison, Table 9 pointed out that there were fewer FP scores than FN scores. Although this finding is similar to that of Orames (1997), it does contradict the findings of previous studies on interpretation accuracies of MRTs

where the results were vice versa (for example, Robbinson, Culpan & Wiggins, 1999; Smith & Younger, 2002). This finding of fewer FP scores than FN scores once again implies that the MRTs in this research had a tendency to under-call abnormal images during the early to mid-stages of the study. However, as explained earlier, the criteria that were used to judge the MRTs' reports for concordance with the gold standard may have elevated the FN scores in the present study and resulted in the observations made. Please refer to the definitions given in Table 3 for more details.

Despite encountering FP and FN scores from the onset to almost half–way through the study, it was noted that they were quite low overall as illustrated in Figure 7. The presence of low FN and FP scores are supported by two of the mentors as well. Tom had expressed that "…during the course of me correcting her reports we did pick out very few FPs and not that many FNs…" Similar findings were made by Ian for the two MRTs in region three. Comparison of the overall TP, TN, FP and FN scores for the 400 interpretations demonstrated in Figure 7 revealed that 93 percent of the MRTs' interpretations agreed with those of the gold standard whilst seven percent disagreed. This finding of the majority of the MRTs' interpretations agreeing with those of the gold standard signifies that there was a low overall error rate in this study, which was also accepted by one of the mentors:

> … the few radiographers who did it here were excellent and well within what I understand is the bounds of less than five percent error rate or discrepancy rate whatever you may want to call it. **Gabrielle** *[mentor]*

The insight by Gabrielle hints that the precision of the interpretations of the three MRTs from region two was very high and underpin the finding of low error rates as a result of low FP and FN scores. However, error has merely been described as a "measure of variance from the perfect result" (Goddard et al., 2001, p. 949). This meaning of error can be applicable to the seven percent of interpretations that were in disagreement with those of the gold standard. It is therefore arguable that a percentage showing the overall correctness rate does not consider those agreements that may have been the result of chance entirely (Sim & Wright, 2005).

To rule out whether the 93 percent of interpretations by the MRTs that did agree with the gold standard were a result of chance or perfect agreement, the kappa score was determined as shown in Tables 10 and 11. It was found that the kappa score had a value of 0.86, which is slightly lower than the value of 0.952 found by Carter and

Manning (1999) in their study involving a MRT undergoing postgraduate training in radiographic reporting at a district general hospital in the UK. Carter and Manning (ibid.) expressed that the observed kappa value of 0.952 in their study was an indication that there was a high level of agreement between the MRT and the gold standard during the study period. With reference to Table 7, it is understood that the kappa value of 0.86 indicates that the strength of agreement between the gold standard and the MRTs in this study was very good. This kappa value of 0.86 further supports that there was no guesswork involved as far as the 400 interpretations were concerned and that there was almost perfect agreement between the gold standard and the MRTs (Viera & Garrett, 2005).

Accuracy levels

The accuracy values that the MRTs reached as they progressed in their educational experience have been presented in Figure 8, which revealed that there were six patterns of progress noted amongst the participants. In the first pattern, the accuracy increased from a particular value in batch one to 100 percent in batch two and the value of 100 percent was maintained throughout the study. This pattern was observed in Pam and Christina. Pam found that "due to hours of work and mentor rostering, we met as often as possible. She [mentor] checked my reports and made comments on how to improve." It is possible that this positive interaction was a contributory factor towards the high level of accuracy achieved by Pam. Christina supported her accuracy trend by expressing that "I feel that my reports are mostly accurate…I think I was reasonably good at the beginning but…now I know I'm more accurate then I was to start with." Christina's mentor supported her high accuracy level in trauma reporting as well:

> …we've had a high degree of agreement in our interpretations…I think her accuracy has been basically the same, probably 95, 98 percent plus…because she started off at such a high level I don't really think there's a lot of room for her to actually improve in that particular regard…she's even more accurate than some of our junior registrars in terms of interpreting extremity plain films. **Peter** *[mentor]*

In the second pattern, the initial accuracy value gradually increased to 100 percent from batches one to three and retained the value of 100 percent for the rest of the batches. Such a pattern was observed in Sam and Jordan. Sam's mentor, Tom, explained that "…a vast majority of stuff she picks up and she's got the right answer

and it just goes through…I think she's quite capable of making, you know, 99 percent of the diagnosis perfectly correctly so from a position where I might not have thought that at the beginning now I'm confident that she's right up to that skill…" thus supporting the pattern that was observed for Sam. It can be assumed that this may have been the situation for Jordon as well. Sam reflected that "I'm more aware of normal variants and I'm less likely to count something as a fracture when it's not a fracture…now I think I'm more accurate than I was to start with…" hence implying that the educational intervention had played an important part in enhancing her accuracy.

The third pattern involved the initial value increasing from batch one to a particular value in batch two. This value was maintained in batch three and then increased to 100 percent from batch four onwards. Such a pattern was characteristic of Sofia who was found to comment that "between my office and CT, I haven't taken many plain films." During the interview, her colleague, Christina had also brought this fact to attention when she commented, "…my colleague…she's rostered in other modalities such as CT…" Both Sofia's and Christina's comments imply that due to Sofia being based in another modality, which was computed tomography (CT), her opportunity to interpret conventional trauma images may have been limited. Similar findings had been made by Haslam and Manning (2006) when they had looked at the interpretation accuracy of four MRTs in comparison to the radiologist. According to Haslam and Manning (ibid.) one of the four MRTs had a low accuracy level due to being based in another modality, which was nuclear medicine.

Christina further commented that "…some people might be very good at major trauma reporting if that's what they're dealing with…" Christina's sentiments are supported by Flyvbjerg (2006) who has argued that experience in observing many cases can allow the participant to move from being a beginner to an expert. Even Donovan and Manning (2006) concluded that experience with a large caseload can sustain the reporting MRT. Hence, it is supposed that Sofia's limited opportunity to interpret conventional images may have resulted in the pattern that was observed in her interpretation accuracy.

In the fourth pattern, the accuracy remained the same value in batches one and two, reduced in batch three, then increased to 100 percent in batch four and remained the same in batch five. Mary, Elaine and Ariel demonstrated this fluctuating pattern. Ariel confirmed that "…it improved heaps from the beginning to the end." Similarly,

the mentor for the three MRTs, Gabrielle, verified that "…I would have just thought initially, their accuracy will have been not as good but it's no doubt their accuracy is extremely good." These sentiments provide further support for the patterns that were observed in the accuracy of the three MRTs and hint that the educational experience that the three MRTs' underwent had played a significant part in the observed patterns.

The fifth pattern involved the accuracy increasing from batch one to batch two, reducing in batch three and then increasing to 100 percent from batch four onwards. Alex reflected that "I've noticed, to be honest, I sort of improved in about the middle…" hence reinforcing the pattern that was observed for his accuracy. Alex further said that he would have preferred being "pre-warned before even you started that your anatomy level had to be up to this level rather than trying to cram it all in…my mentor knew it was of no point starting until you were up to that level…" It may be likely that Alex had to reach a certain standard in his knowledge of anatomy in order to fully appreciate the characteristics of the trauma images that he interpreted. There is a possibility that he started to build his anatomical knowledge base at the onset of the study and reached the desired level towards the middle of the study. Having achieved that, Alex must have then been in a better position to understand the anatomy that he was observing on the images and confirm whether he thought there was any abnormality present or not. This was probably the reason why Alex's accuracy improved in about the middle of the study period.

In the final pattern, an initial value of 100 percent in batch one reduced to a particular value in batch two and returned to the initial value of 100 percent in batch three and remained that value throughout the study. Helen demonstrated this pattern of progress and was found to express that she had faced "…lack of availability of images, that is, films sent to various departments or specialists and not available for discussion with mentor." Such a situation may have caused Helen to face uncertainty in the next batch of interpretations, which could have further hindered her from picking up her mistakes and correcting them in the subsequent batch. It is probable that as Helen became accustomed to the image interpretation activities relative to her education, her accuracy improved. This observation made in Helen is not a new phenomenon. It has been supported by Benner (2004) who advocated that during the acquisition and development of a skill, there is a transformation to perform to the accepted competency levels from not having the experience with the situations in which they are expected to perform.

While Figure 8 illustrated that there was significant improvement in the accuracy of all the participants across the five batches, it was noticed that the image interpretation accuracy of five MRTs worsened over a period of time instead of improving steadily with practice. These five MRTs were Helen, Mary, Elaine, Ariel and Alex. However, these five MRTs did show improvements later in the study. This finding of performance in image interpretation worsening over a short period of time is not something new and is similar to that noticed by McConnell and Webster (2000) and Lesgold et al. (1988).

McConnell and Webster (2000) suggested that since the courses in image interpretation show MRTs how to recognize abnormalities and variations in anatomy, the MRTs may develop an immediate tendency to look for the abnormal rather than the normal, hence experiencing a temporary downfall in their performances. While observing the image interpretation performances of three different groups of radiology residents consisting of eleven first and second year residents, seven third and fourth year residents and five experts, Lesgold et al. (1988) found that the performance of the second group worsened over a short period instead of improving with practice. According to Lesgold et al. (1988), the second group did well initially because they were using an intuitive approach. Lesgold et al. (ibid.) continued that as the group members learnt a more cognitive approach, their confidence decreased and this resulted in a temporary reduction in their performance. However, having combined their intuitive and cognitive approaches, the second group was able to gain more confidence and therefore improve (ibid.). It is possible that the observations made by Lesgold et al. (1988) and the suggestion by McConnell and Webster (2000) were occurring in the five MRTs in this research.

According to the model of skill acquisition discussed by Dreyfus and Dreyfus (cited in Benner, 2004), when individuals start to learn a skill, they first learn the rules which govern the situation before they learn when and how to apply them. As a result of this process, they transit through five different stages of clinical competence (Benner, 2004). These five stages are novice, advanced beginner, competent, proficient and expert (ibid.). In the case of the MRTs whose performances had diminished for a short period, it is presumed that they had undergone a transition from a novice to a competent stage relative to their educational experience. This information provides the evidence that the postgraduate educational intervention had been successful in accommodating the transition of these MRTs from novice image interpreters to competent ones.

The trend observed in the changes in accuracy correlates well with previous published data on accuracy patterns achieved by MRTs relative to their training and education (for example, Carter & Manning, 1999; Hargreaves & Mackay, 2003). The six different patterns of change illustrate that the image interpretation accuracy improved as the MRTs progressed in their educational experience. The observed patterns further point out that the MRTs did reach 100 percent accuracy at some stage in the study and all of them were able to maintain this value of 100 percent until the end. It appears that the improvements that were observed are most likely due to the educational intervention. One of the mentors also thought this may have been the case:

> …they're probably better than they were when they started because they've now got a bit more information about the relevance and significance of what you should do in certain circumstances and so on. **Ian** *[mentor]*

MRTs' clinical practice

When patients present for an imaging examination, the MRTs who perform the examination encounter a range of anatomic and imaging characteristics (Obuchowski & Zepp, 1996). This is supported by Sam who felt that "a large part of being a radiographer is that you judge it quite often as to why you are taking the picture and so often I like to look hard at some of the images that I've taken because I know the patient was pretty mobile or had a good range of movement." To competently produce the desired images, the MRTs need to ensure that they are able to develop their clinical practice adequately. This development in clinical practice usually starts with the accumulation of knowledge that is gradually transformed into practice (Miller, cited in Friedenberg, 2000).

The transformation of the acquired knowledge into clinical practice is achieved through the integration of clinical judgment, problem solving and technical skills by the MRTs (Chesbrough, 1999). It is possible that as the MRTs progressed in their education, they may have transited this knowledge into their clinical practice and attempted to provide better patient care as a result. This is supported by Cowell (2002) who has emphasized that the focus of any change process in medicine should be on the needs of the patient. In the current study, three aspects of the MRTs' clinical practice had been considered. These were their usage of appropriate positioning techniques, confidence to perform extra projections and confidence to

identify 'at risk patients' such as stable fracture versus unstable fracture. Observations of Figure 9 indicated that one of the MRTs (Christina) foresaw that there would not be any change occurring in any of the three aspects of her clinical practice as a result of her educational experience while nine of the MRTs accepted that they foresaw some alterations occurring.

Mary thought the possible changes may entail her having to "appreciate if 'extra' views are needed, why they are needed and what views to do." On the same note, Sofia expressed that she may have "more knowledge of why a better image and the knowledge to know if the extra projection will cause more damage or if it is really needed." Similarly, Helen believed that "I will be more inclined to reconsider clinical practices i.e. what views to demonstrate different abnormalities." Alternatively, Jordon felt that "as you see more films that you actually have to write a report on, I think you will take more care in providing the information necessary to make the diagnosis." These perceptions suggest that they were aware of the possible impact that their educational experience may have on their clinical practice.

The sentiments of Casanas and Coelle (2005) that MRTs often forget that good positioning skills and techniques are required to obtain quality diagnostic images are evident in this study. On reviewing their images relative to their education, many of the MRTs became conscious that some of their images were of very poor quality. This finding was also described by one of the mentors, Gabrielle, who stated that "what is quite interesting is that they've noticed that in some instances the quality of their radiography practice has not been quite as good as it might have been and they have been able to feedback from that view point." This statement implies that as the MRTs learnt about the importance of the final outcome from their educational experience, they found that there was improvement in the standard and quality of films produced, thus suggesting that the educational intervention has the potential to raise the standards of the MRTs' existing clinical practices.

As seen in Figure 10, nine of the MRTs felt that their usage of appropriate positioning technique was 'very good' while one thought it was 'good' at the onset of the study. Sam was the one who felt that her technique was 'good'. Towards the end of the study, all the MRTs confirmed that their usage of appropriate positioning techniques had altered as a result of their learning image interpretation. Ariel acknowledged that "more knowledge of anatomy and pathology helped me anticipate what fractures to

expect and how to demonstrate them." Comparably, another MRT found that his viewpoint regarding suboptimal films changed:

> …for me personally I think it's made me more aware of…how difficult it is to interpret a suboptimal film…previously we would say 'obviously it's hard' but now I have more perseverance of getting a better film…say, you dealing with a drunk patient and you'd say 'oh, that lateral would be enough'…made me lift my game in thinking 'actually it's really hard to report a slightly oblique radiograph, I think I'll give it another go'. **Alex**

The experiences of Ariel and Alex signify the positive impact that the educational intervention had made on the MRTs' confidence to use appropriate positioning techniques. It is possible that it may have made the MRTs more aware of the variation in anatomy, patient presentation and imaging characteristics (Obuchowski & Zepp, 1996). Another reason for the changes mentioned by Ariel and Alex may be attributed to them using their past concrete experiences in comparison to rules and formulas to guide their clinical practice as they progressed (White & McKay, 2004). The reflections further indicate that the MRTs started to give more attention to the manner in which they used appropriate positioning techniques so that they produced quality images that aided in appropriate diagnosis of the condition under investigation:

> …if they can look at images from the diagnostic perspective then that strengthens them as radiographers in the way they apply those images, the care they take over the exposures and projections…they now know why the radiologists will say comments like, you know, 'under-penetrated' or 'over-penetrated' and all those sort of things. **Ian** *[mentor]*

Ian's explanation implies that the educational intervention has the potential to encourage the MRTs to endeavour to avoid producing poor quality images so that useful data is not lost and appropriate diagnosis is encouraged. The finding of the images being of adequate diagnostic quality as a result of positioning techniques has been advocated by Berlin (1996) who felt that such approaches would prevent diagnostic errors from occurring. Berlin (ibid.) also felt that by doing so, adequate patient care would be encouraged and any litigation issues would be prevented. Diagnostic errors and their impact on patient care were described by Guly (2001) and were discussed earlier in the literature review.

When rating their confidence to perform extra projections at the beginning of the study (Figure 10), seven of the MRTs thought it was 'very good'. These were Pam, Sam, Mary, Ariel, Alex, Sofia and Christina. However, two of the MRTs rated it as 'good' (Helen and Elaine) while one rated it as 'excellent' (Jordon). These ratings are demonstrated in Figure 10. Towards the end of the study, all the ten MRTs acknowledged that they noticed changes in their confidence to perform extra projections relative to their educational experience in trauma reporting. Jordon noticed that he was "able to provide better diagnosis with extra projection but conversely also perform fewer projections at times so helps with ALARA [as low as reasonably achievable]."

The ALARA principle is a guideline that aids the MRTs to make professional judgments about how best to use the ionizing radiation for each patient presenting for a MI examination (DiGangi, 2006). Jordon's comments imply that he had become more conscious of the extra projections that he performed; which support the guidelines by the RCR (cited in Dhingsa et al., 2002) that unnecessary examinations should be reduced. This further indicates that Jordon had attempted to use the knowledge gained from his education such that the ALARA principle was effective and the patients' dose was minimal. This suggests that appropriate education can make MRTs more aware of the need to control the amount of radiation that the patients are exposed to due to their MI examination procedure. On the other hand, one of the MRTs found that her attitude about protocols on projections had changed as a result of her educational experience:

> …now I'm more confident at gaining an additional view because I think there is something there but I can't quite see it so doing an oblique or getting something extra for that. Before I'd have said 'I can't irradiate them again, it's not right'…I'd just do the protocols and that's it but now I step outside the protocols if I think it's necessary much more readily. **Sam**

Protocols are official formalities pertaining to the MI department and are frameworks within which the patient is to be managed whilst at the MI department (Owen, Hogg & Nightingale, 2004). Baird (cited in Egan & Baird, 2003) has indicated that the protocols place the MRTs in a position where they are required to follow pre-determined projections without much consideration of the patients' presenting clinical systems and history. The comments by Sam reflects that she was in a better position to make decisions regarding extra projections and even step out of protocols

as a result of her education. Sam's comments further reinforce the discussion by Hargreaves and Mackay (2003) that as a result of being able to detect an abnormality, MRTs are in a better position to decide whether extra projections are needed and which projections are required.

Figure 10 further reveals that at the onset of the study, seven of the MRTs (Pam, Helen, Mary, Ariel, Jordon, Sofia and Christina) thought that they were 'very good' when it came to identifying 'at risk patients' such as stable fracture versus unstable fracture. On the other hand, one of the MRTs (Alex) thought he was 'good' while two (Sam and Elaine) said they were 'fair'. Sam acknowledged that "I'm not totally confident now so more information will help." Likewise, Elaine reasoned that "my current experience and knowledge is not enough to be even slightly confident in classifying stability of injuries." However, by the time the ten MRTs neared the end of their educational experience, they all acknowledged that they had found that their confidence to identify 'at risk patients' was much better than when they had commenced their study.

Since the MRTs became more confident in identifying 'at risk patients', there is an inference that the educational intervention does play a key role in enhancing certain aspects of the MRTs' clinical practice. This further suggests that the intervention may be useful in promoting better standards of practice and care for trauma patients transiting through MI departments. Therefore, it is possible that the education in trauma reporting may be valuable to MRTs who work in departments that have a high number of trauma cases. This is because if the MRTs are able to correctly identify 'at risk patients' such as stable versus unstable fracture, they will be able to provide appropriate patient care for these patients while they are at the MI department. This possibility is validated by Egan and Baird (2003) who advocate that by being able to competently identify the physical condition and the capacity of the patients, MRTs may be able to communicate any shortcomings to others in the healthcare team.

Apart from the changes noticed in the three aspects of their clinical practice discussed earlier, seven of the MRTs (Pam, Helen, Sam, Mary, Elaine, Jordon and Christina) confirmed that there were significant changes in other aspects of their clinical practice as well. This information is presented in Figure 11. The majority of them noticed that their confidence to give their verbal opinion about the images to their colleagues and physicians improved. Pam supports this in saying that "I feel more confident and sure in verbally relaying information to the Accident and Emergency doctors." Similar

sentiments were shared by four of the other MRTs. Mary acknowledged becoming "more confident to give feedback to clinicians", while Jordon said he felt "more comfortable discussing cases with medical practitioners and colleagues." Christina indicated that "I don't hesitate to discuss or recommend ED or orthopaedic referrals." Similarly, Helen noted that she was "…more confident in offering an informed opinion regarding diagnosis, which is frequently required in an unofficial manner in this department."

The insights given by the MRTs indicate that the educational experience had been effective in enhancing their confidence in interpreting images. This in turn enabled the MRTs to liaise more freely with their medical colleagues about the abnormalities or otherwise on the images. Therefore, it is likely that acquisition of formal image interpretation skills enables MRTs to use their skills to influence patient care beyond their traditional boundaries (Snaith, 2007). The insights given by the MRTs provide further evidence that as the MRTs' acquired image interpretation skills at their workplaces, more collegial and less hierarchical relationships with other disciplines such as doctors were seen. As a result of being valued for their image interpretation abilities by their medically trained colleagues, chances of medical dominance identified by Yielder (2006) may have been reduced to some extent. This may have relaxed the atmosphere and promoted better teamwork amongst the different professionals as noted by Price (2005). Such experiences may have motivated the MRTs to enhance their clinical practice and perform better in their interpretations as they progressed.

The current study indicates that, with appropriate educational intervention, the MRTs in NZ were of value to the medical team. This sustains the suggestions made by Smith and Baird (2007) who maintain that the existing workforce models in Australia have constrained MRTs from achieving their potential in image interpretation activities. As a result, Smith and Baird (2007) suggest that MRTs be used to complement the radiologist's reporting role so that valuable support may be provided to the referring physicians and ease the radiologists' workload as well. Thus, it is proposed that further research be conducted on the existing workforce models in NZ to identify whether situations similar to those experienced by the Australian MRT counterparts exist in NZ as well. From the information obtained, more research can then be done to determine possible potential areas of role extension for the NZ based MRTs in future.

