Radiographer Reporting:
Discussion and Australian workplace trial
Aiden P. Cook, Tanya Oliver, Lester Ramsay

ABSTRACT
This paper reports an investigation into the accuracy and effectiveness of two (2) senior Australian radiographers in the reporting of appendicular musculo-skeletal radiographs in the adult trauma situation, and discusses the international debate on radiographer role extension into plain film reporting.

The study of 540 patients referred to a large metropolitan emergency imaging department demonstrated high rates of diagnostic accuracy (sensitivity = 98.00% specificity = 99.11%) in the assessment of appendicular musculo-skeletal radiographs. 294 out of 300 positive examinations were identified correctly (FPR=0.88%) as were 225 out of 227 negative or normal examinations (FNR=2.00%). A discussion on relevant statistical measures and their definitions is outlined. In the study radiologist reports are used as the comparative gold standard.

The findings demonstrate an ability of clinically experienced radiographers to accurately and effectively provide diagnostic opinions on musculoskeletal radiographs. A formalised approach to radiographer reporting can be justified and a formal program to train appropriately experienced radiographers is recommended.

BACKGROUND
Within radiology departments, particularly in the United Kingdom (UK) and to a lesser extent Australia, there is a trend towards radiographers extending their traditional roles. This extension is occurring primarily in two broad areas within the profession of radiography.

In the case of Australia, the first is the traditional peak of the profession, where senior clinical radiographers move into radiographic administration. This role is expanding due to the complex nature of the health finance involved in the purchasing, replacement and upkeep of a modern multi-modality Medical Imaging Department. This area of role expansion is characterised by post-graduate study in health management and business studies and a significant decrease in clinical duties.

The second area of role extension is centred on the opportunity for a radiographer to take on new clinical responsibilities and duties. As new technologies in clinical radiology require specialist training for safe, effective and efficient use, the clinical radiographer’s role is more commonly including post-graduate study, qualification or accreditation to practice in the specific modalities, such as CT and MRI. In-turn, to maintain clinical skills these areas, there is a need for extended clinical exposure in the particular modality.

Other less evident or potential areas of clinical extension in Australia include formal radiographer reporting, direct referral, patient information and advocacy, performing clinical procedures within fluoroscopy and research.

Role expansion for general radiographers has been less dynamic than in the commonly recognised modalities of Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Ultrasound (U/S). The introduction of Computed Radiography (CR) and digital equipment has seen a gradual move away from traditional methods of image production by radiographers as the technology proliferates. Over the past five years, uptake of new tasks such as formal radiographer reporting has been slow, possibly as there has been no real identified service provision issues for plain films. It remains unclear as to the extent to which radiographers, particularly in rural and remote centres have been anecdotally providing informal verbal reporting. Evidence that would seem to support this role was provided to the team compiling the competency based standards in radiography in the 1990s.

The well documented and increasing shortage of Australian radiologists, coupled with the increase in complex cross-sectional imaging studies and imaging-guided interventional procedures, have provided Australian radiographers with a real gap in radiology service provision and patient care. This is an essential requirement in the justification of clinical plain film reporting by radiographers with appropriate enthusiasm, training and experience.

The purpose of this study was to measure the accuracy and effectiveness of experienced radiographers (n=2, both with >8 years of post graduate experience) in the reporting of musculo-skeletal extremity radiographs.

Landmark studies/Literature review
Current literature searches regarding radiographer reporting, reveal a noticeable paucity of Australian authored articles/studies. Only perhaps in the last two years has there been any increase in the number of formal studies or research papers into the implementation of Australian radiographer reporting programs. In contrast, reporting of radiographic images related to the axial and appendicular skeleton by radiographers has been widespread in the UK for some years.

Smith attributes the slower implementation process of radiographer reporting in Australia to the differing structure of the health systems in the UK versus Australia. He concludes radiographers have unique barriers in Australia due to a higher number of radiologists, particularly in the private sector, which has acted...
as a barrier to the effective proliferation of radiographer reporting in this country.

