



University of
Salford
MANCHESTER

Compression force behaviours : an exploration of the beliefs and values influencing the application of breast compression during screening mammography

Murphy, FJ, Nightingale, JM, Hogg, P, Robinson, L, Seddon, D and Mackay, S

<http://dx.doi.org/10.1016/j.radi.2014.05.009>

Title	Compression force behaviours : an exploration of the beliefs and values influencing the application of breast compression during screening mammography
Authors	Murphy, FJ, Nightingale, JM, Hogg, P, Robinson, L, Seddon, D and Mackay, S
Publication title	Radiography
Publisher	Elsevier
Type	Article
USIR URL	This version is available at: http://usir.salford.ac.uk/id/eprint/31924/
Published Date	2015

USIR is a digital collection of the research output of the University of Salford. Where copyright permits, full text material held in the repository is made freely available online and can be read, downloaded and copied for non-commercial private study or research purposes. Please check the manuscript for any further copyright restrictions.

For more information, including our policy and submission procedure, please contact the Repository Team at: library-research@salford.ac.uk.

Introduction and background

Breast compression force during screening mammography requires a degree of practitioner knowledge and expertise to achieve optimum image quality and reduce the mean glandular radiation dose.^{1,2} Whilst it is recognised that the application of compression force is an important skill³ there is, surprisingly, sparse and conflicting guidance available for practitioners as to how to apply compression force and to what pressure. While quantitative studies largely agree on a slow and steadily increasing application of pressure to reduce pain, the traditional measures of checking that adequate compression force has been applied (eg. blanching of the skin and tautness of the breast) have been questioned.⁴ Various studies^{4,5} have found contradicting results, some find that too much compression force is applied whilst others have found that compression force is often insufficient.

Recently pilot work in one mammography screening centre⁶ identified a surprising variability in the amount of compression force applied for similar breast types, with practitioners aligned with consistently low, intermediate or high compression force categories. An extension of this study⁷ assessed compression values over three consecutive analogue screening mammography invitations (500 clients). Individual client compression force over the three screens varied significantly, and was highly dependent upon the practitioner who performed the mammogram, rather than the client. Individual practitioners are assumed to be setting their own compression force tolerance levels, regardless of the client's breast type, and this will likely have implications for the patient experience, their mean glandular radiation dose, and image quality consistency across subsequent screens. This is despite attempts made by manufacturers to reduce variability with technological developments.

While the influence of different amounts of compression force on visual image quality is currently disputed,⁸ insufficient compression force may be detrimental to image quality and lesion visibility resulting in the potential for incorrect diagnoses. Standard texts suggest there may be a level of compression force beyond which additional compression forces cease to have any advantageous effect⁹ and that additional compression force applied does have a marked effect on the woman's tolerance of the procedure and related discomfort⁹. However there is a lack of empirical evidence to substantiate these claims.

Myklebust et al, 2009¹⁰ suggested that there is wide variability in applied compression force where the level of compression force is linked to the patients' experience of pain but found this

did not influence their level of satisfaction with the procedure. However, Drossaert et al (2002)¹¹ concluded that poor compression force experience was found to influence the client's decision to engage in future breast screening.

Whilst quantitative approaches give valuable data, a humanistic, qualitative, perspective is also required in order to fully understand this phenomenon in depth and to provide a unique insight in to the factors influencing how compression force is applied.

Using a phenomenological approach this study investigated the experiences of, and the influences on the behaviour of, practitioners applying compression force in mammography. By exploring the individual and collective beliefs and values that influence compression force practice this paper seeks to identify 'how' and 'why' practitioners practice as they do.

Methodology

Qualitative research is an overall term for a group of approaches that is concerned with the investigation of experiences and behaviour, and the meanings and interpretations that people attach to these¹². It is therefore an exploration of the natural setting; in this case the breast screening units in this study. An ethnographic approach of observing practice was initially considered but this was rejected as being too intrusive for the clients and potentially a contentious ethical issue. It was however recognised that by seeking the practitioners own perspective the validity of the findings were limited to their interpretation of their compression force practice.

