Analysis of the Impact of Digital Image Format on the Evaluation of a Mammography Phantom

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INTRODUCTION: With the evolution of mammography systems to digital, the standard format adopted for image files is DICOM (Digital Imaging and Communications in Medicine). Despite offering high resolution and allowing adjustments to the contrast window, these files are bulky and not recognized by common Windows® software, requiring additional software [1,2]. This study aims to assess the quality of digital mammography images using different file formats (DICOM, JPG at four quality levels: 85, 90, 95, and 100% (8 bits), and PNG with lossless compression (8 bits)), and quantify the impact of compressions in each format.

METHODOLOGY: The study utilized the American College of Radiology (ACR) accreditation phantom to simulate breast structures, as shown in Figure 1. Images were acquired using a Retrofit DR mammography image receptor connected to an analog unit. The images were converted to different formats using Python and evaluated visually and objectively. Acquisition standardized voltage at 28 kVp and varied mAs (20, 40, 50, 56, 63, 71, 80, 90, 100) and target-filter combinations (Molybdenum-Molybdenum (MoMo), Molybdenum-Rhodium (MoRh), and Tungsten-Rhodium (WRh)). Images were normalized to 8 bits and visually assessed for fibers, microcalcification, and tumor masses. The Signal-to-Noise Ratio (SNR) metric was used for objective analysis (equation 1), with a defined Region of Interest (ROI) of 12x12 mm (Figure 2).

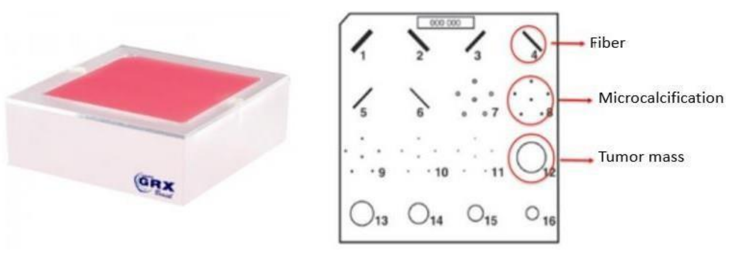

Figure 1: Presentation of the phantom ACR and their respective analysis structures.

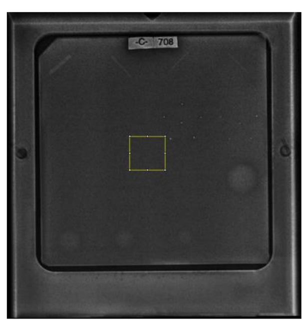

Figure 2: Demonstration of the phantom ACR and their respective ROI.

$$SNR = \frac{MVP_{BG}}{SD_{BG}} \qquad (1)$$

Data were statistically analyzed by comparing SNR values between formats and DICOM images, as well as relative differences obtained by dividing the differences by the DICOM SNR. Subjective results were analyzed using paired T-tests and graphically represented.

RESULTS AND DISCUSSION: Figure 3 displays the SNRs for DICOM images at different exposures, indicating a decreasing trend in SNR with increasing applied load. The MoMo filter showed the best stability for the 4.5 cm phantom, except for one outlier point at 56 mAs.

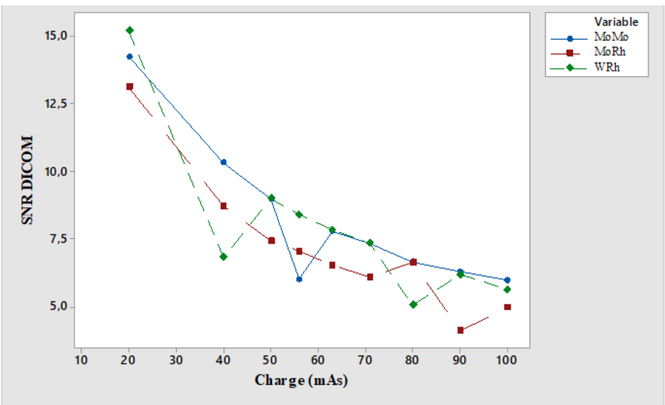

Figure 3: Scatter plot of the SNR for DICOM images.

Figures 4 (a, b, and c) illustrate the relative difference between image formats and the DICOM standard. Results for MoMo, MoRh, and WRh combinations show that extreme formats (JPG Q85 and Q95) had the poorest results, while JPG Q100 performed the best, varying within 0%. Relative differences were small, around 2% for all formats (except JPG Q85), suggesting that SNR may not be the best metric to show significant variations in processed images.

