TECHNICAL EVALUATION OF A NEW VERSION OF THE FUJI AD MAMMOGRAPHY FILM- SCREEN SYSTEM

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This report has been prepared by:

Dr Kenneth C. Young & Jenny Oduko
National Coordinating Centre for the Physics of Mammography
Regional Radiation Protection Service
St Luke's Wing
Royal County Hospital
Guildford GU2 7XX

Tel. 01483 406736/8
Fax. 01483 406742

e-mail ken.young@royalsurrey.nhs.uk

Further copies

Requests for further copies should be made to:

NHS Cancer Screening Programmes
260 Ecclesall Road South
Sheffield S11 9PS

Tel. 0114 271 1060
Fax. 0114 271 1089

e-mail nhs.screening@sheffield-ha.nhs.uk

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www.cancerscreening.nhs.uk

1. INTRODUCTION

There has been an ongoing problem with Fuji AD film-screen systems in which white artefacts appear on films with an appearance similar to calcifications and generally at a location corresponding to brown spots on the screens. Fuji have investigated the cause and found it to be due to screen deterioration. Various attempts have been made to redesign the screens to improve their wear performance. Each type of screen can be identified from its serial number. The original screen design has no letter in front of the serial number. Type-T and Type-K screens have been previously evaluated technically. However in clinical use they were found to suffer from wear resulting in artefacts on film similar to those seen with the original AD screens. This screen damage appeared after only a few months of use. In this report a new screen design called type-T2 designed to overcome the wear problems is evaluated and compared to a K-type screen. Once in production this new screen type will be renamed Type-L, and is expected to replace existing AD screens in the UK as the need arises.

Fuji has also re-designed the AD-M film and are introducing this as a package with the new screens. Boxes of the new film have a black triangle printed on the labels to distinguish them from the original. The ID notch on the edge of the film is also in a different location. The main features claimed for the film are as follows:-

(a) Increased contrast and maximum density
(b) Bluer tint

The new film screen combination was compared to the existing Fuji AD system at one site using the mammography system described in Table 1. Note that these tests to not evaluate the durability of the screens only their impact in terms of image quality and dose. Durability can be best assessed by a clinical evaluation over a period of at least 12 months.

Table 1: Mammography system used for testing film-screen combinations

Location	Jarvis Breast Screening Centre, Guildford
Existing film at centre	Fuji AD
Older type of screen tested	AD mammo fine (K 044457)
New film tested	Fuji AD new
New screen tested	AD mammo fine (T2 046265)
Processor	Fuji FPM 2800
Developer	Photosol CD2000
Fixer	Photosol CD2000
Cycle time	90s
Developer temp	37 degrees C
X-ray set	GE 800T
Target OD	1.70
MGD to standard breast at 28 kV Mo Mo	1.54 mGy

2. LIGHT SENSITOMETRY OF FILMS

The sensitometry of the two films were compared using a 21 step X-rite sensitometer, and the results are shown in Figure 1. Maximum and minimum densities and mean film gradients are shown in Table 2 along with previous data published for films used in the NHSBSP.[1] The film gradients recorded for the Fuji AD "old" film are comparable to those previously measured in the NHSBSP. The average film gradients measured for the new film (Fuji AD new) were about 12% higher. The new film also has a higher Dmax and a processing speed that is about 9% faster.

