TITLE

The increased SID technique: what is preventing implementation in clinical practice?

ABSTRACT
Evidence in the literature demonstrates that increasing the source to image-receptor distance (SID) can optimise specific radiographic projections yet despite this evidence-base the technique is not commonly practiced within all radiology departments. The present work aims to bridge the gap between evidence and practice by interviewing allied health professionals to investigate the feasibility of implementing the technique in clinical practice. Opinions were sought from multiple sources to triangulate the data including radiographers, medical physicists, professional body council members and university lecturers. Data were collected via telephone and departmental surveys, self-administered questionnaires, focus groups and individual interviews. Analysis via key words and themes was undertaken. Tradition, the capacity to change practice and radiographic equipment were perceived as the main obstacles against clinical implementation. Seventy-five percent of radiographers working with modern equipment did not perceive any disadvantage to the radiographer in extending the SID by 30-50cm compared to 59% of radiographers working with older equipment. When radiographer perceptions of implementing the technique were analysed however, 100% of radiographers responded positively to increased SID implementation especially 'if given more information'. The key to effective clinical implementation is to adopt a multi-disciplinary approach and to actively disseminate information amongst hospital management and radiographers. There are no insurmountable issues preventing the implementation of the increased SID technique in clinical practice and encouraging radiographers to explore optimisation strategies has the potential to advance evidence-based practice within the profession.

INTRODUCTION

Increasing the source to image-receptor distance (SID) to reduce patient dose is not a new concept in diagnostic imaging. Numerous studies have investigated the merits of this optimisation technique for various projections using film-screen, computed radiography (CR) and direct digital radiography (dDR) technologies and all have established that increasing the SID reduces radiation dose whilst maintaining image quality, albeit with varying degrees of dose reduction [1-7]. This underlines that increased SID has long been an accepted strategy in dose limitation, which is based entirely on the inverse square law and is independent of the film / image receptor. The SID and the inverse square law are inextricably linked and their exclusive interdependence is paramount when investigating the optimisation capabilities of the increased SID technique. In accordance with the inverse square law if a radiograph is acquired at a longer SID then there is the potential to reduce the dose by a factor of four. In terms of image quality this would result in a radiograph with increased noise unless the automatic exposure control device of the X-ray set compensates for this by increasing the exposure time (mAs) or that the exposure factors are manually adjusted by the radiographer [1]. This highlights the importance of keeping the dose at the image receptor constant when increasing the SID as it provides a means of ensuring that all radiographs have a comparable signal to noise ratio (SNR) [8]. However, despite the research on both old and new radiographic systems the increased SID technique does not appear to be a commonplace optimisation tool in many radiology departments and this requires investigation. Hafslund et al. (2008) believe that radiographers should adopt the evidence-based radiography (EBR) approach and be responsive to the continuous technological development within their field [9]. The aim of the current research is to investigate why the increased SID technique is not more prevalent in the clinical environment and to explore the feasibility of implementing this technique in practice. Three main areas were investigated to address this: (1) the physical limitations of the X-ray imaging equipment, (2) the radiographers' physical limitations and (3) the logistics involved in implementing increased SID in imaging departments.

Equipment Physical Limitations

The area and layout of the X-ray room are important factors to consider when assessing the feasibility of increasing the distance between the X-ray tube and the patient since the physical dimensions of the examination room need to be spacious enough so that the X-ray tube carriage can extend the additional distance in both the vertical and horizontal planes. The availability of grids focused to the newly recommended SID equally may be viewed by some as a physical limitation to the implementation of the increased SID technique in clinical practice; however a review of the literature and product catalogues from radiographic equipment specialists reveals that focused radiographic grids are available with focal distances ranging from 100cm to 180cm; each of these focal distances has an associated focal range thus increasing the flexibility of using each grid for a range of SIDs. The effect of this SID alteration on machine calibration and quality assurance (QA) testing must be considered when proposing to increase the SID by 30-50cm for routine examinations. A number of protocols have been compiled by King's Centre for the Assessment of Radiological Equipment (KCARE) for commissioning, annual and routine testing of CR and dDR systems [10], which are based on documentation from the American Association of Physicists in Medicine (AAPM) [11] and the Institute of Physicists and Engineers in Medicine [12]. The experimental requirement for both commissioning and annual testing of CR and dDR systems is to set the SID to 150cm or greater, depending on the test. The KCARE protocols maintain that they *'have data from performing tests on many manufacturers' dDR systems'*, all using a minimum SID of