As early as 1971, Swinburne\(^1\) proposed training of Radiographers in Musculo Skeletal (MSK) pattern recognition. In a study by Robinson\(^1\) two radiographers undertook reporting of emergency imaging examinations in parallel with the radiologist. An analysis of over 500 cases showed no significant difference in their accuracy compared with that of the radiologist. Robinson concluded that appropriately trained and supervised radiographers can successfully undertake diagnostic reporting of selected skeletal examinations on emergency patients. The bulk of the published literature on the topic is UK based and as such can only be used as a guide due to the differences within the health systems of Australia and England.

Price\(^2\) recognises that radiologists and radiographers initially shared common roles. As radiologists established their profession within the field of medicine, radiographers became technicians while the reporting of images became the primary concern of the radiologists. As technology developed and flourished and workloads within the hospitals increased, a potential role emerged for radiographers to assist in fracture identification to reduce radiologist workloads and unreported images.

In a number of articles, increased responsibilities and autonomy for radiographers\(^3,4\) and new challenges\(^5,6\) were cited as areas which increase job satisfaction for radiographers. There is supporting literature and an identified increasing service delivery problem in MSK plain film radiographs in Australia. Radiographer role extension into reporting in the UK and to a lesser extent Australia and the positive benefits of such a move was a theme in the articles reviewed.

METHODOLOGY

A 10 week radiographer reporting trial program for musculoskeletal (MSK) radiographs was introduced as a potential quality improvement measure entirely within the Royal Brisbane Hospital (RBH) Department of Medical Imaging (DMI). The project used the existing CR and Picture Archiving and Communication System (PACS) network in a filmless environment. The study involved statistical assessment of radiographers to report musculoskeletal examinations, referred from the Department of Emergency Medicine (DEM). No paediatric (<14 years of age) patients were included in the study.

The Radiographers participating in the trial were DMI Senior Radiographers based in emergency full time. Radiographer 1 is Australian trained, has eight years of radiographic experience and is currently undertaking post graduate study in Image Interpretation at Master degree level. Radiographer 2 is UK trained and has 14 years of radiographic experience. Both radiographers undertook self directed education and informal training, estimated at around 30 hours each, with the professor of Medical Imaging at the facility over a period of 12 months. The participants achieved five hours of reporting per week for 10 weeks, which allowed 50 hours for the review of 500 examinations at around 10 per hour. Each anatomical area received a unique number to allow for tracking and correlation of reports.

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Figure 1: Radiographer Results vs Gold Standard

<table>
<thead>
<tr>
<th>Category of reporting</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>294</td>
</tr>
<tr>
<td>TN</td>
<td>225</td>
</tr>
<tr>
<td>FP</td>
<td>2</td>
</tr>
<tr>
<td>FN</td>
<td>6</td>
</tr>
<tr>
<td>Equivocal</td>
<td>8</td>
</tr>
<tr>
<td>Removed</td>
<td>5</td>
</tr>
<tr>
<td>Clinically significant</td>
<td>4</td>
</tr>
<tr>
<td>Missed by radiologist</td>
<td>2</td>
</tr>
</tbody>
</table>

Each radiographer described the features of every image and indicated if the radiographs were positive or negative for abnormal appearances. Radiographs were formally reported by a radiologist, which is taken as the gold standard.

The radiographer’s report was compared with the gold standard by an independent marker and comparisons were tabulated and analysed.

Approximately five per cent of 540 reports were reviewed by the Professor of Medical Imaging. These included radiographer reports marked as false positive, false negative and a number of reports, which the marker found equivocal. The audit process was undertaken to assess the clinical significance of the incorrect radiographer reports and to generally assess the accuracy of the marking in correlating the reports against the gold standard.

All data was treated confidentially and stored in a secure location. Patient specific information and clinical history was available.
for the participating radiographers although none of these details were directly recorded during or after the reporting phase. The study required recording of the unique assigned examination number which was used to correlate the radiographer reports against the gold standard. Only these unique numbers were retained by the authors for validation purposes.

