

SCREENING FOR X-RAY FILM PROCESSING PROBLEMS AT DENTAL  
AND MEDICAL FACILITIES

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INTRODUCTION

Improper film development often leads to higher than necessary skin entrance exposure to patients and or radiographs of less than optimal diagnostic quality. Some facilities with skin entrance exposures within acceptable levels could further reduce patient exposure and improve diagnostic quality of radiographs by optimizing film processing conditions. It is therefore desirable to have a method to measure film processing problems independent of measurements of skin entrance exposure.

A simple method was developed utilizing pre-exposed x-ray films and a questionnaire which may be sent to medical and dental facilities or used at facilities by inspectors during routine inspections. It was determined that films exposed to x-rays or visible light could be stored and later sent or carried to facilities for use in testing film processing systems. Despite anticipated problems with latent image fading, exposure or damage in the mail, and insensitivity of pre-exposed film to non-optimal processing conditions compared with freshly exposed films, this system appears to determine accurately whether a processing system is operating optimally.

The questionnaire is useful in providing a catalog of film processing conditions and workloads that result in optimal film processing as measured with the pre-exposed film. The surveyor can then estimate whether a system is under optimal conditions when the test film is processed at a time that does not represent worst case processing conditions. Optimal processing conditions measured at one facility may then be used to suggest changes at facilities where processing conditions are not optimal.

PROCEDURE

A questionnaire form was developed to be completed at each facility studied. Information concerning the age of the processing chemicals and how often chemicals are changed, temperature, processing time, type of film used, and type of processing system is requested.

Step-wedge images were made on films with a single reproducible dental x-ray unit for dental facilities and with a single sensitometer for medical facilities. These pre-exposed films were then processed as a normal patient radiograph would be processed at each medical and dental facility.

When the processed test films and the questionnaires were returned from the facilities, the films were compared to the control films by use of a densitometer on the step-wedge image. Control films consisted of pre-exposed films from the

same batch which had been processed under optimal film processing conditions.

Comparison of the test film from the facilities being surveyed to the corresponding control film allowed us to classify each facility into one of the following three groups: underdeveloped films, optimally developed films, or uncertain development.

For facilities submitting underdeveloped films, changes in processing techniques are recommended based on the questionnaire information and the test film results. New x-ray technique factors may also be recommended. A later study of the facility may document whether recommended changes were actually made. For facilities with optimally developed films, the facility is notified that its film processing technique appears to be achieving complete development of the film.

When it is uncertain whether the facility is achieving optimal film development, the facility is contacted to clarify information that has led to the uncertainty or to obtain additional information. A second test film and follow-up questionnaire may be sent to these facilities. The facility may be asked to process the second test film on the day before changing chemicals.

To compare each test film to the corresponding control film we measured the ratio of the optical density on the same step of the test film and the control film respectively, the density being corrected for base plus fog in each case. This density ratio appears to be a good indicator of completeness of development, may be regarded as a fraction of completion of development relative to the control film, is useful in comparing film processing conditions, and allows a simple method of tabulating test results from facilities.

## RESULTS

It was found that density ratio was nearly constant over a wide range of step-wedge densities. The density ratio for any specific non-optimal processing conditions will vary somewhat depending on the film used.

The results that we have obtained to date indicate that the density ratio parameter is not sensitive to selection of technique factors used to expose the film. We have established separate control films for each batch of exposed films; however, it may be possible to use control films for more than one batch of test films.

Films and questionnaires were sent to 116 dental facilities and completed at 60 medical facilities by inspectors. Out of 96 dental facilities which returned the survey by mail 72 were determined to be underdeveloping their films, 7 had optimal film processing, and 17 had uncertain processing conditions which required follow-up surveys or phone calls to obtain additional information. Based on the completed processing questionnaires it was found that the facilities underdeveloping were usually not following the recommendations of the chemical manufacturer and/or those of the automatic processor manufacturer. Test films returned from three dental facilities were much darker than the control films. All three of these films were processed within one day after complete change of developer solution at each facility.

This survey method will detect serious film fogging problems which appear as increased density on the test film compared to the control film. Our facility visits have confirmed such film fogging problems noted on test films. Pre-exposed

test films are useful for carrying out darkroom fog tests at facilities during inspections, since they have a step-wedge image resulting in a range of normal radiographic densities when processed; however, when the procedure is used by a surveyor at a facility it is advisable to carry out a separate fog test using film from the facility. Film from the facility will detect fogging due to outdated film or film exposed to radiation at the facility that would not be detected with the pre-exposed film.