150cm, thus illustrating that calibration of the equipment during commissioning and annual testing should remain valid if the SID is increased by 30-50cm during image acquisition. This is similar to the AAPM documentation which specifies that the SID should be at least 180cm during testing to minimise beam divergence and the anode heel effect [13]. Each of the physical limitations of both room and equipment can therefore be overcome using scientific evidence from literature and guidance documentation when considering SID as a method for decreasing patient radiation dose. It should be noted that the height of the examination room is a potential limitation for increased SID as it limits the distance the telescopic arm of the X-ray tube can be extended in the vertical position.

Radiographer/ Operator Physical Limitations

When investigating the use of increased SID as a potential dose reduction technique it is vital to consider how the operators (mainly radiographers) would apply this practice in the clinical setting. Goyal et al. [14] emphasises the importance of maintaining adequate work practices and ensuring that ergonomic conditions are considered when any new optimisation technique is implemented within the radiology department. The primary basis for this is to avoid fatigue and/or injury to the radiographer or clinician as the newly implemented procedure may need to be performed several times a day. In the normal population there are many variations in height and body habitus and for the proposed change in practice operators would need to adapt their technique on an individual basis.

In the UK the National Health Service (NHS) website [15] lists back pain as the second most common cause of long-term illness in the general public. It estimated that approximately 7.6 million working days were lost from 2010 to 2011 due to work-related back pain and other musculoskeletal disorders. The majority of imaging systems require the operator to manually raise the X-ray tube or lower the detector (or radiographic table) when increasing the SID for supine patients thus necessitating consideration of the impact of these actions on operators during clinical implementation. Kumar et al. [16] interviewed radiographers working with CR systems; the three most stressful activities on the back were manually lifting patients from a wheelchair (77.8%), transferring patients using a spinal board (66.7%) and repositioning cassettes under patients (50%). When the same cohort of radiographers was asked to assess the task of pushing or pulling the X-ray tube only 27.8% considered this to be a stressful activity on the back. The study illustrates that although the radiographers interviewed do not consider the task of moving the X-ray tube to be a major contributor towards back strain in relation to other activities, best practice techniques still need to be employed when increasing the SID in the clinical environment to ensure that good ergonomic principles are upheld. Diagnostic imaging is a dynamic field that consists of ever advancing technology [17]; newer imaging systems on the market offer fully automatic system set-up that can be controlled from almost anywhere in the examination room. The robotic positioning of this equipment means that the degree of manual handling incurred by the radiographer is reduced since any increase in SID would be adjusted automatically by the equipment. The current work will review the opinions and perceptions of radiographers' working in modern Radiology departments on the feasibility for routine SID increases based on the equipment in use.

Feasibility of Implementation

Despite previous literature definitively demonstrating that the increased SID technique can be used as an optimisation tool for certain examinations [1-4], anecdotal evidence and teaching practice indicates that the technique is not commonly practiced. This illustrates that implementing a new technique in clinical practice requires more than evidence alone; Grol and Grimshaw [18] concur, reflecting that *'major difficulties arise in introducing these innovations into routine daily practice'*. These authors considered there to be a *'gap between evidence and practice'* in research pertaining to health services and the current work aimed to explore this by investigating the basis of the non-committal approach to clinical implementation of the increased SID technique. The investigation focused on addressing three issues which were seen as paramount in assessing the feasibility of implementing the increased SID technique in radiographic practice:

- Potential physical limitations associated with the equipment;
- Potential physical limitations associated with the radiographer;
- And the feasibility of implementation in relation to the dissemination of research.

METHODOLOGY

Opinions were sought from a number of different sources and professionals such as radiographers, medical physicists, professional body council members and university lecturers to triangulate the data collected via telephone and departmental surveys, self-administered questionnaires, focus group discussions and individual interviews. Recurrent themes and issues could be identified in the data collected under the main areas for investigation.