Since qualitative inquiry is an inductive analysis of human interactions it has to follow a philosophical perspective to be methodologically sound and, quite critically, rigorous in its application¹³. The philosophical stance that underpins this research is that of phenomenology. The discipline of phenomenology may be defined as the study of experiences or consciousness¹². It is the investigation of phenomena or things as they appear in our experience. The historical movement of phenomenology is the philosophical tradition launched by Husserl, Heidegger and Sartre. Phenomenology has been particularly popular in the field of psychology and provided the basis for qualitative research in healthcare^{14, 15}

This particular approach seeks to understand the 'essence' of experiences related to the phenomenon¹⁶. In this case, it was the understanding of the mammographers' beliefs and thus the researchers were capturing the etic perspective-exploring cultural phenomena from the perspective of one who does not participate in the culture being studied.

Hycner's model¹⁷ was used as the framework for this study since it fitted with the focus of the research and provided a clear process in order to illicit units of general meaning (UGM) and units of significant meaning (USM). The use of these units in the analysis of the data provided a series of procedural steps which do not always fit with those of 'true' phenomenologists since they may be seen as reductionist as they are similar to a positivistic approach. However, phenomenology is concerned with lived experience, and is thus ideal for investigating personal beliefs and attitudes. The main focus of phenomenology is with reflective experiences and feelings¹⁸ (the essence of a phenomenon), and a key aspect of this research was exploring practitioners reasoning about the application of compression. Although phenomenology was considered to be the most appropriate approach to address the research question, 'no one particular method should be arbitrarily imposed on a phenomenon since that would do a great injustice to the integrity of that phenomenon' (Hycner, 1985¹⁷ p. 280).

Method

Following NHS (R&D) and University ethics approval, focus group interviews were conducted at six different breast screening centres in England, these included large training centres and smaller screening units. The focus groups were conducted by two researchers: an experienced qualitative researcher and a subject expert in mammography, therefore both interviewers brought a good deal of theoretical sensitivity¹⁷ to the data collection phase. The interviews were carried out with the close adherence to the guidance notes: *Using Focus Groups in Research*¹⁸. Focus groups captured the thoughts of several participants at the same time providing easier access to busy practitioners; they did not limit the in-depth response that may have been obtained by one to one interviews. The questions were semi structured and were derived from the existing body of knowledge in order to address the research question. A similar approach was taken for the educator interviews.

Using a purposive sample six sites were recruited to the study giving a wide geographical spread across the United Kingdom. Information sheets outlining the purpose of the study were sent to each department or education centre. The aim was to recruit a heterogeneous sample from each unit and arrange a convenient time for the focus groups and interviews to take place.

Each group consisted of between 5-8 breast screening staff of different grades and experience. In addition to these focus groups, one to one interviews were conducted with six mammography educators and clinical placement co-ordinators.

The conversations were captured on a digital recorder after each participant had signed the consent form and been allocated an anonymous number for the purpose of the recording. The additional group of educators and placement co-ordinators further informed the study and gave some factual information towards the understanding of this phenomenon. The one-to-one interviews were analysed with a traditional thematic analysis framework²¹. Whilst the focus groups were analysed from a phenomenological perspective, both sets of data were synthesised in order to address the research question.

Following verbatim transcription, a research panel consisting of four very experienced qualitative researchers, bracketed their own presuppositions and 'laid bare' their own theoretical sensitivities within group meetings. Bracketing ensures that the phenomenon itself can be examined without too many prior assumptions or preconceptions,¹² however in reality this is difficult to completely substantiate and Gearing²² speaks of a 'growing disconnection' of bracketing from phenomenology. Analysis commenced by listening to the interviews as a whole, or as Giorgi²³ alludes to as a 'gestalt'. In order to capture the very essence of the words and the sentences, UGMs were extracted from the transcriptions. Hycner¹⁷ suggests that if there is any doubt about its inclusion then the UGM should be included, but rigour was further enhanced by active debate about the inclusion of the UGM within the research team. Reflecting on the research question enabled the researchers to eliminate or accept UGMs and produce a comprehensive list of units of significant meaning (USM), significant because the comment directly responds to or highlights the research question. For example, comments that related to the application of compression force were all deemed significant. Although this is a necessary reduction of the data the inter-rater²⁴ nature of the process by the research panel increased the trustworthiness of the findings. Finally all the clusters of meaning were examined in order to derive themes and to place the units (USM) into context, this gave direction and a location

within the interviews. Hycner ¹⁷ (p.290) describes this final process as: the point where ‘the researcher interrogates all the clusters of meaning to determine if there is one or more central themes which express the essence of these clusters’.