Further, some of the MRTs noticed a change in their approach regarding the provision of additional information on the request forms. The request form indicates the intentions of the referrer and has information about the anatomical region that needs to be examined and the grounds for doing so in order that an appropriate diagnosis may be made by the radiologist interpreting the images (Holmes, 2000). For Elaine, the change that was observed involved "…avoiding any extra information to request forms for radiologists because I know what needs to be on them." Likewise, Alex stated that "…if I really can't manage to make an image better, I'd write to the radiologist and explain as to why I can't make it any better." Dhingsa et al. (2002) have reiterated that the radiologists can justify an exposure for a MI examination only if sufficient information is provided on the request forms. Similar views regarding the provision of additional information on request forms and radiography practice were articulated by one of the mentors:

> As any radiographer would know, they have the benefit of seeing the patient when they take the x-rays whereas we don't and they then realized how important it is to have as much information on the request form or as a radiographer to maybe annotate on the request form additional information if it's not there… **Gabrielle** *[mentor]*

Gabrielle's comments also substantiate previous work discussed in the background and the literature review about how it is the MRTs and not the radiologists who are in contact with the patients. The MRTs interact with patients to discuss aspects of the request forms with them prior to deciding the best projections to use to create the images. This finding verifies that MRTs already have a major input into the reports produced for ED patients. It can be suggested that this MRT-patient contact time may have been useful in enabling the MRTs in this study to enhance their interpretations. The changes in the MRTs' approach towards request forms provide evidence that education in trauma reporting enhance the type of information and the manner in which the MRTs provided this information on the request forms.

The changes noted in the MRTs' clinical practice in terms of information on the request forms support Dhingsa et al. (2002) who stress the importance of this aspect of radiography practice. Dhingsa et al. (ibid.) found that request forms often had inadequate information or were difficult to read, resulting in radiologists having difficulty in appropriately interpreting images. The study concluded that it is important to have sufficient clinical information on the request form to enable the radiologists to

accurately interpret the images. Swenson and Johnson (2005) have also acknowledged the importance of having appropriate clinical information to avoid interpretation errors. It is possible that just as Egan and Baird (2003) highlighted, the MRTs were able to raise their professional profile and satisfaction as well as improve their clinical practice due to adopting an improved approach to the documentation of request forms.

In addition to the aforementioned changes in clinical practice, one of the MRTs found that her image retake/reject rate was influenced as a result of her education:

> Early on in my studies, I noted that my retake/reject rate increased. My hypothesis is that this was a reaction to being more aware of diagnostic requirements demanding the best quality images. This increase in retakes has rectified. **Helen**

The retake/reject rate indicates the quantity of images that are not accepted for interpretation as a result of not meeting the standards set by the MI department. The increase observed in Helen's retake/reject rate indicates that she had probably been producing images that were of poor quality. It further suggests that, as a result of her education, Helen may have become more aware of the standard of her clinical practice and thus attempted to improve on it. With the passage of time and her knowledge about enhancing images, Helen must have managed to reach the desired standard in her clinical practice. This can be a reason why the increase in Helen's retakes was rectified after a while. The change in the MRTs' perceptions about their clinical practice support Bond and Holland (cited in Sloan, 2003) who felt that appropriate education provides the forum for the participants to appreciate their work in relation to the patient. The usefulness of the educational intervention in improving the MRTs' clinical practice in this study is substantiated by these findings.

Summary

At the onset of the study, the MRTs were found to have higher specificity values compared to the sensitivity. This meant that they were under-reporting in the initial stages of the study. There was the possibility that the sample of films that were interpreted and their selection criteria may have skewed these figures. The manner of scoring TN, TP, FP and FN for the interpretations may have further influenced the sensitivity and specificity. However, it was noted that over time, both the sensitivity

and specificity were at a stable value of 100 percent, which was maintained till the end of the study.

An overall accuracy of 93 percent prevailed and the kappa score was found to be 0.86, which indicated that there was almost perfect agreement between the MRTs and the gold standard. It was evident that the initial accuracy ranged from 50 to 100 percent amongst the participants, with the accuracy of five MRTs worsening temporarily instead of improving steadily with practice. This phenomenon was attributed to the possibility that initially the MRTs were intuitively interpreting the images but as they progressed, they became more cognitively involved, hence showing a temporary reduction in performance. However, as the MRTs combined their intuitive and cognitive skills, they showed improvements. About half-way through their education, the MRTs' accuracy was at a fixed value of 100 percent, which was maintained till the end of the study.

When the MRTs commenced their formal education in trauma reporting, a majority of them perceived that their clinical practice was of the required standard. However, as they progressed, most of them found that their clinical practice was enhanced. The aspects of the MRTs' clinical practice that improved included their use of appropriate positioning techniques, confidence to perform extra projections and identify 'at risk patients' such as stable versus unstable fracture. In addition, some of the MRTs observed that their confidence to give verbal opinions to their colleagues developed and they were able to provide useful information on request forms. The observations made for the MRTs' sensitivity, specificity, accuracy and clinical practice indicate that the educational intervention was instrumental in bringing about positive changes. However, there is the possibility that other factors may have either directly or indirectly contributed towards the changes observed in the MRTs' clinical practice and interpretation accuracy. These factors have been analyzed comprehensively in the next few chapters.

CHAPTER SEVEN

Individual circumstances and characteristics of the MRTs

Overview

This chapter looks at some of the individual circumstances and characteristics of the ten MRTs that emerged during the thematic analysis of the qualitative data for the study. The variables that were prominent included the MRTs' personal learning objectives and motives, work experience, previous training in trauma reporting activities, MRTs' emotions while interpreting images, returning to study as a mature student and participant interactions. This approach has been undertaken to identify the influence of these variables on the MRTs' image interpretation accuracy and clinical practice. It may be expected that the different situations of the participants could have projected certain advantages and disadvantages on the processes related to the changes observed in them and influenced the way that they learnt (Weiss cited in Morse, 1994). In other words, the individual circumstances will almost certainly have some control over the parameters that were being tested. Further, it is likely that due to observer characteristics, interobserver variations may have occurred in the image interpretation activities performed by the MRTs. These views are supported by Hutchinson (1999) who believes that each individual in a group has different needs, circumstances and personalities.

Personal learning objectives and motivations

Objectives are defined as statements of what someone wants to achieve and are used to guide individuals in making informed decisions to achieve the identified goals (Connolly, Arkes & Hammond, 2000). Suggestion has been made that the goals and motivation of students can play a large part in the effectiveness of their learning experience (Dixon, 2006). The ten MRTs had chosen to pursue postgraduate education in image interpretation for various purposes. For Helen, it was for "personal professional development" while for Ariel it was to "assist with teaching,

improve my own knowledge". Jordon's reason was to get "formal recognition". Sofia indicated that for her there was a "need to think about images more and this was a good opportunity". She added further that "the country needs role extension". Pam wanted to "provide a better service in patient treatment in diagnostic image interpretation". Elaine felt the same as Pam and added that "learning image interpretation will aid in job interest and satisfaction". Christina expressed that "I want to 'speak with knowledge' and recognize differences in abilities to recognize trauma reporting and how to deal with them". Mary commented that "I want to be useful to junior doctors and help other MRTs and students with diagnosing". Sam had similar reasons to Mary's. Alex was passionate about his profession, "I love being a radiographer and have always tried to promote my profession…now CPD is a requirement so it is necessary to participate in things like this".

The objectives given indicate that the majority of the participants wanted to enhance themselves as MRTs. One of them also wanted to be able to extend her existing role to encompass image interpretation activities through postgraduate education in trauma reporting. The given comments make it apparent that the majority of them were highly motivated to acquire the required reporting skills and enhance their interpretation accuracy. Opportunities for MRTs to be involved in image interpretation activities encouraged them to increase their motivation and develop themselves professionally:

> It has motivated me more and it has actually given me heaps of satisfaction to actually see the trauma and be able to report it and to know that there is fracture… **Ariel**

> It's made it much more interesting, I mean, it makes it more enjoyable when you aren't just turning out pictures. **Sam**

The descriptions regarding job satisfaction and motivation given by Ariel and Sam suggest that the educational intervention had made a difference in their attitude towards their work and enhanced their clinical practice as a result; thus strengthening the value of the education that the MRTs had undertaken. It can be said that the MRTs' personal objectives for pursuing postgraduate education in trauma reporting may have given them a clear understanding of what they wanted to achieve and directed them to try their best to achieve their ambitions. In other words, the MRTs personal objectives may have acted as motivational factors for them. This

presumption is comparable to the discussions by Hardy and Barrett (2004) about how highly motivated participants are more likely to achieve their learning objectives than less motivated ones.

Research has shown that close alignment between the learners' learning needs and the course outcomes can inspire the learners into achieving their personal objectives (Fisher & Ford cited in Shute, 2007). This concept has been quite prominent in the nursing profession (for example, Nisbet, 2006). There is a possibility that as the MRTs in this study identified their individual learning needs in context with the learning outcomes of their education, that were discussed in chapter two, they were able to develop their interpretation accuracy and their clinical practice accordingly.

Previous training in trauma reporting activities

The illustrations in Figure 12 highlight that eight of the MRTs had had some form of training in pattern recognition prior to embarking on their formal educational intervention. These eight MRTs were Pam, Sam, Mary, Elaine, Ariel, Jordon, Sofia and Christina. Four of these MRTs (Pam, Sam, Elaine and Ariel) had attended a pattern recognition workshop at a tertiary institution in NZ; two (Jordon and Sofia) had attended conferences, one (Christina) had informal teaching by radiologists and the other (Mary) had participated in all three mentioned activities. This information has been presented as Figure 13. A similar finding occurred in a study by Haslam and Manning (2006) and led the two researchers to accept that one of the MRTs in their study had prior knowledge and more awareness of the pattern recognition of abnormalities over the other three MRTs who had not had any such exposure. This must have also been the situation for the eight MRTs in this study who had been exposed to some form of training in pattern recognition prior to their commencing their formal postgraduate education in that area. As a result, the prior learning must have added to these participants' experience in trauma reporting and led to a biased initial interpretation rating. This is supported by Figure 8 where it was evident that the majority of them had accuracy levels of over 70 percent at the beginning of the study.

However, although Sam and Sofia had had some previous exposure to pattern recognition activities, they both had an accuracy value of 50 percent in batch one, which was very low in comparison to their other colleagues as well as previous studies on image interpretation (for example Loughan, 1994; McConnell & Webster,

2000; MacKay, 2006). It is likely that the two MRTs had undergone a 'de-skilling' process due to them being unable to follow the recommendations of MacKay (2006). McKay (ibid.) recommends that MRTs who have undergone education or training in trauma reporting should be topping up their image interpretation knowledge and skills before a period of six months has elapsed. This is to ensure that they do not forget their newly acquired knowledge and skills with passage of time and are able to continue practising in a competent manner. This can be one of the reasons why Sam and Sofia had such a low accuracy level at the onset of the study. Since this research looks at the changes in the MRTs' interpretation accuracy and clinical practice relative to their educational intervention, there is scope for further investigation in future to evaluate the image interpretation accuracy of these MRTs after a certain time frame. From this, evidence can then be available to either support or refute the presumptions made earlier.

Work experience

Although the study by MacKay (2006) found no significant relationship between the work experience and the interpretation accuracy of MRTs, the study by Manning, Ethell, Donovan and Crawford (2006) did establish that the work experience of MRTs can have some impact on their image interpretation accuracy. Manning et al. (ibid.) argued that experience in the volume of cases encountered relative to the MRTs' routine work can lead to better performance in image interpretation related tasks. Observations of the MRTs' work experience presented as Figure 14 revealed that one (Elaine) had considerably less work experience as a MRT in comparison to the other participants. Therefore, it can be said that Elaine's confidence to correctly describe abnormalities was affected as a result of her being new to the profession and image interpretation related tasks. Work by Lesgold et al. (1988) on developing expertise in reporting has made a similar comparison between novices and experts within a group and embraces the belief of Manning et al. (2006) discussed earlier. According to Lesgold et al. (ibid.), novices are seen to perform poorly mainly because they have not yet fully mastered their skill in understanding the features present on the images in comparison to their more experienced colleagues.

McLauchlan, Jones and Guly (1997) have the view that an inexperienced person may not be able to gauge when to seek assistance or advice, which explains the fluctuating pattern that was seen in Figure 8 for Elaine's accuracy. Due to the high

performance demands of trauma reporting, Elaine was overwhelmed at the early stages of her educational experience. However, as a result of being a more recently qualified MRT, Elaine's knowledge of anatomy acquired from her undergraduate education may have been an advantage for her and enabled her to demonstrate an accuracy of 87.5 percent at the onset of the study (Figure 8). On the other hand, as Elaine progressed in her educational intervention, she was able to grasp the concept of how to go about performing the reporting tasks and learn about the approach to take in improving her interpretation accuracy. As a result, she achieved the accuracy of 100 percent from batch four onwards as illustrated in Figure 8.

Figure 14 further establishes that the remaining nine participants had been working as MRTs for six years or more. Therefore, they had accumulated meaningful understanding relative to their work experience and developed their level of expertise in image interpretation as they performed their routine work. Similar sentiments have been voiced by Hargreaves and Mackay (2003) when they discussed that although MRTs lack the formal training in the interpretation of trauma appearances, they have a vast experience of viewing the images compared to others. The notion of Hargreaves and Mackay (ibid.) was supported by two of the mentors in this study:

> …they were both experienced radiographers in this particular case so they had seen a lot over all their years of experience and we're talking about observational skills - they've got the necessary anatomical knowledge and they've seen it all before… **Ian** *[mentor]*

> I suspect, it's probably influenced by the fact that she is an experienced radiographer to begin with…you can't deny her experience…she has seen a lot more plain films than I have, even though I have reported more…perhaps if we'd a junior radiographer going through this process, you'd find that, I'd imagine the results being noticeably different at the end compared to the start… **Peter** *[mentor]*

The details given by Ian and Peter can be applicable to the other MRTs who had over six years of work experience as well. The information provided by the mentors confirms that work experience can lead to the high performances noticed in the majority of the MRTs. The two mentors' sentiments provide further evidence that a certain degree of innate image interpretation skills exist amongst experienced MRTs. This can be a reason why the performances of the experienced MRTs were much better than their less experienced colleagues. The explanation given by Donovan

and Manning (2006) that increased experience enhances the sensitivity of those performing trauma image interpretation activities, supports the deductions made earlier. This is because part of the reasoning process evolves from past experience (Woolley cited in Overton-Brown & Anthony, 1998).

Bowman (1991) has also concluded that the more experienced the MRT, the higher their pattern recognition abilities will be. The differences in the initial interpretation accuracies between the experienced and the inexperienced MRTs in this study infer that experience may have been a relevant factor. This inference substantiates the conclusion of Valkenburg, Ralph, Lopatofsky, Campbell and Brown (2000) that MRT image interpretation is a 'natural niche' for experienced MRTs who have had additional formal education in trauma reporting. However, as recommended by MacKay (2006), further research may be needed to explore the role of 'experience' in MI that the MRTs have and try to determine how it might actually affect the performance of MRTs in image interpretation activities.

Returning to study as a mature student

In this case, mature students are adult students who have completed their baseline qualification in a particular field of study a long time ago and have now returned to study so that they can upgrade their existing qualifications. It is a considerable time since they experienced any formal education, therefore, they are exposed to certain issues that add an additional burden to the postgraduate education that they are undertaking:

> I found not enough time because I had to find the time to learn how to use the computer and use the institute's library…for me personally but other people might not have any problem with that…I found the hardest thing was that when I trained for radiography, you handwrote your assignments…the whole computer searching for articles…it's just taken me hours in order to present in the standard format of the assignments, an absolute nightmare for me, although if I had probably thought about all that, I might have taken a computer class before I started… **Alex**

The experience shared by Alex, who was a mature student, has been labeled as cognitive appraisal by Innes (1998). Cognitive appraisal is the intensive personal evaluation of the demands and the ability of the learner to cope (ibid.). Any

imbalance in demand and the ability to cope can cause emotional stress such as feeling of anxiety, guilt and frustration in the learner (ibid.). This was evident in Alex, who found the demands of having computer-written assignments and searching databases overwhelming. His sentiments reveal that he was unable to use the available facilities adequately due to a lack of training and exposure to such facilities in his previous studies undertaken many years ago. Alex's reflections imply that his clinical time for reporting was diverted into learning the basics and other technical aspects of his education. This limited or compromised the actual time he spent on linking the theoretical and the clinical components and probably influenced how he transited from a novice to a competent image interpreter within the period of time allocated for his educational experience.

However, the issue of having difficulty with computer technology is contradictory to the findings of Aucoin (2004). As stated by Aucoin, many colleges and universities have now made it a requirement for the students to have some preliminary knowledge in computer applications as part of the curriculum. It is entirely possible that this was the situation for the tertiary institution in this study. Additionally, it has been recommended that prior to embarking on postgraduate study, students should ensure that they allow adequate time for improving their computer literacy and writing skills if they have not been engaged in any formal educational interventions lately (Innes, 1998). This is an aspect that Alex acknowledged overlooking when he enrolled in his postgraduate study. Therefore, it is suggested that students should upgrade their technical skills in computer literacy if they intend to pursue further education.

Participant interactions

When there is interaction amongst participants undertaking formal education, it can provide certain benefits for the participants:

> …I'm getting to know the rest of the group and exchange of experiences is an integral part of doing a course like this…we had a lot of swapping around and we could exchange frustrations as well about things that weren't going fine so it was good… **Ariel**

As highlighted by Ariel, the participants had different experiences and were able to enlighten and assist each other to understand certain aspects of image

interpretations that would have otherwise been difficult to grasp. Similar thoughts were generated by Ooijen (2000) who believed that group interaction can provide the platform for group members to offer a wide range of professional and life experiences to each other on areas of practice where there is room for improvement. He further expressed that such interactions can avoid chances of collusion, which was prominent in a study by Innes (1998). Whilst studying the experiences of postgraduate radiography students, Innes found that there was poor communication, resentment, jealousy from colleagues and a lack of trust amongst fellow students early on in the course. She concluded that these experiences resulted in a lot of stress for the students and affected their academic performance to some extent.

In this study, it was evident that collegiality was prominent from the onset of the study and the MRTs were in constant communication with each other. As advocated by Steves (2005), the MRTs were able to discuss their practice, seek guidance and support from each other. By finding themselves in similar or contrasting situations, the MRTs were in a better position to identify and rectify their problem areas in trauma reporting. Further, they were able to motivate each other and attempted to develop their image interpretation skills and clinical practices to the desired standards.

Summary

It was found that some of the individual circumstances and characteristics of the research participants influenced their progress in their education. As a result of closely aligning their personal learning objectives to the course outcomes, the MRTs were highly motivated to accomplish the recommended competency in their interpretation accuracy and develop their existing clinical practice. In addition, the majority of them had previous training in pattern recognition, which resulted in their initial accuracy being over 70 percent. However, two of the participants had initial accuracy of 50 percent and it was likely that they had undergone a ‘de-skilling’ process due to not continuously updating their newly acquired skills.

Further, it was found that at the initial stages of the study, the more experienced MRTs were better at image interpretation compared to their less experienced colleagues. This implies that a certain degree of innate image interpretation skills exist amongst the experienced MRTs. It was also found that one of the MRTs, who had returned as a mature student, had difficulties coping with the demands of his

formal studies. This affected his progress to some extent. There was evidence that through interaction amongst them, the participants were able to discuss their practice, seek guidance and support from each other. This communication helped to promote the changes in their interpretation accuracy and clinical practice. However, there is a possibility that the departments where the MRTs worked during the study may have had some influence on the MRTs' clinical practice and image interpretation accuracy. These factors have been considered in the next chapter.

CHAPTER EIGHT

MRTs' work profiles and their operational demands

Overview

Effective performance of MRTs undertaking reporting tasks is dependent on the context of their working environment (Mitchell, 2005) and is significantly controlled by the situation that they find themselves in (Alreck & Settle, 1995). In addition, the local standards of practice at the MRTs' respective workplaces may influence the degree to which they succeeded in learning their image interpretation skills (Hardy & Barrett, 2004). Likewise, workload determines the degree of studying and learning that the students achieve (Chambers, cited in MacMahon, 2006). Taking these findings into account, this chapter examines the impact of the MRTs' work profiles and operational demands on their image interpretation accuracy and clinical practice during the study period. It comprehensively discusses the categories that emerged during the thematic analysis of the qualitative data collected. The variables revolve around issues such as the MRTs' workplace setting, work colleagues and their influence, radiologists at their workplaces, ongoing image interpretation activities at their work, time allocated them to interpret images at work and the location where reporting was performed.

Workplace setting

During the interview, Christina commented that "I think going by who was at the class, there was a different kind of practice for every group, you know, there was one that was within a remote area, there was one within hospitals, that sort of things…". Her comments are supported by Figure 15 where nine of the MRTs were based at public hospitals and one was based at a private clinic run by the DHB. Christina from region four was the one working at a private clinic and her mentor, Peter, acknowledged the fact, "…she's at a private clinic and this department is contracted to provide plain film reporting for it". In addition, seven of the MRTs (Mary, Elaine,

Ariel, Sofia, Christina, Pam and Alex) worked in an urban area, two (Helen and Jordon) worked in a remote area whilst one (Sam) worked in a suburb (see Figure 16). The problems of working in a suburb or remote centre compared to an urban centre were highlighted:

> Even though they may be triaged up there, the films are probably whipped away before the patients are flown down here by helicopter and he wouldn't have access to the films or their reports where he's based. **Ian** *[mentor]*

> …some of the problems we have here is that with severe trauma we get to x-ray them, see the trauma but when it gets sent to the main hospital, the films very often never get reported so I can never compare my reports to the official reports sometimes. **Sam**

Therefore, it is likely that the operational demands at the various workplaces affected the MRTs' interpretation accuracy and resulted in the patterns described in Chapter Six. The MRTs' workload and working conditions must have further influenced the alterations in their clinical practice (discussed in Chapter Six). Alex accepted that working at "…a major trauma hospital…that's probably an influence". Ariel acknowledged how "if you are in a busy area you keep getting interrupted the whole time, it does become very difficult to concentrate, especially for us while we are still learning." Pam admitted that "I felt time constraints as I x-rayed after hours. If very busy – this slowed workflow." These sentiments validate the findings of Dawes, Vowler, Allen and Dixon (2004) who found that variations in the operational demands of the hospitals the students in their study were based at caused differences in the students' image interpretations.

