East Lancashire Hospitals NHS Trust

University of Salford MANCHESTER

Comparison of 2.3 & 5 mega pixel (MP) resolution monitors when detecting mammography image blurring.

Borgen R, Ma V, Kelly J, Scragg B, Aspin R, Millington S, Lanca C and Hogg P

ABSTRACT

Background

Image blurring in Full Field Digital Mammography (FFDM) is reported to be a problem within many UK breast screening units resulting in significant proportion of technical repeats/recalls. Our study investigates monitors of differing pixel resolution, and whether there is a difference in blurring detection between a 2.3 MP technical review monitor and a 5MP standard reporting monitor.

Methods

Simulation software was created to induce different magnitudes of blur on 20 artifact free FFDM screening images. 120 blurred and non-blurred images were randomized and displayed on the 2.3 and 5MP monitors; they were reviewed by 28 trained observers. Monitors were calibrated to the DICOM Grayscale Standard Display Function. T-test was used to determine whether significant differences exist in blurring detection between the monitors.

Results

The blurring detection rate on the 2.3MP monitor for 0.2, 0.4, 0.6, 0.8 and 1 mm blur was 46, 59, 66, 77and 78% respectively; and on the 5MP monitor 44, 70, 83 , 96 and 98%. All the non-motion images were identified correctly. A statistical difference ($p < 0.01$) in the blurring detection rate between the two monitors was demonstrated

Conclusions

Given the results of this study and knowing that monitors as low as 1 MP are used in clinical practice, we speculate that technical recall/repeat rates because of blurring could be reduced if higher resolution monitors are used for technical review at the time of imaging. Further work is needed to determine monitor minimum specification for visual blurring detection.

INTRODUCTION

Image blurring due to motion unsharpness in Full Field Digital Mammography (FFDM) is a widely recognized problem and various explanations exist about how it occurs [1, 2]. One explanation is breast/paddle movement whilst the exposure is being made [1-4]. Technical recalls due to blurring also has the potential to increase false negative and false positive results. Repeat imaging increases client radiation dose, overall examination time and can raise client anxiety.

In 2000 Seddon et al. reported that over 90% of their screening mammogram technical recalls were due to blurred images [5]. More recently blurred images were found to be a major source of technical recall [6]. Audit in one of our breast screening units found that 0.86% of clients were recalled due to image blur; this contributed approximately one third (29%) of the 3% maximum permissible recall rate in the National Health Breast Screening Programme (NHSBSP) [7].

For some images blurring could only be detected when they were displayed on 5 mega pixel (MP) reporting grade monitors at the time of reporting. Blurring was missed when the images were checked for technical accuracy on the lower specification technical review monitors.

Our study aims to investigate: whether there is a difference in visual detection of blurring between a 2.3 MP technical review monitor and a 5 MP reporting grade monitor; and to propose an observer standard for the visual detection of blurring on reporting grade 5 MP monitors.

METHODS

Twenty eight radiographers qualified in mammography imaging from two breast screening units were invited to review 120 blurred and non-blurred images on a 2.3 MP technical review monitor and a 5.0 MP reporting grade monitor.

Selection of FFDM images

Using published quality criteria [8], two experienced image readers independently reviewed several hundred images to identify an initial set of 100 normal artifact free FFDM images. Mathematical simulation software [3] was used to simulate the effect of motion in 20 FFDM images, thereby creating simulated blur. Simulated blurring was imposed from 0.2 to 1.0 mm at 0.2 mm increments. In total 120 images were used, comprising 20 with no blur and 100 with varying levels of simulated motion and therefore blurring (0.2mm (20); 0.4mm (20); 0.6mm (20); 0.8mm (20) and 1.0mm (20)). Figures 1 and 2 show examples of FFDM images with and without simulated blur imposed.