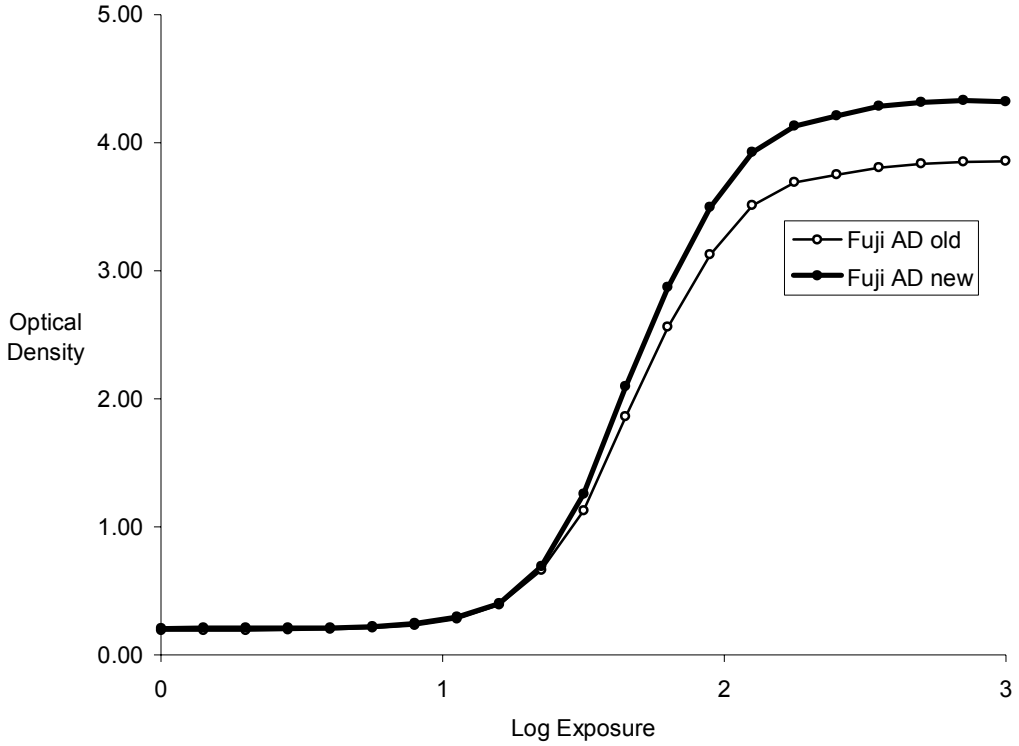

Figure 1: Light Sensitometry

Table 2: Sensitometric indices for different types of film

	Gradients measured in the NHSBSP				Measured in this study		
	Agfa HDR	Fuji UMMA	Fuji AD-M	Kodak Min-R2000	Fuji AD old	Fuji AD new	Increase with new film
Average film gradient from densities 0.25 to 2.0 plus base and fog	3.18 +/- 0.08	3.05 +/- 0.20	3.62 +/- 0.21	3.63 +/- 0.21	3.55	3.95	+11%
Average film gradient from densities 1.0 to 2.0 plus base and fog	3.72 +/- 0.14	3.73 +/- 0.31	4.63 +/- 0.41	4.97 +/- 0.33	4.83	5.42	+12%
Dmin					.21	.19	
Dmax					3.86	4.33	
Rel. Speed at a density of 1.70					100	109	+9%

3. X-RAY SENSITOMETRY OF FILM-SCREEN COMBINATIONS

To assess the characteristic curves, using x-rays rather than light, an aluminium step-wedge was imaged at 28 kV Mo Mo with the two film-screen combinations. The step-wedge had been previously calibrated for this spectrum. The characteristic curves for the two film-screen combinations and the corresponding "gamma" or gradient curves are shown in Figure 2. The average gradients calculated from these curves shown in Table 3. The increase in contrast of 6-8% with the new Fuji AD film is a little lower than the 11-12% measured with light sensitometry.