Two large university teaching hospital clinical sites were chosen: one that predominantly uses dDR equipment (Department A) and one that predominantly uses CR equipment (Department B). An initial survey was performed on both clinical sites to evaluate whether the examination rooms in each department were physically suitable to accommodate the increased SID technique in practice. Quantitative measurements and experiments were performed in each unit for a range of increased SIDs and radiological examinations. Radiographers from each department were questioned via a qualitative and quantitative questionnaire on their attitudes and opinions and physical use of the equipment to achieve both standard and non-routine SIDs for a range of examinations. Informed consent was obtained from all participants prior to completing the questionnaire. The survey methodology included a five minute oral presentation by the lead researcher on the increased SID technique followed by the completion of the 4-page questionnaire. The same presentation was delivered at each site. In Department A sixteen completed questionnaires were returned to the researcher and in Department B seventeen questionnaires were returned. The data collected by the clinical surveys were then triangulated by consulting with council members of the radiographers' professional body and university lecturers in diagnostic imaging. Krueger and Casey [19] advocate the use of *'information rich'* participants in focus group sessions and thus the current work enrolled two cohorts of experts: those who specialise in the promotion of best practice in clinical practice (n = 3) and those who specialise in educating radiography students (n = 5). The opinions and perspectives of these cohorts were gathered using a focus group with two group facilitators present; the general consensus amongst authors is that the strength of focus groups lies in the ability of participants to interact with one another [20-22]. The duration of the session with the council members of the radiographers' professional body was approximately 20 minutes in length and the duration of the session with the university lecturers was approximately 40 minutes in length. The dialogue was subsequently transcribed and colour-coded to reflect the varying emergent themes during the analysis stage.

An individual face-to-face interview was conducted with an additional council member who works as a radiography clinical practice tutor in a Dublin based hospital that uses an increased SID for a number of examinations [23]; questions focused on the potential benefits of the increased SID technique from a patient's standpoint as well as the ergonomic practicalities of implementation for radiographers working with a CR system. Another interview session was arranged with a clinical practice tutor (CPT) to gain further perspective on the feasibility of implementing the increased SID technique in practice. Medical physicists play an instrumental role in ensuring that radiographic equipment is fit for use [24]; thus the implementation of any new technique that would require a change in the calibration set-up, should be done in consultation with the medical physics team. The chief medical physicists from both hospitals involved in the study participated in one-to-one interviews to triangulate the clinical survey and to strengthen the assessment of clinical implementation. Consent was received from all participants prior to taking part in the study.

Data Analysis

The majority of information generated from the radiographer questionnaires was based on categorical variables and as such the initial analytical approach was to generate descriptive statistics [25]. Demographics and characteristics of the radiographers were analysed using Predictive Analytics Software (PASW) for Windows Version 18 (SPSS Inc., IBM Corp., New York, USA). The non-parametric Spearman's correlation co-efficient was used to assess if any correlation existed between the demographic variables and the response categories chosen. Qualitative data obtained from the focus group sessions and individual interviews were analysed using the technique of thematic content analysis [26], which facilitated the identification of major themes and categories within each transcript by colour-coding the text according to specific themes and keywords. The main themes that emerged from the transcripts were tabulated under major and minor categories to demonstrate similarity or diversity between research groups [27]. The themes and keywords were then collated under the three major headings: physical limitations of the X-ray imaging equipment, radiographer physical limitations and the logistics involved in implementing the increased SID in imaging departments for discussion.

RESULTS

Since a number of different methodologies were employed to address the issue of clinical implementation a summary of the main outcomes will be presented before a more detailed analysis of each methodology is explored. Table 1 gives an overview of the main findings from each assessment group focusing on the following three research questions:

1. In terms of implementation, are there physical limitations associated with the equipment?
2. In terms of implementation, are there physical limitations associated with the radiographer?
3. Is it feasible to implement this technique in clinical practice?