In addition to causing time constraints and difficulty in concentration for the MRTs, the workplace has an influence on the availability of trauma cases as well:

> I don't know how much is covered in smaller institutions but we are a large…institution and trauma for us is readily available and we can actually pick and choose to a certain degree… **Ariel**

From Ariel's comments it was evident that due to working at a large institution, getting trauma cases for interpretation was not an issue for her and her two colleagues. This means that the three MRTs from Region Two were exposed to a greater variety and intensity of trauma caseload in comparison to their other seven

colleagues in this study. The mentor from Region Three had expressed similar concerns:

> The radiographer at the other centre is certainly a little less exposed to trauma than the radiographer here via the spectrum of pathology readily available but by definition of numbers the other radiographer might have seen as many but, the level of trauma is probably less than what we see here, you know, he may see more peripheral hands, wrists and knees whereas we get the more central trauma. **Ian** *[mentor]*

The statements given by both Ariel and Ian further emphasize the impact that the work setting has on the type and frequency of the trauma cases that were available for interpretation by the MRTs in the present study. An analysis of the frequency of encountering trauma to appendicular skeleton cases per week by the MRTs at their various workplaces indicated three different frequencies. This information is demonstrated in Figure 17, which shows that the three frequencies were comprised of ten or less than ten cases per week, eleven to twenty cases per week and more than twenty cases per week. The first category applied to four of the MRTs (Helen from Region One, Alex from Region Three and Mary and Ariel from Region Two). One of the MRTs from Region Two (Elaine) fell into category two. The third category was applicable to one MRT from Region Three (Jordon) and two MRTs from Regions One (Pam and Sam) and Four (Sofia and Christina).

The finding of three frequencies of encountering trauma cases reiterates the sentiments of Mitchell (2005) and Alreck and Settle (1995). This finding provides evidence that the setting of the MRTs' workplace did influence their image interpretation accuracies to some extent. Nonetheless, there was confirmation of other issues emerging as a result of the participant working at an urban centre:

> …the frustrations in a large trauma hospital are related to shortage of staff so time has become a bit precious…especially if we were doing trauma on work time we weren't able to spend much time because we had to preference…it's very tedious trying to do it after hours when you're tired…
>
> **Ariel**

The difficulties and limitations that Ariel and her two other colleagues, Mary and Elaine, faced as a result of working in a large trauma hospital compromised their reporting time and concentration levels during reporting. The fact that it is difficult to

report images when one is tired cannot be neglected. This aspect of reporting has been highlighted by Prabhu, Gandhi and Goddard (2005) as well. According to Prabhu et al. (2005), tiredness during interpretation activities can result in more errors, which concurs with the previous discussions in the literature review about diagnostic errors and their aftermath. Alternatively, Emrich (cited in Booth & Manning, 2006) has contemplated that MRTs who work in fast-paced or short staffed settings are placed under stress to process as many patients in the shortest time. Emrich (ibid.) added further that such situations may hinder the degree of interaction that MRTs have with patients.

Sam revealed that "…I had a little more time to spend with the patients to find out exactly where it's sore and had time not to feel rushed so much here probably as it is in bigger centres." This suggests that MRTs in smaller centres are able to take advantage of the time they spend with each patient so they can determine the exact localization of the complaint (Egan & Baird, 2003). As Sam explained, the close contact with the patients and the ability to cross-check the situation with the patients and relate them to the images may have enabled her to improve her interpretation accuracy as well as her clinical practice. It may be presumed that her other colleagues who were based in either suburb or remote centres had similar experiences, which contributed towards the patterns observed in their interpretation accuracy and the changes acknowledged in their clinical practice.

The interaction between the MRTs and their patients during the image interpretation activities indicate that the MRTs were able to focus on improving the standards of care given to the patients. This finding of improved patient care through proper communication between the patient and MRT has also been highlighted by White and McKay (2002). Thus, this study indicates that MRTs can play an important role in enhancing patient care if they are allowed to interpret images whilst the patient is still at the department, which further substantiates the proposal by Oakley (2001) discussed in the literature review.

Work colleagues and their influence

Daniel (cited in Fitzgerald, 2001) has the opinion that individual performance can be enhanced through positive reinforcement such as recognition, praise and encouragement from colleagues. When the MRTs were asked about how their work colleagues regarded them doing interpretations of images of trauma to the

appendicular skeleton, many of them gave some interesting insights. Sam commented "I get my colleagues asking for my opinions…they just ask me 'do you think that's a fracture or otherwise'…they are pretty good themselves and we have good discussions amongst ourselves". Jordon said that "it is appreciated by both allied health professionals and medical officers". These comments show that as a result of them undergoing formal education in trauma reporting, there is more utilization of the MRTs' image interpretation skills by their colleagues at work. This suggests that the educational intervention was providing the means via which the MRTs' knowledge in image interpretation was being appreciated more by their colleagues. As identified by Nightingale and Hogg (2003), these kinds of experiences encourage improved working relationships between professional groups. Due to the team spirit being conducive, the MRTs achieved higher performances in their interpretation accuracy. This is because when a healthy environment is fostered, learning occurs through the sharing of experiences:

> …often when we walk down the corridor the mentor or one of the other radiologists will say 'hey that's a good call you made'…I interact with the patient and the medical staff which probably contributes to more accurate results. **Christina**

On the other hand, two of the MRTs acknowledged having slightly different reactions from their work colleagues:

> Radiologists – mixed opinions – some very supportive. **Mary**

> Mixed reactions. Enthusiasm from radiographers. From radiologists not involved with mentoring I suspect some skepticism and wonder if the course has been somewhat of a threat. I am unsure as to how local referring doctors feel as I have not made my reports available to them. I would be very interested in their response. **Helen**

These comments verify the earlier discussions in the literature review about how some radiologists may consider reporting by MRTs with either hostility or reservations (Cunningham, 1997; Hare, 2003). When the participants were asked whether the opinion of others at their workplace had influenced their interpretation accuracy and skill acquisition in any way, six of them (Helen, Sam, Ariel, Alex, Elaine and Sofia) felt that it had not whilst four (Pam, Mary, Jordon and Christina) felt that it had. This information is illustrated in Figure 18. Ariel said she was not influenced

because she had pursued formal education in trauma reporting "for personal gain and not prestige". Likewise, Alex expressed that "I never have and probably never will care what others think. I'm doing this for me and my profession. People will either be for or against or apathetic". These sentiments substantiate the previous discussions about the personal objective of MRTs and what have motivated them to accomplish their goals.

On the other hand, Jordon commented that "it has boosted my confidence and need to educate myself further". Mary said that she "tried harder to prove we can do it" while Christina stated that others' opinions "made me investigate causes or reasons and outcomes of various findings". The actions taken by the MRTs as a result of their workmates influences must have resulted in the changes noted in their interpretation accuracy and clinical practice. The comments indicate that the opinion of their workmates did encourage some of the research participants to enhance their performances by becoming more aware of the interpretation process and skills.

Radiologists at the workplace

The availability and accessibility of radiologists at the MRTs' various workplaces to interpret the trauma images of ED patients were diverse. Jordon confirmed that there were "none on site, films must be sent to base". His mentor explained that "…we are two whole time equivalent radiologists short so we are actually a very staffing struck department". The circumstance regarding availability of radiologist was slightly different for Christina. She said she "can walk to hospital (one block away) and try to find one". However, the situation for Helen was that "the radiologists (two regular) for our department are located at the Base Hospital, two hours from our hospital, so films are sent daily for reporting". From the feedback given it was apparent that there was no radiologist available on site to provide formal reports at the three MRTs' workplace. The status of their workplaces was that the films had to be either sent or taken to the radiologists based at the main hospitals for the official reports. As a result, these participants did not have the opportunity to compare their interpretations with the official reports on a regular basis:

> …films sent to various departments or specialists and not available for reporting and or discussion with mentor. **Helen**

This drawback must have manifested itself on the interpretation accuracy that was achieved by the three MRTs during the study. Christina indicated that "…an urgent report is supposed to come back the next day, but often it doesn't…They [doctors] rely a lot on the MRT input…". Helen and Jordon also acknowledged being relied upon by the doctors at their workplace for information on the images that have no formal reports. This form of reliance on the MRTs' opinions must have contributed towards the high initial accuracy value illustrated by these three MRTs in Figure 8.

The scenario regarding radiologist availability was different for Sam from Region One. According to her, a radiologist was available "two to three days per week from 8.30am to 2pm". She further pointed out that "…we usually have a different radiologist once every six weeks." Finding herself in such a situation made it quite difficult for her to communicate with the radiologists so that she could develop her image interpretation skills. This must have been why her initial accuracy in Figure 8 had been so low in comparison to her other colleagues. On the other hand, it is likely that as she gained knowledge in trauma reporting through her formal education, she became accustomed to the interpretation tasks, which is supported by her comment that the intervention "provided the education needed to build knowledge and confidence".

In comparison, Pam, also from Region One, indicated that there were "12 radiologists" who worked "daily from 9am to 5pm" and the remaining hours were covered by "on-call registrars". Alex from Region Three was in a similar situation to Pam but had only half the number of radiologists based at his workplace. In comparison, Mary, Elaine and Ariel from Region Two confirmed having "over 20 radiologists" who interpreted the images on a "24 hour basis". Due to being exposed to different radiologists at their workplaces, these MRTs were predisposed to encountering limitations when writing reports for the images that they interpreted. This is because the different styles of report writing amongst radiologists must have created situations of uncertainty about what the MRTs could include or exclude in their reports:

> …we didn't get a constant type. She likes things a certain way and other radiologists like it a different way so it was very tough…nobody knew what anybody was doing…it was a placid feeling around trying to find out what we needed. I personally had an incident with her where I had a torus fracture which is a buckling of the fracture and she had never heard of a torus fracture because they normally refer to it as a greenstick and so she giggled

> and said you are correct but you just need to use greenstick so that was just a learning curve so in future I will not use torus but I'll use greenstick but that's just specific to a radiologist… **Ariel**

Experiencing dilemmas similar to the ones mentioned by Ariel could have influenced the MRTs' accuracy, thus resulting in the patterns illustrated in Figure 8. This is supported by Connolly et al. (2000) who highlighted that different radiologists call the same thing by different names and produce reports that are not standardized. Likewise, Gabrielle had the opinion that "as with any group of people, radiologists will vary from a short salient report to a detailed one…". On the same note, Weiner (2005) has expressed that the opinion that existence of variation in the use of terminology by radiologists make it difficult to understand the information at times. This has led researchers such as Swenson and Johnson (2005) to suggest there is a need for a unified and consistent radiological word list and adaptation of an itemized reporting template.

Further, one of the mentors, Peter, mentioned that "I noticed this - the wording, if you're a bit unsure you try to hedge your bets but that's what a lot of radiologists tend to do". Peter's sentiments have also been echoed by Connolly et al. (2000). Hobby, Tom, Todd, Bearcroft and Dixon (2000) identified that expressions such as 'unlikely', 'likely', 'probable' and 'appears present or absent' were consistently used in reports by radiologists. This finding led Hobby et al. (ibid.) to conclude that significant differences in the radiological expressions used by radiologists may cause uncertainty in and misunderstanding of reports. It is possible that the radiologists produced non-standardized reports, which could have confused some of the MRTs in writing their reports. It is also possible that variation in reports further prevented the participants from confirming whether they were correct or not and made them continue to make the same mistakes (Donovan & Manning, 2006).

Apart from having difficulty with the wordings of reports, it must have been hard for the MRTs to obtain enough support from the radiologists to facilitate their learning due to there being so many of them around daily at their workplace. In other words, it may be presumed that very few radiologists may have taken personal responsibility to see that these MRTs got through their postgraduate education in trauma reporting:

> Not enough time to do it at work…no teaching right from the beginning about how you report – was just expected to do it. **Mary**

Mary's comment suggests that she and probably her other two colleagues in Region Two may have found it hard to identify their mistakes and learn from them due to lack of teaching, which may have resulted in the fluctuating patterns demonstrated in their interpretation accuracy in Figure 8. When interviewed, Ariel described the dilemma that she, Mary and Elaine had faced at their workplace:

> …for the three of us, we found it very much of self-learning and having to utilize other radiologists wherever possible…approximately five to six radiologists because…it was very tricky finding a radiologist when you could have some time and they could have some time…hence in our case the mistakes could only have been realized or rushed in the end. **Ariel**

Ariel's statement about the situation suggests that some of the radiologists were committed to fulfilling their responsibilities towards their workplace and they were therefore unable to spare time to assist the three MRTs. This information verifies the details given earlier by Mary about the lack of teaching and supports the concerns of Friedenburg (2000) about sacrificing teaching time for productive and profitable practice time in medical settings. Similar apprehensions were voiced by Chesbrough (1999) when he noticed that there was a decrease in the devotion of faculty time and commitment to training radiology residents in a residency program in the USA. Chesbrough (ibid.) linked this observation as an effect of departments measuring clinical effort to determine their income. He continued that as a result, none of the staff had time to attend meetings to discuss the performance of the residents. This resulted in there being neither any curriculum nor any requirement to cover specific materials for the residents.

Nonetheless, as mentioned by Ariel, the difficulties associated with accessing radiologists encouraged the three MRTs to become self-directed learners. This concept is well explained by Brown (cited in Steves, 2005) who identified that there are three stages involved in self-directed or experiential learning. In the first stage, the learners concentrate on learning the technical skills. In the second stage, they learn how to perform those skills and in the third stage, the students set their own learning agendas and choose their personal learning experiences to accomplish whatever they set out to achieve. Therefore, it is possible that despite having inadequate support from the radiologists at their workplace, Ariel, Mary and Elaine developed their experiential learning and succeeded in overcoming the pitfalls in their image interpretations skills.

Ongoing image interpretation activities at the workplace

There was an implication that in addition to their formal education in trauma reporting, some form of additional image interpretation activities were being undertaken by the MRTs at their respective workplaces. This information has been presented in Figure 19 which showed that seven MRTs were involved in other image interpretation activities, which were a part of the operational demands of their workplaces. They were Pam, Helen, Christina, Sofia, Alex, Jordon and Sam and they either participated in the RDS or provided verbal comments to the doctors or a combination of the two as illustrated in Figure 20. Pam, Helen and Christina were involved in providing verbal comments. Pam revealed that she had to "report back to ED staff verbally if any abnormality detected" while Helen was involved in "providing comments verbally to GPs and MOs if requested". For Christina, the verbal comment required her to "Provide instant 'report' to GPs who are on duty at practice. Provide opinions on follow ups at fracture clinic sessions at the practice. Interpret radiologists' reports for GPs".

The scenario of MRTs providing verbal comments has been acknowledged in the code of conduct published in 1994 by the CoR (cited in Friedenburg, 2000) where the idea of MRTs providing verbal and written reports on image appearances was promoted. In the present study, being involved in such forms of activities taught the MRTs certain concepts and skills in trauma image interpretation even before they commenced their formal education. This predisposition gave these participants a significant advantage and enhanced the degree of accuracy with which they interpreted the images. Evidence is available in Figure 8 which shows that Pam, Helen and Christina had initial accuracy values of over 70 percent.

Sam and Sofia were involved in the RDS. During the interview, Sam's mentor provided some insight about the operation of the RDS at Sam's workplace:

> …we've got sort of an alert system here because this place is not continuously staffed by radiologists…the radiographers place a red dot on a film if they suspect a fracture to help the house surgeons and also the house surgeons will put a little sticker on it to indicate whether they say it's a fracture or not so we have a feedback system and I know whether they've done a FP or a FN. **Tom** *[mentor]*

Tom's reflections highlight that prior to commencing formal postgraduate education in trauma reporting, the MRTs were already involved in bringing the presence of abnormalities to the attention of the doctors providing front-line care for the patients. This suggests that the image interpretation accuracy and clinical practice of MRTs involved in the RDS was enhanced by those activities, but this was not the case for Sam and Sofia who, as illustrated in Figure 8, had the lowest accuracy levels at the onset of the study. It is possible that these two MRTs were interpreting images intuitively at the beginning of the study. However, exposure to formal study must have encouraged them to combine their intuitive and cognitive analysis, thus resulting in the positive changes in their accuracy and their clinical practice as they progressed.

Alex and Jordon from Region Three were involved in a combination of both the RDS and provision of verbal comments to GPs. According to Alex, there was "no formal programme apart from starting this course but as part of being a 'senior' MRT you are often asked for an opinion on x-rays after hours; in our department we also have a very informal red dot system". Their mentor, Ian, further explained that "…we operate an informal red dot system so we are actually formalizing to some extent what they've been doing in practice for many years". Ian's comment supports the sentiments of researchers such as Yielder (2006) and Donovan and Manning (2004) that were discussed in the literature review. However, Smith and Baird (2007) have commented that although providing verbal opinion and participating in the RDS was an important role by MRT counterparts in Australia, the contributions of MRTs were rarely acknowledged. It is possible that similar situations are occurring in some of the MI departments in NZ. This area was discussed earlier in the literature review, where it was found that the RDS usage was acknowledged in some institutions in NZ but nothing was said about its success or the MRTs' contributions. It is even likely that some of the MRTs were providing verbal comments or participating in the RDS merely out of obligation to their departments. Therefore, a lack of recognition of their informal contribution via the RDS and verbal comments may have had the opposite effect on some of the MRTs and resulted in them not being motivated enough to perform to their best standards. Ariel's comment that "I think in life there has to be some kind of recognition for what you do and if you don't get that then it becomes very difficult to keep continually doing that…" further supports the assumption made earlier.

As rationalized by Hargreaves and Mackay (2003), prior involvement of MRTs in the RDS and/or provision of verbal comments initiate informal learning, thus giving the MRTs a significant advantage in the study. This reasoning is applicable to the seven MRTs who were participating in some form of ongoing image interpretation activities at their various workplaces and is supported by the high accuracy levels that were demonstrated in Figure 8 by most of these MRTs at the onset as well as throughout the study. As suggested by Smith and Baird (2007), this may be an opportune time to formalize the MRTs' already on-going but under acknowledged role in bringing the referring clinicians' attention to abnormalities via the RDS and verbal comments. The situation, however, was different for the three MRTs (Ariel, Mary and Elaine) from Region Two. Figure 19 indicated that apart from their formal education, none of them had any form of involvement in other trauma image interpretation activities at their workplace. This finding suggests that their image interpretations were mostly influenced by their education and reiterates that MRTs can be trained to perform interpretations of trauma image on par with radiologists.

Time allocated to interpret images at work

It was brought to my attention that the majority of the MRTs did their reporting activity outside of their normal working hours. This is reflected in Figure 21 where three different ranges of percentages for reporting during normal working hours are given. The most common range constituted zero to five percent of six of the MRTs' normal work schedule. Pam from Region One; Mary, Elaine and Ariel from Region Two; Alex from Region Three and Sofia from Region Four fell in this category. The second most common range was eleven to fifteen percent. Helen and Sam from Region One as well as Jordon from Region Three were in this category. The smallest range was sixteen to twenty percent and was applicable to Christina from Region Four. The factors which hindered the participants to report at their respective workplaces during their routine working hours are described below:

> If you do it during the day, people basically ask questions about various films and it's hard to concentrate…I had to report after hours because I didn't get time during work…not because they are grumpy about it but because you don't have time off or staff...that kind of thing puts a lot of strain…I think basically that our department probably didn't realize how much time is involved…I think they did not realize how much time they needed to allocate me to do stuff… **Alex**

Being distracted during the image interpretation activity was one of the reasons that made Alex resolve to interpret the images after hours. Equally, some of his colleagues indicated that they too had to make certain provisions to enable them to perform their image interpretation so that the operational demands of their workplaces were not affected. Pam expressed that "working part-time I have extended my non-pay hours to cope". Helen said that "reporting has been performed during 'down times' in the department." Ariel acknowledged that "I had to cut back on my hours and availability – to ensure I get my own time to report". Sofia tried to "do the study out of work hours – e.g. lunch". These viewpoints reveal that most of the participants adjusted their schedules to enable them to better cope with their extended role of interpreting images. This observation about making adjustments is in line with Diamond (1998) who recommends that MRTs pursuing image interpretation tasks should look for alternative ways that ensure they are able to accomplish the desired competency in their new activities.

Alex's comment also suggests that it seemed as if his department was not aware of the importance of allocating him some time to do the reporting activities. This was also the case for Elaine who expressed that "often I need to stay beyond working hours to do reporting as the department cannot give me time during work hours often enough". This is supported by Sim, Zadnik and Radloff (2003) who highlighted that when departments judge the MRTs' efficiency in terms of them performing daily procedures and clearing patient waiting lists, there is a lack of support by the department to allow the MRTs to undertake other activities during their working hours. It may be possible that similar judgments were made by the MI departments where the participants in this study were based. As mentioned by Alex, there is the possibility that the lack of support by the MI departments was not intentional, but was an oversight by the respective departments.

The finding of the MI departments not being supportive contradicts the suggestions in the literature review, where emphasis was put on the importance of the department being involved in the development of the MRTs' reporting skills from the start. In addition, it can be seen as a breach of the initial request made by the teaching institution asking for support from the departments where the MRTs in the study were working during their educational intervention period. The request for permission has been discussed earlier in the background and research procedures of this thesis. As a consequence of the lack of support from their department, there is the likelihood that the MRTs' progress relative to their educational experience may have been

hindered. It is also possible that the lack of time to interpret images during working hours may have had a counter-effect on the MRTs' clinical practice as well. Nonetheless, it is noteworthy that in spite of having lack of support and compromised time to do the actual reporting during their normal working hours, the ten MRTs did show improvements in their accuracy and they showed levels comparable to radiologists.