Reports benchmarked against the gold standard were classified into four categories. True positives, False positives, False negatives, True negatives. From this collected data, the information was calculated relating to the prevalence of positive radiographs, the sensitivity, the specificity, the predicted value of a positive finding, and the positive posterior odds for a person having a fracture who has a positive report. See Figure 2.

**Ethical Considerations**

Formal ethics approval was not obtained. After discussion with local researchers it was considered a local quality improvement activity and involved no extension of personal information access to the participants.

**RESULTS**

A total of 540 musculo-skeletal examinations of the appendicular skeleton were assessed by the radiographers and then compared with the gold standard radiologist report. Thirteen examinations were considered equivocal or did not comply with the scope of the study and were discarded. 519 out of the remaining 527 examinations were correctly identified giving 98.48 per cent accuracy within the distal femur, one haemoarthrosis of the elbow with no obvious fracture or overcalled and six out of 230 were found to be falsely positive or overcalled and six out of 230 were found to be falsely negative or missed diagnosis.

Upon review by the professor of Medical Imaging, there were two cases where the radiographer correctly identified an abnormality missed by the reporting radiologist, one of which was considered clinically significant. Of the six cases determined False Negative or Misses by the Radiographer reports, three were considered clinically significant to varying degrees. Significant diagnosis missed were one osteochondritis desicans within the distal femur, one haemoarthrosis of the elbow with no obvious fracture and one cystic lesion of the wrist. No acute fractures were missed by the radiographers. False negative radiographer reports, not considered significant, were failure to mention the diagnosis of minor degenerative changes.

Figure 1 demonstrates the breakdown of the reports into the classifications used in the calculations. Statistical analysis of the accuracy of radiographer reporting with respect to the radiologist gold standard is given in Figure 2.

The prevalence of a positive finding, which refers to the number of positive cases per population, as a percentage, was 56.93 per cent. A positive case was defined as the presence of an anatomical abnormality such as a fracture, dislocation, subluxation, degenerative or other pathological process. The study was carried out in a large DEM hence most examinations are acute and traumatic in origin, this could explain the high prevalence value. Other pathology and degenerative processes are expected to make up a small percentage of the results.

Prior odds or chance odds is related to the prevalence of a positive result and in this case is expressed as odds of 1.32/1. This basically is a measure of how likely a random choice that the examination as positive would be of being accurate. By actually describing the abnormality to ensure successful identification of the correct positive finding the results are more accurate than this figure suggests.

The Likelihood Ratio (LR) is a measure of how well the test performs. It basically states the likelihood (or probability) that the radiographer has correctly identified a fracture or abnormality. Statistically it is the ratio of the Positive Sensitivity (TPR) to the False positive rate (FPR) and for this study is 111.36/1 or 99.11%.

Positive Posterior Odds (PPO) of 99.32 per cent are the odds of a person having a fracture and a positive radiographer report.

### Figure 2:
**Statistical summary of radiographer reporting in musculoskeletal radiography n=541.**

<table>
<thead>
<tr>
<th>Reporting Radiologist report positive</th>
<th>Reporting Radiologist report negative</th>
<th>Radiographer Predicted</th>
<th>Prior Odds</th>
<th>Likelihood ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographer reported positive</td>
<td>True Positive (TP)</td>
<td>294</td>
<td>300</td>
<td>1.32 // 1</td>
</tr>
<tr>
<td></td>
<td>False Positives (FP)</td>
<td>2</td>
<td>227</td>
<td>111.36 // 1</td>
</tr>
<tr>
<td>Radiographer reported negative</td>
<td>False Negative (FN)</td>
<td>6</td>
<td>225</td>
<td>99.11%</td>
</tr>
<tr>
<td></td>
<td>True Negative (TN)</td>
<td>231</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TPR Sensitivity</th>
<th>FPR</th>
<th>Included Population</th>
<th>Total Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.00%</td>
<td>0.88%</td>
<td>527</td>
<td>540</td>
</tr>
<tr>
<td>FNR 2.00%</td>
<td>TNR Sensitivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99.32%</td>
<td>99.11%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Statistical summary of radiographer reporting in musculoskeletal radiography n=541.
While similar to the Likelihood Ratio it differs in that the likelihood ratio measures the chance of the radiographer being correct, where the PPO measures the chance that the report is correct. This calculation involves Bayes Theory and is calculated by multiplying the Prior odds with LR.