Table 1: Overview of the main findings from each of the assessment groups focusing on three broad research questions

Research Group	Are there physical limitations associated with the equipment?	Are there physical limitations associated with the radiographer?	When asked to consider the feasibility of implementation
Radiographers, Dept A:	43.5% Yes	33.3% Yes	75% positive views
Radiographers, Dept B:	47.1% Yes	52.1% Yes	76.9% positive views
University lecturers:	Majority yes	Majority yes	Majority negative views
Professional body council:	Majority yes	Majority yes	Majority positive views
Radiography CPT 1:	Yes	No	Positive view
Radiography CPT 2:	No	No	Positive view
Medical Physicist, Dept A:	No	No	Positive view
Medical Physicist, Dept B:	No	Yes	Indeterminate

Key: CPT = Clinical Practice Tutor, A = automated radiology system, B = manual tube positioning equipment

Analysis of Radiographer Questionnaires

Although the provision of demographic information by the radiographers was discretionary, the majority of participants completed this section of the questionnaire and analysis of the main variables for both departments can be found in Table 2.

Table 2: Demographics of radiographers surveyed in both departments

Variable	Category	Department A	Department B
Sex	Male	6.3%	11.8%
	Female	93.8%	88.2%
Age	20-27 yrs	18.8%	52.9%
	28-35 yrs	56.3%	29.4%
	36-42 yrs	6.3%	0.0%
	43-49 yrs	12.5%	5.9%
	Over 50 yrs	6.3%	11.8%
Weight	Underweight	6.3%	0.0%
	Normal BMI	81.3%	88.2%
	Slightly overweight	12.5%	5.9%
	Heavily overweight	0.0%	5.9%
Height	Mean	172.4 cm	167.2 cm
	Max	185.0 cm	177.8 cm
	Min	160.0 cm	155.0 cm
History of Back Pain	No	56.3%	41.2%
	Intermittent	25.0%	52.9%
	Chronic moderate	12.5%	5.9%
	Chronic severe	6.3%	0.0%
Experience	0-5 yrs	18.8%	52.9%
	6-10 yrs	6.3%	23.5%
	11-15 yrs	50.0%	5.9%
	16-20 yrs	6.3%	0.0%
	Over 21 years	18.8%	17.6%

Descriptive statistics were also used to illustrate the percentage of respondents associated with each response category in the questionnaire for the various themes investigated. The perception that ergonomics and the physical attributes of the radiographer performing the examination could impact clinical implementation was addressed using open-ended and closed- questions. The results of the analysis can be found in Table 3 which shows the percentage of radiographers associated with each response category from both departments.

Table 3: Percentage of respondents associated with each response category which investigated if there were perceived limitations in relation to ergonomics and the physical characteristics of the radiographer

In general, for radiographers pronounced fit for work would there be limitations associated with increasing the SID by 30-50% due to...	Level of agreement	Dept A	Dept B
a) …the radiographers height?	Yes*	**62.5%**	**75.0%**
	No*	37.5%	25.0%
	Unsure	0.0%	0.0%
b) …the radiographers weight?	Yes	0.0%	25.0%
	No	**93.7%**	**56.3%**
	Unsure	6.3%	18.7%
c) …the radiographers age?	Yes	0.0%	31.3%
	No	**75.0%**	**62.5%**
	Unsure	25.0%	6.2%
d) …the radiographers level of fitness?	Yes	18.7%	31.3%
	No	**75.0%**	**60.0%**
	Unsure	6.3%	6.2%
e) …the radiographers level of mobility?	Yes	6.2%	**56.2%**
	No	**62.5%**	31.3%
	Unsure	31.3%	12.5%
f) …the radiographers history of back pain?	Yes	31.2%	**62.6%**
	No	**50.0%**	18.7%
	Unsure	18.7%	18.7%
Q10 (Open question)			
Would there be any disadvantage to the radiographer if the SID was increased by 30-50% for routine examinations?	Yes	18.7%	**58.8%**
	No	**75.0%**	11.8%
	No answer	6.3%	29.4%

Key: A = automated radiology system, B = manual tube positioning equipment

* *Note:* For all questions the Likert item *'yes'* refers to respondents who chose either the *'agree'* or *'strongly agree'* response category in the questionnaire, and *'no'* refers to those who chose either *'disagree'* or *'strongly disagree'* as a response. In all cases the response category *'agree'* or *'disagree'* was the majority and outweighed the *'strongly agree'* or *'strongly disagree'* response. The figures marked in **bold** represent the majority. This notation is also applicable to Table 4 below.