Site where reporting was performed by the MRTs

There has been emphasis in the literature that the reporting process may vary as a result of the viewing and reporting facilities being used (Morris, Grieve, Thomas & Hughes, 2002). It is possible that the lack of standardization of these facilities during image interpretation activities may contribute towards the error rates that occur in the observers (DeCorato, Kagetsu & Ablow, 1995). There was an indication that various areas were used by the MRTs for their actual image interpretation activity. This has been presented as Figure 22, which showed that four of the MRTs (Pam and Helen from Region One; Jordon from Region Three and Christina from Region Four) undertook their interpretation in the film sorting area at their workplace. On the other hand, three MRTs (Mary and Elaine from Region Two as well as Sofia from Region Four) were using a special room allocated for that purpose. In contrast, two MRTs (Ariel from Region Two and Alex from Region Three) were utilizing the radiologists' room. Alternatively, one MRT (Sam from Region Three) was performing her interpretation in a mixture of areas, which included the film sorting area, the radiologist's room and the MRT viewing area. The degree of involvement of the place of reporting on the interpretation accuracy of Sam was commented on by her mentor:

> ...there aren't too many places where she can get peace and quiet to give it a chance…that was probably a disadvantage to her - not having say a little office that she could hop into… **Tom** *[mentor]*

This finding about Sam can be seen as a contributory factor towards the pattern of change that was noted in her accuracy across the five batches as illustrated in Figure 8. The possibility of the area where all the MRTs did their image interpretation having an impact on their interpretation accuracy cannot be ignored. As explained by McCarthy and Brennan (2003), it is common practice for the film sorting and MRT viewing areas to have either shielded windows or switched off lights in comparison to

the other areas in the MI department. Therefore, it is likely that the lighting was not optimal for those participants who used these areas to interpret their images and this may have affected their abnormality detection rates in the images that they interpreted for the purpose of this study. In addition, these areas may have been in constant use by the participants' work colleagues, which may have caused some distractions and interruptions for the participants. As a consequence, the patterns of change observed in their accuracy levels illustrated in Figure 8 may have occurred.

Further, the quality of the monitor on which images are viewed has the possibility of affecting the interpretation accuracy of the observer (Wade & Brennan, 2004), which is supported by McCarthy and Brennan (2003), who expressed the view that diagnostic efficacy is strongly dependent on the image viewing conditions. According to McCarthy and Brennan (ibid.), if the brightness of the viewing light is low then the observer's visual acuity will be affected and the observer's ability to adequately assess the images will be hindered. They argued that optimum lighting is needed to enable the observer to appreciate the different areas within an image in order to arrive at the correct diagnosis. The deliberations about viewing conditions imply that these factors may have impacted considerably on the interpretation accuracy of most of the MRTs. Despite encountering these limitations, the participants have demonstrated that they were able to achieve accuracy levels that were on par with those of the gold standard, thus suggesting that they were able to successfully overcome certain obstacles and enhance their abnormality detection skills in the process. Since the focus of this research is to evaluate the changes in the accuracy and the clinical practice of MRTs relative to their educational experience, the impact of viewing conditions on image interpretation will not be pursued any further. Nonetheless, there is scope for this aspect to be investigated through future research.

Summary

This chapter indicated that the MRTs' work profile and their operational demands may have contributed towards their accuracy and clinical practice. Those participants who worked at either remote or suburb centres faced issues such as the types of trauma images that were available and the unavailability of formal reports for comparison. However, they interacted more with the patients, which enabled them to focus on improving the standards of care given to the patients. Conversely, those

MRTs who were based at urban centres encountered issues such as lack of time to interpret images due to staff shortages. This resulted in them reporting when they were tired or frustrated.

In addition, the situation regarding radiologists was diverse. For those MRTs who worked at remote or private centres, there were no radiologists available on site to do formal image interpretation. Alternatively, the centre located in the suburb had radiologists working there on certain days of the week only. As for the urban centres, the number of radiologists ranged from six to twenty. As a result of the difference in reporting styles of the radiologists, the MRTs at the urban centres faced difficulties in writing reports. As a result of varying numbers of radiologists, some of these participants had to resort to self-learning. Further, six of the MRTs commented that the opinion of their work colleagues influenced their interpretations.

There was evidence that the majority of the MRTs were involved with ongoing image interpretation activities such as the RDS, provision of verbal comments to doctors and a combination of both as part of the operational demands of their workplace. These activities may have provided significant advantage for these participants and enhanced their accuracy to some extent. However, it was found that due to work commitment and inadequate support from their departments, there was very limited interpretation undertaken by the MRTs during normal working hours. These two factors further influenced the location where the reporting was performed by the participants.

It seems that the factors related to the participants' work profile and their operational demands may have had an impact on their clinical practice and accuracy. Upon reflection, it may be likely that although these factors were prevalent in the present study, the MRTs proved themselves so well and compared to the radiologists. It may be envisaged that the education in trauma reporting may have counteracted the effects of these factors one way or the other. The components of the educational intervention and their significance are discussed in detail in the next chapter.

CHAPTER NINE

Educational intervention in trauma reporting

Overview

The descriptions of the postgraduate education courses in Chapter Two indicate that in order to ensure that the curriculum was effective, the teaching institution offering the course in NZ had used a model similar to Bines and Watson (cited in Nisbet, 2006). According to this model, professional education takes place mainly at the participants' workplaces. However, there is block release to an institution of higher education where the MRTs acquire the required facts and competencies, which are then developed and transmitted into a systematic knowledge base. Finally, they acquire the required professional competencies by applying the knowledge through practice and reflection on practice under the supervision of a mentor.

In considering all of the above, this chapter comprehensively discusses the categories that emerged during the thematic analysis stage of the data. The categories include lecture notes and readings, assignments, block lectures and objective structured clinical examinations (OSCE), logbooks, mentoring of the MRTs by the radiologists, mentoring scheme and feedback by the mentors. They have been allocated into two themes, that is, theoretical and clinical components of the educational intervention. In addition, the chapter explains the influence of these themes on the image interpretation accuracy and the clinical practice of the research participants. It further looks at the significance and success of the identified components in developing the participants' skills as competent image interpreters. The chapter concludes with a discussion on the future applications of the MRTs' newly acquired skills in trauma reporting and possibilities of role extension for the MRTs in NZ.

Theoretical component

It has been acknowledged that errors in image interpretation may be reduced by improving the skills and the knowledge of those doing the reporting (Goddard et al. 2001). This can be achieved through "awareness of history and clinical symptoms, comparison with previous studies, systematic analysis of all anatomical compartments, careful selection of the initial and subsequent radiological or clinical investigation" (ibid. p. 951). From the feedback obtained from the MRTs, it was evident that the theoretical aspect of the courses involved the adaptation of resources such as lecture notes and readings, assignments, block lectures and OSCE.

Teaching resources such as lecture notes and readings have the potential to encourage the learners to acquire knowledge and use them accordingly to develop their image interpretation skills:

> …the slides and the little key things that they give you…soft tissue signs - I never realized the important role they do actually play in the x-rays. We've just looked at details of 'oh, that's a fracture'…I've never realized before how important soft tissue signs were… **Ariel**

The reflections by Ariel emphasize that the lecture notes and readings had motivated the MRTs to search for principles and integrate them with their existing knowledge and understanding. This was further elaborated upon by one of her colleagues:

> …lots of lectures online on BlackBoard…about the images themselves and how quickly they need to be spot on otherwise you would miss something. The information from the course telling you that you have to check all the edges and make sure nothing is out of line…it makes you think about it a lot more and keep your eye open for all kind of things you have read about and studied and that just makes you more aware of other possibilities.
>
> **Sam**

By being able to learn the importance of relationships and cues relative to their educational experience, the MRTs were capable of mastering their interpretation skills and enhancing their existing clinical practices. Similar conclusions were made by McConnell and Webster (2000) who had seen the performance of the MRTs participating in a short course on recognizing trauma patterns on conventional images improving relative to their progress in the course. McConnell and Webster

(ibid.) felt that the changes that occurred in their participants' accuracy were partly a result of the comprehensive notes that were given to them.

Further, it was acknowledged that the development of the MRTs' knowledge of anatomy and normal variants in these courses was accomplished through assignments:

> We learnt a lot and realized how much anatomy we don't know and how much anatomy you should know. **Ariel**

> It encouraged you to research things a bit further and perhaps do a bit more thinking about things than what I'd do normally. They encouraged me to expand my knowledge base, and were an ongoing measure of achievement and progress. I think the normal variant paper was a good one…and also the fact that it did make you learn your anatomy and your reasons behind bone healing, I mean, I'd done all that but I'd forgotten it. **Christina**

Clearly, as realized by Reeves (2004), it is possible that the MRTs also became aware of how their FP scores may have been influenced by their inability to recognize the extent of normal anatomy. The sentiments of Ariel and Christina signify that the assignments were effective in teaching them to differentiate between normal, abnormal and normal variants; which may then have enabled them to improve their FP scores in the study. This is a useful finding and supports the recommendation of Manning, Leach and Bunting (2000) that advanced knowledge in anatomy and understanding of normal variants are key factors in improving performance in reporting. In addition, the assignments seemed to encourage the MRTs to become self-directed learners as well as more aware of the interpretation process:

> …the assignments were the best because you are obviously doing a lot of self-directed learning. **Ariel**

> …particularly doing the assignment is when you know you are looking at something really close up. When you are doing the assignment, it makes you think about that area and so when every film comes along you look really closely…studying particular areas in depth definitely helps. **Sam**

It is possible that as a result of doing assignments as part of their educational intervention, the MRTs were encouraged to scrutinize the image and its surroundings more intently than they used to do before commencing their education. This exposure may have minimized their error rates relative to their progress. A similar experience was acknowledged by Reeves (2004), whose error rates reduced greatly due to his formal education in trauma reporting. There was also evidence available that by providing key lectures during the allocated lecture block sessions and allowing the participants to explore the ideas presented amongst them helped in facilitating their learning:

> …the key points which were given to us by the lecturer…big learning tools for us. **Ariel**

> The formal block sessions were helpful and offered constructive platforms for discussion and the methodology of reporting… **Christina**

It is possible that the block lectures may have provided the information for the MRTs to increase their knowledge base on trauma reporting. This may have enabled them to understand the patterns that they were supposed to be looking for when interpreting the trauma to appendicular skeleton images. It is possible that the block lectures may have provided the MRTs with the information about the sequence to follow when evaluating the images. This may therefore have impacted positively on most of their future interpretations and resulted in the patterns of changes observed for their accuracy in Figure 8.

However, Christina's comment that "…Greater time should have been given to discussion (even within the group)" leaves the impression that a more student-centred teaching and learning environment would be beneficial in programmes teaching trauma reporting. Such strategies have been found to enable the students to be responsible for their learning and have been recommended to be appropriate in situations where the learning involves an integration of theory with practice (Dixon, 2006); as is the case for educational interventions in trauma reporting. In addition to the issues mentioned previously, issues regarding the timing of the block lectures were also highlighted:

> The first block needs to be sooner at the beginning of the course so that everyone knows where they stand, what's going to be coming out and how everything works… **Sam**

Sam's feelings stress the need for the courses to map the learning outcomes with sessions that are timetabled at an earlier period than actually occurred in the study. It is possible that the delayed sessions may have manifested in the MRTs being unable to integrate their acquired theory into practice as required, therefore impacting on the accuracy levels of some of them at the onset of the study. This association between students' understanding and performance in radiological diagnosis is supported by Lesgold et al. (1988) who believe that when beginning a residency program in radiology, the students are in unfamiliar surroundings which present either new or confusing facts for them. Lesgold et al. (ibid.) maintain that as a result, the learners may initially face difficulty assimilating the available information. However, as they become more aware of their environment, their performance is enhanced because they have developed some idea of how to go about achieving it (ibid.).

Hence, it is assumed that after having attended the first lecture blocks in October 2006, the MRTs may have been able to better understand what they were expected to achieve, which may have resulted in them showing improvements in their interpretation skills as they progressed in their study. However, there is the possibility that attending the lecture block made the MRTs realize the importance of having an attendance, therefore, resulting in Sam reiterating the need for having it earlier. Ariel further commented that "obviously, being a pilot program, they would iron out those problems and structure it correctly". This comment hints that there are possibilities that the teaching institution may consider the issue relating to the timing of the lecture block and avoid any similar drawbacks from occurring in future. Nonetheless, the extent to which the teaching institution may be able to achieve the changes may be dependent on its improvement policies and procedures (Harvey, 2003).

There has been emphasis in literature that assessment is fundamental in guiding students in their learning and determining what they have learnt (Dixon, 2006). The assessment was in the form of OSCE, which was a timed examination in which the MRTs were required to interpret a set number of powerpoint images and answer written questions. The use of power point images is an example of the application of simulation technology (Schuwirth & van der Vleuten, 2006). The purpose of the OSCE was to determine whether or not the MRTs were mastering the goals of the

courses designed to prepare them as competent image interpreters. OSCE is not a new concept in assessment and has been argued to be the best tool in measuring skills (ibid.).

However, using OSCEs to assess image interpretation performances in medical imaging can be difficult (Smith, 1999) because, although they can be useful in identifying weak students, they cannot predict these students' success during their clinical practice (Adams, Adamson & Poulos, 2004). In addition, the difficulties related to the complex nature of the image interpreters' responsibilities, which include doing tasks such as acquiring a cognitive knowledge base, focusing perceptual attitudes and forming abilities to integrate information, can affect success rates in OSCEs (Smith, 1999). It is also possible that some of the MRTs did not have enough experience in looking at computer generated images in comparison to the hard copies that they have been used to since their basic training in MI (Scott et al., 1995). Considering these explanations, it is possible that the OSCE may not have allowed the MRTs to exhibit their image interpretation skills fully and may have affected the accuracy that they attained in the OSCE. In addition, as described by one of the participants, the timing of the OSCE may have had influenced the MRTs' progress:

> What I did find is having our examination and our test sort of three quarters of the way through the course, we got a bit demoralized there and sort of just had to get our logbooks finished. It would have been better if we had it more towards the end because it would have been a build up towards it.
>
> **Ariel**

From Ariel's comments, it is clear that the timing of the OSCE was found to be inappropriate and discouraging for some of the MRTs. It may be assumed that due to the OSCE being held earlier in the course, some of them found it difficult to continue with their image interpretation tasks at the same or even better standards than before the OSCE. It is possible that the accuracy of these MRTs was affected. In addition, there is a possibility that although the image display system that was used for the OSCE fitted with the institutional requirements, it may not have been sufficient for the needs of some of the MRTs:

> …the exams, the OSCE, maybe needed a dedicated image viewing system rather than just powerpoint where you can't preview in a real-life situation

> so if we had a system mainly with image viewing software or actual films, that would have been good… **Sam**

Researchers such as Swee et al. (1997) and Kundel et al. (2001) have found that soft-copy image interpretation is as reliable as hardcopy interpretation but Eng et al. (2000) provided evidence that the image interpretation accuracy is significantly greater when the images are interpreted on viewing boxes in comparison to computer monitors. Sam and those of her colleagues who have been interpreting conventional images using dedicated viewing boxes may have found it difficult to interpret the simulated images on the computer screen. As a result, they may have found this form of assessment less valuable in stimulating or enhancing their interpretation accuracy and/or clinical practice. In other words, it may be assumed that the MRTs may have encountered difficulties in correctly interpreting the images for the OSCE due to the difference in the image display systems. Christina's comment that "The exams, the OSCE – that was my weakness!" support the assumption made earlier. Her sentiment also brings to light the recommendation of Briggs (cited in McMohan, 2006) that the assessment needs to be aligned with the learning outcomes of the intervention and the learning needs of the students.

However, Frank (2006) argued that assessment tools should be selected based on how they work instead of the preferences of those being assessed. Future research may be needed to assess the relevance of Frank's comment, as well as to identify whether the use of simulation technology for teaching image interpretation courses in NZ has its benefits or not. Since assessment is an important component of education due to its role in determining how students learn, it is recommended that any assessment tools that are adapted for the intervention are closely monitored by the educational institution (Adams et al., 2004).

Further acknowledgement has been made of the stress related to the process of undergoing OSCE compared to performing the actual reporting during clinical practice:

> I think that's the thing when you did the exam, you're under a huge pressure because you've got this much time whereas when I'm reporting ten cases I just sit there until they are reported. **Ariel**

It may have been the situation that due to the anxiety related to the completion of a certain number of trauma image interpretations within a given period of time, the accuracy of the MRTs in the OSCE may have been different in comparison to what they may have actually achieved due to interpreting at their own pace at their workplaces. It is entirely possible that the accuracy for some of the MRTs may have been better when the MRTs interpreted at their own pace. Thus, it is suggested that the educational institution ensures that the assessment tools that are adapted for the courses are successful in providing a learning environment that promotes the MRTs' development of their competency in image interpretation activities at a pace that is acceptable to both the students and the teaching institution.

However, the latter part of Ariel's comment does imply that she was doing the image interpretations at her own pace. This is not a luxury that Ariel and maybe her other colleagues would have had if they were formally reporting a session like the radiologists. According to Lesgold et al. (1988), a radiology registrar interprets 40 cases per day while a senior radiologist interprets between 65 to 70 images per day. Considering that Ariel was interpreting only ten images implies that she was far from meeting the standards for the radiology registrar and the senior radiologist. This may be a result of the different roles that she has, that is, she has a MRT role to fulfill as well. This is an area that the teaching institution may probably need to think of considering in their future courses in trauma reporting. On the other hand, it is possible that other factors such as the time for reporting and so on that were identified in the earlier chapters, may have had some influence on the number of images that Ariel and her colleagues were able to interpret per day.

The rate at which a trauma image is interpreted by the reporter is known as report speed. In this study, Ariel disclosed that "…it used to take us half an hour to just look at an x-ray, it's improved…" suggesting that as she progressed in her education, she became faster in interpreting the images. Sam noticed similar changes in her report speed as well. On the other hand, Alex divulged that "…I've noticed that I've got faster and still, I think, maintained the same accuracy" hence implying that report speed may not have had any impact on his interpretation accuracy. This revelation about report speed and accuracy is supported by Edwards, Ricketts, Dubbins, Roobottom and Wells (2003) as well.

When determining whether reporting plain films at faster reporting rates resulted in a deterioration in accuracy, Edwards et al. (2003) found that the FP scores for the 14

radiologists in their study were relatively low with respect to their increased reporting speeds. They concluded that there is no significant change in accuracy if the reporting speed increases. Although, Alex acknowledged having a similar experience to the findings of Edwards et al. (ibid.), this finding cannot be generalized to his nine colleagues due to a lack of substantial evidence to support it. However, there exists potential for research to determine the relationship between the image interpretation accuracy and reporting speeds of MRTs who undertake trauma reporting in NZ in the future.

Clinical component

Critical elements of film interpretation that the MRTs learnt through their postgraduate education involved knowing what to look for in the images and why. Brealey and Scally (2002) have highlighted that the fundamentals of image interpretation can be achieved by encouraging reflective thinking and self-directed learning in those MRTs doing these activities. This was supported by Elaine who emphasized that the improvement in accuracy was a result of "continued practise and supervised practice". The clinical aspect of the course encompassed two things. Firstly, the MRTs were required to complete a logbook for a caseload of 500 appendicular skeleton images. Secondly, the MRTs were supposed to learn reporting skills at their various workplaces under the mentorship of a radiologist.

Logbooks have been identified for use in the training of radiology registrars in the UK (RCR, 2007). The purpose of the logbook is to allow the students to document the skills and experience attained relative to their clinical placement. However, Oliver (2007) has argued that the logbook is simply a traditional means of recording the students' skills training. Oliver (ibid.) further argues that although the logbook gives a record of the caseload attempted by the students, it is quite limited in indicating their competency. The limitations identified by Oliver (ibid.) did not seem to be apparent in this study where the caseload of 500 appendicular skeleton images was acknowledged as being useful in aiding the MRTs to learn to diagnose the images:

> …the LOG BOOK which was our "project" was a good directive. It encouraged me to expand my knowledge base, and was an ongoing measure of achievement and progress. **Christina**

From the comment given by Christina, it was evident that by having a logbook, the MRTs in the existing study probably had the opportunity to consider each case as a potential learning experience (Lesgold et. al., 1988). It is possible that the logbook may have influenced the level of supervision that was provided by the radiologists and promoted the degree of competency achieved by each of the MRTs in the current study. The use of the mentoring approach for supervision has been acknowledged to be integral to the learning process and the development of the MRTs' skills in learning image interpretation (Reed, 2002; Reeves, 2004). This focus was also supported by one of the participants:

> Mentoring is ideally the best way to go. This is the same as what we do in radiography by rights of teaching students, we mentor them and if it was done correctly I think it's the only way to go, it's the best way to learn. **Ariel**

Using radiologists to mentor MRTs undergoing education in image interpretation has been the focus of much of the work by Reeves (2004) where it was advocated that interpretation errors can be avoided through the expert guidance of a radiologist who mentors the MRT. The educative role of mentoring allows the MRT's reports to be monitored in comparison to those of the radiologist's and enables negotiation of necessary changes in the MRT's reporting performances through appropriate tuition and guidance (Ditchfield & Fink, 2003; Chan & Gunderman, 2005). Two of the mentors reflected this benefit of mentoring in this study:

> I think I've understood what they've been trying to achieve and…I sort of help them how best to approach their reports that they are getting for the institute… **Gabrielle** *[mentor]*

> …we sort of cultivate 'report speak' in them and explain to them how it would best be written down. **Ian** *[mentor]*

The understanding of Gabrielle and Ian about the mentoring of the MRTs is in line with Wright (cited in Winstanley & White, 2003), who advocated that supervision is a meeting between two people, who have a collective interest in examining a piece of work. Hence, mentoring can be seen to create an environment in which the MRTs are given an opportunity to evaluate, reflect and develop their own interpretation skills and clinical practice via a support system provided by the radiologists acting as their mentors. Subsequently, it was brought to my attention that the mentoring of

MRTs in image interpretation activities at their various workplaces was the first of its kind in NZ:

> We have often had educative sessions with them but in terms of formal training courses this is the first time we have done it. **Ian** *[mentor]*

As a new phenomenon in NZ, it is possible that the radiologists, who acted as the mentors for the MRTs, may not have been aware of which mentoring approach to use. Hence, it is likely that they may have opted for mentoring schemes that either they used to train radiology registrars or to which they may have been exposed during their own training in radiology. It is also likely that the radiologists may have selected mentoring schemes that they felt would work best or fit their work profile:

> I've taught registrars for years and basically it was based on that type of experience; I don't think I'm wrong there…that's the way it's meant to be…there is very little time when we can actually sit down and do this when one of us is free and that's why we've done it this way so if we don't have the radiographer and the radiologist free together, we can work around it - it fits in nicely with our workload... **Ian** *[mentor]*

> …we are severely understaffed at the consultant level so therefore they had to find allocated time in the roster, which was extremely difficult but when my clinics allowed it we definitely could clear up some time so I would have specific sessions when I could… **Gabrielle** *[mentor]*

> It was simple and we can get through quite a large number of films relatively easily. **Tom** *[mentor]*

It was further established that the ten MRTs had found the practise of a radiologist acting as their mentor of benefit to them. Pam stated that "my mentor was very supportive; she was encouraging and positive with this course". Helen found her mentor's "comments were appropriate and useful". Mary thought this practice was "essential, however, not enough time with them was had". Similar views were expressed by Elaine and Ariel. Jordon said he "was able to have discussions on difficult and on false reports", while Alex felt that "they have a wealth of knowledge and experience that would be foolish to ignore and their forte is reporting, you need a radiologist to guide you". From the insights given, it can be assumed that the radiologists' views and their co-operation were considered vital and necessary to aid

the transition of the MRTs from the onset to the end of their educational intervention in trauma reporting within the clinical placement scenario. The comments further correspond with those of Dhingsa et al. (2002), who found their research participants expressing the opinion that meetings with radiologists are constructive and beneficial for them. These findings extend the reflections of Woodford (2005) that the radiologists have an important role to play in developing the MRTs' skills in image interpretation activities.

