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TECHNICAL REPORT

Rating the extent of surface scratches on photostimulable storage phosphor plates in a dental school environment

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Objective: The aims of this study were (1) to subjectively quantify the degree of scratching and smudging that had taken place in the junior clinic in the 9 months following the implementation of digital radiology; (2) to compare the findings with a previously published report; and (3) to identify areas in the protocol and training that can be refined to minimize future scratching and smudging.
Methods: Seven sets of blank clinical photostimulable storage phosphor (PSP) plates were scanned after exposing them at 65 kV and 7 mA for 0.80 s. Scanned plates were lightly wiped with a soft cloth and alcohol, repackaged in plastic sleeves, re-exposed and rescanned. The two sets of resulting images were subjectively rated independently by two investigators for artefacts and placed in five categories.
Results: Of all the images, approximately 75% were rated in the top 3 categories (most readable), leaving 17% and 8% in the poor and unsatisfactory categories, respectively. Mean rated values of the two image sets (before and after wiping) were not statistically different, but ratings slightly improved after cleaning the plates.
Conclusions: Wiping all plates to remove surface contamination may not always be necessary or desirable. Systems that are designed to minimize handling of the plates may help minimize scratching of them.
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Keywords: photostimulable storage plates; digital images; surface scratches

Introduction

Digital radiology promises many advantages over traditional film-based radiology.[1,2] These include acquisition speed, reduced radiation exposure to patients and healthcare workers, and environmental advantages of eliminating processing chemicals. There are several ways to acquire digital images, including solid-state electronic sensors such as charge-coupled devices (CCDs) and complementary metal oxide semiconductor active pixel sensors (CMOS-APS) and photostimulable storage phosphor (PSP) plates, which are processed indirectly.[3,4] Each imaging system has advantages and disadvantages.[5–8]

Among the advantages of PSP plates is their reported substantial dose reduction compared with D-speed film.[9] They also have a wide dynamic range, which may provide the flexibility when correcting underexposed and overexposed images without the need for retake.[3,9–11] Finally, when compared with thicker and harder CCD or CMOS direct digital sensors, their wireless design is thought to improve patient acceptance.[12] They come in formats similar in size, shape and flexibility to those of a traditional radiographic film. All of these traits make them appealing acquisition sources for dental schools, especially when first transitioning to digital radiology.

One of the disadvantages of PSP plates is their reported propensity to scratch, with a concomitant deterioration of image quality.[13–15] In fact, one study found that 95% of the plates used for 10 weeks became undiagnostic.[15] The sources of scratches and smudges on PSP plates has been postulated by users, but the actual cause has not been thoroughly investigated. Three general types of artefacts appear on the plates over time:

(1) small short scratches (which can appear individually or there may be several of them throughout the plate)

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(2) larger, wider scratches (which may appear individually or in groups) can be 2–5 mm long or longer, and sometimes appear as straight lines or as curved arcs
(3) smudges, sometimes almost invisible on the plate, look like clouds on the resulting images, may be small and wispy or heavy, almost opaque and may consist of one smudge or multiple smudges.

Popular consensus attributes the smudges to surface contamination on the plates, possibly as a result of the adhesive used in the barrier sheaths being transferred to the plate prior to the scanning process.

A second disadvantage of PSP plates in a dental school environment, possibly related to the first, is the number of people handling the plates, especially while they are unsheathed and therefore unprotected and vulnerable. In the authors' programme, plates are distributed by the dispensary, exposed and processed by the students, returned (unwrapped) to a dirty instrument bay, wiped down with alcohol solution by a technician, then returned to the dispensary (still unwrapped) for rewrapping in their infection control sleeves. With this number of handlers there is increased opportunity to introduce scratches; likewise, it is more difficult to train the different groups or instil ownership of the problem.

Many of the durability issues of PSP plates were identified and evaluated in a previous 2004 dental school study.[15] The study of Bedard and Davis[15] focused on a different system that had some common and some unique problems. If appropriate universal or systematic quality control protocols are to be developed, more information is needed to define the problem and solutions. That is, various types of PSP systems must be tested.

Radiology in the pre-doctoral dental clinic in the authors' institution transitioned from a film-based system to a PSP digital radiographic system in August 2006. The intraoral system that was selected for this change was OpTime, manufactured by Soredex (Milwaukee, WI). OpTime claims to have advantages over other current PSP systems. The system has an almost instant (4.3 s) image display, plates are self-erasing and they provide reduced handling for increased plate life. The aims of this study were (1) to subjectively quantify the degree of scratching and smudging that had taken place in the junior clinic in the 9 months following the implementation of digital radiology; (2) to compare the findings with a previously published report; and (3) to identify areas in the protocol and training that can be refined to minimize future scratching and smudging.