The second theme investigated whether specific radiographic equipment and the layout of the examination room are limiting factors in terms of clinical implementation of the proposed technique. The results of this analysis can be found in Table 4.

Table 4: Percentage of respondents associated with each response category for questions relating to perceived physical limitations associated with the examination room and the X-ray equipment

If the SID was increasing by 30-50% would there be limitations associated with…	**Agreement**	**Dept A**	**Dept B**
a) …the height of the X-ray room when imaging patients in a supine position?	Yes*	43.7%	**94.1%**
	No*	**50.0%**	5.9%
	Unsure	6.3%	0.0%
b) …the floor space of the X-ray room when imaging patients in a supine position?	Yes	0.0%	**52.9%**
	No	**100.0%**	29.4%
	Unsure	0.0%	17.7%
c) …the floor space of the X-ray room when imaging patients in an erect position?	Yes	50.0%	41.2%
	No	50.0%	41.2%
	Unsure	0.0%	17.6%
d) …the use of a computed radiography system?	Yes	18.8%	18.8%
	No	**62.5%**	**56.2%**
	Unsure	18.7%	25.0%
e) …the use of a direct digital radiography system?	Yes	6.2%	31.2%
	No	**87.6%**	**50.0%**
	Unsure	6.2%	18.7%
f) …the range of motion in the telescopic columnar support of the X-ray apparatus?	Yes	**46.8%**	**50.0%**
	No	26.6%	25.0%
	Unsure	26.6%	25.0%
g) …the use of radiographic grids?	Yes	37.5%	41.2%
	No	18.7%	17.6%
	Unsure	**43.7%**	41.2%

Key: A = automated radiology system, B = manual tube positioning equipment

The questionnaire queried if the radiographer would *'consider implementing this suggested technique in clinical practice'* and in both departments all radiographers either responded with *'maybe, if given more information'*, or *'yes'*. Table 5 shows the percentage of radiographers that consider the longer SIDs to be easily implementable in the clinical setting.

Table 5: Percentage of radiographers that consider the specific SIDs to be easily implementable in the clinical setting for the projections listed

Projection:	Department A		Department B	
	130cm	**150cm**	**130cm**	**150cm**
Lateral lumbar spine	56.30%	68.80%	87.50%	43.80%
AP pelvis	50.00%	68.80%	87.50%	50.00%
AP abdomen	50.00%	68.80%	62.50%	62.50%
Skull reverse 30° Townes (OF)	37.50%	43.80%	68.80%	37.50%
OF 10° skull	43.80%	31.30%	62.50%	43.80%
Lateral skull	43.80%	37.50%	68.80%	50.00%
Projection:	**180cm**	**210cm**	**180cm**	**210cm**
Lateral cervical spine	43.80%	43.80%	50.00%	68.80%

Key: A = automated radiology system, B = manual tube positioning equipment

Analysis of Focus Group Data & Individual Interviews

Content analysis of the transcripts from the focus group sessions and individual interviews was colour-coded to assist with analysis where a specific colour corresponded to one of the main themes that emerged from the data (Table 6). Under each of the theme headings, major and minor categories could be identified from the text.

Table 6: List of the main themes common to each interview group

Main themes common to each interview group
1) Reasons why this technique should be implemented in clinical practice
2) Positive aspects of the equipment in terms of implementation
3) Negative aspects of the equipment in terms of implementation
4) What is currently limiting clinical implementation?
5) Factors limiting implementation specific to the radiographer
6) What needs to be done? (How to get the technique into hospitals)
7) Where should the change come from?

The information gathered from each of the research groups was combined and analysed together to create an overall representation of the data. The transcripts were coded using keywords and the frequency distribution of the most recurrent themes associated with implementation limitations can be found in Figure 1.