On the other hand, Nightingale and Hogg (2003) maintain that supervision of MRTs for extended activities can be problematic at times due to variation in supervision approaches. It appears that the delivery of the mentoring process used for the purpose of supervision can have diverse formats (Sloan & Watson, 2002). This has led researchers such as Duarri and Kendrick (1999) and Price and Chalker (2000) to reiterate that no matter what format is adopted, appropriate frameworks should be in place to ensure that the process is guided and delivered effectively. This is also supported by Eraut (cited in Nisbet, 2006) who has suggested that competency is achievable when professional support structures are in place. In this study, the professional support structure was the mentoring scheme used by the radiologists to support the progress of the MRTs relative to their education:

> We sort of self-selected how we did it…what we did was they at times collected request forms reported them blind and then looked up the formal consultant report and considered that as the gold standard…they tended to do them in blocks and they would turn and catch me when they have done their block and ask me to review the ones where there have been discrepancies… **Gabrielle** *[mentor]*

The feedback from Gabrielle implies that the three MRTs from Region Two were personally involved in comparing their reports with the gold standard for concordance. This may have resulted in their being either too critical or not sufficiently critical of their reports, therefore causing arbiter review bias in the study (Brealey & Scally, 2001). Hence, it is possible that the presence of this bias may have falsely elevated or deflated the indices for the MRTs' performances relative to their progress in their education. In addition, it may be assumed that the adopted mentoring scheme may not have enabled them to gauge their mistakes correctly and probably encouraged them to continue making similar mistakes in their subsequent reports. This is supported by Fitzgerald (2001) who believes that errors fall into

recurrent patterns and error traps need to be uncovered and highlighted so that repetition of the same errors can be avoided. Therefore, it can be suggested that the mentoring scheme used in Region Two may not have been that effective in developing the interpretation skills of the MRTs from that region. The comment made by Gabrielle further indicates that the reports of the three MRTs that she mentored were compared with the reports of different radiologists. There is a likelihood that by having a variety of radiologists, inconsistencies and variations may have occurred in the reports available to them. The consequences of using many radiologists' reports have been discussed comprehensively in Chapter Eight where it was implied that such variances may affect the MRTs' interpretation accuracy rates.

On the other hand, a slightly different mentoring approach was used by the other mentors:

> It's just basically allowing the MRT to report an unknown case where she doesn't know what I think…it's a double blind system…what we do is the MRT will do a written report as the trauma films come through and even before I see them, she will do a written report. When the films come through to me with the clinical request and her little report form I get to read the film and compare what I think of what she has written on her form…
>
> **Tom** [mentor]

Tom's reflection indicates that he had acted as the gold standard and the reports of the MRTs in Region One were personally compared by him with the reports that he had written. Similar approaches were adapted by Ian and Peter to mentor the MRTs in Regions Three and Four. Just as Goddard et al. (2001) have highlighted, the use of a double blind system for the mentoring scheme is based on the principle that the divergence or discrepancy between the mentor and the MRT is related to the error of the radiologist being more correct than the MRT. This theory is based on the notion that radiologists are the medical experts in image interpretation (Hardy & Barrett, 2004). On the same note, Connolly et al., (2000) mentioned that experts provide reassurance and are deemed to be accurate and confident in their professional responsibilities and duties.

However, there have been different sentiments expressed about agreement amongst radiologists in the existing study. Ian articulated that "…it's not an exact science in some cases…we'll disagree as radiologists." The beliefs of Swenson and Johnson

(2005) that much of the radiologists' work is not evidence based and that there are no sound scientific data to either support or refute the performance of specific examinations in MI further verify Ian's comment. Likewise, Peter pointed out that "…no single radiologist knows everything about every particular investigation or every particular x-ray…or every single anatomic variants of any particular part of the body." Tom also had similar sentiments to Peter's.

From the opinions given, it can be inferred that due to variations in patient anatomy and condition, radiologists may not totally agree with each other's reports. This finding therefore stresses that radiologists are not 100 percent accurate in their interpretations, which supports the findings of researchers such as Williams and Berry (1999) who have established that radiologists are prone to interpretation errors. Although this implies that there may have been variances in the reports produced by radiologists, Christina stated that "radiologists' words are still considered to be the definitive report". This suggests that even though there may have been instances where the MRTs were correct, their interpretations may have been regarded as incorrect since the radiologist was treated as the gold standard.

In spite of having variations and issues relating to the accuracy of their reports, the mentors felt that the mentoring schemes that were adopted had been effective. Ian states that "It's pretty good; we've found it satisfactory because we're able to read their interpretations, look at the films they have interpreted and actually make comments in a very supportive and critical way". Tom indicates that "....it gives me a good idea of how well they are perceiving the abnormalities and picking up at interpreting them…it was very good, excellent! because the MRT learnt a lot." However, the sentiments of some of the MRTs about the effectiveness of the mentoring scheme were different to those shared by their mentors. Despite finding the input of the radiologist beneficial, four of them (Mary, Elaine, Ariel and Jordon) rated the mentoring scheme as ineffective. This finding has been reflected in Figure 23.

A justification for the low rating was linked to the way the mentoring process was structured. Ariel commented that the mentoring scheme was "ineffective but if structured correctly – would be a huge bonus". Her comments suggest that despite emphasis being made in the literature that mentoring activities can be enhanced through the adaptation of appropriate supervision models (for example, Powell, Gospel & Williams, 1991; Sloan & Watson, 2002), none of these aids was utilized in

this study. The supervision model specified by Powell et al. (1991) is a developmental one. It is a guide that enables appropriate attention to be given to the essential elements during supervision and encourages improvement in the professional practice for those being supervised. This may have been practical for the purpose of the supervision aspect of this study. It is possible that due to insufficient information being provided to both the radiologists and the MRTs, appropriate mentoring schemes and/or models could not be utilized:

> As a mentor, there was no guideline given to me. **Ian** *[mentor]*

> I think there is a need to provide firm guidelines as far as mentorship is concerned and what the institute expects of the mentor…both parties have to be fully informed and aware of the guidelines or it doesn't work…the guidelines we had were very wishy-washy and we actually had nothing to fall back onto with the main mentor… **Ariel**

In clinical supervision, issues pertaining to the supervision processes cannot be overlooked and it is good practice to have a guideline to fall back on. The absence of guidelines is contrary to the sentiments of Dhingsa et al. (2002), who reiterate that guidelines offer structure and uniformity. Similarly, Adams and Kilburn-Watt (2000) highlight how guidelines can ensure that the scheme that has been adopted for the supervision process enhances the development of the mentee. From the input by Ian and Ariel, it is possible that as a consequence of insufficient guidelines on the mentoring requirements, some of the errors made by the mentees may not have been identified until the later stage of the study.

Another justification for the low rating was related to the contact between the MRTs and their mentors, which most of the MRTs found quite difficult to accomplish. For Elaine, there were "sporadic meetings only". Mary identified that for her it was "use when we can, used other radiologists to watch report also" while Helen said "we met once a month to discuss the images that I had reported". Ariel commented that they would "get together once in a blue moon and where possible sit in on any radiologist reporting." During the interview, she further expressed that "I can count on under ten times that we actually met her, which is exceptionally bad." Jordon described that "shortage of radiologists made it ineffective at times" and more insight was given about the physical meetings by his mentor:

> It was easier for the radiographer based here to look at the roster and come into 'hot reporting' when I'm there but we've followed the process on a handful of occasions only for the radiographer who is based at the other centre…he's got less opportunity for that... **Ian** *[mentor]*

The remarks imply that some of the MRTs had very limited contact with their mentors during their supervision. This finding is in contradiction to that of Lyth (2000) who expressed the opinion that for supervision to be successful, a high level of commitment is required from the parties involved. Suen and Chow (2001) argue that minimal contact between the mentor and the mentee makes the mentoring process ineffective and results in the mentors being unable to fully perform their roles. Therefore, the limited contact time in this study hints that the some of the participants were unable to seek their mentor's assistance easily at times when they were confused or indecisive about the findings in an image. This may be one of the reasons why some of the MRTs were still having FN and FP scores until batch four:

> Very sort of hit and miss, to be honest…because he didn't have the time to actually sit with me so when he writes a comment, then you have to find him with your packet of films and reports and say where did I go wrong and what do you mean… **Alex**

Christina was found to comment that "…that's what was very interesting on the course, the registrars would have had sessions with their mentor, we didn't, neither my colleague nor I, have had many official sessions". Her comment reflects the differences in contact time available for the mentoring of MRTs compared to registrars training in radiology, which further corresponds to the requirement for supervision of trainee registrars defined in the accreditation standards of the RANZCR (cited in Ditchfield & Finck, 2003). According to the definition, a qualified radiologist has to be available to supervise the registrar all the time, including after hours (ibid.). Christina's statement indicates that the amount of mentoring in image interpretation that she and some of her colleague received was different to what a registrar training for radiology would receive. One of the mentors supported this and felt that more could have been done to make the mentoring process effective for the MRTs:

> I suppose perhaps to formalize it a little bit more at certain times…perhaps more frequent brief meetings…that would be quite useful as opposed to the

> time when we haven't professionally as a mentor/mentee situation caught up and sat down…just to make sure that the mentee is comfortable with how they are progressing and that the mentor is playing his or her role appropriately. **Peter** *[mentor]*

The sentiments of Peter communicate the recommendations of Ditchfield and Fink (2003) that the supervision of trainees should have structure and address issues such as frequency and duration of supervision, learning objectives, assessment and goal setting. However, one of the participants noticed that there were certain limitations linked to having structured arrangements:

> To start with I tried to make it a bit more formal and tried to actually have sessions sitting with him but he's always in a hurry to report and so I found that first thing in the morning he's always just going slap, slap, slap and do them really quickly and I didn't get really much out of it really because I was just sitting there and if I tried to ask him questions, he'd say 'I have to get these done'…but that didn't really work so it became more informal and that worked out much better. **Sam**

The limitations encountered initially by Sam have been acknowledged by Steves (2005) as well. According to Steves, there will be circumstances when a question will need to be deferred due to the nature of the radiological work and the time required to accomplish it. He further explained that such situations are acceptable provided the supervisor remembers to address the question at a more appropriate time. From the sentiments of Sam, it was apparent that her mentor was not able to adequately supervise her when the mentoring arrangement was structured. Her reflections further imply that once the mentoring arrangement took an unstructured approach, she was able to enhance her learning in trauma reporting, which was supported by her mentor:

> …we had to have a system where it didn't too seriously affect the work profile of the department because, I mean, time is an essence. This fitted right in with the hospital system without disturbing too many…I mean it's a bit of work for her but it's not too much work for me and I'm able to look at a set load…I wouldn't have been able to do it if it was extra work.
>
> **Tom** *[mentor]*

Tom's reflections reproduce the discussions in Chapter Eight about the operational demands and their influence on the MRTs' progress. They also support the previously mentioned ideas of Steves (2005) about the nature of radiology work and the time needed to accomplish it. The insights discussed illustrate that the method of mentoring was not prescribed in the existing study. On reflection, I think that it would have been beneficial if it had been established at the start of the educational intervention. However, given the feedback, a particular approach would probably not have suited every situation. The justifications for the ineffectiveness of the mentoring schemes confirm the feelings of Ditchfield and Fink (2003), who said that supervision in radiology practice is inadequately developed and investigated. There is possibly scope for further investigation in this area.

Although there were drawbacks encountered in the mentoring schemes, it was observed that the same MRTs were able to achieve and maintain high accuracy levels of 100 percent as well as improve their clinical practice. It can be said that they most probably had an optimistic attitude and made the most of whatever was available to them to ensure that they were able to develop their image interpretation skills and clinical practice. Also, it is likely that the information that the MRTs obtained from the academic component may have enabled them to integrate the knowledge gained into their routine work in such a way that positive developments were produced in their interpretation accuracy and clinical practice.

There is a possibility that the supervision relationship that was established between the radiologists and the participants may have played a role in the developments noted in the MRTs. The mentors were qualified members of staff with a professional responsibility that gave them a position of superiority relative to the MRTs. It was obvious that a line of authority existed between the radiologists and the MRTs, which is supported by the MRTs' responses given in Questionnaire Two. Elaine "took her word - she is the radiologist and has the final say as far as I'm aware". Ariel, Mary and Alex had adapted similar approaches to Elaine's. Ariel expressed that "what the radiologist says goes – she was ready to listen – but at the end the decision was hers". As for Alex, "it was very much dependent on 'he's my mentor'. Basically, I knew from the start that his reports were correct, he left me under no illusion from the beginning, what he said went…"

The position of authority that these radiologists had may have manifested as a power relationship over the MRTs. This dominance may have caused the radiologists to

adhere to directive feedback approaches whilst making their decisions about the MRTs' image interpretations. This concept has been talked about by Black and Wiliam (cited in Shute, 2007) who felt that directive feedback, similar to that given to the MRTs in this study, told the students what needed to be amended with minimal room for them conceptualizing for themselves. Therefore, it is likely that these MRTs found themselves in a compromising situation where the radiologists' words were the ultimate ones. Being obliged to accept almost everything that the gold standard said may have been quite a trying exercise for them and may have exerted influences that compromised their efforts to improve their performance relative to their progress.

However, Steves (2005) has recommended that the mentor must ensure that such imbalances in the mentoring process are exercised in a manner that encourages positive development to occur in the mentee. It was evident that some of the MRTs in the existing study were actually exposed to the approach recommended by Steves:

> …where we agree I'll send them through, where we disagree or I think 'hello she's not seeing that at all, she needs to know more about that' so we'll pull that out and we'll go through it within a week's time and that hammers hard her interpretation of the abnormality again… **Tom** *[mentor]*

The descriptions given about the manner in which disagreements were dealt with indicate that the mentor in Region One had attempted to facilitate the MRTs' learning and avoid merely providing information. Likewise, Sam commented that "my mentor's door is always open if you want to ask him a question…anything I want to talk about I could go and ask my mentor…I think it's good to be able to go to a certain person…" This may have provided a more collaborative relationship instead of a hierarchical one between the mentor and the MRTs in that region. Further, the approach described by Tom may have allowed the participants to be provided with the correct answer and also be given the opportunity to reason the way to the answer. This may have provided them with a platform to develop their image interpretation competencies at a more successful rate.

As observed by Ooijen (2000), the supervision relationship grows and develops over time. From the comments given, it is obvious that the supervision relationship between some of the MRTs and their mentors was positive and enabled them to communicate freely with their mentors. It can be assumed that this development

may have occurred as a result of their mentors accepting their points of view and this approach may have established an environment that was favorable to the MRTs' learning (Merriam & Caffarella cited in Chan & Gunderman, 2005). As a result, these participants may have been able to take ownership of their thoughts and actions thus demonstrating the progress discussed in Chapter six.

It was brought to my attention that a slightly different approach was used by the mentor in Region Four to deal with lack of concordance:

> What we did, we would refer to standard texts…like for instance Keats…to see if perhaps there were differences in a particular abnormality or perhaps it was a normal variant or a true fracture or an old injury…we never had to resolve or resort to going to a third party…we always sorted it out between the two of us…sometimes indeed my mentee has been shown to be correct and I've been wrong and vice versa so it has been very professional, very upfront. **Peter** *[mentor]*

Peter's sentiments are in line with those expressed by Steves (2005) who feels that the instructor should refer the learners to other professionals, books and instructional materials so that the learners' independence and clinical judgment skills are developed. He further suggested that seeking the information together encourages learners to discover how to locate appropriate information, teach them to accept information about their performance and decide for themselves how to act on that information. In addition, Steves emphasized that the instructor should show willingness to accept that they do not know the answer to the question or that they may be wrong. By doing so, the instructor will serve as a role model for lifelong learning.

The fact that Peter referred to reference texts to clarify doubts about normal variants and fractures verifies earlier findings of radiologists not being 100 percent sure of everything that is on the images being interpreted, that is, no one can be perfect. The finding of the mentor making reference to textbooks further highlights the need for reference materials and other relevant resources to be readily available for those involved in reporting tasks; a sentiment that has been shared by Reeves (2004). Further, I feel that by acknowledging gaps in his personal knowledge base about images, Peter may have been able to maintain an open communication with his

mentee, Christina, who may have benefited in the manner described by Steves (2005).

There were indications that at some stage during their educational experience, the participants did encounter lack of concordance with the gold standard. The incidence of this occurring has been illustrated in Figure 24, where nine of the MRTs expressed that they sometimes had disagreements with the gold standard whereas one of them (Christina) found that to hardly ever occur. However, her mentor, Peter, did comment that "…there have been disagreements but they have been very minor and very infrequent and they've been easily resolved." When lacks of concordance are encountered, they act as good learning experiences for the MRTs because they encourage the MRTs to perform better in their future interpretations:

> Each was treated as a learning experience in its own right. Some were inaccurate on my part, and a few were wrongly reported by the radiologist…I would find out where I went wrong and discover it and learn from it. **Sam**

The information shared shows that the manner in which the accuracy of Sam's interpretations was addressed aided in enhancing her learning and encouraged her to realize her particular errors and misconceptions. It is also likely that instances where the MRTs' pick up abnormalities that were missed by the radiologists may play an important role in the MRTs' teaching and learning process. This is because the feedback associated with such instances communicates the differences between the learner's actual performance and the required performance standards (King & Young, 2002). An example is quoted below:

> …sometimes we've had a discrepancy with the radiologist and we have picked up a lot and that's gone through the quality assurance meeting and after that we were the flavor of the day with some of the staff because we had picked up a few ones that had slipped through the net… **Ariel**

It is possible that the future interpretation outcomes of Ariel and her colleagues may have been influenced by the impact that the experiences she described had on them. If the feedback from the experience provided a positive impact, it may have acted as a constructive learning environment for the MRTs and encouraged them to improve their accuracy in the future. This is supported by the work of Steves (2005) who reiterated that feedback plays an important role in how students view their

performance and willingness to change. Similarly, Shute (2007) summed up that positive actions may significantly influence learning by encouraging students to improve their knowledge and skill acquisition. However, experiences of being correct compared to the gold standard may have drawbacks as well:

> … I suppose for a while you feel super confident and good about yourself but then you get a false positive or a false negative and then you don't feel so good anymore, I think you start making mistakes, you're not as good as you think. **Alex**

From the insight given by Alex, it seems likely that encountering instances where the radiologists missed abnormalities made the MRTs become over confident and begin to make unnecessary errors. King and Young (2002) support this by saying that at times feedback can cause more harm than good. They reasoned that this may be a result of the feedback being insufficient to make the learner realize that their accuracy level is still undergoing a learning curve. On the other hand, Steves (2005) has expressed that when appropriate and timely feedback is provided to the students, then the students are able to learn and their professional development is facilitated. Although Fitzgerald (2001) said that errors should be brought to the learner's attention in a sensitive and constructive manner, there was evidence of mixed approaches being used for some of the MRTs in the study:

> I liked my mentor in that he's very forthright, he doesn't worry about hurting your feelings. The other radiologist tends to soften the blow when he tells you that you are wrong whereas my main mentor just tells you –'you are wrong'. **Alex**

Alex's insight indicates that the mentoring relationship between his main mentor and himself was not an emotional but an educative one (Morton-Cooper & Palmer, 1994). This approach is also supported by Steves (2005) who maintains that an honest interaction should occur so that the students are given the opportunity to improve. Steves further suggests that ways should be developed to supply the feedback about negative performances in a way that motivates the learners; which was confirmed by the action of Alex's other mentor. In addition, it was revealed that the mentors used strategies such as written comments on the mentees' report forms and discussions with the mentees as forums for feedback:

> The most useful things were probably when we were sitting together and actually going through them. You make written comments but by the nature they are relatively limited but when you are sitting with somebody then there is dialogue and that dialogue was more valuable perhaps than the written comments, for example, 'I don't think you should have mentioned that because…' and 'you know, you can talk a little bit more on that and discuss that …' **Ian** *[mentor]*

Ian supports the ideas of Steves (2005) that evaluations are meaningful if there is frequent dialogue between the mentor and the mentee about the mentee's performance. It also appears that the mentors may have been using the concept of reflective practice to accommodate the education of their mentees. Jarvis (1992) defines reflective practice as the use of professional situations as potential learning opportunities so that the learner is allowed to learn, grow and develop with practice. Upon reflection, it is apparent that although there were not that many occasions when the MRTs and their mentors could meet physically to discuss their progress, having feedback in the form of written comments probably enabled the MRTs to develop, improve and become competent in their interpretation accuracy as well as their clinical practice relative to their education.

