



A taxonomy of anatomical and pathological entities to support commenting on radiographs (preliminary clinical evaluation)



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ABSTRACT

It has been shown that radiographers have a lot to offer the patient by providing their expert opinion in a timely intervention; including the possibility of Radiographer Led Discharge. Some excellent paper based 'commenting' systems have been developed locally and the Society and College of Radiographers has issued national guidance with a pro-forma to support implementation. However, delivery and audit of the PCE service can be burdensome. There is also an ongoing training need linked in to annual reviews.

This paper provides a brief introduction to the field of controlled vocabularies and ontologies in radiology and serves to identify their potential for PCE systems. The current work has constructed a prototype taxonomy and accompanying ontology (list of relationships) that enable the generation of radiographer comments using an electronic, fast, and structured web based interface. For example, in the current implementation any one of thousands of possible unique comments could be constructed by making just six selections from filtered lists of terms.

The prototype taxonomy has been tested to refine and validate the concept. The resulting taxonomy and its evolution is described here. Finally, the taxonomy was trialled by 23 participants who generated structured PCE's after reviewing 27 cases on DICOM workstations. An analysis of agreement between participants and the 'gold standard' is presented.

In conclusion, a taxonomy has been created that would provide for: a standardised framework for training staff and students, efficient and robust delivery of the service, and audit of individual practice.

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Introduction

The practice of placing a red dot onto a radiograph considered abnormal has been adopted by UK hospitals steadily since its introduction in the 1980's.^{1,2} The current practice is termed a Radiographer Abnormality Detection (or signalling) System (RADS). It has evolved from the use of red-dot stickers on film to the application of an asterisk or question-mark annotation on a digital image. While the technology has changed, some of the initial limitations remain. The painting of pixels is both indelible and invisible in equal measure. First, any future observer will always be shown the outcome of a preliminary radiographic opinion that may or may not have proved incorrect. Second, the pixel data are not amenable to even the simplest audit questions such as "how many 'wrist' exams were flagged last month?" RADS have also been implicated

in generating a significant number of queries from referrers who wish an explanation for an ambiguous asterisk.

These limitations (time consuming queries and inability to audit or correct) have led to the Society and College of Radiographers (SCoR) to champion a more involved system; the Preliminary Clinical Evaluation (PCE).^{3,4} The PCE system requires the Radiographer to provide documentation separate from the image that details any manifest abnormality. This system is routinely referred to in practice as 'commenting'. It overcomes two limitations of RADS by 1) providing detail to avoid ambiguity and 2) creating an audit trail. However, most commenting systems still use an indelible asterisk (or similar) on the image to alert the referrer.

Since November 2007, the Health Professions Council (now the Health and Care Professions Council, HCPC) have included radiographer 'first post' proficiencies that underpin the use of PCE systems.⁵ It follows that HCPC registered radiographers in practice could engage with a local PCE system. However, despite the advantages of RADS and the extra benefits of PCE, there are still a significant number of trusts without either system.⁶

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PCE has significant barriers for introduction; universities have concerns about resourcing the underpinning proficiencies of specific identification of abnormalities, practitioners and Radiology business managers are concerned about the extra time operation of PCE systems require⁶ and current PCE systems often rely on paper and pen to record and store information thus introducing data security risks. However, foregoing PCE also has disadvantages. Trusts may be operating a type of instant reporting system (hot reporting) instead. This system is preferred by some radiologists⁷ but widespread adoption has been slow.⁸ Other trusts are relying on the referrer opinion alone for discharge decisions but this leads to increased risk of medical error and the subsequent litigation costs.^{9,10} Finally, PCE is a necessary precursor to some service improvement initiatives, such as Radiographer Led Discharge (RLD).¹¹

These on-going challenges to the practice of diagnosis, treatment and discharge (and specifically implementation of PCE) may lead to a less than ideal patient experience. This work attempts to utilise informatics to support training and practice of PCE by radiographers. Medical information science (informatics) is “the science of using system-analytic tools ... to develop procedures for management, process control, decision making and scientific analysis of medical knowledge.”¹²

