Distortion introduced in radionuclide camera views by multiformat imagers

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The degree of spatial distortion of radionuclide camera images introduced by the multiformat imager is compared in six different cameras. The instruments tested were the Ohio Nuclear 110 and 410S, Searle Pho Gamma LFOV, and the General Electric 400T. We found image nonlinearity variations of 4 to 25%; this illustrates the need for industrial standards applied to imager spatial distortion performance.

Key words: radionuclide camera, multiformat imager, spatial distortion

INTRODUCTION

Multiformat imaging systems for displaying radioisotopic camera images on standard x-ray film are commonly used in nuclear medicine departments. This paper will investigate distortion or nonlinearity of scintigraphic views introduced by the imager. The National Electrical Manufacturers' Association (NEMA)[1] has placed special emphasis on performance measurements of the scintillation camera but standards for proper imager operation have not been specified. In the NEMA standard, camera performance is measured by interfacing a multichannel analyzer directly to the camera's energy and position signals. This technique is described in detail by Lewellen *et al.*,[2] who also mention limitations of the procedure.

However, the NEMA criteria assess only one part of the imaging system, the camera; formatter performance is not considered. The image formatter comprises one of the critical elements in the total imaging unit and must be included in a complete assessment of imaging system performance. This report will investigate distortions in scintigraphic images caused by the imager and compare image degradation in six separate camera systems.

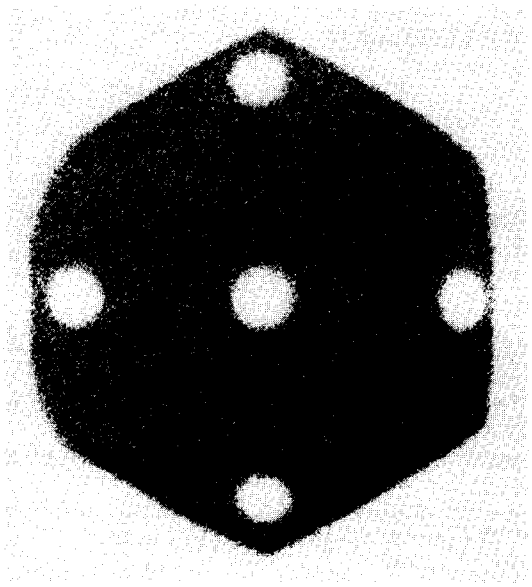

FIG. 1. Ohio Nuclear Ulti Mat image of 4.4 cm diam lead disks. Single image format was utilized.

EXPERIMENTAL METHOD AND RESULTS

If precise linearity of the displayed image is not maintained, critical measurements made directly from the film (e.g., lesion size) will be in error. The following studies will illustrate the image distortion problem and the magnitude of the error that nonlinearity may cause.

TABLE I. Image nonlinearity on a model 100 Ulti Mat. Dimensions normalized to the central disk size.

Image position	Horizontal size	Vertical size
12 o'clock	0.94	0.88
3 o'clock	0.75	1.00
6 o'clock	0.93	0.81
9 o'clock	0.88	1.00

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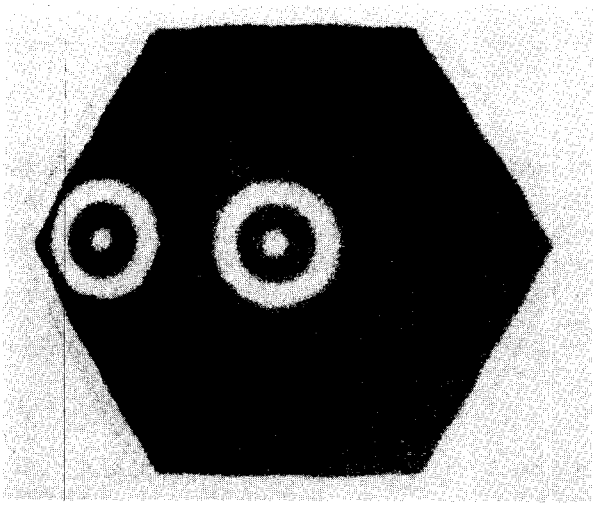

FIG. 2. Ohio Nuclear Ulti Mat image of 10 cm (outer diam) disks. Single image format was utilized.