Results

The sample were all female with an average age of 46.5 years, and they had a significant amount of mammography-specific experience (mean 10.1 years). There was also a good spread of grades from assistant practitioners to consultant radiographers; these consisted of 6 grade 4 assistant practitioners, 24 grade 6 practitioners, 10 grade 7 advanced practitioners and 1 grade 8 consultant practitioner this giving a typical representation of a screening unit.

Each focus group lasted approximately one hour, and included a total of 41 participants. 28 USMs were derived from the data. Six hours of focus group data with six hours of one to one interview data gave a total of 12 hours of data collection. Further analysis grouped these into 10 themes being divided into two broad categories: Humanistic and Technological (Table 1).

Humanistic themes referred to the professional-client interactions and appeared to be part of the culture in some departments. Technological themes were evident where practitioners spoke about the application of compression force with respect to the equipment itself. Digital technology had, in their opinion, improved the client experience, and interestingly there was rarely any reference to the numerical scale indication of the level of applied compression force.

Table 1 Themes derived from the units of significant meaning

Humanistic	Technological
Client empowerment	Compression controls
White lies	Digital technology
Time for interactions	Dose audit- safety net
Uncertainty of own practice	Numerical scale
Culture	
Power	

Discussion

Each theme is now illuminated against the existing literature using the voice of the participants in italics to highlight the phenomenon.

Client Empowerment

One breast screening unit insisted in empowering the clients to comment on the compression force themselves, or at least advising when the level was uncomfortable. There were other examples of practitioners asking the client to tell them when it was ‘too much.’ This was considered to be an effective coping strategy for all the clients and usually resulted in the practitioner being able to apply one further increase in compression force. One practitioner stated to their client:

I'm going to compress, my hand is on your breast and it won't compress quickly but you can stop me if it's too tight, but it is going to be tight, it is how the x-rays are done but, you know, shout out if you find it very difficult. I do believe that if you give the patients, ladies, the chance to opt out; "so you can stop me, you don't have to do this", they will tolerate more than if you try to steamroll them.

This is contrary to the findings of Robinson, Hogg and Newton-Hughes (2013)²⁵ who reported that from the client's perspective the mammography examination can be disempowering and that some mammography practitioners enforce this perspective. Lovemore and Dann (2002)²⁶ did however identify many facets in empowering the patient in nursing. However it should be recognised that patients are within the sick-role in nursing as opposed to a client-role in screening mammography.

White lies

A white lie is defined as a minor or unimportant lie uttered in the interest of tact ²⁷ .

One participant described this as follows:

I find sometimes it tricks their [clients] mind a little bit, they think that it's not as much[compression force], but it is, because you do it so, so slowly. I say the last bit won't hurt but I know it will and gain compliance

The white lies identified in this study were usually viewed as ‘information’ in the clients’ best interests. Similar to the patient empowerment above, the use of white lies, although considered to be helpful by some of the practitioners to the final outcome, could also be viewed as a form of deviant behaviour, as described by Murphy (2009)²⁸ with respect to medical imaging. From a nursing perspective, Banja (2010)²⁹ felt that any form of deviant behaviour can

become 'normalised' within an institution and quickly established as part of the daily routine. It is therefore important to recognise it as being part of the unit's culture.

Time for interaction

This was a very common theme throughout all the interviews. Practitioners reported a typical time of 6 minutes to complete the entire procedure. This meant there was almost no latitude to deal with complications and in some instances produce an optimum image. Also, since the practitioners were very aware that the first experience very often influenced the decision to re-attend³⁰ they empathised and tried to make the short encounter a good experience, as would be the case in diagnostic radiography. However, the time restrictions made this difficult and as a result the practitioners felt that care and compassion, whilst applying compression force, were compromised in favour of the technical considerations of the examination. One practitioner stated:

Given the numbers of women we are screening, we do not have time to look at individual images...it's a quick glance and onto the next

Uncertainty over own practice

Perhaps surprisingly, a large number of practitioners reported uncertainty about their own practice. Faced against their peers in the focus group, many expressed concerns such as '*well erhm, I don't do it like that*' and there was a notable difference in how some of them applied compression force. Gallagher et al (2003)³¹ noted reluctance for staff to disclose contentious information about clinical practice within the confines of a focus group and this is also seen as a limitation of this study. In reality these practitioners almost exclusively undertake mammography alone and rarely observe others performing the procedure. This isolated practice seemed to raise concerns within the groups with a large number unable to benchmark their practice against their colleagues. Several noted that some form of peer review of practice would be worthwhile, as they could experience the practice of their colleagues in order to satisfy themselves that they were doing everything correctly. Since they worked in isolation, they needed their 'performance' to be approved and to learn from their peers:

we don't see [each other] as a whole group, very often, to know[what happens] so I don't know really, you would have to go in a room with each other and we don't very often obviously so I don't know.