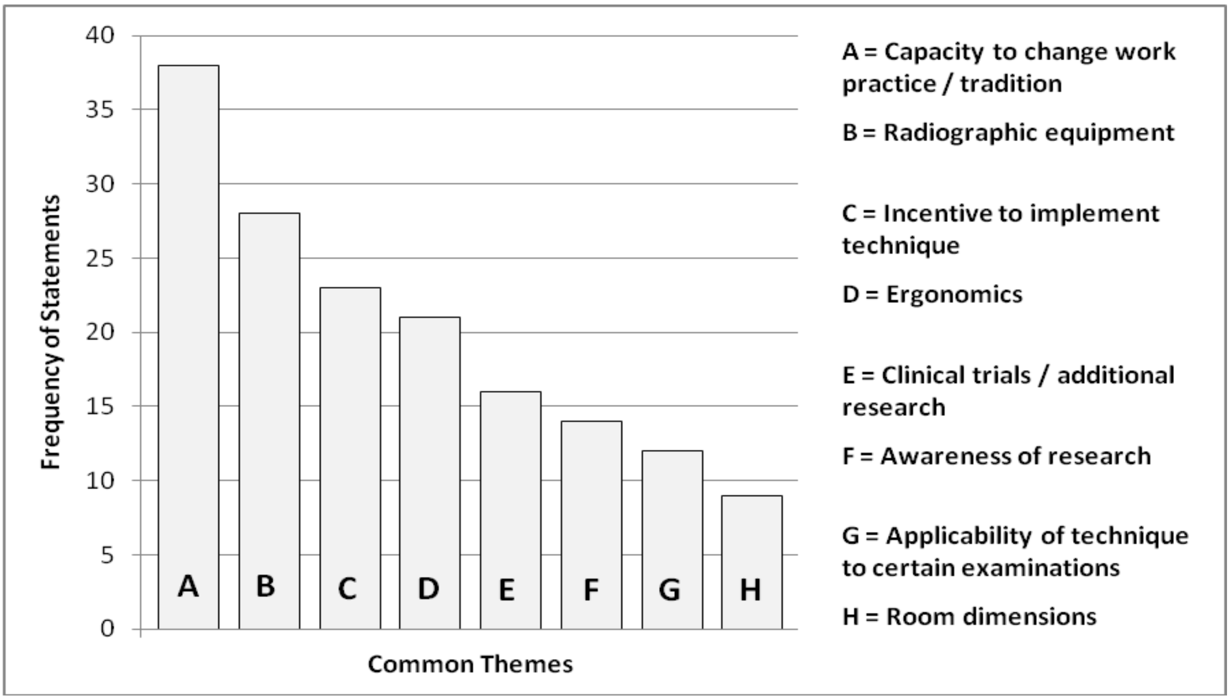

Figure 1: Perceived limitations in order of frequency in relation to implementing the increased SID technique in practice. Data is based on an accumulation of the information gathered from the interviews held with professional body council members, university lecturers, radiography clinical practice tutors and medical physicists.

DISCUSSION OF RESULTS

The use of questionnaires in the current study to investigate the perspectives of the two radiographer cohorts was preferred over a group interview methodology as it reduced the chance of biasing the results by giving the radiographers space in which to formulate their own opinions. A purposive sampling approach was adopted to ensure inclusion of radiographers from departments that use the two principle radiographic technologies, dDR and CR, as work practices can vary depending on the type of imaging system in place. The findings from the radiographer surveys reinforced this opinion as analysis revealed that the type of imaging system installed in the department may influence how radiographers' perceive the increased SID technique and the possible impact it may have on their work practice. When asked to consider if there would be any disadvantage to the radiographer in extending the SID by 30-50cm, 75% of radiographers in Department A (comprising automated positioning systems) did not perceive any difficulty, in comparison to 41.2% of radiographers in Department B (comprising manual tube positioning equipment). Analysis revealed that 62.6% of the radiographers in Department B felt there would be limitations associated with the technique if the radiographer had a history of back pain and 56.2% of the radiographers in this department felt there would be limitations associated with the radiographer's level of mobility. Interestingly in Department B, 52.9% of the radiographers reported that they had an intermittent history of back pain even though the majority of radiographers in this department were in the 20 to 27 years age category. No significant correlation was determined however between this data and the perception that a history of back pain would be a limitation in relation to implementing the increased SID technique in practice. Healthcare workers experience high rates of work related injuries particularly musculoskeletal injuries [16, 28] and as such it is important to ensure that ergonomic conditions are reviewed when any new optimisation technique is implemented within the radiology department [14].