Materials and methods

The junior clinic has 300 PSP plates for radiographic imaging. They are packaged in 15 sets of 20 PSP plates for student use. These packages contain 12 size 2 and 8 size 1 plates. For this study seven package sets were randomly selected. Images were exposed using 65 kV and 7 mA for 0.80 s. The position indicating device (PID) was 12 inches long and the plate–focal point distance was 90.2 cm for each exposure. Exposed plates were processed through the OpTime scanner following the manufacturer's instructions. Once scanned, plates were lightly wiped with 95% alcohol to remove any surface smudges, repackaged in their infection control sleeves, re-exposed and scanned again. These procedures gave 40 images for each package or 280 in images total, half of the sets as dispensed, the other half "cleaned" with 95% alcohol. All were rated and categorized as described below. The ratings for the two sets were compared for paired and ordered data. The exact P value for a marginal homogeneity test for a row by column contingency ordered table (the ordered responses were the variables compared) was calculated through data permutation with StatExact 7 Statistical Software for Exact Nonparametric Inference (Cytel, Cambridge, MA).

While preparing to wipe surface contaminants off the plates, it was noted the plates had to be rubbed harder to remove contaminants if 70% alcohol was used than when 95% alcohol was use. In addition, it was observed that harder rubbing itself produced scratches. Therefore, it was decided to use 95% alcohol and light rubbing.

Images were viewed on a Viewsonic (Milwaukee, IL) VA 800 flat screen monitor and subjectively rated independently for scratches and smudges by two investigators using the following ordinal rating scale (sample images of each category are shown in Figure 1) Category 1, few or no artefacts; Category 2, moderate number of small, light scratches and artefacts, isolated "blobs"; Category 3, some isolated medium, dark scratches and artefacts; Category 4, moderate medium, dark scratches and artefacts, isolated "blobs"; Category 5, many medium, dark scratches and artefacts, multiple "blobs".

After the images were rated, the two investigators discussed the images scored differently. A consensus was reached for those images. Their consensus opinion provided the subjective standard.

Results

First the mean category score was calculated for the images in the pre-cleaned and post-cleaned sets. Prior to cleaning the mean value was 2.57; following cleaning it was 2.35. The ratings for the two sets were compared for paired and ordered data with a marginal homogeneity test. There was no difference between baseline and repeat assessments (marginal homogeneity test $P = 0.11$).

Figure 2 shows the percentage of the images rated in categories 1–5 for the pre-cleaned and post-cleaned plates. Notice that approximately 75% of both sets were rated in the lower 3 categories (most readable), with 12–17% and 7–8% in the 2 unsatisfactory categories. This is in contrast to the system in the previous study[15] evaluated, which showed 45% of the plates in the 2