Image distortion was measured in the following manner. Circular lead forms were placed on a camera's parallel hole collimator and an image made utilizing either a ^{99m}Tc or a ^{57}Co flood source. A 20% symmetrical window was used and between 0.5 to 1 $\times$ 10^6 counts per view were obtained. Single image format views of the disks were then examined for measurable distortion of the circular objects. The dimensions of the circular images were measured with vernier calipers. Figure 1 is a view of a series of 4.4 cm diam lead disks placed on the low-energy all-purpose collimator of an O.N. 110 camera and imaged with the Model 100 Ulti Mat (Ohio Nuclear, Inc., Solon, Ohio)[3] in the single image format mode. This 5 $\times$ 10^5 count image was made with a ^{99m}Tc flood source resting on the 4.4 cm diam lead disks. The source-to-collimator distance was 1.3 cm. Table I shows the measured horizontal and vertical dimensions of each circle at the image periphery normalized to the central circle dimensions. These results illustrate a variation in circle size of as great as 25% over the camera's field of view. The table also shows that the magnitude of the distortion is not constant about the periphery of the image. This prohibits the formulation of a scale factor for measurements made directly from the film.

A second Ohio Nuclear camera, the Sigma 410S, and the Model 100 Ulti Mat were tested and the results are shown in Fig. 2. This is an image of two 10 cm diam, 30-mm thick, lead disks placed on an O.N. low-energy all-purpose collimator. The image has 1 $\times$ 10^6 counts and was formed by placing a 2.0 mCi ^{57}Co flood source on the disks. The dimensions of the distorted circle relative to the central image are 0.83 $\times$ 0.95. This demonstrates a 17% deviation from linearity.

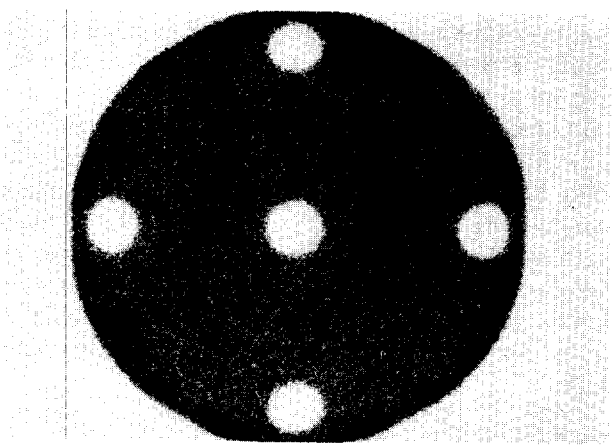

FIG. 3. Searle LFOV image of 4.4 cm diam lead disks. Single image format was utilized.

TABLE II. Image nonlinearity in a model 3132 Micro Dot imager. Dimensions normalized to the central disk size.

Image position	Horizontal size	Vertical size
12 o'clock	0.90	0.85
3 o'clock	0.95	1.00
6 o'clock	1.00	0.95
9 o'clock	0.85	1.00

In order to determine if the distortion could be due to the camera's detection system or electronics, the imager was bypassed and views of the disks were recorded with a computer. A matrix size of 128 $\times$ 128 was used for the data acquisition. One disk was placed in the center of the field of view and the other at the periphery. The relative dimensions of the digitized images of the two disks were determined by counting the number of pixels across the horizontal and vertical dimensions of each circle. The dimensions of the circle at the periphery relative to the central circle were 1.02 $\times$ 1.03. The distortion shown in Fig. 2 must have been introduced by the imager.

Figure 3 illustrates nonlinearity in a Searle Pho Gamma LFOV system with the Micro Dot imager (Searle Radiographics, Inc., Des Plaines, Illinois).[4] This single image format view shows a maximum distortion of 15%. Table II details the results of dimensional measurements of each circle at the periphery normalized to the central circle. Two other Searle LFOV systems with the Micro Dot imager were studied; in the single image mode circular image distortions of 2% and 5% were found. A maximum distortion of 4% was found on a G.E. 400T with G.E. formatter (General Electric, Milwaukee, Wisconsin).

CONCLUSION

Image formatter performance measurements must be included in a complete assessment of scintillation camera performance. As illustrated in this paper, gross nonlinearities may be introduced by the formatter. It is suggested that service representatives have signal generation test equipment for generating imager test patterns as is done for video imagers in order to adjust imager linearity, resolution, and uniformity. In addition, manufacturers should specify expected performance standards and how these are to be measured.

[1]National Electrical Manufacturers' Association: Performance Measurements of Scintillation Cameras. Publication NU 1-1980. Washington, D.C., 1980.

[2]T. K. Lewellen, D. L. Williams, R. Murano, G. W. Hamilton, and W. B. Nelp, J. Nucl. Med. **19**, 954 (1978).

[3]Technicare Inc.

[4]Siemens Inc.