Dose reduction in Hologic Selenia FFDM units through AEC optimization, without compromising diagnostic image quality.

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Aims and objectives

Hologic Selenia Full Field Digital Mammography (FFDM) is FDA approved for conventional 2D, 3D tomosynthesis and C-view 2D images. More than 75 digital units have been installed in South Africa since 2007 which include more than 40 units capable of performing 3D tomosynthesis. One of the many reasons for this vendor’s popularity is its Automatic Exposure Control (AEC) function which has 3 different modes. In the popular AUTOFILTER mode the AEC automatically selects the filter and kV based on compressed breast thickness and the mAs based on calculations after a low dose scout exposure to compensate for breast parenchymal density.¹

The amount of photons to produce an image is proportional to dose and affects the Signal-to-Noise ratio (SNR) and the Contrast-to-Noise ratio (CNR). These ratios in turn affect image quality, contributing to image’s smoothness or grainy appearance. In digital mammography there should always be a balance between image dose and diagnostic quality.

The purpose of the study was to determine if dose reduction in Hologic Selenia FFDM is achievable through AEC optimization. To compare the diagnostic quality of the current higher- to new lower dose images. Investigate if radiologists have a preference towards higher- or lower dose images in FFDM.
Methods and materials

A phantom study was done to evaluate AEC optimization using the European Guidelines.\textsuperscript{2,3} Using an ionization chamber and 20-70 mm of Perspex, simulating 21-90 mm of compressed breast thickness, the monitor displayed mean glandular dose (MGD) values was confirmed to be the same as the measured values. The CDMAM phantom (Figure 1) was then imaged at different dose settings and simulated breast thicknesses to obtain a Contrast-Detail Curve for our institutions’ Selenia. The selected settings were the current AEC setting, 25% more and 25%, 35% and 50% less.

After the phantom study a before-and-after clinical trial was done on patients recruited after their routine annual mammography investigation at the institution. Patients were selected based on their compressed breast thickness and parenchymal density but excluded if they were younger than 40 years, had a previous mastectomy or presented with painful breast lesions.

After consent, each participant had 1 additional same day lower dose image, cranio-caudal (CC) or medio-lateral oblique (MLO) projection, to each breast after AEC optimization. Optimization was achieved by adjusting the AEC compensation to -2, effectively reducing the dose per image by 22-33% depending on the individual breast characteristics.

The corresponding paired dose images (routine study and new lower dose CC or MLO image) were then evaluated separately by two mammography radiologists who were blinded to the image dose. Images were firstly evaluated for:

- Benign or malignant masses
- Macro- or microcalcifications
- Architectural distorsion
- Axillary lymphnodes
- Pectoral muscle detail

Secondly, radiologists were asked to indicate their preferred image.
Images for this section:

Fig. 1: The CDMAM phantom

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Results

The Phantom study proved that our institutions’ Selenia complied with international image quality standards. The **Contrast-Detail Curve** for this Selenia (**Figure 2**), showed that the contrast achieved in the current AEC setting *(black dotted line)* was way below the European achievable line, indicating room for AEC optimization. Comparing the curves of the other dose settings, data confirmed that a theoretical dose reduction of 25-35% could be achieved *(green triangles and red squares in curve)*.

Twenty one patients were recruited for the clinical trial. All participants were female with an average age of 59 years (Range 40-76 years). For the purpose of the study, participants were divided into 3 groups based on their breast parenchymal density (using the TABAR classification) to ensure comparable numbers in terms of patient age, breast thickness and density (**Figure 3-4**). Apart from three patients with suspicious BI-RADS 4 and 5 breast lesions, all participants had benign mammography findings.

Radiologists found that the malignant lesions were clearly visible in both set of images and that there was no significant difference in the diagnostic quality for the remainder of the breast characteristics (**Figure 5**).

Out of 42 paired images there were a total of six concerns raised by the radiologists (**Figure 6**).

Data analysis showed that radiologists did not have a clear preference to any set of dose images and this remained true when breast density and compressed breast thickness were considered (**Figure 7-10**).

After AEC optimization an AGD reduction of 25% for all CC views and 26.5% for all MLO views was achieved. A breakdown of the dose reduction for each of the parenchymal density groups shows that the low density breast group had the most benefit followed by the denser breast groups (**Figure 11**).
Fig. 2: Contrast-Detail Curve. The European 'acceptable and achievable values' are indicated by the red and green straight lines. Ideally readings should be close to the 'achievable' line to indicate optimal AEC function.

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Fig. 3: The graph illustrates equal distribution in terms of patient age (y-axis) and the number of patients (x-axis) in the different breast density groups.

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Fig. 4: Equal distribution of patient numbers (y-axis) in terms of compressed breast thickness (y-axis) for the three breast density groups.

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![Graph showing breast thickness and density distribution]

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Fig. 5: Summary of the radiologists’ findings when comparing the higher- to the lower dose images.
**Fig. 6:** Summary of the 6 concerns raised by the radiologists. Note that the same concern was not identified by both radiologists and that most concerns were related to benign breast characteristics and issues regarding breast re-positioning. In 50% of cases these concerns were seen in the original higher dose AEC setting.
Fig. 7: Summary of the combined and individual radiologists' image preference data.

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Fig. 8: The graph illustrates that lower dose images were preferred in the lower density breast group and higher dose images more often preferred in the denser breast groups. The latter could be explained by less noise in higher dose images.

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Fig. 9: In terms of breast thickness it was interesting to see that radiologists more often preferred higher dose images for thinner breasts and low dose images for thicker breasts, irrespective of breast density (Fig 10). This suggests that thicker breasts will not limit the use of lower dose images even in dense breasts.

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Fig. 10

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Fig. 11

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Conclusion

Our study achieved an average breast dose reduction of 25-26% in digital mammography through AEC optimization.

There appear to be no significant difference in the diagnostic quality between the higher and lower dose images.

In terms of the radiologists' preference towards image dose, data showed that both breast density and compressed breast thickness influence this decision. Although higher dose images were more often selected in denser breasts, there was a preference for lower dose images in thicker breasts, irrespective of breast density.
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