Culture

There was a distinct culture in many units and the practitioners readily acknowledged the fact that the application of compression force was viewed differently by different screening units. This was evident both on analysis of individual units and analysis between units. The reasons for using more, or less compression force, seemed to fluctuate within and between screening units and was an inherent part of the beliefs culture of that unit. In addition numerous comments were made about how things were dealt with in previous places of employment. This practitioner reflected the views of a few when she said:

Where I was before here it was very much about showing how to do it on the basis of you must [all] make sure you get a compression of about seven/eight[Deca Newtons].

It was reiterated several times that the practice of staff within the unit was correct and they all adhered to the standards for compression force application. One practitioner stated:

We seem to stand out as being a unit that's doing well, our repeat rates haven't gone up whereas everywhere else has.

This was a type of tribal culture, where they collectively believed that they were correct, not necessarily supported by an evidence base but more associated with local social factors. This tribal culture was first identified in medical imaging by Castle (2002)³².

Power

Power was not overtly characterised in the transcripts but nevertheless the participants were aware that they exercised a high level of medical dominance. This sort of phenomena has been described in the imaging literature³³. Many recognised the trust placed in them as professionals and behaved accordingly.

They trust you to professional and to know what you are doing. They rarely question that.

At the point of applying compression force they had the 'authority' to give whatever level of compression they felt appropriate and in that respect they had 'power' over the client. This theme differs from the empowerment theme above since it relates to the practitioners influence over the client and not the empathetic nature of giving the patient some degree of control.

Compression controls

An interesting technique for applying compression force was expressed by a few practitioners. This involved using the foot pedal for most of the compression force application but ‘fine – tuning’ the final component by using the hand control. It was felt that this was kinder for the client since the speed of compression force application is slower using the hand winding and also made the practitioner feel more at ease. The final amount of compression was still the same but it was felt more caring and was not as abrupt as just applying the full amount in one go. This was expressed eloquently by one practitioner:

I think that the patient thinks you’ve got less control with the foot, I bring it down so it’s[compression paddle] touching the skin with the foot control and if they’re really anxious I’ll do it slowly with my hand winding it down, so that then they think it’s...you’re still getting the same compression most of the time but using your hand they think that you’re doing it a lot slower because you have to twist it in gradual stages. So sometimes I’ll do that when they’re really anxious as well.

Digital technology

Digital technology was considered to have made the whole mammographic encounter a better experience. The images were available to view almost immediately and the quality was thought to be much improved. The influence this had on compression force application was however unclear. Some practitioners considered that the level of compression force had to be increased to compensate for digital blurring but this was not a universal comment with several participants making similar comments to this one:

I also feel that digital has brought into everybody’s conscious creases and folds in the skin which is demonstrated really clearly on a digital film but not necessarily in an analogue film, so that in itself has changed techniques slightly. Whether it has increased the compression or not I’m not sure.

It is however noted that the transition from analogue to digital was not accompanied by any particular revolution in techniques or technologies for compression force application. Largely speaking the same compression application systems were transferred from the older analog systems into the new digital systems. It is therefore not surprising that there were no defined changes in compression force application behaviour noted by the practitioners in the study.

Dose audits- safety net

Practitioners were rarely worried about the client dose; irrespective of the level of compression they relied upon the dose audits to act as a 'safety-net' to ensure that dose was not an issue.

I think the dose is less if you can reduce the breast thickness but I don't know at what stage or how much...and all that shows the importance of QA

This was a very common theme and seemed to give the practitioners a lot of reassurance. It is however an interesting point that one of the major advantages for using compression is the reduced dose¹ but this was never a consideration in this sample.