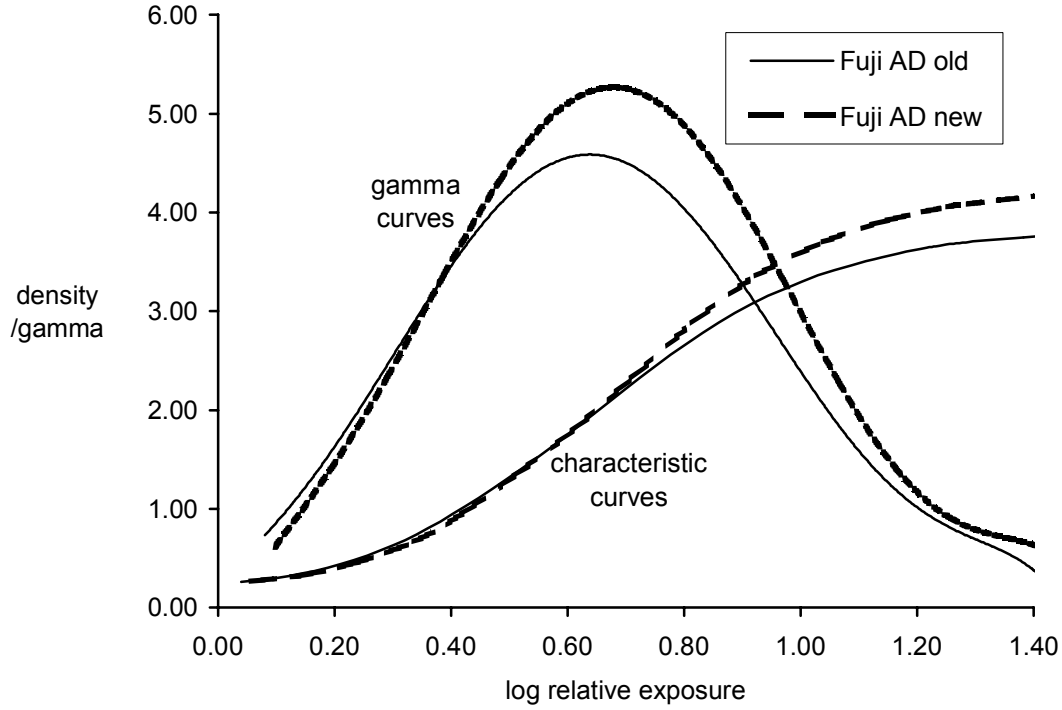

Figure 2: X-ray sensitometry. Curves are normalised to have the same exposure at a density of 1.70.

Table 3: Average film gradients measured using a calibrated Aluminium step-wedge

	Fuji AD old	Fuji AD new	Increase with new combination
Average film gradient from densities 0.25 to 2.0 plus base and fog	3.54	3.74	+6%
Average film gradient from densities 1.0 to 2.0 plus base and fog	4.39	4.74	+8%

4. SPEED MEASUREMENTS

The relative speeds of the film-screen combinations tested at 28kV MoMo with a 4cm thickness of PMMA and a target density of 1.70 are shown in Table 4. The new T2 screen appears to be about 2% slower than the older K-type screen. However when the new screen is used in combination with the new AD-M film there is an increase in speed of about 9%. This implies that the new film is about 11% faster than the old film. This is in good agreement with the 9% speed difference noted using light sensitometry. The new screen appears to be slightly less attenuating than the older K-type (i.e. 4% lower mAs selection) so that the resulting film density is only 0.05 greater than the older combination. This indicates that AEC systems may not need adjusting when the new combination replaces the old.

The relative speeds of the original AD and T-type screens also shown in Table 4 have been derived from a previous study with the original AD-M film. The new T2 screens have a speed that is very similar to the original and K-type screens.

Table 4: Results of speed tests using 4cm PMMA at 28 kV MoMo

Film	Screen	mAs selected in AEC mode	OD of film	mAs for OD of 1.7	Relative speed	Relative mAs selected (%)
old AD-M	K	50	1.69	50.3	100	100
old AD-M	T2	48	1.60	51.4	98	96
new AD-M	T2	48	1.74	45.9	109	96
old AD-M	T	(speed from previous report)			96	96
old AD-M	original	(speed from previous report)			100	90

5. AEC THICKNESS COMBINATION

The ability of the X-ray sets AEC to maintain thickness compensation with the new film-screen combination was tested by exposing 2, 4, 6 and 7cm thicknesses of Perspex block. The resulting densities for the two film screen combinations are shown in Table 4 and Figure 3. The thickness compensation worked satisfactorily without adjustment for the older film used with the older screen type (K), and for the new film used with the new screen type (T2). However thickness compensation appeared to be less effective for the old film used with the new screen type.

