



Evaluation of Tetenal Roentoroll AC-M Mammography Chemistry

Introduction

A technical and clinical comparison of Tetenal Roentoroll AC-M & Champion CD2000 developers was carried out at Ardmillan House, Edinburgh. Screening, assessment and family history clinics take place at Ardmillan House, where they currently use Champion CD2000 developer & Fixaplast XF2 fixer, Fuji FPM 3800 processor (4) set at 37-38°C, 90s, Fuji AD-M MAMMO fine screens (latest design) with AD-M film.

Many Scottish breast screening centres were experiencing stability and supply issues with the Champion chemistry, and at Ardmillan House, staff were using the chemistry at high temperatures (38°C) to achieve acceptable film speeds. It was agreed with A. Somerville Ltd. to carry out a trial of the Tetenal chemistry, where no significant changes in performance were anticipated.

An initial formulation of Roentoroll gave disappointing results (approx 10% slower speeds whilst still at 38°C). However, the chemistry was adjusted and Roentoroll AC-M was produced. Processing temperature was adjusted to achieve matched sensitometry results before proceeding to a thorough technical and clinical comparison.

It was hoped to use a more dilute mix of the Roentoroll AC-M chemistry (1:3 compared to the routinely used 1:2 mix) and these results are shown. However, due to slightly slower speeds with the more dilute mixture, the clinical tests were carried out using the stronger 1:2 mixture.

The aspects evaluated were sensitometry, dosimetry, AEC performance, technical and clinical image quality.

Summary

- The sensitometry results for the CD2000 & Roentoroll AC-M (1:2) chemistries at 37°C were matched (to within 2.5%). The mean glandular doses for a standard 5.3cm breast were also matched to within 2.5%, and the same density setting was used clinically for the 2 chemistries
- The sensitometry results for the Roentoroll AC-M (1:3) chemistry showed a 10% speed drop compared to CD2000. The mean glandular dose for a standard 5.3cm breast was 4% higher than the CD2000 dose, though would be approx. 15% higher in reality due to the need for an increase in density setting. For this reason, the clinical trial did not proceed with the Roentoroll AC-M (1:3) formulation
- No recalibration of AEC's would be required for the Roentoroll AC-M chemistry
- No significant difference was observed in image quality scores using TOR[**MAX**] and TOR[**MAM**] test objects. All threshold contrast and line pair measurements were within NHSBSP remedial levels
- A significant difference was observed in the scores of sharpness and contrast between the 2 sets of clinical films, with a greater preference shown for the Roentoroll AC-M (1:2) chemistry
- The Roentoroll AC-M chemistry used at a 1:2 dilution performs at least as well as the CD2000 in all technical and clinical aspects tested.

Technical Comparison:

Sensitometry

Single sensitometry films were produced over a range of temperatures (35-37°C) for both chemistry types. Both long edges of each film were exposed and the 2 strip densities averaged for each film. The sensitometry curves for 3 chemistry mixes at 37°C are shown in Figure 1 and the parameters summarised below:

Chemistry	Base+Fog (B+F)	Speed Index*	Contrast Index**	D _{max}
Champion CD2000	0.21	1.30	1.76	4.29
Roentoroll AC-M (1:2)	0.21	1.30	1.77	4.30
Roentoroll AC-M (1:3)	0.21	1.19	1.75	4.17

* Taken from Step 12 density

** Derived from Step 14 – Step 12 densities

Champion CD2000 and Roentoroll AC-M (1:2) gave almost identical sensitometry results at 37°C. The speed was approx. 10% slower for the Roentoroll AC-M (1:3) mix at 37°C. All further tests were carried out using a developer temperature of 37°C.

All X-ray exposures were carried out using the Instrumentarium Performa mammographic X-ray unit at Ardmillan House. The following tests were carried out:

AEC Performance for 2-7cm thicknesses

The 4cm daily block test was carried out using AA mode (fully automatic) to determine which density setting should be used for each formulation. Films were then taken for 2,6 & 7cm thicknesses. The results are summarised below:

Chemistry	Density Setting	mAs	kV/Target/ Filter	Film Density	Density Range for 2 - 7cm
Champion CD2000	-1	67	26/Mo/Mo	1.73	1.69 – 1.77
Roentoroll AC-M (1:2)	-1	56	27/Mo/Mo	1.74	1.62 – 1.78
Roentoroll AC-M (1:3)	0	76	26/Mo/Mo	1.86	1.79 – 1.90

The same density setting could be used for the CD2000 and AC-M (1:2) formulations. However, the AC-M (1:3) formulation required an increase of 1 density step. No recalibration of the AEC would be required as all densities were within the remedial levels set in NHSBSP Publication No. 63, Quality Assurance Guidelines for Mammography (i.e. the density variations were within 0.2 of the 4cm density, the total density range was <0.3 or all densities were within 1.3-2.1).

