Optical density and latitude requirements of high contrast mammography films

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Introduction
Fuji AD-M and Kodak min-R 2000 film screen combinations produce higher contrast mammograms than with film types previously used. The objective of this study was to evaluate the implications of using these film screen combinations in the UK NHS Breast Screening Programme (NHSBSP). For comparison the Fuji UM-MA (Hi) film was also investigated since it has a lower contrast than both Fuji AD-M and Kodak min-R 2000, and is still in widespread use in the NHSBSP.

Quantitative Film Assessment
• The film screen systems evaluated clinically are detailed in Table 1.
• Clinical films were digitised at 210 µm resolution, using a laser scanner. A pixel value to optical density (OD) calibration was used to create images with pixels in OD units.
• Images were analysed using the regions of interest (ROI) shown in Figure 1. Macro programmes selected the ROI, and performed image analysis. Measurements included the maximum, minimum and mean OD in each ROI.
• To compare the characteristic curves of the three film types, an Aluminium step-wedge was imaged at 28 kV with each film.
• The lateral altitude in the lower half of the characteristic curves (L lower) can be used to estimate what percentage of films can be expected to optimally display areas of dense glandular tissue. The lower altitude available in each film type was calculated using Equation (1), and the lower dynamic range for each mammogram (DR lower) was calculated using Equation (2).

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L_{\text{lower}} = \log_{10}(E)_{\text{mean OD of 1.8}} - \log_{10}(E)_{\text{suggested minimum OD limit}}
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DRL = \log_{10}(E)_{\text{mean OD in the main breast ROI}} - \log_{10}(E)_{\text{minimum OD in the main breast ROI}}
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Table 1: Film screen systems evaluated clinically.

Results of Clinical Film Analysis
• Figure 5 illustrates that for each grade of glandular tissue density the Fuji AD-M film had lower mean minimum ODs than the Kodak min-R 2000. For both film types, the mean minimum ODs were lower for films that were judged to have low or slightly low glandular tissue densities than those whose glandular tissue densities were judged to be OK.

• The mean minimum ODs for each grade of glandular tissue visualisation are listed in Table 2 for both imaging systems. The mean minimum ODs for Fuji AD-M were of the order of 0.2 OD lower than for Kodak min-R 2000.

• Clinicians graded as having areas of low glandular tissue density had a minimum OD below approximately 0.8 for Kodak min-R 2000 and below approximately 0.6 for Fuji AD-M.

• In a similar test to assess the acceptable maximum density in the main breast region, tissue density was generally graded as slightly high or high above an OD of 2.9 for Kodak min-R 2000, but there was no clear relationship for Fuji AD-M.

Discussion
• The Fuji AD-M film generally had the highest film gradient over the mid-range of exposures. However as shown in Figure 3 the gradient fell very rapidly at lower exposures corresponding to OD of less than approximately 0.5 (equivalent to a log10E of -0.3). At these exposures the film contrast was less than that of the other film types.

• The suggested minimum OD limits for ideal glandular tissue visualisation are 0.8 for Kodak min-R 2000 and 0.6 for Fuji AD-M. These limits are based on radiologists’ opinions, but appear to be related to the lower film contrast below these limits. In earlier studies a minimum OD limit of 0.6 was suggested for Fuji UM-MA and Sterling Microvision C films.

• Lower was calculated as a measure of the dynamic range from mid to low OD. Both Fuji AD-M and Kodak min-R 2000 have smaller L lower than the Fuji UM-MA film indicating narrower latitude.

Conclusions
• The main breast regions of the mammograms produced using both Fuji AD-M and Kodak min-R 2000 were satisfactorily visualised when breast tissues were displayed with optical densities above approximately 0.6 and 0.8 respectively.

• Although the use of modern very high contrast films improves the appearance of most mammograms, the problems of visualising breasts with dense glandular tissue using such high contrast films mean that unless there is a change in imaging technique, there may be an increase in the number of films which have excessive contrast and need to be repeated.