Fig 1 FFDM image with no blur

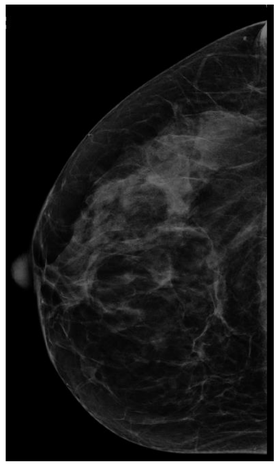
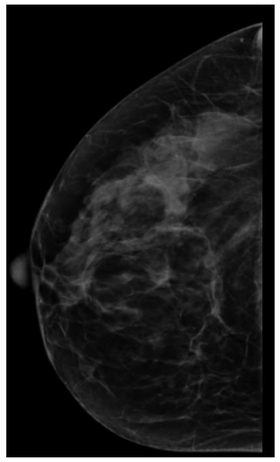


Fig 2 FFDM image with 1mm simulated blur



The 120 images were de-identified, randomized and displayed on 2.3 MP (NEC, Multisync EA248wm) and 5 MP (NDS, Dome ES Ci5) monitors. Both Monitors were calibrated to the DICOM Grayscale Standard Display Function [9] Images were displayed using MediViewer (Schaef Systemtechnik, Petersaurach, Germany) and viewed at approximately 75 cm from the monitor on a blinded basi by the 28 radiographers. Radiographers were not permitted to manipulate the images or adjust the brightness and contrast of the images.

Data collection took 8 months to complete with a period of 2 months between each monitor review.

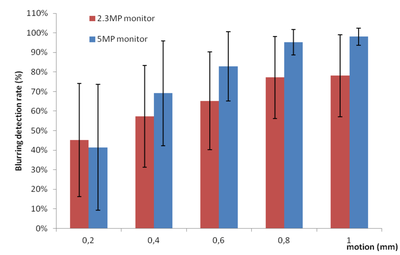
Chi-square was used to test whether significant differences in blurring detection existed between the 2.3 and 5 MP monitors.

RESULTS

The average blurring detection rate for the 2.3 and 5 MP monitors are shown in Figure 3.

- All the non-motion images were identified correctly.
- Blurring detection rate increases with simulated motion and monitor resolution.
- The 5 MP monitor has a higher average blurring detection rate.

Figure 3: Blurring detection rate against level of motion, the error bars represent the standard deviation.



- For 0.2 mm motion, there is no significant difference (p=0.20) in blurring detection between the 2.3 and 5 MP monitors,
- For motion larger than 0.2 mm there is significant difference (X^2 (1, N = 5475) =110.07, p<0.05) in blurring detection between 2.3 and 5 MP monitors.

The technical recall rate for 2.3 and 5 MP monitors at each level of motion were calculated and summarized in Tables 1 and 2.

- Technical recall rate appears directly related to the level of motion and inversely related to monitor resolution.
- The technical recall rate for the 2.3 MP monitor varies from 3.6% to 9.1% and for the 5 MP monitor it varies from 0.3% to 9.8%.
- The 2.3MP monitor has a higher overall technical recall rate (29.5%) compared to 5MP monitor (18.9%).

Table 1: Technical recall rate for 2.3MP monitor

Level of motion (mm)	0.2	0.4	0.6	0.8	1	Total
Technical recall rate	9.1%	7.1%	5.8%	3.8%	3.6%	29.5%

Table 2: Technical recall rate for 5MP monitor

Level of motion (mm)	0.2	0.4	0.6	0.8	1	Total
Technical recall rate	9.8%	5.1%	2.9%	0.8%	0.3%	18.9%

Table 3 indicates the median, upper quartile and lower quartile increases with the level of motion. The minimum amount of motion required for visual detection of blurring is 0.4 mm and the minimum standards for blur detection at 0.4, 0.6, 0.8 and 1 mm are 96, 100, 100 and 100% respectively.