Mean Glandular Dose

The mean glandular doses (MGD) to a standard 5.3cm compressed breast for the 3 chemistry formulations are compared below. These doses were simulated by exposing 4.5cm Perspex in AA mode (28kV, Mo/Mo). Dose values have been interpolated to a density of 1.75:

Chemistry	mAs	MGD to Standard Breast (mGy)	% Dose change from Fuji
Champion CD2000	64.3	1.89	---
Roentoroll AC-M (1:2)	62.9	1.85	- 2.1
Roentoroll AC-M (1:3)	66.5	1.96	+ 3.7

All dose values are below the 2.5mGy limit (Consolidated Guidance on Standards for the NHSBSP, NHSBSP Publication No. 60, 2005). The AC-M results for both concentrations are within 5% of the CD2000 results when interpolated to 1.75OD. In reality, the doses for the 1:3 mix would be approx. 15% higher than the CD2000 doses due to the need to use the higher density setting.

Image quality

Three images of each of the following test objects were obtained, using Auto mode, 28kV, Mo/Mo and a 5 minute dwell time:

- o TOR[MAX] + 4cm Perspex
- o TOR[MAM] + 3cm Perspex

All image quality films were scored by 2 observers and the results from each film and observer were averaged. The results are tabulated below and shown in Figures 2-3:

Chemistry	mAs	Film Density	Line Pairs per mm		% Threshold Contrast		
			Anode-Cathode	Lateral	6mm	0.5mm	0.25mm
Champion CD2000	61.3	1.64	16.6	16.2	0.60	3.7	7.0
Roentoroll AC-M (1:2)	61.3	1.71	16.6	16.6	0.58	3.1	7.0
Roentoroll AC-M (1:3)	68.7	1.80	16.6	16.6	0.67	3.0	5.6
Remedial Level*			<12	<12	>1.2	>5	>8

* Set in NHSBSP Publication No. 63, Quality Assurance Guidelines for Mammography

Chemistry	mAs	Film Density	Filaments	Particles	Discs	Total
Champion CD2000	43.3	1.79	35.7	11.8	27.2	74.7
Roentoroll AC-M (1:2)	44.3	1.81	36.5	12.3	27.8	76.7
Roentoroll AC-M (1:3)	48.3	1.98	35.3	11.7	26.8	73.8

All TOR[MAX] scores are well within the NHSBSP remedial levels. Applying the independent 2 tailed T-test to both test object scores, all p values are >0.05 (range 0.1-1) indicating no significant difference in scores between the different chemistry formulations at this level.