Relevance of the educational intervention

When the MRTs were asked their opinion about interpreting images without any formal education in trauma reporting, nine of them said that they would not participate in any such activity, while one had a different viewpoint, as shown in Figure 25. Sofia was the one who had a different opinion in comparison to her colleagues. She was "happy to give opinion but not take responsibility". On the other hand, Helen commented that "prior to the postgraduate programme my response would probably have been 'will participate'; however, having been educated I realize how poor my knowledge was and how inadequate this would have been." Helen's comments reiterate the importance of having appropriate education in trauma reporting prior to engaging in such activities.

Often, the success of any education is related to the change that is inculcated in the knowledge, attitudes and behavior of the learner (Chan & Gunderman, 2005). For the ten MRTs in this study, the transformations were related to the wording of the reports and their confidence in interpreting trauma images. In addition, the

alterations were linked to how their newly acquired skills and knowledge would be utilized.

Wording of the reports

The reports are the mode of communicating the information about the image and are qualitative in nature (Donovan & Manning, 2006). However, interpreting images and writing reports for them can be a very subjective process (Elliot, 2003). Due to this subjective nature, it is likely that the MRTs in this study may have encountered some difficulties in wording their reports as they commenced their formal education in trauma reporting:

> …one of the biggest problems for radiographers is learning 'report speak' and it's a bit different from looking at something and saying 'no, that rib's broken' to actually phrasing that as a report… **Ian** *[mentor]*

When batch one reports were collected at the beginning of the study, the reports merely described in detail everything that the participants saw in the images. An example of the MRTs' report and the one by the gold standard for the same image in Batch One is quoted below:

> X-rays of the left hip and pelvis demonstrate a left THJR. The left head of femur replacement has dislocated anteriorly from the acetabulum replacement cup. There is no evidence of fracture. Incidentally, there is significant degenerative change within the right hip. **Mary**
>
> There is dislocation of the head of the left hip prosthesis. **Gold standard**

In the example given above, the MRTs had included incidental findings that would not have any impact on the management of the patient. As a result, wordy reports containing descriptions of findings that were irrelevant to the clinical history of the patient were produced. Pearson (2001) had similar findings in his study and acknowledged that this is commonly encountered when developing reporting skills in MRTs. He further indicated that reports of a descriptive nature are encouraged in the early stages of MRT reporting. In spite of the fact that the MRTs may have had problems learning 'report speak', there was evidence of marked improvement in the language used by them in their reports as they progressed in their educational experience:

> I've certainly learnt to explain myself a lot better. At the beginning…I didn't know…whether you should have mentioned something or not mentioned something…whether you are blabbing on… **Alex**

> My wordings became more concise as time went on…got them around the right way or managed to construct the sentences around so they were to the point… **Sam**

The insights given by Sam and Alex about their wording in the reports indicate that as they progressed, they were better able to include relevant information in their reports. Hence, the two MRTs' viewpoints stress that their learning experiences created awareness about the type of information that is important for inclusion in reports during trauma image interpretation. This may have been the case for their eight colleagues as well. When the final batch of reports was analyzed at the end of the study, it was evident that all of the participants had made huge strides in their phraseology and description of findings. An example of the MRTs' report and the one by the gold standard for the same image in Batch Five is quoted below:

> There is an effusion in the suprapatellar pouch but no bony involvement is demonstrated. **Christina**

> There is a small effusion within the knee. The joint space is maintained. There is no evidence of any bony injury. **Gold standard**

From the example given above, it was established that the radiological reports by the MRTs as they neared the end of the study were found to convey only necessary and meaningful information about the images. This finding was supported by the MRTs' mentors as well. Ian observed that "…the relevance of the comments was getting sharper and more focused and they realized what was important and what wasn't…." Likewise, Gabrielle found that "…they've got more accurate in their use of the literature…" The finding that the MRTs selected and used only information which is most relevant has been noted by Connolly et al. (2000) when they described the decision making ability of experts.

After undergoing their education, the MRTs in the study showed that they were able to provide reports that were responding to the question posed on the request forms. The changes in the wording of the participants' reports point out that the educational

intervention was successful in enabling them to generate relevant information and enhance their interpretative accuracy. Such a contribution is supported by Robinson (1996) who claims that as MRTs learn image interpretation, they develop their ability to understand the context of the MI examination and know what to look for in the image and why.

Towards the completion of her formal education, Christina stated that "my wording became almost synonymous with my mentor's because that was the model I used." Sam had also made similar observations in her phraseology. One of the mentors, Peter, acknowledged that the MRTs adapted to the way their mentors were saying things, "I guess I know this from my own training, you tend to sort of use the same words as the people who train you do." This finding is in line with the opinion of Hay (cited in Crow & Matthews, 1998) that the process of mentoring can encourage cloning. It further suggests that the person acting as the mentor has the potential to greatly influence the development of the MRTs and that care has to be taken in selecting mentors who are suitable for the purpose of teaching and guiding MRTs in image interpretation tasks. This suggestion was further exemplified by one of the mentors in the study:

> …whoever you've got as the mentor has to be interested in it and have some interest in teaching otherwise it's all sort of a rubberstamping exercise. **Tom** *[mentor]*

MRTs' confidence while interpreting images

When the MRTs were performing their image interpretation tasks, they admitted exhibiting different levels of confidence as illustrated in Figure 26. Seven of them disclosed feeling confident when interpreting images. These were Pam, Helen, Sam, Ariel, Jordon, Sofia and Christina. "I think I was always confident! I was able to argue the case better with increased formal education" was how Christina felt. Christina's belief about her level of confidence supports the high accuracy values that were achieved by her in the five batches of reports and reinforce the role of her experience in her interpretation ability. However, the emotions expressed by Ariel were unlike those of Christina:

> From the beginning, I was so nervous and if I looked at a case I was too scared to do that, I didn't want to see it; but towards the end…it became far easier and I became far more confident. I could take the next step to put my name to something and actually sign at the bottom of the report… **Ariel**

Similar feelings were shared by Sam when she was interviewed. It is possible that Pam, Helen, Jordon and Sofia observed equivalent positive progress in their level of confidence. A study by Eyres and Williams (1997) in the UK had also noticed that the five MRTs who had participated in the study had shown similar improvements in their confidence levels relative to their educational intervention. As explained by Manning et al. (2006), it is possible that as the MRTs progressed in their education, their caseload trained them to better locate and identify features on the images that they interpreted. One of the mentors in the existing study thought so too:

> It's just a case of seeing more and more cases and getting used to looking right around the films…you are able to pick up abnormalities and the more confident you are about interpreting them. **Tom** *[mentor]*

Further analysis of Figure 26 revealed that one of the MRTs (Alex) was wary while two of them (Mary and Elaine) were unsure while interpreting trauma images at their workplace. Alex's reasoning that "…I guess it's just that you are worried you don't know enough…so you are just sort of thinking am I doing it right?" communicates that as a result of his being suspicious about the correctness of his interpretations, his accuracy may have been affected, resulting in the pattern discussed earlier. Elaine's disclosure that her indecision was linked to her doing the "reporting before enough theory was covered – this discouraged me sometimes and hindered my confidence" suggests that she may not have been adequately prepared to begin her reporting activities at the onset. Therefore, it may be presumed that this lack of preparation affected her initial progress.

On the other hand, uncertainty is an aversion state that motivates the learner to use strategies that would help reduce it (Bordia, Hobman, Jones, Gallios & Callan, 2004). Therefore, it can be assumed that Elaine made attempts to better understand the image interpretation processes relative to her educational experience and this resulted in improvements in her interpretation accuracy in the subsequent batches. By becoming familiar with the requirements of the course, she may have been able to overcome the obstacles in her progress and enhance her confidence in interpreting images. This was highlighted by one of the mentors too:

> …they've realized they can interpret things and they've been exposed to that for the first time in a validated way - somebody's actually looked at it and said

> 'yes, you are actually right' or 'no, you are wrong' or whatever, that gives them confidence that when they say it's right it usually is and you know, that strengthens their interpretative skills. **Ian** *[mentor]*

Ian's explanation further reiterates the guidelines by Loughran (cited in Friedenberg, 2000) that when reporting trauma cases, the MRTs need to be confident in their reports. From the discussions earlier about the MRTs' emotions, it seems that their confidence to report images was boosted relative to their learning experience. This confidence in image interpretation can now enable the participants to utilize their newly acquired skills in various ways.

Application of the MRTs' newly acquired skills

The manner in which the MRTs' apply their newly acquired skills in the future is dependent on the individuals and what their purpose was in doing the courses in trauma reporting. Most of the MRTs and their mentors felt that the MRTs could use these newly acquired skills in interpreting trauma to enhance themselves as MRTs:

> …the insight it's given to me…I think it's worth its weight in gold…I've always liked being a radiographer…it sort of gave me an extra sort of 'wow, I do like my job!' **Alex**

Alex's insight indicates that his job satisfaction and motivation was boosted as a result of his education. As maintained by Clemmer (cited in Mitchell, 2005), Alex will not need to be pushed to perform to his best as a result of him recognizing his passion for being a MRT. This boosted job satisfaction and motivation may have been experienced by his nine colleagues too. Therefore, the ten MRTs will now be providing added benefits to the MI departments where they are based. One of the mentors has shared his thoughts on how this may occur:

> Two things - one is that she'll play a greater part in the clinical side of the department. Secondly, she's got the ability to pass on some of the knowledge to the other MRTs and that by itself will raise the standard of radiology in this department. **Tom** *[mentor]*

As a result of imparting their newly acquired knowledge to their colleagues, the MRTs will be able to improve the clinical practices at the department where they work. Improvement in standards of practice will further aid in the MI department providing

better patient care. This assumption is supported by Cowling (1995) who states that when MRTs are given the responsibility to provide the initial assessment of the images they produce, their commitment to the images and the patients is greatly enhanced. Ultimately, the learning experiences can promote a better mentoring of the students joining the MI profession:

> …I suppose I'll be able to share this with my students, which is important for me… **Ariel**

As new students come into the profession, they will be inspired and guided by MRTs like Ariel to develop their own excellence in practice. Just as Mitchell (2005) explained, such preparations will provide the students with a great foundation to build their clinical practice throughout their professional career as MRTs. Although there have been suggestions made that the MRTs may need to embrace role extension activities to keep themselves rewarded and satisfied throughout their professional career (Nightingale and Hogg, 2003), the degree to which such role extension activities may occur will vary from country to country and also between hospitals (White & McKay, 2002). This is supported by the sentiments regarding trauma reporting in NZ by one of the mentors in the existing study:

> …whilst this is an interesting exercise, I'm not aware of what the college of radiographers view is upon this - as to whether this is going to have any long term implication with the way radiography is practised here in New Zealand. You may be aware that the main reason it was done in the UK was to share the staffing since the lack of staff was a crisis, whereas here, particularly in a teaching hospital environment where we're trying to teach registrars as well, I can see that it won't be as easy but I've no doubts that a well trained radiographer can provide a very useful means of providing ED reporting or peripheral limb reporting. **Gabrielle** *[mentor]*

Prime, Tobin and Le Masurier (2001) state that undergoing postgraduate education in trauma reporting does not automatically guarantee that reporting by MRTs will be introduced in the respective MI departments where they underwent their educational experience. As a result, there is a risk of 'de-skilling' being encountered if the MRTs are not allowed to continue practicing their newly acquired skills in image interpretation:

> …but on the whole the fact is that if we aren't going to use it, we're definitely going to lose it… **Ariel**

The sentiment expressed is in agreement with those of Nightingale and Hogg (2003), Donovan and Manning (2006) and MacKay (2006) who believe that the reporting abilities of the MRTs can diminish as a result of continued lack of practice. To combat the issue of 'de-skilling' in MRTs, MacKay (ibid.) recommends that the MRTs who have undergone education or training in trauma reporting should be topping up their image interpretation knowledge and skills before a period of six months has elapsed. For this reason, it is suggested that the participants in this study be allowed to continue practicing their newly acquired skills and knowledge in places where there is scope for them to do so:

> I think possibility is over here to use it especially in a situation of a country practice, like this is a country hospital where there isn't continuous supervision over a weekend. I don't see why people with that type of qualification shouldn't be able to do further frontline interpretation for management of the acute in a clinical situation provided there is backup, say on a Monday after work, something like that because, I mean, the situation is otherwise that the house surgeons are doing precisely that - they're interpreting films with say more worse skills in areas where less graduate radiologists are. **Tom** *[mentor]*

The suggestions made imply that there is scope for role extension by MRTs in NZ to interpret images in practices that are either remote or do not have continuous radiologist availability for reporting images. However, as reasoned by Kerr and Vinjamuri (cited in Haslam & Manning, 2006), the support of the local practices and professional bodies will be required to effectively extend the role of the MRTs in NZ to include trauma reporting activities. This is an area that needs further investigation.

Summary

The education in trauma reporting had two components, that is, theoretical and clinical. Although there were some issues related to certain aspects of the theoretical aspects, they were found to be effective in meeting the image interpretation needs of the MRTs as image interpreters. Likewise, the clinical component was found to provide the platform that encouraged the participants to develop and become competent in their image interpretation tasks. The learning experience further

enabled the MRTs to enhance their existing clinical practice. Whilst there may not be a need for role extension in urban centres, there may be scope in practices that are either remote or have minimal radiologist service available. Further, the course boosted the job satisfaction and motivation of the MRTs and some of them were keen to use their knowledge and skills in mentoring the students entering the profession. Therefore, the ways that the participants intend to use their newly acquired skills can help raise the standard of the MI departments to provide better patient care.

CHAPTER TEN

Research conclusions

Overview

This thesis examined the image interpretation accuracy and the clinical practice of MRTs relative to their educational experience in emergency settings in New Zealand. The aim of this study was to evaluate the effect of a postgraduate educational intervention in interpretation of trauma to the appendicular skeleton images on the MRTs' reporting accuracy and clinical practice. The research question was "how do the accuracy and clinical practice of MRTs change relative to their postgraduate educational experience?" Four key questions were further derived from the main research question to add clarity to the topic and the aim of the study:

- How does the accuracy of the MRTs' image interpretation of trauma to the adult appendicular skeleton compare against the gold standard of the radiologists' reports as they progress in their postgraduate education?
- Is the clinical practice of the MRTs altered in any way by the postgraduate educational experience?
- Do the individual circumstances and the characteristics of the MRTs and/or the MRTs' workplace profile and its operational demands have any influence on their image interpretation accuracies and clinical practice as they go through their educational experience?
- What impact do the academic and clinical components of the postgraduate education have on the image interpretation accuracy and the clinical practice of the MRTs?

In consideration of the research topic, aim and research questions, this chapter discusses the key findings of the thesis and describes the limitations encountered during the study. It further discusses the implications for practice and/or future

research and provides suitable recommendations. The chapter closes with the conclusions that were drawn from this study.

Key findings

The results have shown that at the onset of the study, seven out of the ten MRTs had a specificity of 100 percent. However, the three MRTs whose specificity was less than 100 percent were found to improve towards the middle of the study. The specificity of these three MRTs improved to 100 percent and was maintained till the end of the study. The results have further indicated that the MRTs initially had lower sensitivity levels compared to the specificity. This means that the MRTs were under-reporting the presence of abnormalities when they commenced their educational intervention in trauma reporting. It was noted that as the same MRTs progressed, not only their sensitivity but their specificity and accuracy in image interpretation improved to a stable performance of 100 percent and remained as such until the end of the study.

The participants in the study had an overall accuracy rate of 93 percent and a kappa score of 0.86 which indicates that the image interpretations of the ten MRTs in the existing study had almost perfect agreement with the gold standard. Although there was improvement noticed in the performances of the MRTs relative to their educational intervention, it was apparent that the performance of five of the MRTs diminished temporarily from Batches Two to Three, instead of improving steadily with practice. This phenomenon was also identified by Lesgold et al. (1988), McConnell and Webster (2000) and MacKay (2006) and has been acknowledged by Lesgold et al. (1998) to occur as a result of movement from intuitive perception to a cognitive one.

As a result of their educational experience, the ten MRTs found that they tried to enhance their clinical practices so that they could better focus on the needs of the patients they attended to. First of all, they started using appropriate positioning techniques to produce good quality images that will aid in proper diagnosis and treatment of the patients. Secondly, they became more confident in performing extra projections that may provide more details for making a correct diagnosis of the suspected condition on the image. Thirdly, they were more confident in identifying 'at risk' patients therefore ensuring that the needs of these patients were properly addressed whilst they were at the MI department. In addition, they found that they

gave more confident and relevant opinions about the trauma images to their colleagues as well as the doctors providing frontline patient care at their workplace. This action promoted more collegiality and teamwork amongst the two professional groups. Finally, the participants took more incentive in providing additional information that may be necessary to aid the radiologist to make a diagnosis. The benefits of correct diagnosis and improved clinical practice as a result of the MRTs interpreting the images that they produce were summarized by one of the mentors:

> I think that when you are interpreting films yourself you can see much more point in the various projections you have to do for different things. You also get better at relating what a patient says about what they saw to the type of injuries that you have been seeing so in that sense you've got a much greater depth of knowledge about which part to x-ray and which views to take so that should mean that your detection rate is better than a radiologist who's just going through the patient's views…it's your authenticity outside the square because of the extra knowledge. **Tom [mentor]**

There was a strong suggestion that the individual circumstances and characteristics of the ten MRTs may have impacted on their interpretation accuracy and clinical practice in some way during the study. These factors were the MRTs' work experience, personal learning objectives and motivation, previous training in pattern recognition activities, returning to study as a mature student and participant interactions. The accuracy value being high at the onset of the study for most of the MRTs reflects that work experience can also be a relevant factor in image interpretation activities. In addition, the personal objectives set by the MRTs seem to play an important part in motivating them to try their best to accomplish the required competencies of 90 percent or more relative to their education. The personal objectives also seem to encourage MRTs to enhance their existing clinical practices. For some of the MRTs, previous training in pattern recognition was found to add to their experience in image interpretation. Returning as a mature student had its implications for one of the MRTs. However, as this particular MRT became familiar with the technical aspects (such as computer literacy and database searches) of the educational intervention, his performance relative to the educational experience became more stable. Participant interactions also contributed positively in enhancing the MRTs' image interpretations as well as clinical practices.

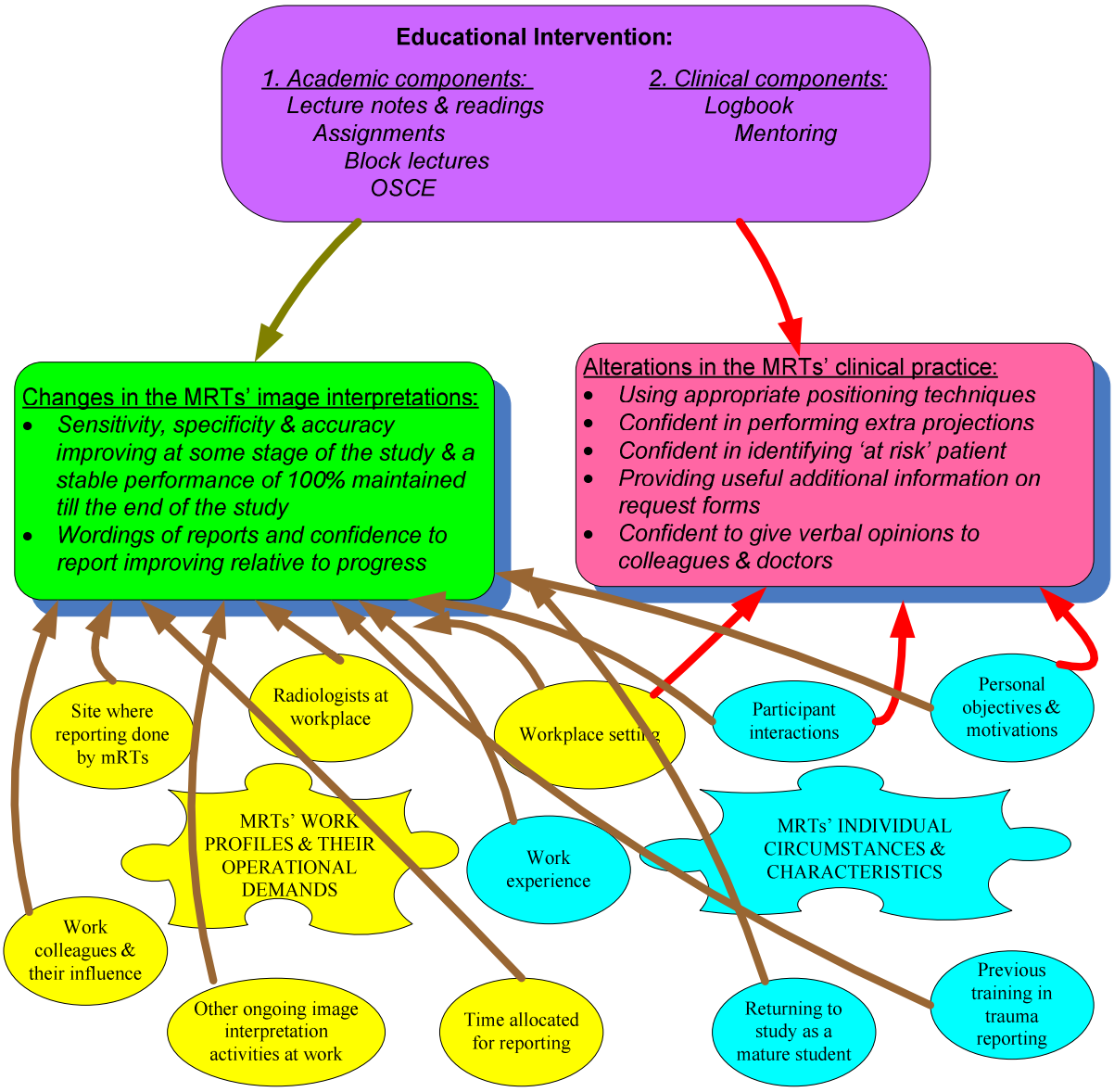
There was a strong suggestion that the MRTs' work profile and their operational demands during the study period also contributed towards the changes observed in their interpretation accuracy and clinical practice. The location, size and type of workplace (for example, a large trauma institution in an urban area compared to a small remote centre) play a certain part in the changes observed in the MRTs' accuracy levels and clinical practices. If the MRTs were based at a remote centre then they had more time and opportunity to liaise with their patients and enhance their interpretation skills compared to their colleagues who were based at larger centres where the pressures of work were quite high. Alternatively, some of the participants were involved in ongoing image interpretation activities at their workplaces, which also added to the quality of their experience in image interpretation. These findings strongly indicate that the MRTs have a wealth of untapped resources in image interpretation, which have the potential for delivering quality radiology services for ED patients particularly in smaller or remote centers in NZ where staffing issues relating to radiologist availability exist. At such places, the MRT is usually left with the responsibility to decide on the projections most likely to aid in diagnosis as well as give a verbal opinion of the findings to the doctors treating the patients.