To compare D speed and E speed dental film we asked dental facilities to process test films of both types as they would process a normal dental radiograph. We then calculated the density ratio for each film type using separate D speed and E speed control films. The calculated density ratio for Kodak E speed film was greater than the calculated density ratio for Kodak D speed film unless the processing conditions were extremely poor (i.e., density ratio of D-speed film less than 0.5). For processing conditions that were nearly optimal for D-speed film (i.e. density ratio greater than 0.9 but less than 1.0) E speed test films sometimes indicated optimal processing conditions. Therefore, choice of E speed dental film to test processing conditions may not accurately determine optimal processing conditions for D speed film as noted above. These results indicate that many facilities with less than optimal processing could switch to E speed film without problems resulting from film processing and with little, if any, loss of contrast at the same selected kVp. E speed film appeared to be more sensitive to film fogging than D speed film.

For medical facilities we have tested several commonly used film types and so far have found no indication that testing with one type of film will lead to false conclusions about a processing system used for another film type. However, we have found that use of high contrast medical film, such a Kodak XRP film, gives less reproducible testing results than use of a medium speed medical film, such as Kodak XL film pre-exposed films.

#### CONCLUSIONS

The results of this screening procedure indicate it to be a useful and inexpensive method of determining film processing problems. The method is versatile in that it can be used while visiting facilities, or it may be used by sending the questionnaire and test films through the mail. When the questionnaire and films are sent through the mail and the results are presented to the facility by telephone or form letter, it is estimated that the personnel time expended on each facility averages approximately 30 minutes.

It is apparent from our results that the density ratio may vary with the film type used for testing. We have found that a convenient way to assess the magnitude of this problem is to use one film type as a standard and run pre-exposed films of other film types through the same processing systems. A density ratio is then calculated for each film type processed under identical conditions and a plot of density ratio of one film type vs density ratio of another film type may be made. Using this graph one may determine whether a particular type of film is appropriate as a test film depending on which film type(s) are used by the facility. This additional factor may be incorporated into the testing procedure. Although the density ratio results are somewhat dependent on the type of film used for testing the system, this method appears to detect serious film processing problems accurately when the test film type is not identical to the film type used at the facility.

The reproducibility problems that we have encountered with high contrast

medical film point out the need to check for reproducibility of results by processing several films through the same processing system before using a batch of pre-exposed films.

Film processing problems detected with this procedure may be grouped into two types. First is selection of inadequate film processing conditions that will not achieve complete film development even immediately after the chemicals have been changed; this is apparent when a test film processed very soon after the chemicals have been changed is not fully developed. Second is failure to replenish or change chemicals frequently enough to avoid depletion of chemicals; this is obvious when a test film processed just before the facility changes chemicals is not fully developed and a test film processed immediately after the chemicals have been changed is fully developed. Film processing problems may also be due to a combination of both of the above situations. We have found less film processing problems of the second type at medical facilities using automatic processors with automatic replenishers than at facilities using tanks or at dental facilities.

Using a density of greater than 2.0 for the control film area used to calculate the density ratio may have an advantage in that the higher density portion of the test films appears to be more sensitive to the second type of film processing problem noted, failure to change or replenish chemicals often enough. In this case the density ratio for high density areas of the control film tends to be lower than the density ratio for lower density areas on the control film.

We have used control films which are overexposed for dental facilities to aid in detecting "sight development" which results in the facility being classified as underdeveloping.

The overall results of this study indicate that dental film processing may be less than optimal in most facilities, including facilities that do not have skin entrance exposures above the accepted normal range. This method can be used in conjunction with other procedures to aid in decreasing patient exposure and to improve diagnostic information.

Some of the anticipated problems with this screening procedure have not been found once the survey was implemented. For example, there has been no evidence of latent image deterioration between the time of first use of pre-exposed films and the time of processing at subsequent facilities several months later. Test films were not processed until at least five days after the initial exposure of the film. Results have been consistent in that test films processed at facilities that are following proper processing techniques do match the control films. Conversely, when test films indicate a processing problem exists we have been able to find correct conditions to obtain a processed test film that matches the control film. The films have not been damaged in the mail.

While attempting to improve processing conditions at dental and medical facilities, the need to know specific conditions which give optimal results in a given system becomes apparent. Tabulations of data and the manufacturer's recommendations are essential to the effective use of this processing survey technique. Without these aids, the questionnaire answers have little meaning and it may require several test films and changes in processing conditions to achieve optimal film processing. Storage of these data and appropriate form letters on a computer system would allow creation of computer software to diagnose film processing problems based on questionnaire data and a density ratio.