Figure 1: Sensitometry Curves

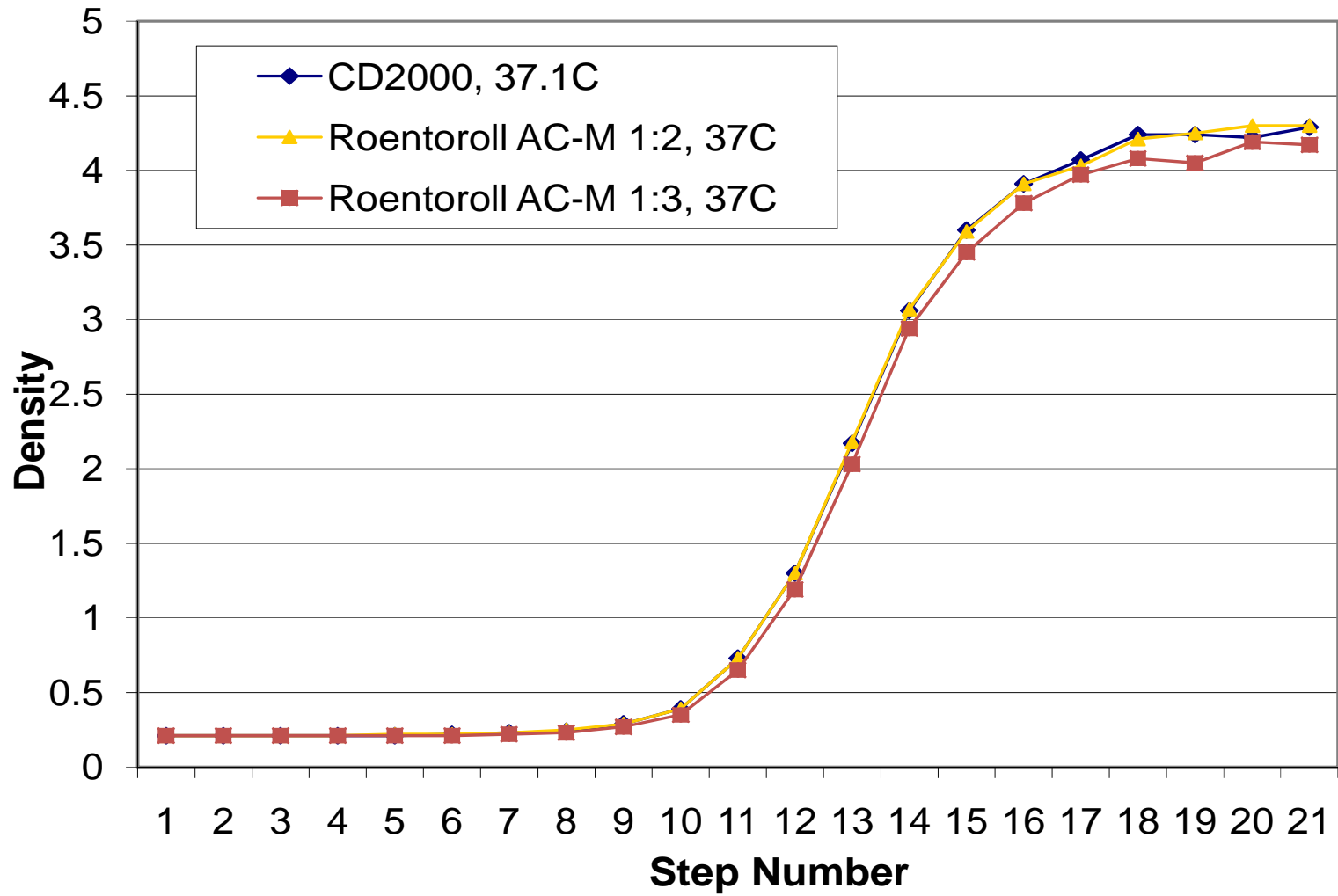


Figure 2: TOR[**MAX**] Contrast