Table 5: Thickness compensation by AEC, with target density of 1.70 +/- 0.15

		Densities measured in AEC mode (Thickness of Perspex)			
Film	Screen	2 cm	4 cm	6 cm	7 cm
old AD-M	K-type	1.75	1.69	1.70	1.70
new AD-M	new T2	1.75	1.74	1.70	1.68
old AD-M	new T2	1.76	1.60	1.53	1.54

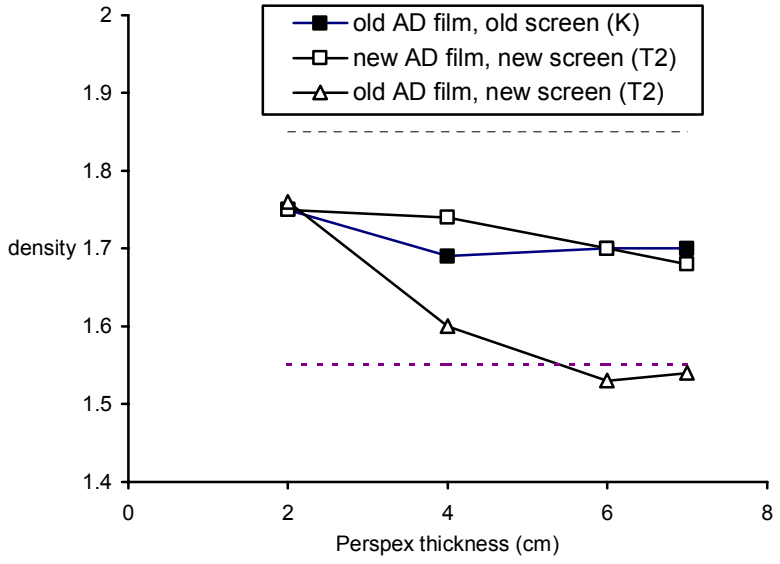

Figure 3: AEC thickness compensation with a target of 1.70 +/- 0.15

6. HIGH CONTRAST LIMITING RESOLUTION

The high contrast limiting resolution of the old and new film-screen combinations was measured using a CIRS gold resolution test pattern on top of 4cm of PMMA, both parallel and perpendicular to the tube axis. The test object has gratings every 1 line pair per mm. The results shown in table 4 are the average of three observers. No significant difference was detected between the film/screen combinations.

Table 4: High contrast limiting resolution

		HC Resolution (lp/mm)	
Screen	Film	Parallel	Perpendicular
K type	Fuji AD-M old	12.7 +/- 0.5	14.3 +/- 0.5
T2 type	Fuji AD-M new	12.7 +/- 0.5	13.7 +/- 0.5

7. IMAGE QUALITY (USING TOR-MAX AND TOR-MAM)

Image quality of the old and new systems was assessed using a TOR-MAM test object on top of 3cm of PMMA, and a TOR-MAX test object on top of 4cm of PMMA. All exposures were made with 28kV Mo/Mo and a target density of 1.7. The results are shown in Table 5 and are the average for three observers. There was no significant difference between the two films, considering the errors in the method of visual inspection. Both film screen combinations met the NHSBSP minimum image quality requirements on the X-ray set used.

Table 5: IQ test results with TOR-MAM and TOR-MAX test objects

	Criteria	Fuji AD-M old	Fuji AD-M new
TOR-MAM score	> or = 70	85 +/- 5	85 +/- 5
No of 6mm details in TOR-MAX	> or = 7	8 +/- 0.5	8 +/- 0.5
No of 0.5mm details in TOR-MAX	> or = 8	8 +/- 0.5	8 +/- 0.5
No of 0.25mm details in TOR-MAX	> or = 7	7.7 +/- 0.5	7 +/- 0.5

8. CONCLUSION

The new design of Fuji AD film-screen combination has been found to show a slight increase in speed and contrast of about 10% when compared to the existing system. No significant change in image quality using image quality test objects was observed. The higher contrast and greater maximum film density will tend to reduce the latitude slightly and may make the visualisation of the skin edge more difficult. However users may prefer the higher contrast mammograms produced with the new film.

9. REFERENCES

1. Young and Ramsdale. *Performance of mammographic equipment in the UK Breast Screening Programme in 2000/2001*. Sheffield, NHS Cancer Screening Programmes, 2003 (NHSBSP Publication No 56).