One factor that both cohorts agreed upon was that the radiographer's height could be a limiting factor in the implementation of a 130-150cm SID (62.5% of radiographers in Department A and 75% in Department B). The data was further analysed by calculating the Spearman correlation coefficient and no relationship was established between the radiographers own height or other demographics and the decision that height would limit implementation. The majority of radiographers in both departments did not agree with the suggestion that age, weight or fitness were limiting factors in terms of implementing the technique. The only correlation established from the data was for the radiographers in Department A (automated radiographic dDR system) which linked radiographer age and experience to back pain. The majority of radiographers in this department were aged between 28 and 35 years old and more than half (56.3%) of the cohort reported that they had no history of back pain. This suggests that the younger radiographers who have predominantly worked with newer imaging systems (or mainly with the automated system in their current department) are less exposed to back-related injuries than their more senior colleagues who may have spent the majority of their careers handling older, heavier equipment. This issue of older versus newer imaging equipment was also raised in the focus group session with the professional body council members where one member of the group was of the opinion that increasing the SID may cause *'more repetitive strain, especially if the equipment is old and heavy and not new lightweight equipment'*. However, when the radiographers were asked directly if they perceived limitations in implementation associated with the use of a CR system, in both departments less than 20% of radiographers agreed with this statement. By comparison however clinical practice tutors did not perceive this as a limitation provided that the radiographic table was kept at a comfortable working height for the radiographer.

A major theme recurrent in each of the individual interviews and focus group sessions was the perception that radiographer routine and the capacity to change current work practice is one of the main limitations associated with introducing the increased SID technique in clinical practice (Figure 1). Hafslund et al. [9] believe that radiographers should adopt the evidence-based practice approach employed by other healthcare professions, thus resulting in a practice which is *'informed and based on the combination of clinical expertise and the best available research-based evidence*, *patient preferences and available resources'*. The authors refer to this as evidence-based radiography (EBR) and attribute the approach to helping radiographers become *'better prepared for changing procedures'* as well as encouraging them to *'prioritise different tasks and choose the best available evidence in decision making'*. EBR is not commonly recognised within the profession however [26, 29] and Ahonen and Liikanen [26] suggest that the implementation of this practice is dependent on factors such as *'knowledge, understanding, attitudes, motivation, abilities, competency, informational needs, culture, self-confidence, support, resources such as time and money, and access to evidence'*. Hafslund et al. [9] do not consider individually conducted research as a necessity for EBR but rather that radiographers increase their awareness of research and assess the benefits of implementing a specific technique into their work practice.

Analysis of the radiographer questionnaires in the current study revealed that the majority of radiographers in both hospitals admitted to having *'moderate'* knowledge of the increased SID technique prior to the survey. The level of knowledge was based on subjective scoring. No radiographers in Department A and only 5.9% of the radiographers in Department B admitted to *'full'* knowledge of the technique despite literature in this field dating as far back as twenty years [30]. This highlights the need to increase radiographers' awareness of research and to address the manner in which information is disseminated. The professional body council members placed the most significance on this issue and considered the dissemination of research and the promotion of best practice an integral aspect of their organisation. The proposed strategies for dissemination were through conference presentations, publications and the circulation of best practice guidelines. In an individual interview a Professional Body council member disclosed the belief that information needs to come from a source closer to radiographers such as the departmental Radiology Services Manager (RSM) or Radiation Safety Officer (RSO) and that for change to occur there *'needs to be a change in protocols which will come from management'*. The sample size for the questionnaire methodology was moderately low (n=16 and n=17) but this formed a high percentage of the total population in each type of centre examined. Although Barclay et al. (2002) claim that response rates are an important aspect of questionnaire design they also acknowledge that '*compromise and trade-off*' are required when resources are '*balanced against minimising survey error*' [31]. The compromise in the current work was the obligation for radiographers to attend a five minute presentation on the increased SID technique prior to completing the questionnaire. Attendance at this presentation was deemed a necessary aspect of the methodology as it created a standardised platform from which to gather information from radiographers across both clinical sites. It also served to minimise ambiguity between radiographers in relation to specific terminology referred to in the questionnaire. The oral presentation and subsequent survey were scheduled for inclusion in the weekly staff meetings with the intention of targeting the largest audience and minimising time disruption to the radiographers; however this meant that only those radiographers present on the given day were included in the study.