Comparison

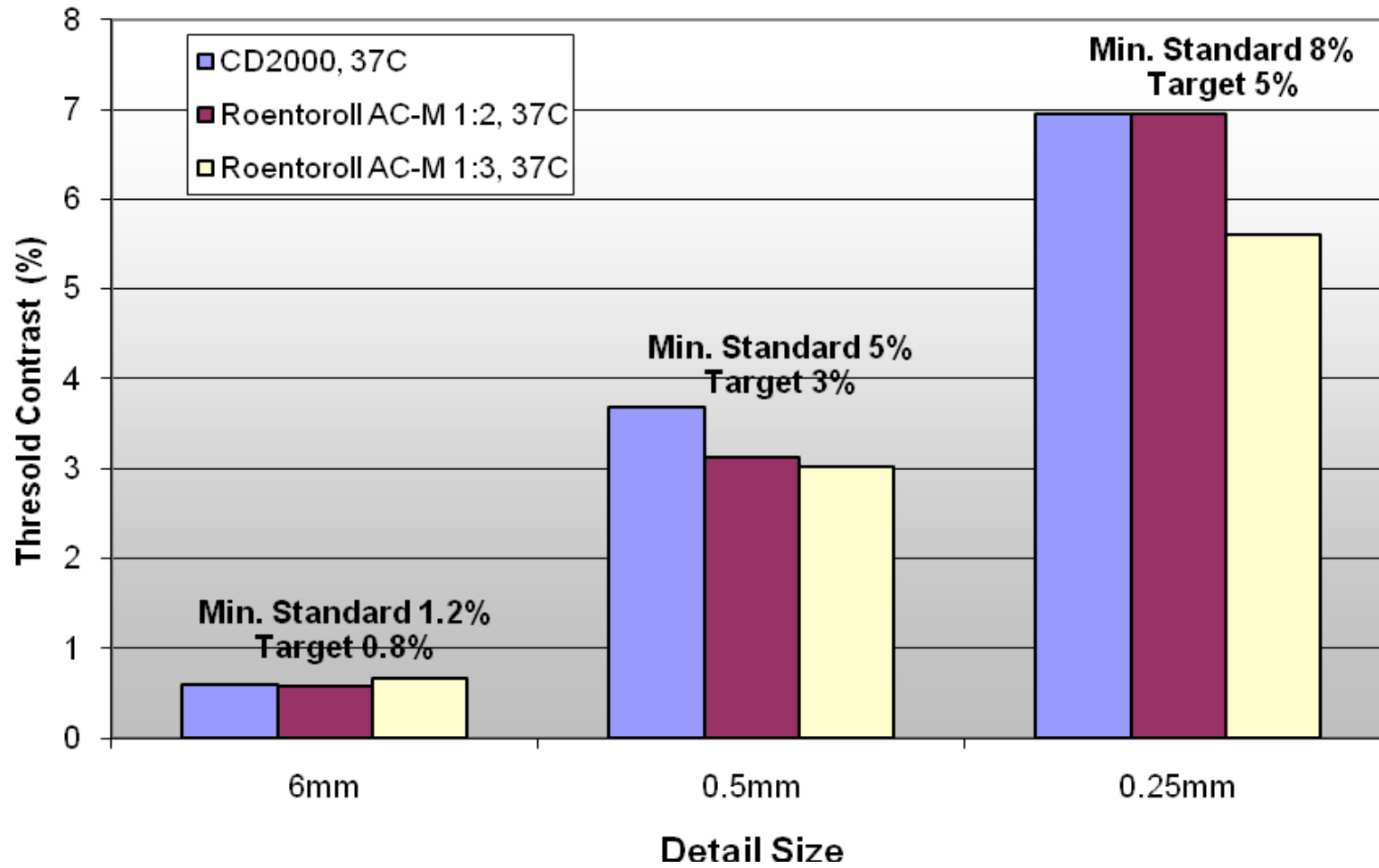
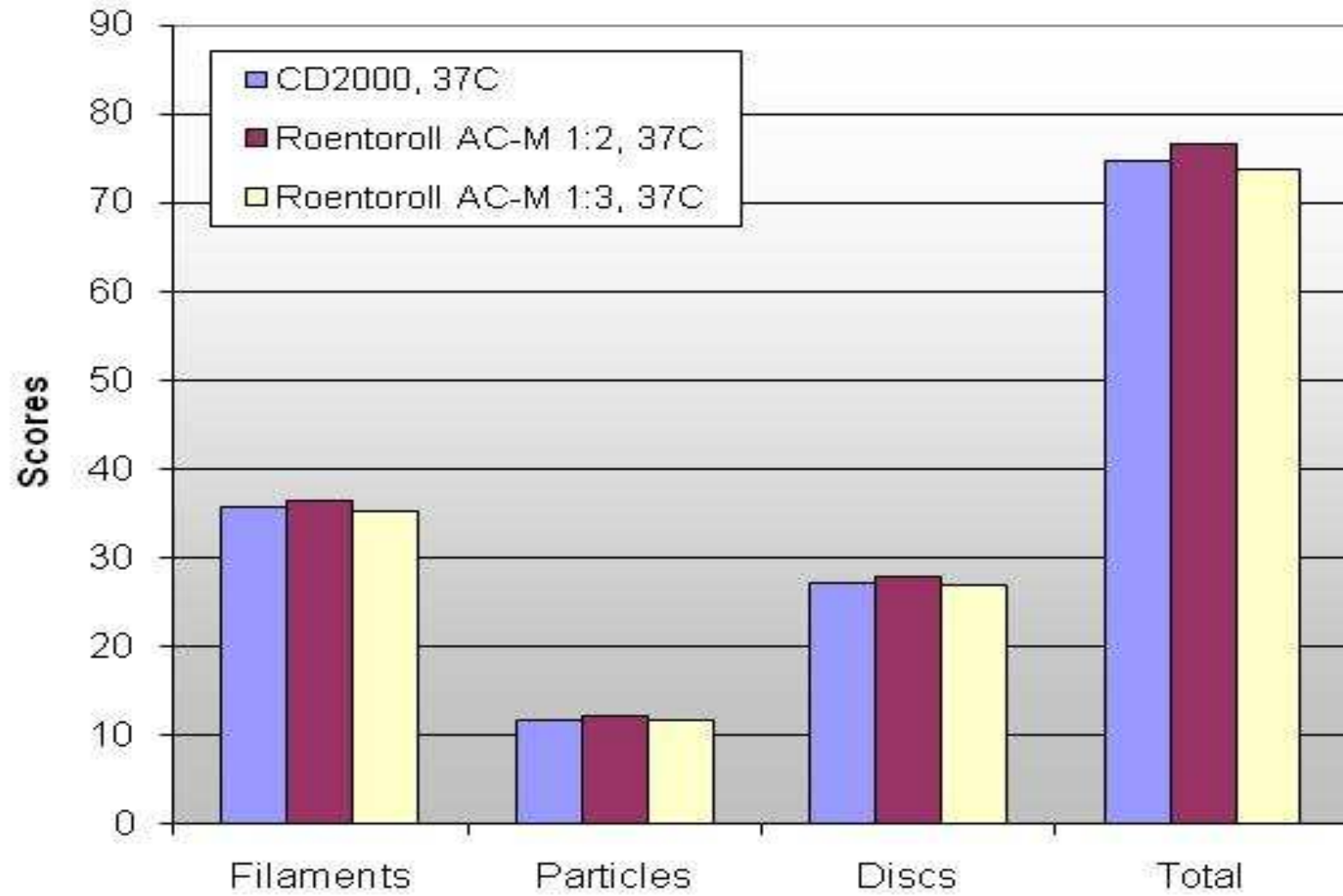