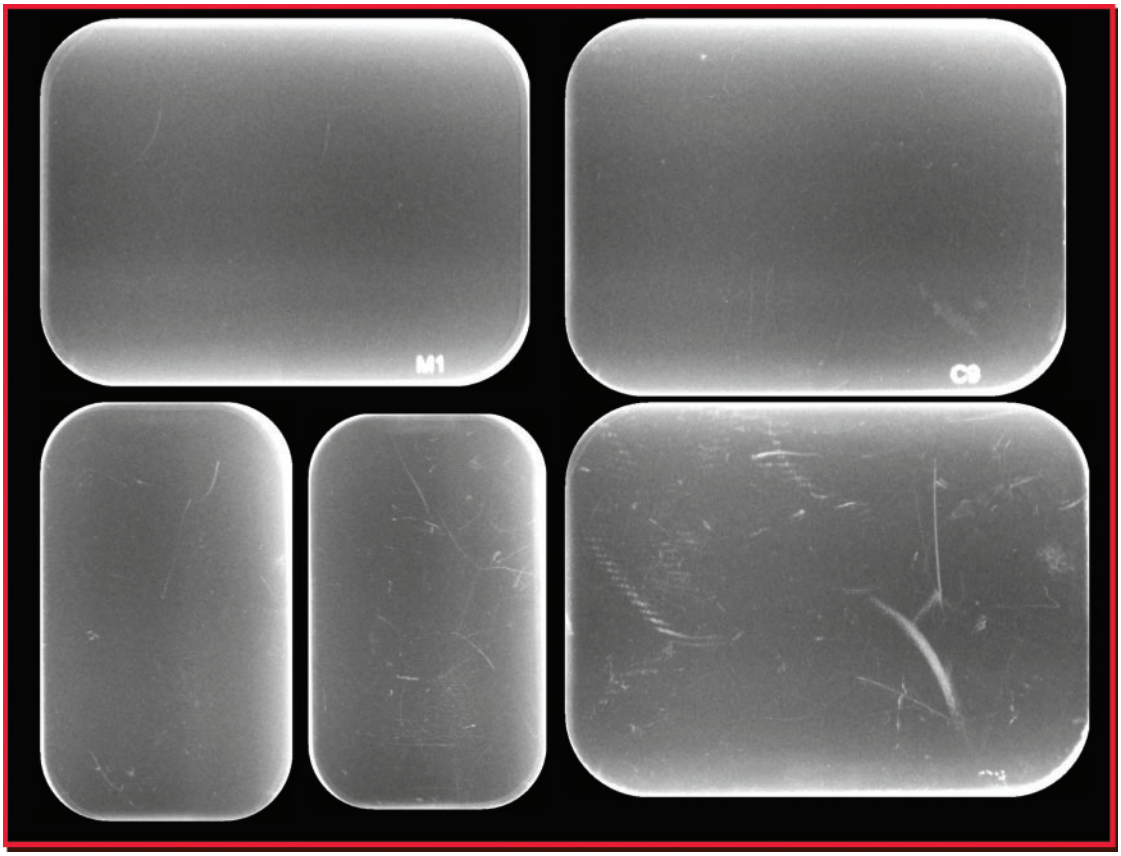

Figure 1 The categorization of the scratched plates into five different categories from the least damaged to the most severely damaged. (Category 1 on the left top corner, Category 2 at the right top corner, Category 3 on the left bottom corner, Category 4 in the middle and Category 5 on the bottom right corner)

worst categories after 8 weeks of use and 95% after 10 weeks of use.

Although the mean rated values for the two image sets were not statistically different, Chart 1 does indicate a small improvement of ratings after cleaning the plates.

Discussion

As stated above, there has been speculation about the sources of scratches and smudges on PSP plates, but the cause of most are unknown. With the OpTime system, however, opportunities for scratching have been minimized. During the exposure process the plates are protected; after exposure they are removed from their infection control sheaths and, without touching the plate, transferred from a cardboard protector to the OpTime scanner/processor. The protecting cardboard has one corner removed to expose a small metal button on the back of the plate. When the protected plate is placed in the feed slot of the scanner, the button is engaged by a magnet in the scanner and the plate is introduced into the machine without being touched. After scanning the plate and erasing it with a bright light prior to its next use, the plate is discharged into a receptacle. Consequently, the only opportunity to scratch the plate is from the finish of processing until placement in a new cardboard sheath. The protocol recommends that the plates be emptied from the processor receptacle into a paper cup to be transferred to the dirty instrument bay, where they are wiped down to remove surface (optical) contaminants, then transferred back to the dispensary, where they are repackaged.

At the time of this study, the clinic had used phosphor plates for 9 months and more than 15 000 exposures were charged by the system. Assuming that all the 300 plates used in the clinic (15 sets of 20) were used throughout the 9 months, each plate has, on average, been used approximately 50 times. This figure is consistent with the plates that had 10 weeks of use in the previous study.[15] Actually, the digital operation began with 10 sets and after 9 months increased to 15 sets, so some of the first 200 plates probably had even more exposures per plate, perhaps as many as 60 or 70. From the authors' experience, the plates are likely to be damaged if the plates are excessively bent to fit into the instruments and rubbed against rough surfaces. The operators are advised to be cautious to avoid these situations to increase the longevity of the plates. Handling the plates with gloves and wiping the soiled plates with a soft cloth will definitely help to increase the re-usability of phosphor plates.