The calculation of the PPO gives the same value as for the predicted value of a positive result (or PVP). PVP is calculated via a different manner (TP/TP+FP x 100) and is ultimately identical. The predicted value of the negative finding was 97.40 per cent and conversely is a measure of how many of the radiographers negative reports are confirmed as negative by the radiologist.

There are some limitations to this study, which need to be considered. This study does not discriminate between the varied areas examined and the intricacies of reporting each area. Smith1 describes a variation in research methodology whereby radiographer reporting was divided into subcategories of upper extremity and lower extremity. This discrimination was not determined in our study. Anatomical areas examined were shoulder girdle, acromio - clavicular joints, clavicles, humerus, elbow, radius and ulna, wrist, hand, pelvis, hip, femur, knee, tibia and fibula, ankle, foot and calcaneum.

There were also varying levels of skill and experience of the reporting radiologists (Gold Standard), from 1st year registrars to experienced consultant radiologists. While we have assumed 100 per cent sensitivity and specificity for the radiologist, in one particular study by De Lacey, four per cent of radiologists reports were found to be inaccurate and one per cent equivocal.21

DISCUSSION

The RBH is an 800 bed tertiary hospital located within 2km of the Brisbane City Central Business District. This study was undertaken with radiographs produced within the 24 hour Dr Robert Paterson Emergency Imaging Department. With a daily throughput of around 130 plain film examinations requested through the DEM, approximately 40-50 per cent of daily plain film examinations actually take place between the hours of 5pm and 9am. See Figure 3

The DEM medical team consists of 25 resident medical officers (RMO), nine registrars, eight emergency consultant medical officers, one GP and two visiting medical officers spread over the three shifts. An emergency consultant is on duty until 11pm each evening with registrars of varying experience levels on at all times. The bulk of MSK requests are anecdotally coming from either the resident medical staff with less than three years of post graduate experience or from FastTrack, where Nurse Initiated X-Ray (NIX)22 is extensively utilised. The current radiology reporting structure unfortunately means that if a fracture is missed by the RMO, there is a significant chance that the x-ray will remain unreported indefinitely.

Plain film radiologist cover is generally available within the Emergency Imaging Department from 9am to 5pm. Radiologists are on call between the hours of 5pm and 9am for modality support only. There is an identified gap in the provision of plain film radiological opinion to the emergency medical staff during this time.

Figure 3 demonstrates the volume of reporting being generated by the emergency department over time. This graph was produced from data obtained from the PACS and Radiology Information System (RIS) within the department for a typical 24 hour period.

With 60 or more examinations taking place after hours and no radiologist cover during the same period, there are potential benefits to the patient and the health service from radiographer reporting. The increased accuracy and decreased time required to derive a MSK diagnosis means increased efficiency in this large emergency centre.

Clinically experienced radiographers are an existing under utilised resource as far as image interpretation is concerned. There are a number of papers describing their effectiveness in pattern recognition and musculo-skeletal film reading accuracy.1-9 Large benefits can be achieved at minimal costs to the health service. A structured program of radiographer reporting could aid in the reduction of patient recalls and more importantly allow for improved patient outcomes from early pick-up
of potentially missed injuries, which could be complicated by non-treatment.

The updated Australian Institute of Radiography (AIR) radiographer code of conduct specifies that a radiographer should recognise their responsibility to the patient and as a health professional report any abnormalities to the medical officer responsible for the patient’s treatment. It goes further to state “at the request of such personnel may provide an opinion that lies within their knowledge and expertise”. This ethical responsibility can be argued to constitute unofficial radiographer reporting. The reporting of radiographs by a radiographer involved at the time of the examination, either directly or in a supervision role, has obvious advantages. As argued by Egan and Baird, the radiographer has the advantage over radiologists of intimate patient contact and the opportunity to interview the patient so as to obtain clear clinical histories and mechanisms of injury not included by the requesting doctor.