Numerical scale

Although the mammography equipment had numerical scale readers to indicate the level of compression force that is being applied to the breast, numerical readouts were not always referred to by the practitioners as they compressed the breast. It was the look and feel of the breast tissue that was considered to be important. Practitioners described the optimum compression using descriptive terms such as 'orange peel texture' and 'blanching' but the majority concurred that:

It's not by seeing how much compression, it is in numbers, it's basically how it feels.

Some recalled being given a numerical level for compression in their training.

One stated:

I was taught it's a minimum of 10, I'd never, ever do that. I was taught that everybody, every projection had to be a minimum of 10. AND If I went to anything like 10 I'd think I'd been cruel. We did have a radiographer ages ago and I am sure she used to put like 15 on everybody, all the patients came back and said it was dreadful, it was always the same woman.

This last statement concurring with the findings of Mercer et al (2013)^{7,8,9} in that some practitioners consistently applied high compression force irrespective of the client type. Furthermore, a subjective approach is more likely to result in difference in compression force than by using the readout force measurement in isolation or in combination with subjective measures.

Overall the results demonstrated a wide variation in how compression was applied and offered some possible explanations for differences in compression force as reported in earlier quantitative studies^{7,8,9}.

Furthermore there was little scientific rationale or basis for the choice of compression force and this was reiterated in the educator interviews. Educator Interviewees commented that compression force application was 'taught' by mentors in the clinical situation since none of the educational institutions offered lectures or teaching specifically about compression, rather it was included in the general technique teaching. Educators stressed the importance of not seeing compression force in isolation, but integral with good positioning and client information.

Rarely did the practitioners refer to a numerical value in the application of compression force since they were more concerned with other indicators. They expressed good patient empathy while working under tight time pressures- a point also recognised in a United Kingdom- wide analysis of emotional intelligence in the radiography profession ³⁴. Their practice was therefore heavily guided by subjective measures, and less guided by an objective measure of compression force. This was an important finding because the subjective measures applied in compression force can result in large inter and intra difference between practitioners, as found by Mercer ^{7,8} (2013). Whilst the results cannot be generalised to the whole population from this small sample the findings may well resonant with current practitioners and adds to the limited evidence base within this speciality.

Conclusion

The paradox of humanistic caring against the technical demands of imaging technologies have rarely been explored in radiography ³⁵ but they were very evident in the behaviour and actions of practitioners applying compression force in mammography. Reflecting on the research aims, the themes described how and why compression force is applied within a very tight time period and made in isolated environments with little reference to the working styles of their colleagues. Moreover, the strongest recommendation to emerge from this study was the need for peer observation to enable practitioners to observe and compare their own compression force practice to that of their colleagues. However, this idea may not be a solution if colleagues working in close proximity are all applying compression force incorrectly. Reflective practice based on an evidence base plus examples of good practice may be a more appropriate solution.

The reference to the mean score, in this case the numerical scale, is rarely made and it is the culture and practice of the units that create beliefs and attitudes in addressing how and why compression force is applied.

References:

