Evaluation of Phantom Image Quality with Curved and Flat Compression Paddle in 2D Mammography

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INTRODUCTION

The American Cancer Society recommends women aged 45 – 54 receive annual screening mammograms for early detection of breast cancer.[1] The FDA's MQSA National Statistics indicate almost 40 million mammography procedures have been performed in the US since 1998.[2]

Compression paddles are a necessary component of the mammography system. They reduce breast thickness which reduces scatter radiation and improves contrast. Thus high quality images can be obtained with less dose to the patient. Compression paddles also restrict patient movement during image acquisition, which limits motion blurring artifacts.

Compression paddles, however, are a source of patient discomfort.[3] This may be one reason for lack of compliance with screening guidelines. Hologic SmartCurve™ compression paddles are designed with a curved bottom and aim to reduce patient discomfort while maintaining the image quality performance of flat-bottomed compression paddles. A clinical trial concluded that SmartCurve™ paddles offer better patient comfort vs. flat paddles without loss in clinical image quality.[4]

AIM

Our institution recently acquired SmartCurve™ compression paddles for use in 2D full-field digital mammography (FFDM). The purpose of this clinical project was to investigate the SmartCurve™ paddle prior to clinical use. Specifically, we wanted to quantitatively compare the image quality obtained with the SmartCurve™ paddle to that of the flat paddle by using readily available test equipment and other supplies.

METHOD

Images were obtained using a Hologic Selenia Dimensions 2D FFDM system. Compression paddles chosen for the comparison were the 24 cm x 29 cm SmartCurve™ paddle and 24 cm x 29 cm flat paddle. Phantoms were constructed from available supplies. For the SmartCurve™ paddle, a 500 mL saline bag was placed on top of a 1" thick piece of acrylic. When using the flat paddle, the saline bag was replaced by a second 1" piece of acrylic. Both phantoms are shown in Figure 1. SNR and CNR were evaluated by placing 0.1 mm Al filters on top of the lower acrylic block. A Leeds TOR 18FG phantom was similarly placed, and the bar pattern section used to calculate relative MTF curves for the curved and flat paddles.

RESULTS

Rather than compare the SNR and CNR measured with the SmartCurve™ paddle to that with the flat paddle, we chose to look at the change in SNR and CNR from the central axis to the phantom edge in the left-right direction. The Al filters were placed so as to measure the SNR and CNR both centrally and off center to the left and right in order to account for the maximum difference in phantom thickness with the SmartCurve™ paddle as shown in Figure 2. We avoided placing ROI's in areas of unavoidable saline bag folding or air bubbles. The flat paddle phantom was of equal thickness and we anticipated minimal change in SNR and CNR at the off center locations. Our results showed that the SNR decreased by approximately **12%** from the center of the field to the off center measurement location with the SmartCurve™ paddle. With the flat paddle, SNR differences are only approximately **2%**. CNR increased by about **30%** from the center for the curved paddle, while it increased by only **4%** for the flat paddle.

Spatial resolution was evaluated at one location for both the SmartCurve™ paddle and the flat paddle. The bar pattern section of the Leeds TOR 18FG phantom was positioned centrally in the right-left direction and towards the chest wall side of the phantoms. ROI's were positioned over the different line pair areas of increasing spatial frequency to generate relative MTF curves. As shown in Figure 4, the high contrast spatial resolution did not decrease when using the SmartCurve™ paddle and the two curves are very similar.

Figure 1. Simple breast phantoms used for compression paddle image quality evaluations. The SmartCurve™ phantom is shown on the left and the flat paddle phantom on the right. Aluminum sheets were used to determine SNR and CNR.

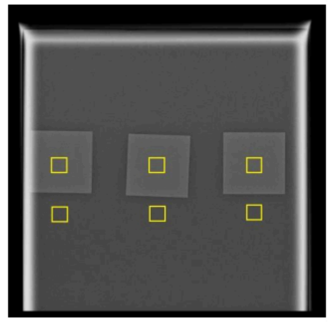

Figure 2. Phantom image used to calculate SNR and CNR for flat paddle.