The results of this study have found that radiographers could be an accessible, effective tool to provide informed opinions to junior medical staff. Smith reinforces these findings by highlighting that radiographers, when they do report, have high levels of accuracy, particularly in the area of MSK radiographs. This second reading of the images could significantly reduce the chances of a patient being discharged with an untreated fracture or abnormality.

In any discussion of this proposal the question of medical-legal responsibility is likely to arise. It must be remembered that medical clinicians always assume the final responsibility for diagnosis and care of patients, since the patient is placed under their care, and they have access to the patient far beyond that which is available to the radiologist or radiographer. There is a need to recognise that it is the radiographer’s duty of care to the patient to report any abnormalities seen to the appropriate medical officers.

Any radiographer who decides to work independently will obviously be responsible for their actions but a legal relationship is created when radiographers sign an employment agreement and when work is delegated to them. Employment law also dictates that employers are not responsible for employees who work beyond their authorised duties. Current legal constraints can be overcome by thorough documentation by the radiologist, radiographer and employer as to the delegated roles and responsibilities in an endorsed protocol. There is a role for the AIR to make a clear positional statement including legal advice on radiographer reporting, both as a role extension and support.

Akroyd and Shewchuk found that pay scales and more importantly the potential for increases in earning were concerns for radiographers. The radiologist assistant positions in the United States (US) and the tiered pay structure in the UK were successfully achieved following a number of years of research, review and justification. Even with role extension in Australia slowly gaining pace, it is going to take a few people willing to take on the extra responsibility with no immediate remuneration to achieve similar structural changes. Neither the US nor the UK systems may be the best for the Australian health system; we will undoubtedly end up with a hybrid of both with our own particular Australian tilt.

RECOMMENDATIONS
The results of this study could be used to argue for a staged approach to the implementation of wide spread radiographer reporting in Australia. Radiographers have been shown to exhibit high sensitivity and specificity rates for MSK examinations in emergency situations. A tiered program of training, qualification and accreditation in clinical radiographer reporting could be implemented as follows: The first level of proficiency could include appendicular musculo-skeletal reporting. Those qualified in this could then participate in level 2 which involves the axial musculo-skeletal reporting and upon completion and assessment move onto complete Level 3 – chest/abdomen or effectively the whole body.

Structured postgraduate education and local support and training is essential to the long term expansion of the radiographer's role into these areas. Concurrent to this, hospital executives and governments need to be convinced of the benefits to patient outcomes and improved efficiency. Possibly the most important of all is to include radiologists in this project as they will be the source of on-going training, support and identification of knowledge gaps.

CONCLUSIONS
The statistical analysis of the accuracy and efficiency of senior radiographers performing reporting tasks within appendicular musculo-skeletal trauma has shown highly positive results. The sensitivity of 98 per cent and specificity of 99.11 per cent clearly illustrate that experienced radiographers can have a high level of accuracy in the reporting of appendicular musculo-skeletal examinations and that perhaps a staged approach to radiographer reporting would be beneficial to the health care system.

A formal radiographer reporting program of training and support, followed by a detailed study into the effect the program is having on patient outcomes is the next logical progression for this topic within our facility. More analytical studies in Australia are needed to justify any of this type role extension on the basis of clinical accuracy and effectiveness.

Radiographer reporting has the potential to benefit the patient, the health service provider and extend the role of the Australian diagnostic radiographer. With experience and post graduate education, studies in the UK and increasingly in Australia show that radiographers have the high levels of diagnostic knowledge and clinical acumen required to provide effective descriptive reports of musculo-skeletal examinations.

Published data and literature suggest UK and Australian based radiographers have comparable results for accurate and effective reporting of radiographs. Regardless of the differences between the health systems of the two countries, radiographers in Australia could be effectively used in a similar manner as a clinical tool to provide informed opinion.

Postgraduate courses involving image interpretation should be encouraged, developed and supported. In house, on-going training of radiographers by radiologists is essential and beneficial to both professional groups. To realise this type of role extension for radiographers, a more cooperative approach with the radiologist community needs to be developed.

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REFERENCES

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