1. NHSBSP. National Quality Assurance Coordinating Group. Quality Assurance Guidelines for mammography including radiographic quality control. NHSBSP Publication No 63 April 2006
2. Tucker, A, Ng Y. Textbook of Mammography, 2001 2nd Edition. Churchill Livingstone
3. Kopans, D. Breast Imaging. 2007, 3rd Edition, Lippincott Williams and Wilkins
4. Poulos, A., McLean., The application of breast compression in mammography; a new perspective. *Radiography* 2004; 10 :131-137.
5. Poulos A, McLean D, Rickard M, Heard R. Breast compression in mammography; How much is enough? *Journal of Medical Imaging and Radiation Oncology*, 2003; 47(2):121-6
6. Mercer CE (b), Hogg P, Lawson R, Diffey J, Denton ERE. Practitioner compression force variability in mammography: a preliminary study *British Journal of Radiology* (2013) 86, 20110596
7. Mercer CE (c), Hogg P, Szczepura K, Denton ERE. Practitioner compression force variation in mammography: A 6-year study *Radiography* 19 (2013) 200-206
8. Mercer CE (a), Hogg P, Cassidy S, Denton ERE Does an increase in compression force really improve visual image quality in mammography? - An initial investigation. *Radiography* 19 (2013) 363e365
9. Lee L, Strickland V, Wilson R, Evans A. Fundamentals of Mammography. 2003 2nd Edition. Churchill Livingstone
10. Myklebust A, Seierstad T, Strandén E, Lerdal A. Level of satisfaction during mammography screening in relation to discomfort, service provided, level of pain and breast compression. *European Journal of Radiography*, 2009; 1(2): 66-72
11. Drossaert CHC, Boer H, Seydel ER. Monitoring women's experiences during three rounds of breast cancer screening: results from a longitudinal study. *Journal of Medical Screening* 2002; 9(4):168-175
12. Holloway, I Qualitative Research in Health Care. 2006. 3rd Edition. Open University Press.
13. Murphy FJ, Yelder J. Establishing rigour in qualitative radiography. *Radiography* 2010;16(1):62-67
14. Benner P. Interpretive Phenomenology : Caring and ethics in health and illness. 1994. Thousand Oaks. Sage
15. Svenaeus F. The hermeneutics of medicine and the phenomenology of health: Towards a philosophy of medical practice. Linköping University press.
16. Cresswell, J.W. 2009. Research Design. Thousand Oakes, California
17. Hycner RH. Some guidelines for the phenomenological analysis of interview data. *Human Studies* 1985; 8:279-303 Available online at -20/11/2013 <http://people.usd.edu/~mbaron/edad810/Phenomenology%20Hycner.pdf>
18. Ajjawi, R, Higgs J. *Using Hermeneutic Phenomenology to Investigate How Experienced Practitioners Learn to Communicate Clinical Reasoning.*

The Qualitative Report Volume 12 Number 4 December 2007 612-638

<http://www.nova.edu/ssss/QR/QR12-4/ajjawi.pdf>

19. Strauss, A., Corbin, J. 1990 Basics of qualitative research techniques and procedures for developing grounded theory. 2 nd Edition. Sage Publications, London.
20. Litosselliti L (2003) *Using Focus Groups in Research*. Bloomsbury Publishing PLC, London
21. Burnard P. A method of analysing interview transcripts in qualitative research. *Nurse Education Today*, 1991; 11:461-6
22. Gearing R.E. (2004) Bracketing in research: a typology. *Qualitative Health Research* 14 (10), 1429-1452.
23. Giorgi A (1975) An application of phenomenological method in psychology. In: Giorgi A *et al* (eds) *Duquesne studies in phenomenological psychology*. Vol II. Pittsburgh, Duquesne University Press.
24. Armstrong D, Gosling A, Weinman J, Marteau T. *The place of inter-rater reliability in qualitative research: An empirical study*. *Sociology* (1997) 31 (3) 597-606.
25. Robinson, L.; Hogg, P., Newton Hughes, A. 2013. The power and pain: Mammographic compression research from the service –users’ perspective. *Radiography* 2013;19: 185-280.
26. Lovemore N , Dann K Empowerment in nursing: the role of philosophical and psychological factors. *Nursing Philosophy* 2002; 3 (3): 234-239.
27. Collins English Dictionary. 2013 2 nd Edition
28. Murphy, FJ. 'Act, scene, agency: The drama of medical imaging' , *Radiography*, (2009) **15** , pp. 34-39.
29. Banja J. *The normalization of deviance in healthcare delivery*. *Business Horizons* (2010). 53 (2) PP. 139-148.
30. Ong G, Austoker, J. Recalling women for further investigation of breast screening: women’s experiences at the clinic and afterwards. *Journal of Public Health Medicine*. 19(1): 29-36.
31. Gallagher T, Waterman A, Ebers ,Fraser V, Levinson W. Patients' and Physicians' Attitudes Regarding the Disclosure of Medical Errors. *Journal of the American Medical Association*. 2003; 289 (8).
Accessed 22/11/2013 <http://jama.jamanetwork.com/article.aspx?articleid=196045>
32. Castle A. Radiography: Nature of knowledge and academic tribe. *Radiography* 2002; **6**: 4 261-268
33. Yelder J. Leadership and power in medical imaging. *Radiography* 2006; **12**: 305–13.

34. Mackay, S.J, Hogg, P, Cooke, G, Baker RD, Dawkes, T. A UK-wide analysis of trait emotional intelligence within the radiography profession. *Radiography* **18** (2012) 166-171.
35. Murphy FJ The paradox of imaging technology: a review of the literature. *Radiography*, (2006) **12** , pp 169-174.