Purpose

One of the most important factors in determining the success of a screening programme is screening uptake\(^1\) and the causes of any non-uptake are multifactorial. A systematic review (2013) indicated that between 47,000 and 77,000 women do not re-attend for breast screening in a year due to pain directly related to a previous mammogram\(^3\). Pain from mammography can arise from the application of compression force\(^3\). It has been demonstrated that the position of the breast under the compression paddle can affect the amount of pressure in different portions of the breast\(^4\).

Quality assurance is essential to ensure the National Health Service Breast Screening Programme (NHSBSP) continued effectiveness\(^5\). It is extraordinary that a screening service has no standards or guidelines on the application of compression force other than a statement 'the force of the compression on the x-ray machine should not exceed 200 Newtons (N)\(^6\) with various highly subjective proposed descriptors such as 'taut to touch' or 'until the skin blanches'\(^7\)\(^-\)\(^11\).
Methods and materials

Building on previous studies\textsuperscript{12,13}, this retrospective evaluation of practitioner compression force variation was conducted over a six year screening cycle in three screening units in the North of England. To exclude mammography machine breast readout inaccuracies\textsuperscript{14}, data was gathered from one mammogram machine at each location all operating within NHSBSP and manufacturer specifications\textsuperscript{15,16}.

Analogue images were utilised - NHSBSP screening sites had not been converted to digital technology for a six year period at the time of the study. Clients were selected using consecutive stratified sampling.

Inclusion criteria:

- Three consecutive screening events
- First recorded mammogram experience as their first event
- Four standard projections (left / right CC (cranial-caudal) and left / right MLO (medio-lateral oblique)

Recorded image data available: size of film, breast compression force value in deca-Newton (daN) or Newtons (N), compressed breast thickness (mm) and the practitioner who performed the mammogram. Exclusion criteria were applied.

The breast density was read by 5 observers in the three screening units using the 4 point BI-RADS® scale (Breast Imaging Reporting and Data System)\textsuperscript{17}. Inter and intra observer characteristics ascertained prior to this\textsuperscript{18}. Near complete intra-observer agreement (Kappa >0.81) and strong or above inter-observer variability was demonstrated (First score Fleiss kappa 0.77 second score 0.65)\textsuperscript{18}.
Results

Practitioner Variability\textsuperscript{20}:

The mean number of clients imaged by all practitioners at each site was assessed (Figure One and Two) by analysis of variance (ANOVA):

- Significant difference (p<0.0001) between sites 'one and three', and 'two and three'. This holds true within each BI-RADS grade.
- Sites one and two demonstrated no significant difference (CC p>0.5, MLO p> 0.1). This holds true within each BI-RADS grade.

Compression Force\textsuperscript{20}:

First and third quartile results at all sites were analysed:

- Significant difference (p<0.0001) between sites 'one and three' and sites 'two and three' for CC and MLO views. Holds true within each BI-RADS grade.
- Sites one and two demonstrated no significant difference (first quartile p>0.1, third quartile p>0.5). Holds true within each BI-RADS grade.

Percentage changes in breast compression force from 3 screening Mammograms (Figure Three):

- MLO: Sites 'one and three' and 'two and three' demonstrated a significant difference (p<0.0001) and this holds true within each BI-RADS grade.
- CC: Sites one and two demonstrated no significant difference (p>0.2), this holds true for each BI-RADS grade.
- No significant difference was demonstrated between sites 'one and two' (p>0.5).
- Site three displays low client variability over the three screens

Breast Thickness\textsuperscript{20}:

Compressed breast thickness ranges at all sites were compared (Figure Four), first and third quartile values (Figure Five) for CC and MLO.

ANOVA of mean compressed breast thickness values:

- Significant difference (p<0.0001) between 'site one and three' and site 'two and three' (CC and MLO).
Site one and two demonstrated no significant difference in mean CC values of thickness (p>0.5) - Holds true within each BI-RADS grade.
Practitioners at site three applied higher compression values - breast thicknesses at this centre are smallest.

ANOVA of first and third quartile compressed breast thickness values:

- Significant differences (p<0.0001) in first and third quartile breast compressed thickness values between sites 'one and three' and sites 'two and three' - holds true within each BI-RADS grade.
- Site 'one and two' demonstrated no significant difference in values of thickness (p>0.5) - holds true within each BI-RADS grade.
Fig. 1: Mean Compression Force Values CC View

Fig. 2: Mean Compression Force Values MLO View

Fig. 3: Overall Mean Percentage Change in Compression levels per Site

<table>
<thead>
<tr>
<th>Site</th>
<th>MLO Thickness (mm)</th>
<th>S.D</th>
<th>CC Thickness (mm)</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site One</td>
<td>53.8</td>
<td>13.7</td>
<td>50.9</td>
<td>11.3</td>
</tr>
<tr>
<td>Site Two</td>
<td>57.9</td>
<td>12.2</td>
<td>56.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Site Three</td>
<td>47.1</td>
<td>12.7</td>
<td>43.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Fig. 4:** Mean Breast Thickness Value (mm)

<table>
<thead>
<tr>
<th>Site</th>
<th>First Quartile</th>
<th>Third Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MLO Thickness (mm)</td>
<td>S.D</td>
</tr>
<tr>
<td>Site One</td>
<td>44.55 3.43</td>
<td>43.96</td>
</tr>
<tr>
<td>Site Two</td>
<td>49.78 2.94</td>
<td>50.46</td>
</tr>
<tr>
<td>Site Three</td>
<td>38.23 3.70</td>
<td>36.32</td>
</tr>
</tbody>
</table>

**Fig. 5:** Quartile Thickness Values (mm)

Conclusion

DEMONSTRATED IMPACT ON CLIENT EXPERIENCE

We have demonstrated that practitioners across three breast screening sites behave differently in the application of compression force when undertaking mammography. Two of the three sites demonstrate variability. Variability within these two sites and between the three sites could result in variations in image quality, radiation dose, re-attendance rates and client experience\(^{20}\).

IMPACT ON MAMMOGRAPHY IMAGES

Direct comparison between images on successive screens is vital to ensure accurate visualisation of subtle changes within the breast. We have demonstrated that compression force and breast thickness differences exist between and within sites, the latter could influence image quality. If differences in quality exist for the same client then this could confound comparison of images on successive screens\(^{20}\).

RE-ATTENDANCE AND STANDARDS

Pain and non-re-attendance are related\(^{3}\) and a standardised approach to compression force levels within a specified range is required to offer clients a consistent expectation and experience. Further research is needed into client pain and levels of applied compression force\(^{20}\).

A DIFFERENT PERSPECTIVE

A recent study by de Groot and colleagues\(^{19}\) questioned if standardisation by compression force was meaningful and they suggested a focus towards pressure. At present clients with small breasts experience more pressure than clients with large breasts with the same applied compression force. They suggested standardisation based upon pressure which shows great promise\(^{20}\).
Claire Mercer qualified as a Radiographer in 1995 from S. Martin's College, Lancaster. She worked in Bolton Hospital for 5 years as a Radiographer and progressed into the field of Mammography in 2000. She developed into an advanced practitioner and QA Radiographer in 2004, followed by Superintendent in 2006. She completed her MSc with distinction in Advanced Medical Imaging in 2011. The following year Claire was appointed into the post of Lead Radiographer for Breast Imaging at the Nightingale Centre & Genesis Prevention Centre at the University Hospital of South Manchester. She has just completed her PhD by publication at the University of Salford. Her research work is centred on practitioner variation in breast compression and Claire has published several papers in this area.
References