(a) (b) (c)

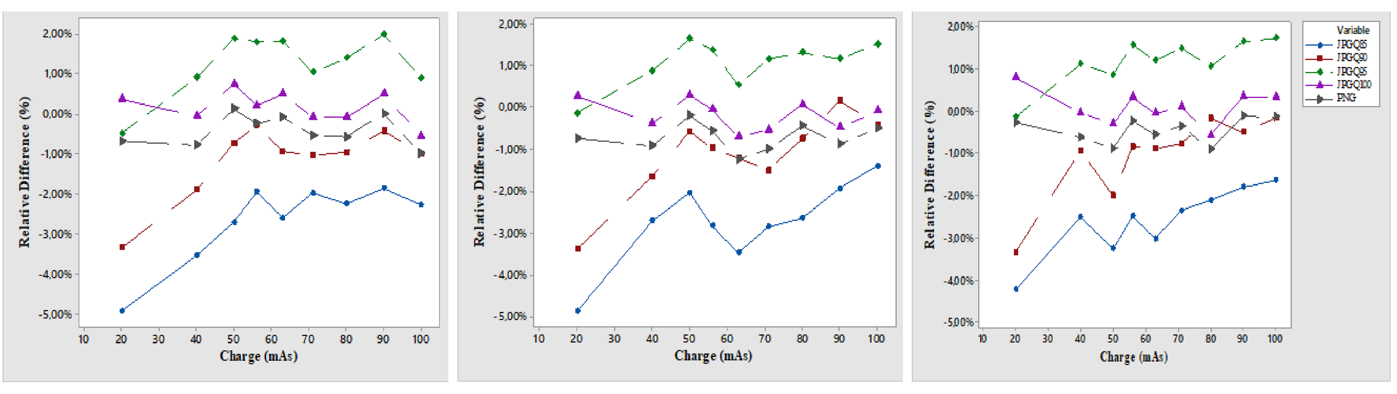

Figure 4: Scatter plots illustrating the SNR metric for the different formats and parameters in the following target - filter combinations: (a) MoMo; (b) MoRh; and (c) WRh.

Figure 5 shows discrepancies in means among image formats for phantom structures. JPG Q85 had the largest discrepancy, while PNG had the smallest for microcalcifications and masses, possibly due to its lossless compression. JPG Q100 yielded good results for fibers and tumor masses, but not for microcalcifications, possibly due to the lack of an objective metric for high-contrast structures, such as the contrast-to-noise ratio (CNR).

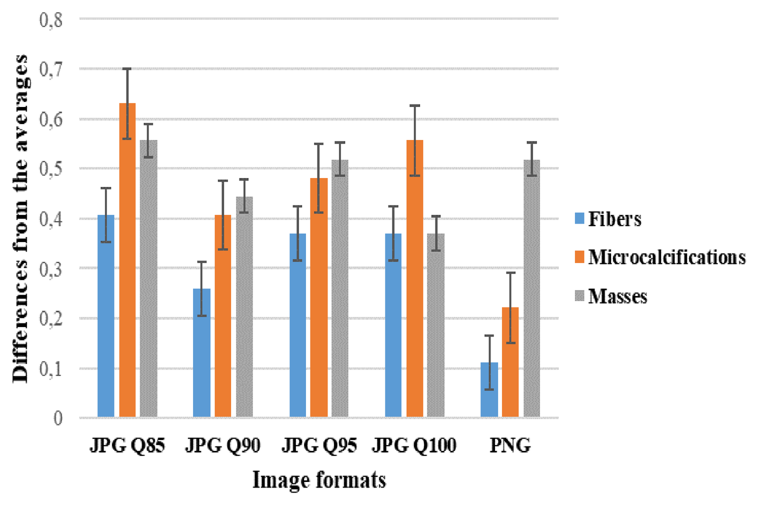

Figure 5: A stacked bar graph illustrating the differences in structure averages for the different formats for the ACR phantom.

CONCLUSIONS: The study concludes that the format of digital images significantly impacts the image quality of the ACR phantom. The JPG Q100 format was the most favorable, with smaller differences compared to the DICOM standard, while the JPG Q85 and JPG Q95 showed the worst performance, indicating a greater difference in quality. PNG format exhibited visually similar results to DICOM, suggesting close quality, although a reduction in quality was noted due to a decrease in bit depth. Overall, all formats are within an acceptable range, but it is crucial to consider the image format when evaluating the quality of mammography phantoms to ensure an accurate representation of anatomical structures.

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