Figure 3: TOR[MAM] Score Comparison



Forty sets of films were collected from screening and family history clinics, to clinically evaluate the Roentoroll AC-M (1:2) chemistry in comparison to CD2000. For each woman, all left side films (both CC and MLO) were processed through Processor 4, which contained Roentoroll AC-M chemistry. All right side films were processed through Processor 5, containing CD2000. When using CD2000 chemistry, processors 4 & 5 are very closely matched. The films were then evaluated by 6 readers (radiologists, film readers and a physicist) who were unaware as to which side had been processed through which chemistry. Readers indicated whether they preferred one side and made comments on artefacts or other general features. They also allocated each film with a 0-4 score for sharpness and contrast (see below):

Sharpness: 1 = poor 2 = satisfactory 3 = good 4 = very good / excellent
 Contrast: 1 = flat 2 = low contrast 3 = high contrast 4 = very high contrast

The appearance of both sides was generally very similar, and any artefacts present were not due to the processing. The sharpness of the films was generally acceptable, with a slight preference for the sharpness of the Roentoroll AC-M side. The contrast for the majority of films was low, due to the composition of breasts included in the sample, a large proportion of 24x30 films and in some cases, sub-optimal selection of AEC position. This did make scoring difficult, but still resulted in a slight preference for the Roentoroll AC-M side (see summary below).

Statistic (n = 80)	Sharpness		Contrast	
	CD2000 (Right)	Roentoroll AC-M (Left)	CD2000 (Right)	Roentoroll AC-M (Left)
Mean Score (0-4 range)	2.55	2.83	2.51	2.76
Standard Deviation	0.31	0.25	0.31	0.28
Range of values	1.3 – 3.0	2.2 – 3.5	1.7 – 3.0	2.0 – 3.6
p-value*	<< 0.0001		<< 0.0001	
t (79)*	8.3		8.2	

*t-Test: Paired Two Sample for Means using Microsoft Excel

The low p values indicate that the readers' sharpness and contrast scores were significantly better for the Roentoroll AC-M processed films ($p < 0.0001$).

No preference for either side was indicated for the majority of films (57%), however, 4.5% of CD2000 films were preferred compared to 38.5% of Roentoroll AC-M (1:2) films.

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