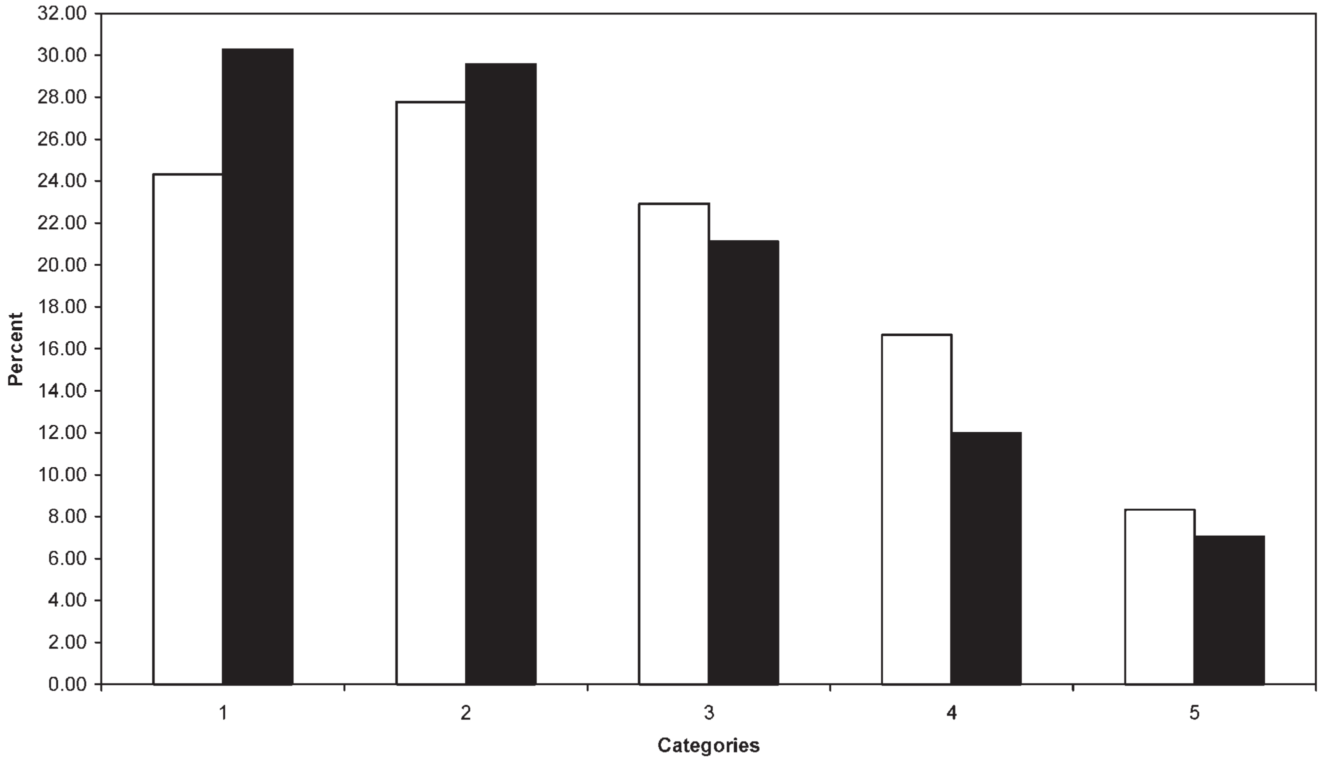

Figure 2 Chart 1 shows the image rating distribution of the 5 ratings before and after they were wiped with 95% alcohol. The *y*-axis shows the percentage of the plates in each category. □, pre-cleaned; ■, post-cleaned

When observing a 20-image series of processed PSP plates, one clearly sees scratches on most. The question becomes: "When do these scratches or the accumulation of scratches begin to interfere with our diagnosis?" Clearly, this study does not provide data on any diagnostic deterioration of subsequent images. Plates from different categories were not tested against diagnostic tasks. The authors' believe the subjective grading model is a reasonable first step for a systematic quality control protocol and provides an ability to compare one system with another. The relatively low number of worst category plates (25%) after 9 months of use in this study compared with the 95% plates in the 2 worst categories found in the previous study[15] speaks well for the OpTime system.

The "wipe-down" procedure was not intended to be for disinfection purposes; it was implemented to remove visible surface contamination that was believed to degrade the scanned radiographic image. We investigated wiping the plates with 70% alcohol and 95% alcohol. 2 × 2 gauze, pre-packaged alcohol gauze and tissue wipes were used in the preliminary study. All combinations removed visible contaminants, but, as stated, the amount of rubbing required to do so varied. It was also observed that vigorous rubbing, even with gauze, produced substantial scratches on the PSP plates. This unpublished mini-pilot study leads us to believe that wiping the plates can have a negative effect on plate quality by increasing the number of scratches. That and the fact that this current study showed no statistical improvement in the ratings of the wiped plates implies that wiping all plates may not always be necessary or desired, since it may increase the potential for scratches. Perhaps only plates that have visible surface contamination should be wiped. They should be *lightly* wiped with alcohol and checked to make sure the contaminant is removed.

The authors' believe that a 7–8% condemnation rate (the percentage in the worst category) of scratched plates is not unreasonable for plates with 50–70 exposures. As part of the quality assurance assessment, the plates should be evaluated routinely by staff, and any that are badly damaged should not be used for clinical radiographs.

This study and the previous study[15] both demonstrate the vulnerability of PCP plates to scratching. The addition of the cardboard protector and automated scanner seems to help, but as digital dental radiology becomes the imaging standard plate manufacturers will have to add a more protective coating to improve longevity. It also seems clear that dental offices and dental school clinics have a continuing challenge to encourage staff, faculty (practitioners) and students to handle the plates more gently.

It is concluded that wiping all plates to remove surface contamination may not always be necessary or desired. Systems that are designed to minimize handling of the plates may help minimize scratching of them.

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