Computed Radiography Printing Problems: A Quantitative, Observer-Independent Solution

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Even though facilities using computed radiography (CR) operate in an electronic environment, the production of hard-copy films is still necessary during the transition period, as well as for particular needs following complete implementation. We have implemented a quantitative technique to match the response of printed CR film with that of previous screen/film combinations. A stepwedge is radiographed using the conventional system. The same stepwedge is then radiographed (same geometry and technique) using the CR system. Following processing and printing, the plot of optical density versus step for the CR system is compared with that of the screen/film system. Adjustments are made to the printing parameters until the response curves are identical. All other translation tables in the system are set to be linear. This has proven to be a valuable technique for us and provides CR printed image quality that is equivalent to that of our previous screen/film combinations.

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COMPUTED RADIOGRAPHY (CR) is increasingly being implemented in radiology departments. With the introduction of this technique, most institutions discover that they must also produce hard-copy images for, at the very least, the time of transition from conventional screen-film imaging to electronic practice. Hence, it is necessary to produce hard-copy images for the department, as well for as the rest of the institution and outside referring physicians. These images must be of at least the same quality as the conventional screen-film imaging within that department. The difficulty in establishing these techniques is twofold: first, there are often seven different variables to alter, with either continuous range or up to 18 discreet values. Second, the criteria used to determine that the print quality is sufficient are often subjective and performed either by the opinions of a single radiologist or panel of radiologists. In either case, such polling for opinions can be extremely time-consuming and fraught with difficulty.

PROCESSING PARAMETERS

The processing parameters available for CR images exist primarily to provide for the conversion from the wide dynamic range of CR to the relatively narrow range of film. This can result in four parameters to adjust contrast, with an addi-

tional three parameters used for spatial frequency enhancement. These may be available on either the CR reader or on a processing workstation.

FILM QUALITY DETERMINATION

Once an image has been processed and printed, it is then necessary to determine whether the set of processing parameters used is the most desirable. Typically, an institution will process a given CR image with many different changes and have a radiologist judge which of those he or she prefers. An alternative approach is to establish a panel of three to five radiologists and determine the optimal processing parameter based on a consensus opinion. The difficulty with this approach is its qualitative nature, as well as personnel intensive methodology. In addition, this raises the possibility of a facility using print parameters that are observer-dependent.

MATERIALS AND METHODS

For the current approach, the CR system used was a Fuji 9000 Reader (Fuji, Stamford, CT) interfaced to a Siemens CR Gateway (Siemens, Iselin, NJ), which then transmitted images to a quality control workstation (MagicView 1000, Siemens). With this configuration, the image print processing is performed on the MagicView 1000, and the processed images are routed to a camera server, which then transmits the images to a laser printer (DryView 8700, Kodak, Rochester, NY). An aluminum step wedge and densitometer are used to provide and measure quantitative response. The seven parameters available for processing CR data and their explanations are given in Table 1. In general, our method consists of exposing a step wedge, using both the current screen-film system and the CR system. Following processing and printing, the resultant density curves are plotted and subsequent processing seeks to match the CR curve to that of the screen-film combination used. Specifically, the screen-film cassette is exposed (table-top) with an aluminum step wedge centered perpendicular to the anode-cathode axis. For this study, exposures were performed at 60 kVp with an mA to produce an optical density of 1.5 at the center step (for our

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0897-1889/00/1302-1009\$10.00/0

doi:10.1053/jdim.2000.6823

Table 1. CR Print Processing Parameters

Parameter	Processing Effect	TML Match	InSight Match
GT	Contrast type (density transfer curve)	F	F
GC	Rotation center (point of inflection for curve)	506.0	506.0
GA	Rotation amount (slope of the contrast curve)	1.12	0.96
GS	Density shift (speed)	-120	-120
RN	Frequency rank (edge enhancement frequency)	9	9
RE	Frequency enhancement (amount)	1.12	0.5
RT	Frequency type (adaptive enhancement)	T	T

system, 3.2 mA at 48-inch SID). Using identical exposure values and the identical geometry, another exposure was performed with the CR plate and cassette. The image was processed on the workstation using the recommended parameter values. Following printing, the 17 density steps were measured and the densities plotted against the step number. The values were adjusted until the resultant curve matched that found for the screen-film combination.

This procedure currently takes us approximately 30 minutes to perform for a new system. For our routine clinical work, we use two sets of parameters that reproduce the densities obtained using the Kodak TML film and Kodak InSight film. The time for a given system will depend on how close the initial selection of parameters is to the curve that is desired.

RESULTS AND DISCUSSION

The seven processing parameters for both screen-film combinations used at our facility are listed in Table 1. We have used these parameters successfully for both chest and general radiography for

more than 3 years. Our referring clinicians have been satisfied with image quality and sometimes feel that the CR printed images are superior to previous screen-film work. Our previous attempts to establish processing parameters that produced images equivalent to screen-film imaging were complicated and time-consuming. We had made earlier attempts to establish these parameters using a hybrid cassette and a panel of three radiologists to review the images for a three-view L-spine. Since our approach was to have the original image with two different processing techniques, this resulted in nine images to be reviewed by each of three radiologists. We found this approach extremely time-consuming for both technologists and physics staff, as well as radiologists. Even more disturbing was the possibility for lack of consensus due to the qualitative nature of this method. In addition, during this process some staff felt that they would like to have "their" images processed in a specific way. Thus, implementing such a procedure can have a negative impact on workflow and image management within the department.

In summary, we have found this technique to be robust and to produce laser-printed images of high quality, consistent with previous screen-film standards.

ACKNOWLEDGMENT

The authors thank Drs Thomas H. Berquist, John M. Knudsen, and Jerald H. Pietan for their assistance in our earlier film reviews. Dr J. Anthony Siebert is thanked for his physics consultation and discussion, which produced the inception of this approach.