The opinion of the university lecturers was that there needs to be a *'strategic approach'* to addressing the issue of implementation and that changes need to be introduced in an all encompassing manner to achieve the greatest uptake for the change. Their suggestions on implementation comprised consistent teaching of the technique by lecturers and CPTs, liaising with equipment manufacturers, and hospital management communicating research to all staff. Another recurrent theme from the interviews and focus group sessions was the perceived limitation that radiographers may require an incentive to encourage them to change current practice. Yielder and Davis [32] maintain that *'a conforming workplace culture'* and a reluctance to challenge and question work practices reduces motivation for learning in radiographers and that *'given opportunities to develop and advance, radiographers are likely to fear new ideas and be resistant to change'*. Other literature however places an onus on radiographers to actively engage in research and suggests that research should be *'a requirement, not an option'* [33, 34]. This reinforces the EBR approach to clinical practice whereby research within radiography should be encouraged and developed as this will lead to radiographers *'providing the best evidence and knowledge-based care for their patients'* [35].

Ahonen and Liikanen [26] refer to the translation of research to practice as one of the ultimate goals of EBR and the findings from the authors' work demonstrated that radiographers consider multi-professional teamwork *'as the best way to conduct research activities'*. The implementation of the work conducted by Humphreys [23] in the Dublin-based radiology department embodies this paradigm as it required the cooperation of radiographers, radiologists, medical physics and management. The clinical practice tutor for this specific hospital stated that radiographers utilise this optimisation technique *'without thinking'* as it is written into hospital protocol and has become *'standard practice'* within the department. Significance was placed on the RSM and RSO to take an active role in implementation as radiographers may struggle in choosing what they know to be *'professionally correct'* or to follow protocol and do what they are *'told to do'*.

A significant and revealing finding from the medical physicist interviews is that these individuals exhibited an enhanced understanding of the obvious nature of dose saving with the increased SID technique in comparison to that exhibited by the practitioners who deliver the radiation dose. When questioned on the efficacy of increased SID for different radiographic systems the medical physicists responded that the *'physics of the technique does not change regardless of CR or DR'* and that the *'the principles for dose reduction are still the same at the patient'*. In contrast to this, one of the professional body council members stated that increasing the SID *'will reduce the number of photons reaching the patient, reducing the softer energy radiation'*. This is a clear misunderstanding of the physics of how the dose reduction operates and illustrates that for the technique to be implemented across the board, the departmental protocols need to be amended and the theory behind the increased SID technique communicated with all staff. The successful implementation of the technique in practice requires full co-operation from a multitude of individuals: lecturers, clinical practice tutors, medical physicists, management, radiographers, policy makers, manufacturers and radiologists.

CONCLUSIONS

This research was carried out to bridge the gap between evidence and practice and it investigated the feasibility of implementing a proven optimisation technique into clinical practice. The results demonstrate that although all research groups involved in this investigation recognise that the technique is beneficial in reducing the radiation dose to the patient, a number of perceived *'barriers'* were identified which may have contributed to the poor uptake of this technique in practice despite published reports advocating the merits of implementation. Radiology departments should consider testing the technique as part of the clinical audit requirements and thus establish whether it is a suitable optimisation technique for their specific department. The research concludes that there are no insurmountable issues preventing the clinical implementation of increased SID and the key to effectively implementing the technique is to adopt a multi-disciplinary approach. Department protocols should be updated and information sessions held for all radiology staff.

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