It was evident that the MRTs were either using the MRT viewing areas or the film sorting areas for their image interpretations and the lighting conditions in these areas were not ideal for them. It was also found that there was hardly enough time allocated by the MRTs' respective departments to allow them to pursue their image interpretation activities effectively. Some of the MRTs acknowledged that their work colleagues influenced them in some way during their interpretations. These influences presented in the form of disturbances, distractions or encouragements from colleagues. The MRTs who were either distracted or disturbed had difficulties concentrating on their image interpretation activities during normal working hours in comparison to the MRTs who had support from their colleagues. In addition, there was a range in the number of radiologists at the various workplaces from between zero to twenty. This range produced certain limitations such as unavailability of reports for comparison, variation in wording of reports and inadequate support from the radiologists. As a consequence, interpretation errors may have been introduced in the MRTs reports.

The study also suggests that certain issues relating to the postgraduate course components may have affected the progress of the ten MRTs. For the academic

component, the limitations were related to the timing of the block lectures, the format of the OSCE and when the exams were held. On the other hand, the issues for the clinical component revolved around the mentoring activity. Despite these limitations, the MRTs were found to have image interpretation accuracies that were on par with the radiologists. In addition, there were improvements noted in their clinical practice, wording of reports and their level of confidence in image interpretation activities. These improvements were related to the enormous contributions of both the theoretical and clinical components of the courses. A summary of the research findings is presented in Figure 27 below.

Figure 27 Summary of the research findings



As reflected in Figure 27, the educational intervention consisted of two components, that is, academic and clinical. The academic components included lecture notes and readings, assignments, two lecture blocks and one OSCE. These components had significant contributions towards the positive changes noted in the ten MRTs' wordings of reports, confidence to report, sensitivity, specificity and accuracy during the study period. Likewise, the clinical component encouraged the MRTs to alter their clinical practices such that patient care was enhanced. However, it was evident that the MRTs' work profiles and their operational demands and the MRTs' individual circumstances and characteristics also contributed to some extent towards the changes observed in the MRTs' image interpretations and clinical practices. Factors such as site where reporting was done, radiologists at workplace, work colleagues and their influences, other ongoing image interpretation activities at work, work experience of participants, returning to study as a mature student and previous training in image interpretation were found to affect the changes that were seen in most of the MRTs' image interpretations. On the other hand, factors such as workplace setting, participant interactions and personal objectives and motivations were seen to influence changes in both the image interpretations and the clinical practices of many of the participants.

Research limitations

During the course of this thesis, several limitations came to my attention. First of all, since a non-probability sampling procedure (i.e. convenience sampling) was used to select the sample for this study, the sampling error could not be estimated. Secondly, the allocation of a false negative response to any deviation of the MRTs' report from that of the gold standard could have impacted on the research results by artificially improving specificity and reducing sensitivity. Thirdly, since the questionnaire and the interviews involved questions on sensitive information, there may be possibilities of social desirability bias occurring. According to Neuman (2000), this form of bias occurs when the respondents give what they believe to be the 'normative' or 'socially desirable' answer hence either over-reporting or under-reporting the true situation. Finally, although the MRTs learnt about image interpretation of trauma to the appendicular skeleton of both adults and children, this study only considered the MRTs' accuracy for adult patients. Therefore, the study is not providing information about the overall ability of MRTs to interpret images of the appendicular skeleton of these two groups.

Personal limitations

In my capacity as the researcher, I had interviewed, transcribed and analyzed the data that was collected during the study. Although I had endeavored to remain objective throughout the process, there is a possibility that my personal bias may to some extent have misinterpreted the observations made.

Implications for practice and future research

The outcome from this research may encourage the MRTs in NZ and their professional body, the NZIMRT, to consider the development of role extension in the area of trauma reporting in emergency settings. The results may be useful in initiating discussions on the possibility of such role extension activities in NZ. Since the findings in this thesis indicate that the MRTs who have undergone appropriate education in trauma reporting can report trauma to adult appendicular skeleton images on par to radiologists, there is likelihood that there may be some opposition from this professional group due to two reasons. Firstly, as a result of the issue of medical dominance, there may be a preference for the images to be interpreted by a medically qualified person. Secondly, if the responsibility for interpreting trauma images is delegated to MRTs, then there will be a reduction in income for the radiologists, who have been traditionally responsible for image interpretation.

The research findings strongly indicate that MRTs have the potential to interpret trauma images, especially in ED settings. If these MRTs discontinue practising image interpretation, there is a possibility that they may tend to forget their newly acquired skills and not be as competent in their accuracy levels as time passes. It is suggested that the respective professional bodies (such as the Medical Council, RANZCR and NZIMRT) in NZ identify whether radiologist shortages do exist in NZ. If there is confirmation that it does exist, then these professional bodies may have the opportunity to try and address the issue through proper delegation before its impact is felt on the healthcare system similar to those felt in the UK in the 1990s. To avoid compromising the best interests of the patients, reporting of certain trauma images (such as appendicular skeleton) in EDs can be delegated to appropriately trained MRTs instead of being left to groups outside the boundaries of radiology (for example, nurse practitioners) or to radiologists who are not even based in the country as is usually the case with teleradiology. The MRTs planning to extend their roles in

trauma image interpretation in EDs need to demonstrate appropriate competency levels and commitment to providing the service in a professional manner.

MRT reporting may have its potential in certain areas within NZ. Although there might not be an immediate need in larger centers which have radiologist services readily available on a 24 hour basis, thoughts can be directed towards role development of MRTs working in smaller or remote centers in NZ where staffing issues relating to radiologist availability exist. If successfully implemented, this approach may help overcome the issue of ED trauma images being left unreported as a result of being sent with patients when they are transferred to a larger centre. However, this potential area and any associated medico-legal issues need thorough consideration by the professional bodies (NZIMRT and RANZCR) as well as the DHBs that may be affected. In addition, more research will be needed to evaluate the effect of role development in image interpretation on the new career progression framework and the practice of MI in New Zealand.

Recommendations

This research has led to the following recommendations, which have been considered from the perspective of the educational institution, the stakeholders who may be involved in possible role extension activities for the MRTs in NZ and the MRTs who may pursue postgraduate educational interventions in trauma reporting in future:

- Training and education courses that prepare MRTs for trauma image interpretation in EDs should be reviewed, revised and validated as needed to ensure that they accomplish their objectives.
- It is suggested that the educational institution attempts to have in place some form of guidelines for the supervision activity in their future educational interventions. As suggested by Dhingsa et al. (2002) such guidelines may best be devised in collaboration with all stakeholders who will be involved in their implementation and usage.
- A suitable supervision plan regarding the mentoring process must be drawn up between the mentee (MRT) and the mentor (radiologist) at the onset of the postgraduate education to avoid disappointments later and provide some form of guidance for those involved in the supervision activity.
- To aid judgments regarding allocation of TN, TP, FP and FN scores to the MRTs' interpretations, relevant information and parameters need to be provided by the

teaching institution to the MRTs undertaking the course, the clinical departments where the MRTs will be based as well as radiologists acting as the mentors.

- Better communication, commitment and collaboration between the teaching institution and the clinical departments where the MRTs work may be needed to help provide the support for those MRTs who decide to pursue this educational intervention in future.
- It is suggested that the educational institution considers the effect of performance worsening temporarily relative to some of the MRTs' educational experience in its future interventions and attempts to have some measures in place to assist those MRTs who may experience this phenomenon and probably get demotivated as a result.
- MRT reporting of trauma images in ED should be embraced as a positive step forward and be based on mutual trust and respect amongst those involved. The findings from this study can be useful in providing the starting point for arguments regarding the possible transition into role extension activities by MRTs in NZ in future.

Concluding Statements

This study investigated the image interpretation accuracy and the clinical practice of MRTs relative to their educational experience in emergency settings in NZ. It used a case study method conducted longitudinally. The triangulation approach was used to gather the information from three sources. The data that resulted was used to analyze the progress of the ten MRTs who participated in this study. The findings support the view that postgraduate education in trauma image interpretation in emergency settings can considerably enhance the interpretation skills and accuracy of MRTs. This study further strengthens the findings of previous studies conducted on MRT counterparts in countries such as the UK and promotes the existing theories in literature regarding image interpretation by appropriately educated MRTs.

Data from the research strongly supports that the courses were fundamental in enhancing the overt, but under-recognized, image interpretation skills that most of the MRTs had due to their routine work. It also signifies that as a result of their educational experience, the MRTs were capable of correctly identifying the presence of abnormalities and describing the type of abnormalities that were present on the images:

> …She's got better as things have gone on, better to the point where I think she's quite capable of making, you know, 99 percent of the diagnosis perfectly correctly so from a position where I might not have thought that at the beginning now I'm confident that she's right up to that skill.
>
> **Tom** *[mentor]*

In addition, this study shows that education allows MRTs to improve their clinical practice whilst providing optimum patient care. It further indicates that, with appropriate educational intervention, the MRTs in NZ were of value to the medical team. These findings about the clinical practice of the MRTs alleviates the deficiency in knowledge that was apparent during the literature review about the relationship between postgraduate education in trauma reporting and the clinical practice of those MRTs undergoing such interventions. Therefore, it is concluded that the educational intervention in interpretation of images of trauma to the appendicular skeleton enhances the existing clinical practice of MRTs and prompts them to approach their image interpretation tasks with a greater understanding and level of confidence.

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Glossary

accuracy	agreement of the candidates with the external reference standard; expressed as the sum of the true positive and true negative findings as a proportion of the total cases interpreted
ALARA principle	when performing medical imaging examinations, it is necessary to ensure that the dose that the patient receives is kept as low as reasonably achievable without compromising the quality of the image
anonymity	purposefully withholding any information that may make the true identity of the participant known to the public
appendicular skeleton	part of the human skeleton from the shoulder joint to the tip of the fingers and from the pelvis to the tip of the toes
barium enema	special medical imaging examination of the colon where a contrast agent (barium sulphate) is pumped into the colon via an enema tube inserted into the patient's rectum
clinical indication	the reason for the patient visiting the MI department for an imaging examination
clinical practice	traits such as usage of appropriate radiographic techniques, confidence to perform extra projections and confidence to identify at risk patients (for example, stable fracture versus unstable fracture) that enable the MRTs to produce good quality conventional images that aid the referrer in diagnosing and treating the patients
computed tomography	imaging modality that produces cross-sectional computerized densities and images from an x-ray beam and detector system
confidentiality	although the participant will be known to the researcher, the researcher does not divulge any of the participants names to the public
contrast	the various shades of gray seen on the images
contrast agent	a special dye that enhances the contrast of the body part being examined

conventional images	x-ray images of patients undergoing general radiography examinations.
diagnosis	an inference about what is wrong
diagnostic error	when a condition is diagnosed after the patient has left the emergency department without having any treatment for that condition
epiphyseal growth plates	cartilaginous part of bone that enables growth in the length of bones in children
experiential learning	process whereby concepts are derived from and are continuously modified by experience, hence encouraging a person to think, grow and develop
extremities	upper or lower limbs (arms or legs)
false positive	patient does not have an abnormality but has been diagnosed as having it
false negative	patient has an abnormality but has been diagnosed as not having it
gold standard	reference standard that is assumed to be 100 percent accurate
hard-copy	image produced on x-ray film
incidental finding	findings on the image that are not related to the clinical indication for which the patient is had the MI examination
informed consent	procedures in which individuals choose whether to participate in an investigation after being informed of facts that would be likely to influence their decisions
ionizing radiation	energetic particles or waves from the electromagnetic spectrum that have the potential to cause interactions in atoms or molecules
kappa score	test that indicates whether the agreement between observers in a study is merely through guesswork or perfect agreement
mammography	medical imaging examination of the breast tissues
Medical Imaging	allied health professional responsible for producing good quality x-ray images on patients undergoing radiological procedures and/or examinations
Medical Radiation Technologist	allied health professional responsible for producing good quality x-ray images on patients undergoing radiological procedures and/or examinations
neurosurgery	surgery of any part of the nervous system

objectives	statements of what one wants to achieve and are used to guide the individuals in making informed decisions to achieve the identified goals
over-penetrated	when too much ionizing radiation has been used to produce the image and useful information is lost
pattern recognition	ability of the observer to recognize abnormalities and variation in anatomy
Physician	medical doctor or general practitioner
professional practice	synonym for clinical practice
Radiographer	synonym for Medical Radiation Technologist commonly used in the UK and Australia
radiographic examination	use of x-rays to produce images of a particular body part
Radiography	synonym for Medical Imaging
Radiologic technologist	synonym for Medical Radiation Technologist commonly used in the USA
Radiologist	specialist doctor who interprets the conventional images and provides the formal report
receiver operating curve	method of analysis that provides a graphical representation of the overall diagnostic accuracy in terms of specificity and sensitivity as a single parameter A_Z, the area under the curve
Red Dot System	a system where the Medical Radiation Technologists informally advise the emergency department physicians about any abnormality on the image by flagging it with a red dot (or similar derivative) stickers
reflective practice	process of learning where concepts are derived from and are continuously modified relative to the experience of the learner
report	written interpretation of the images taken for a single medical imaging examination performed on a particular body part
request form	form the referrer gives to the patient to take to the MI department for an imaging examination
sample size	a subset of the population that gives a true representation of the population
sensitivity	proportion of true positives that were correctly identified; also known as the true positive fraction (TPF) and true positive rate (TPR)

specificity	proportion of true negatives that were correctly identified; also known as the true negative fraction (TNF) and true negative rate (TPR)
spectrum bias	ability of the observer to comment on a range of appearances that have the likelihood of limiting the trauma types, their severity or demographic presentation thus skewing the performing of the observer
soft-copy	image produced on computer screens
subtle abnormalities	irregularities that are not immediately obvious or understandable in the images hence making it difficult for the observer to perceive it on the image
teleradiography	outsourcing of radiology services such as reporting of images to overseas radiologists over the internet
trauma	injury caused by either a fall, assault or accident
true negative	patient does not have an abnormality and has been correctly diagnosed as not having it
true positive	patient has an abnormality and has been correctly diagnosed as having it
under-penetrated	when too little ionizing radiation has been used to produce the image and useful information is lost
urography	special medical imaging examination of the urinary system
viewing box	special lighting system that transilluminates dark areas of the image so that each part of the anatomical area on the image is viewed for abnormalities

APPENDICE ONE

Research proposal and ethical considerations

Research Proposal Approval

Unitec
NEW ZEALAND
Te Whare Wānanga o Wairaka

phone +64 9 849 4180 fax +64 9 815 2901 web www.unitec.ac.nz
address Carrington Rd, Mt Albert, Private Bag 92025, Auckland, New Zealand

26 June 2006

Reshmi Kumar
2/1034A New North Rd
Mt. Albert
AUCKLAND

Dear Reshmi

Thank you for submitting your research proposal '*Evaluation of the contribution of education on the accuracy and clinical practice of Medical Radiation Technologists interpreting conventional images of the appendicular skeleton of adult trauma patients attending Emergency Departments in New Zealand'*. The proposal was clearly written.

A subcommittee of the Postgraduate Board of Studies has considered and approved your proposal. We have several suggestions which we would like you to consider and these are on the attached sheet. Please talk these over with your supervisors.

Your principal supervisor is Jill Yielder and your associate supervisor is Frederick Murphy (on his arrival).

Please be aware that ethical approval may be required for your research once you have finalised your proposal. To determine the need for ethics application and approval, we recommend that you read the Guidelines for Ethical Approval in the *Research* folder on the Blackboard site *Postgraduate Students Resources*, to identify any ethical issues that may arise. Discussion with your supervisor or the ethics committee (email: ethics@unitec.ac.nz) may also assist in this decision process. This will help determine the need, or otherwise, for a full application for ethical approval. Ethics applications and accompanying documents should be submitted as email attachments to the above address.

Please contact me if you have any questions, or if I can assist you in your research (my extension number is 7465 and my email address jbillot@unitec.ac.nz).

We wish you every success in completing your research project.
Yours sincerely,

Jennie Billot

Dr Jennie Billot
Postgraduate Student Research Director
Division of Postgraduate Studies

Suggestions

Explain who the mentors are and their role in the project.

- State clearly why there is an assumption of 100% accuracy of the radiologists' reports (section 5) and that this is a limitation of the study. Clarify what constitutes 'education'. If you are referring to a particular postgraduate context, then explain how you will show the relationship between this education process and clinical practice. Be more overt in stating that you are following participants over a period of time and intend to assess changes in their accuracy of interpretation relative to their education experience.

Research Ethics Approval

Unitec
NEW ZEALAND
Te Whare Wānanga o Wairaka

phone +64 9 849 4180 fax +64 9 815 2901 web www.unitec.ac.nz
Private Bag 92025, Auckland Mail Centre, Auckland 1142, New Zealand
Mt Albert campus Carrington Rd, Mt Albert, Auckland, New Zealand
Waitakere campus Ratanui St, Henderson, Auckland, New Zealand

Reshmi Kumar
2/1034A New North Rd
Mt Albert
Auckland

July 17, 2006

Dear Reshmi

Your file number for this application: 2006.579
Title: Evaluation of the contribution of postgraduate education to the accuracy and clinical practice of Medical Radiation Technologists interpreting conventional images of the appendicular skeleton of adult trauma patients attending Emergency Departments in New Zealand

Your application for ethics approval has been reviewed by the Unitec Research Ethics Committee (UREC) and has been **approved** for the following period:

Start date: 17 July 2006
Finish date: 30 June 2007

Please note that:

1. the above dates must be referred to on the information AND consent forms given to all participants
2. you must inform UREC, in advance, of any ethically-relevant deviation in the project. This may require additional approval.

This letter has been copied to the Principal Supervisor for Unitec student research projects.

You may now commence your research according to the protocols approved by UREC. We wish you every success with your project.

Yours sincerely

Portia Richmond

pp. Dr Andrew Stewart
Deputy Chair, UREC

RMOL ref#: 797

cc: Jill Yielder

Information sheet for participants

Evaluation of the accuracy and clinical practice of Medical Radiation Technologists undergoing postgraduate education in adult trauma appendicular skeleton image interpretation in Emergency Departments in New Zealand.

(Please note that this working title has been modified)

Dear prospective Participant,

As part of my Master of Health Science programme requirements at Unitec, I will be doing research on a subject related to Medical Radiation Technology.

What I am doing?

I intend to evaluate how education in image interpretation contributes towards the accuracy and clinical practice of Medical Radiation Technologists interpreting conventional images of the appendicular skeleton of adult trauma patients attending emergency departments in NZ.

What it will mean for you?

- As you undergo postgraduate education in image interpretation at [redacted] from Semester Two, 2006, I will like to request you to:

1. Report a total of 40 appendicular skeleton images of adult trauma patients attending ED during your clinical practice in five batches from September – October 2006, November – December 2006, January – February 2007, March – April 2007 and May – June 2007 (i.e. 8 different images for each batch).
2. Send the Radiologist's and your reports for each batch to me as soon as you are able to in a professional manner. Please ensure that you erase any patient details and provide the indication and a general description of the patient, for example, a 26-year old male presenting with history of fall on outstretched hand.
3. Complete a questionnaire at the beginning and towards the end of the course regarding your education, image interpretation skills and clinical practice.

- Depending on your responses in the questionnaire, I may interview you and your mentor for an hour during the last week of June, 2007. The interview will be recorded and the conversation typed later. The tapes will be kept in a safe locked place for confidentiality and stored for a period of 5 years following the completion of this research. For the purpose of the interview, you will be required to self-select a representative from your allocated demographic location.

How will you benefit?

By participating in this research, you will help me to evaluate the image interpretation accuracy of Medical Radiation Technologists and the contribution of education in image interpretation on clinical practice. This research will form a project within research the New Zealand Institute of Medical Radiation Technologists (NZIMRT) is conducting on role development. It may have the potential for the possibility of NZ Medical Radiation Technologists being given the opportunity to interpret trauma images in emergency department in future.

What will I do with this?

A feedback regarding the results will be provided to Unitec, your mentor and you. Also, a copy of the thesis will be available at the Unitec Library. I intend to present this research at the annual conference of the NZIMRT by virtue of them being responsible for the continuous professional development of the NZ Medical Radiation Technologists. In addition, I intend to publish the information in a reputable, professional journal. However, strict anonymity will be adhered to and your name will not appear in the information.