Table 3: Median, lower quartile and upper quartile of blurring detection for 5 MP monitor

Level of motion (mm)	0.2	0.4	0.6	0.8	1
Lower quartile (25th percentile)	10%	50%	74%	94%	100%
Median	28%	70%	85%	98%	100%
Upper quartile (75th percentile)	68%	96%	100%	100%	100%

DISCUSSION

The results from this study confirm that a monitor with lower resolution (2.3 MP) would likely have a poorer visual detection rate for FFDM image blurring compared with a higher resolution reporting grade monitor (5.0 MP) and is confirmed by the difference in technical recall rates.

In clinical practice some monitors have resolutions as low as 1 MP, and we assume that such monitors would have even poorer visual detection rates than a 2.3 MP monitor, thereby leading to even more technical recalls.

On examining practitioner ability to visually detect blurring on a 5 MP monitor (Table 3), using our dataset of 120 images, we propose that the 75th percentile should be used for the minimum standard for educational and clinical purposes.

One of the limitations of this study is the use of motion simulated images as they may not be fully representative of real blurring.

The version of software used in this study only blurs the *whole image* while real mammography image blurring may fully or partly affect the image.

An update to our software has the ability to introduce regional blurring. Using this updated software further studies could be carried out to investigate the effect of regional blurring on the blurring detection rate.

Monitor resolution is one of the factors which might affect the visual detection of blurring.

Other factors, such as contrast resolution, room brightness and visual acuity might also affect the ability of observers to visually detect blurring.

CONCLUSION

- Monitors equal to or below 2.3 MP are probably not suitable for technical review of FFDM images for the detection of blur.
- Further research is needed to identify the minimum monitor specification for technical review in clinical rooms for blur detection.
- Using our image dataset, minimum standards for blur detection at 0.4, 0.6, 0.8 and 1 mm level of simulated blurring are 96, 100, 100 and 100%.
- The minimum amount of motion required for visual detection of blurring is 0.4mm.
- This information could be used to help inform competence assessment standards of radiographers in training programmes and routine practice.

REFERENCES

1. Ma WK, Brettle D, Howard D, Kelly J, Millington S, Hogg P. Extra Patient Movement During Mammographic Imaging: An Experimental Study. Br J Radiol 2014; 87(1044):20140241. DOI: 10.1259/bjr.20140241.
2. Ma WK, McEntee MF, Mercer CE, Kelly J, Millington S, Hogg P. Analysis of motion during the breast clamping phase of mammography. Br J Radiol 2016; 89: 20150715. DOI: 10.1259/bjr.20150715
3. Ma WK, Aspin R, Kelly J, S. Millington, Hogg P. What is the minimum amount of simulated breast movement required for visual detection of blurring? An exploratory investigation. Br J Radiol 2015; 88: 20150126. DOI: 10.1259/bjr.20150126
4. Ma WK, Hogg P, Kelly J, Millington S. A method to investigate image blurring due to mammography machine compression paddle movement. Radiography 2014; in press. Epub ahead of print. doi: 10.1016/j.radi.2014.06.004
5. Seddon D, Schofield K A, Waite C A. Investigation into possible caused of blurring in mammograms. Breast Cancer Res. 2000; 2(suppl2): A64. DOI: 10.1186/bcr253
6. O'Rourke J, Mercer CE, Starr L. Programme evaluation: Technical recall and image blur within a breast screening service. Symposium Mammographicum 2014, UK: Bournemouth, 2014.
7. NHS Cancer Screening Programmes. Consolidated guidance on standards for the NHS Breast 240 Screening Programme. NHSBSP Publication No 60 (Version 2), UK: Sheffield, 2005.
8. Perry N, Broeders M, Wolf C, Törnberg S, Holland R, Karsa L. European guidelines for quality assurance in breast cancer screening and diagnosis. 4th ed. Luxembourg: European Communities, 2006.
9. National Electrical Manufacturers Association (NEMA) Digital Imaging and Communications in Medicine (DICOM) Part 14: Grayscale Standard Display Function; 2011.

For additional information please contact:

Mrs. Rita Borgen
Breast Screening Unit
East Lancashire Hospitals Trust
Rita.borgen@elht.nhs.uk