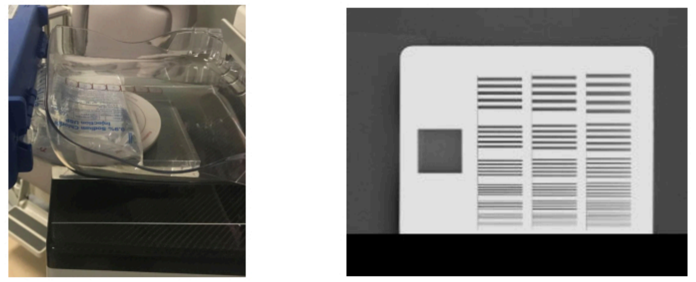

Figure 3. Image of Leeds TOR 18FG phantom setup and image used for relative MTF plot.

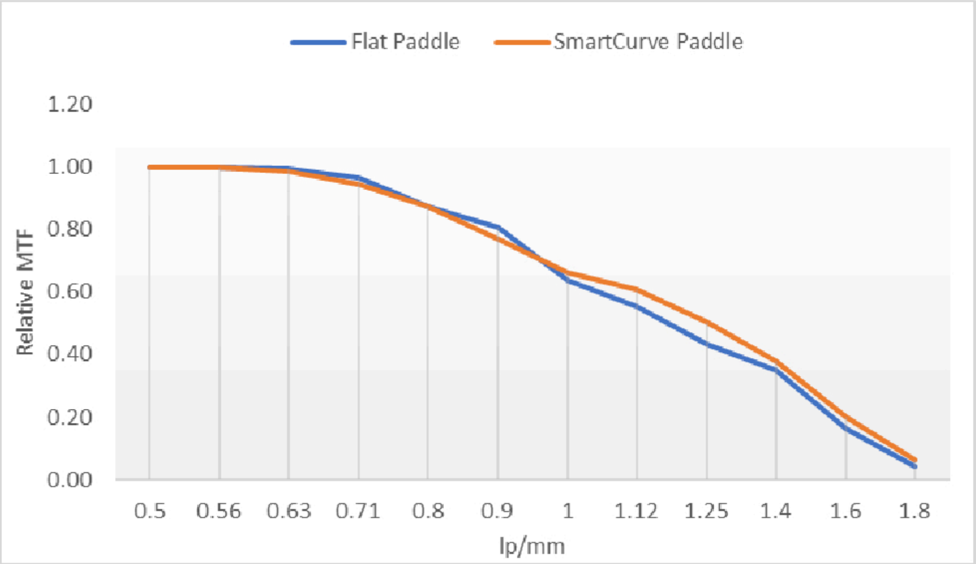

Figure 4. A plot of the relative MTF as a function of spatial frequency for the flat paddle and the SmartCurve™ paddle.

CONCLUSIONS

The image quality portion of the clinical trial comparing the SmartCurve™ compression paddle to a standard flat paddle was a reader study and did not include quantitative image quality metrics such as CNR or MTF. The radiologists did not show a preference for one paddle over the other when reading clinical images.[4]

Our work indicates that there is variation in SNR and CNR across the field of view when using the curved compression paddle. This is expected due to the different tissue thicknesses and attenuation encountered by the x-ray beam under the curved paddle. High contrast spatial resolution (MTF), on the other hand, was not clearly affected by the curved paddle and breast thickness differences for sufficient signal levels.

The advantages of digital mammography, such as a wide dynamic range and image post-processing capabilities, may play the important role when using the curved paddle for 2D mammography and explain why there was no preference for the flat paddle in clinical images. Hologic has developed a software algorithm (SmartCurve™ breast stabilization system) which is intended to compensate for breast thickness changes caused by the curved shape of the paddles. This could also explain the similarity in image quality seen in the clinical trial.

REFERENCES

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