Consent

- If you agree to participate in this study, you will be requested to sign a consent form.
- If you are invited to be interviewed, you will be asked to consent to being audio taped.
- Please note that you may withdraw from this research before October 15, 2006.

Confidentiality and Anonymity

Any information that may identify you will be kept confidential and will be stored in a safe locked place. For anonymity, you will be given an alphanumeric code and allocated a demographic location known only to the researcher and the research supervisors.

If you have any concerns about the research project at any time, you can contact the research supervisors:

1. Dr Frederick Murphy, Lecturer – Medical Radiation Technology, School of Health Science, Email: fmurphy@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8103
2. Dr Jill Yielder, Associate Professor/ Programme Director – Medical Radiation Technology, School of Health Science, Email: jyielder@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8109

If you need any further information, please do not hesitate to contact me.

Thank you.

Reshmi Kumar
Student ID Number: 1249532
Email: kumarr22@studentmail.unitec.ac.nz
Mobile: (021)2507504

Mailing Address:
Reshmi Kumar
C/- Dr. Jill Yielder
School of Health Science
Mt. Albert Campus
Unitec NewZealand.

This study has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretariat (Ph: 09 815 4321 ext.7254). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome. The file number for SHREC matters is 2006.579

Consent form for research participants

Evaluation of the accuracy and clinical practice of Medical Radiation Technologists undergoing postgraduate education in adult trauma appendicular skeleton image interpretation in Emergency Departments in New Zealand.

(Please note that this working title has been modified)

This consent form will aid in obtaining information for a research looking at how education in image interpretation contributes towards the accuracy and clinical practice of Medical Radiation Technologists interpreting conventional images of the appendicular skeleton of adult trauma patients attending emergency departments in New Zealand.

I have read and understood the information sheet and the research project has been explained to me.

I understand that:

- any information that may identify me would be kept confidential.
- all information collected from me will be kept in a safe locked place and the only people having access to this information would be the researcher, the research supervisors, my mentor and me.
- in addition to the results of this research being provided to myself, my mentor and Unitec, the results will also be disseminated to NZIMRT and maybe possibly published in a reputable professional journal.
- if I am invited for an interview then my discussions during the interview will be audio taped and transcribed.
- if I have any concerns or queries regarding the research at any time, I can contact the Research Supervisors:
    1. Dr Frederick Murphy, Lecturer – Medical Radiation Technology, School of Health Science, Email: fmurphy@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8103
    2. Dr Jill Yielder, Associate Professor/ Programme Director – Medical Radiation Technology, School of Health Science, Email: jyielder@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8109

I have had time to consider everything and I give my consent to be a part of this research.

Participant's Signature: ……. Date: ……

Researcher's Signature: ……. Date: ……

This study has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretariat (Ph: 09 815 4321 ext.7254). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome. The file number for SHREC matters is 2006.579

Covering letter for Questionnaire two

02/04/07

Evaluating MRTs' image interpretation accuracy and clinical practice relative to their postgraduate education experience in New Zealand.

Dear Participant,

We have reached the phase of implementing the second questionnaire in the research on image interpretation that you are currently participating in. The purpose of this questionnaire is to allow information to be collected on the contribution that the academic and clinical aspects of the educational experience has had on your interpretative accuracy and clinical practice.

Please note that this is the first time for a postgraduate course in appendicular skeleton image to be offered and for a research to be conducted on it. Therefore, this questionnaire is quite comprehensive and addresses a lot of questions on your personal views about the postgraduate education, the mentoring and the reporting activities. To protect your privacy and maintain anonymity, any information that may identify you will be kept confidential.

I will be grateful if you could please spare some of your precious time to complete this questionnaire and return it to me by the 27th of April, 2007.

Please find enclosed a postage paid envelop with the return address for you to send the completed questionnaire.

If you need any further information, please do not hesitate to contact me.

Thank you.

Reshmi Kumar
Student ID Number: 1249532, Email: kumarr22@studentmail.unitec.ac.nz, Mobile: (021)2507504

Mailing Address:
Reshmi Kumar
C/- Associate Professor Jill Yielder
School of Health Science
Mt. Albert Campus
Unitec NZ
Auckland
New Zealand.

Consent form for interviewee

Evaluation of the accuracy and clinical practice of Medical Radiation Technologists undergoing postgraduate education in adult trauma appendicular skeleton image interpretation in Emergency Departments in New Zealand.

(Please note that this working title has been modified)

This consent form will aid in obtaining information for a research looking at how education in image interpretation contributes towards the accuracy and clinical practice of Medical Radiation Technologists interpreting conventional images of the appendicular skeleton of adult trauma patients attending emergency departments in New Zealand.

The research project has been explained to me and I have understood the information given.

I understand that:

- I will be interviewed for one hour and my discussions during the interview will be audio taped and transcribed.
- I will be given a copy of the transcription later to verify its content
- any information that may identify me would be kept confidential
- in addition to the results of this research being provided to myself and Unitec, the results will also be disseminated to NZIMRT and maybe possibly published in a reputable professional journal.
- if I have any concerns or queries regarding the research at any time, I can contact the research supervisors:
  3. Dr Frederick Murphy, Lecturer – Medical Radiation Technology, School of Health Science, Email: fmurphy@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8103
  4. Dr Jill Yielder, Associate Professor/ Programme Director – Medical Radiation Technology, School of Health Science, Email: jyielder@unitec.ac.nz , Phone: +64-9-815 4321 ext. 8109

I have had time to consider everything and I give my consent to be a part of this research.

Participant's Signature: ……. Date: ……

Researcher's Signature: ……. Date: ……

This study has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretariat (Ph: 09 815 4321 ext.7254). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome. The file number for SHREC matters is 2006.579

Approval letter – Radiology Manager

C/- Associate Professor Jill Yielder
School of Health Science
Mt. Albert Campus
Unitec NZ
Auckland,
New Zealand.
21st November, 2006.

The Radiology Manager
C/- Radiology Department
[redacted]

Dear Sir/Madam

RE: Image Interpretation Research

I am a Master in Health Science (Medical Radiation Technology) student at Unitec New Zealand and have just commenced my thesis this semester. I am trying to evaluate the contribution of postgraduate training in image interpretation to the accuracy and clinical practice of Medical Radiation Technologists in emergency settings in NZ.

The participants in my research are the MRTs who are doing the postgraduate course [redacted] and its partner course [redacted]

I have been advised that [redacted] has negotiated and obtained permission and support from your department to enable some of the participating MRTs to do the clinical applications component in your department. I would like to inform you that my research will involve the usage of these interpretations to determine the changes in the interpretative accuracy and clinical practice of these MRTs relative to their education experience. The MRTs who have given their consent to participate in this study have been requested to submit 40 copies of reports for the duration of the course.

I would like to reassure you that any data collected will be treated with utmost confidence and anonymity. The hospital or patient details will not be disclosed. If you need more details or any other information, I can be contacted at this mobile number: 0212507504 or e-mail address: kumarr22@studentmail.unitec.ac.nz

Thank you in advance for your assistance.

Kind regards,

Reshmi Kumar

This research has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007 and the file number for SHREC matters is 2006.579. My supervisors are Dr. Frederick Murphy and Dr. Jill Yielder.

Approval letter – Radiologist (mentor)

C/- Associate Professor Jill Yielder
School of Health Science
Mt. Albert Campus
Unitec
Auckland,
New Zealand.
21st November, 2006.

Dear Dr [redacted]

RE: Image Interpretation Research

I am a Master in Health Science (Medical Radiation Technology) student at Unitec New Zealand and have just commenced my thesis this semester. I am trying to evaluate the contribution of postgraduate training in image interpretation to the accuracy and clinical practice of Medical Radiation Technologists in emergency settings in NZ. This research has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007 and the file number for SHREC matters is 2006.579. My supervisors are Dr. Frederick Murphy and Dr. Jill Yielder. I would also like to inform you that this research is part of the NZIMRT research on possible areas of role development for MRTs in NZ in future.

The participants in my research are the MRTs who are doing the postgraduate course [redacted] and its partner course [redacted] at [redacted] from Semester 2, 2006. I have been advised that Unitec has negotiated and obtained permission and support from your department to enable some of the participating MRTs to do the clinical component in your department.

As part of the research data collection, I would like to conduct an interview sometime in June, 2007 with a radiologist acting as a mentor for the participating MRTs from your department. It is anticipated that the interview will be for a maximum of one hour. The mentor's consent to record the interview will be requested and he/she is free to withdraw from the study at any time. The purpose of the interview is to provide insights about the mentoring process and the changes in the interpretative accuracy and clinical practice of the MRTs participating in this research.

I would be grateful if you could allow the interested mentor to be available for the interview and enlighten me on his/her observations please. I would like to reassure you that any data collected will be treated with utmost confidence and anonymity. If you need more details or any other information, I can be contacted at this mobile number: 0212507504 or e-mail address: kumarr22@studentmail.unitec.ac.nz

Thank you in advance for your assistance.

Kind regards,

Reshmi Kumar

APPENDICE TWO

Data collection – Forms and instrument

Exampler Reporting Form

REPORT TEMPLATE

EXAMINATION: DATE

NHI/VISIT NUMBER: **DOB:**

Indication/s:

Findings:

Summary/conclusion:

NAME OF REPORTER

Questionnaire One

Please answer the questions and tick the most appropriate box provided where necessary

Personal Information:

Name: …….. Years worked as MRT:……

1. How often do you encounter trauma patients for appendicular skeleton imaging at your practice?

☐ **less than five per week** ☐ **between 5-10 per week** ☐ **other (please specify)** .....

2. Are you currently involved in any form of trauma image interpretation at your workplace?

☐ **Yes** ☐ **No**

If Yes, please elaborate

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3. Have you had any form of training in image interpretation before?

☐ **Yes** ☐ **No**

If Yes, please elaborate

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……

4. How would you rate your image interpretation skills at the moment?

☐ **Poor** ☐ **Fair** ☐ **Good** ☐ **Very Good** ☐ **Excellent**

5. Why have you chosen to pursue postgraduate education in image interpretation of trauma appendicular skeleton?

……
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6. Please list some personal learning objectives that you hope to achieve from this postgraduate course in trauma appendicular image interpretation?

……
……
……
……
……

7. How would you rate your current clinical practice in terms of:

(a) usage of appropriate positioning techniques

☐ Poor ☐ Fair ☐ Good ☐ Very Good ☐ Excellent

(b) confidence to perform extra projections

☐ Poor ☐ Fair ☐ Good ☐ Very Good ☐ Excellent

(c) confidence at identifying at risk patients e.g. stable versus unstable fractures

☐ Poor ☐ Fair ☐ Good ☐ Very Good ☐ Excellent

8. Do you foresee that learning image interpretation will alter any of your clinical practice as identified in Q7?

a) usage of appropriate positioning techniques

☐ Yes ☐ No

If Yes, please explain

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(b) confidence to perform extra projections

☐ Yes ☐ No

If Yes, please explain

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(c) confidence at identifying at risk patients e.g. stable versus unstable fractures

☐ Yes ☐ No

If Yes, please explain

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9. Describe any limitations and/or difficulties that you foresee having an impact on your interpretations as you gain supervised experience in reporting images of the appendicular skeleton

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10. Do you have any solutions to overcome these limitations and/or difficulties?

☐ Yes ☐ No

If Yes, please explain

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11. Please feel free to make any other comments or observations

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Thank you for your participation.

This study has been approved by the Unitec School of Health Science Research Ethics Committee from July 2006 to December 2007. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the UREC Secretariat (Ph: 09 815 4321 ext.7254). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome. The file number for SHREC matters is 2006.579

Questionnaire Two

PART 1: Personal and Additional Information:

Please answer the following by filling in the space or ticking the most appropriate box provided where necessary

1. Name: ……..

2. Years worked as MRT: ……..

3. Type of practice working at: ☐ Public ☐ Private

4. Area practice located: ☐ Remote ☐ Urban ☐ Suburb

5. Number of radiologists working at practice: ……...……...

6. Availability of radiologists at practice to provide official reports:

☐ Daily (9am -5pm/normal working hours)

☐ Daily (24 hours)

☐ Other (please specify) …….

7. Timeliness of availability of formal report to referrer(ED doctor/GP etc.)

☐ Within a few hours

☐ Within 5 days

☐ Between 5 – 10 days

☐ Other (please specify) …….

8. Any other comments regarding practice

……

……

……

……

……

……

PART 2: Information regarding postgraduate education experience, image interpretation skill acquisition and clinical practice

Please answer the questions and tick the most appropriate box provided where necessary

1. **How would you rate your image interpretation skills after undergoing appropriate education in trauma appendicular skeleton image interpretation?**

   ☐ Poor

   ☐ Fair

   ☐ Good

   ☐ Very good

   ☐ Excellent

2. **What was your personal reaction when interpreting trauma appendicular skeleton images at your practice relative to your education experience?**

   ☐ confident

   ☐ unsure

   ☐ other (please specify) .....

3. **What would be your attitude if you were asked to interpret images without supervision at your workplace?**

   ☐ will participate

   ☐ will not participate

   ☐ other (please specify) ……

4. **What would be your attitude if you were asked to interpret images without any education in image interpretation?**

   ☐ will participate

   ☐ will not participate

   ☐ other (please specify) ……

5. **Where did you do your reporting of the trauma appendicular skeleton images?**

   ☐film sorting area

   ☐radiologist's room

   ☐special room allocated for reporting

   ☐other (please specify) …….……..

6. **Out of a scale of 100%, what percentage would you allocate to the following activities performed by you on a routine work day?**

   ☐general radiography duties

   ☐administrative duties

   ☐reporting trauma appendicular images

   ☐other (please specify) …….……..

7. How have you adjusted your work schedule to cope with this extended role?

……

……

……

6. (a) How do others at your workplace regard you doing image interpretation of trauma appendicular skeleton?

……

……

……

(b) Has this opinion of others influenced your image interpretation skill acquisition in any way? ☐ Yes ☐ No

Please elaborate

……

……

……

7. Please describe your personal criteria for the selection of your case images for the five batches in the study?

☐ area of confidence

☐ case frequency

☐ no criteria

☐ other (please specify)…….

8. Comment on the relevance of the postgraduate education on your image interpretation skills and clinical practice.

……

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……

9. Was the use of the radiologist as a mentor of any benefit to you?

☐ Yes ☐ No

Please explain

……

……

……

10. What was the supervision arrangement between you and your mentor?

☐ Meet once a week to discuss the images you reported

☐ Sit-in with the mentor as he/she reported the images you had interpreted

☐Other (please specify) …….

11. How would you rate your mentoring arrangement in terms of effectiveness?

☐ Effective

☐ Ineffective

☐ other (please specify)…….

12. (a) How frequently did your interpretations agree with your mentor?

☐always

☐often

☐sometimes

☐never

☐other (please specify)…….

(b) How frequently did your interpretations disagree with your mentor?

☐always

☐often

☐sometimes

☐never

☐other (please specify)…….

(c) How did you deal with any disagreements?

……

……

13. Describe any limitations and/or difficulties that you have encountered which had an impact on your interpretations as you gained supervised experience in reporting images of the appendicular skeleton?

……

……

……

14. Has learning image interpretation of trauma appendicular skeleton altered your clinical practice in terms of?

(a) usage of appropriate positioning techniques ☐ Yes ☐ No

If Yes, please explain

……

……

(b) confidence to perform extra projections ☐ Yes ☐ No

If Yes, please explain

……

……

(c) confidence at identifying at risk patients e.g. stable versus unstable fractures

☐ Yes ☐ No

If Yes, please explain

……

……

15. In addition to the factors in Q7 above, has learning image interpretation of trauma appendicular skeleton altered your clinical practice in any other way?

☐ Yes ☐ No

If Yes, please explain

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16. Please feel free to make any other comments or observations

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Thank you for your participation.

Interview schedule for the MRTs

1. (a) Did you have enough trauma cases for interpretation during your formal postgraduate education?
   (b) Which examinations were commonly encountered?
   (c) Do you see any relationship between the availability of these different cases and your image interpretation accuracy? Please explain.

2. (i) When you first embarked on interpreting trauma images during your clinical practice, what approach did you use?
   (ii) Why did you use this approach?

3. Have you found the location of your workplace influencing your interpretation accuracy in anyway? Please explain.

4. (a) How many radiologists have been involved in your mentoring?
   (b) Can you explain the approach that was used for your mentoring process?
   (c) Why was this process of mentoring selected?
   (d) What was your experience regarding the mentoring process used?
   (e) How practical and effective have you found the mentoring process?
   (f) Has there been any change in your mentoring approach over the year of involvement?
   (g) Can you identify any particular strengths of the mentoring process that was used?
   (h) Can you identify any particular weaknesses of the mentoring process that was used?
   (i) Can you describe any ways in which the mentoring process can be improved?
   (j) If given the opportunity to redo the whole mentoring activity, is there anything you would have done differently?

5. (a) Can you describe the method/scheme/guideline used by your mentor to assess your accuracy in interpreting images?
   (b) Were there any allocation of TP, TN, FP, FN scores to your interpretations?
   (c) Can you describe how effective you found the use of the TP, TN, FP and FN scores?
   (d) How did the TP, TN, FP and FN scores contribute towards your image interpretation performance during your educational experience?
   (e) Did you encounter any drawbacks/limitations with the usage of the TP, TN, FP and FN scores?

6. (a) Have there been instances when there was a disagreement between you and your mentor? Please explain.
   (b) What have you done in circumstances where your interpretations have been incorrect in comparison to your mentor?
   (c) What have you done in circumstances where your interpretations have been correct in comparison to your mentor?
   (d) Apart from disagreement of interpretations, can you describe any other issues that you have encountered with your mentor in relation to the mentoring activity?
   (e) How have you dealt with the issue(s) that you mentioned earlier?

7. How would you describe your image interpretation accuracy in comparison to your mentor's at the beginning, during and towards the end of the mentoring period?

8. How would you describe your progress with respect to skill acquisition in image interpretation at the beginning, during and towards the end of the educational experience?

9. (a) How did you find the postgraduate education in enhancing your image interpretations?
   (b) Can you describe the aspects of the postgraduate education which you found to contribute positively towards developing your image interpretation ability?

10. (i) What are your observations of the wordings of your reports as you progressed in your education?
    (ii) What are your observations of your confidence in reporting the trauma images as you underwent formal education in trauma reporting?

11. (a) Has the postgraduate education in trauma image interpretation altered your clinical practice in anyway? Please explain.
    (b) Which aspects of the postgraduate education have you found to have contributed towards your clinical practice?
    (c) Has the location of your workplace had any influence on your clinical practice as you underwent formal education in trauma image interpretation?

12. Can you identify any particular strengths and weaknesses of the:
    (i) academic components of the trauma image interpretation course?
    (ii) clinical components of the trauma image interpretation course?

13. Do you have any suggestions for improving this postgraduate course in trauma image interpretation either academically or clinically?

14. How has this postgraduate course in trauma image interpretation impacted on your job satisfaction and motivation?

15. How do you see your future after you have completed this formal education in image interpretation?

Interview schedule for the mentors

1. (a) How many MRTs undertaking formal education in image interpretation have you been involved in mentoring?
   (b) Can you explain the approach that you used for the mentoring process?
   (c) Why did you opt for this process of mentoring?
   (d) What was your experience regarding the mentoring process used?
   (e) How practical and effective have you found the mentoring process?
   (f) Have you made any changes to the mentoring approach over the year of involvement?
   (g) Can you identify any particular strengths of the mentoring process that was used?
   (h) Can you identify any particular weaknesses of the mentoring process that was used?
   (i) Can you describe any ways in which the mentoring process can be improved?
   (j) If given the opportunity to redo the whole mentoring activity, is there anything you would have done differently?

2. Do you think your mentee had enough trauma cases for interpretation during his/her formal postgraduate education?

3. (a) Can you describe the method/scheme/guideline used by you to assess your mentee's accuracy in interpreting images?
   (b) Were there any allocation of TP, TN, FP, FN scores to your mentee's interpretations?
   (c) Can you describe how effective you found the use of the TP, TN, FP and FN scores?
   (d) How did the TP, TN, FP and FN scores contribute towards your mentee's image interpretation performance during his/her educational experience?
   (e) Did you encounter any drawbacks/limitations with the usage of the TP, TN, FP and FN scores?

4. (a) Have there been instances when there was a disagreement between you and your mentee? Please explain.
   (b) What have you done in circumstances where your mentee's interpretations have been incorrect in comparison to yours?
   (c) What have you done in circumstances where your mentee's interpretations have been correct in comparison to yours?
   (d) Apart from disagreement of interpretations, can you describe any other issues that you have encountered with your mentee in relation to the mentoring activity?
   (e) How have you dealt with the issue(s) that you mentioned earlier?

5. How would you describe your mentee's image interpretation accuracy in comparison to yours at the beginning, during and towards the end of the mentoring period?

6. How would you describe your mentee's progress with respect to skill acquisition in image interpretation at the beginning, during and towards the end of the educational experience?

7. (i) What are your observations of the wordings of your mentee's reports as he/she progressed in his/her education?
   (ii) What are your observations of your mentee's confidence in reporting the trauma images as he/she underwent formal education in trauma reporting?

8. (a) In your opinion, how effective have you found the postgraduate education in enhancing your mentee's image interpretation accuracy?

   (b) Would it be possible for you to comment on the aspects of the postgraduate education which you found to contribute positively towards developing your mentee's image interpretation ability?

9. Can you gauge if the location of your mentee's workplace may have had any influence on your mentor's interpretation accuracy? Please explain.

10. Do you see any relationship between the postgraduate education in image interpretation and the clinical practice of your mentee? Please explain.

11. Do you have any suggestions for improving this postgraduate course in trauma image interpretation either academically or clinically?

12. How do you see the future of your mentee after he/she has completed his/her formal education in image interpretation?