Literature review

When describing appearances on a radiograph to a referrer - which is preferable, making choices from pre-defined lists of possibilities or writing thoughts freehand? The latter is much more common but there have been several attempts by information scientists to construct ‘pick-lists’ of defined terms for radiological reporting in the past (also known as taxonomies, lexicons, controlled vocabularies, controlled terminologies, or ‘an index’). The American College of Radiologists (ACR) first published the ‘Index for Roentgen Diagnoses’ in 1955. Updates of what is now come to be known as ‘the ACR Codes’ came in 1961, 1986, 1999. This system was mainly seen as an academic tool to assist in research.¹³ The Radiological Society of North America created RadLex, a controlled vocabulary for radiology reporting, teaching, and research.¹⁴ This combines terms held in a lexicon with relationships among those terms (ontology). The ACR’s 1993 Breast Imaging Reporting and Data System (BI-RADS) included a taxonomy which was specifically aimed at improving the quality of reports in mammography.¹⁵ BI-RADS is maintained by a committee and it has evolved over three subsequent editions (1995, 1998, and 2003).

The appeal of these information science approaches, such as taxonomies, is that they can be used to communicate concise and structured descriptions of findings in plain, standardized language. They can reduce ambiguity, include evidence based thresholds, and allow automated storage and retrieval of information. The defined relationships between terms also enable a system to be built that guide users, through filtering, to the only available terms. However, the user’s ability to choose rich descriptive language is curtailed. Understandably, users sometimes do not want to be constrained in their descriptions. Heilbrunn, (1994) criticised the BI-RADS approach stating “*expertise is the heart of the problem, not terminology. BI-RADS, with its emphasis on words and definitions, is barking up the wrong tree*”¹⁶ But D’Orsi and Kopans (1994) counterclaimed that “Without standardized terms to describe important features ... there is no means of obtaining objective data to improve”¹⁷. Within ten years of this debate, the structured BI-RADS system has been widely adopted¹⁸ and the ACR and the Society of Breast Imaging are now mandating BI-RADS in radiology education.¹⁹

Successes for informatics in specialist practice (Breast, Liver, etc) have not been replicated generally. This may be because use of

these taxonomies has a reputation of being slow and cumbersome for data entry in a reporting room, where dictation is favoured.²⁰ However, this work is not concerned with reporting but documenting PCE’s (comments), primarily from accident and emergency referrers. The working environment of the radiographer engaged in PCE may be very different to a reporting room. In DR environments, the PCE may have to be created in the x-ray room itself, where patients might be present, there is probably limited availability of reference material, and ambient noise levels may be relatively high; dictation may not be possible or desirable.

Materials and methods

An informatics approach was followed based on adaptation or construction of lists of radiographic imaging procedures, anatomical entities, and possible pathologies. These were then linked to derive a practical, clinically relevant, and manageable taxonomy that could be adopted and accredited for use across institutions nationally. This was a research ethics board approved prospective study that consisted of three phases.

Phase one: creation of the taxonomy

The main focus was on process issues and human factors relating to the evaluation of the radiograph at the point of care. The initial version of the taxonomy was developed from a subset of the National standard representation of clinical imaging procedures (NSRCIP).²¹ This enabled a quick focus on the anatomy and pathology shown in the examination. Each main class is then divided into subclasses and codes. Each code is comprised of several basic elements. Each term is required to have: a unique identifier (UID), a name, and a relationship to at least one other term in the taxonomy (e.g. “is a”, “part of”, or “branch of”). Some terms also have a definition (to clarify meaning), a source (which identifies any publications, committees, or other taxonomies from which it was developed), or comments (offering clarifications, such as how it should be used). The scope of the taxonomy included all projection radiography examinations.

Single observer testing and revision

The taxonomy created in phase one was evaluated by the authors for (1) comprehensiveness (i.e. adequate to describe all possible relevant diagnoses); (2) uniqueness (i.e. a single meaning

<p>Patient Name: SW024243 Patient DOB: 1991 Initial Comment Author Name: Dr. James Dean BSc. MSc. PhD. Initial Comment Author Designation: Band 6 (Radiographer) Referring Location: Casualty Referrer: Nurse Gladys Emmanuel Institution: Holby City Hospital</p> <p>Summary Findings</p> <p>Examination: WRIST XR LT Accession: 4451162</p> <p>Abnormal: Acute - Bone - radius left, Fracture Not Involving Joint, Transverse (non avulsed) type</p> <p>Disclaimer. This initial comment should not be considered as a formal radiological report. It is an initial finding by the radiographer and is dependent on their individual clinical knowledge. This initial comment is intended to assist with preliminary patient management. The final clinical interpretation of the image is the responsibility of the referrer. A formal written radiological report will be issued and authorised in due course.</p>
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Figure 1. An example PCE created using the taxonomy.

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