RESEARCH ARTICLE

Infection control and patient discomfort with an alternative plastic barrier in intraoral digital radiography

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Objectives: (1) To compare the efficacy of a commercially available hygienic sheath and an alternative plastic bag in preventing contamination of the imaging plate during intraoral radiography and (2) to compare patient discomfort when using the hygienic sheath and the plastic bag.

Methods: 60 sterilized Size 2 imaging plates covered with either the hygienic sheath ($n = 30$) or the plastic bag ($n = 30$) were used to simulate digital periapical radiographic examination in 30 volunteer patients. After disinfection, each plate was swabbed. The swabbed medium was then plated on trypticase soy agar and incubated. Bacterial colonies were counted. Patient discomfort was assessed using a visual analogue scale (VAS) score. The comparison of the number of bacterial colonies and VAS scores between the two groups was tested by paired t -test at $p < 0.05$.

Results: There was no significant difference in the number of bacterial colonies between the two groups ($p = 0.745$). Of all the plates, 10% plates yielded bacterial colonies. The mean count of bacterial colonies for both groups was $10\text{--}20 \text{ CFU ml}^{-1}$. However, there was a significant difference between VAS scores for the two systems ($p = 0.000$). The mean VAS scores (range 0–10) for patient discomfort for the hygienic sheath group and the plastic bag group were 3.03 and 5.33, respectively.

Conclusions: Based on the design of this study, the alternative barrier provided similar results to those commercially available. Regarding the type of barrier envelope, the hygienic sheath induced less discomfort than the plastic bag.

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Introduction

Recently, digital radiography has become more commonly used in dental clinics. However, infection control in intraoral digital radiography using both Charge-Coupled Device/Complementary Metal Oxide Semiconductor sensors and imaging plates (or phosphor plates) is still

difficult and remains a problem because these two systems must be reused with each new patient but cannot be heat-sterilized.^{1–4} As a result, cross-contamination can occur. Digital intraoral receptors must be covered with protective barriers to prevent contamination.

Up to the present, research regarding contamination of image receptors in intraoral digital radiography and the effectiveness of barrier envelopes in preventing contamination has been scarce, although intraoral digital radiography has been in use for more than

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20 years.^{1–3,5,6} Methods to prevent cross-contamination include the use of protective barriers accompanied with antiseptic wiping before removing the plate from the protective barrier,^{1,3,7–9} or sterilizing the plate using ethylene oxide gas.⁶ The feeling of discomfort from using a protective barrier is another issue that should be considered in clinical application and only one study on this issue, by Wenzel *et al*,³ has been reported. Moreover, research regarding the effectiveness of other plastic barriers for use in the prevention of contamination on imaging plates has not been reported. Generally, the commercially available protective barrier is more expensive than a plastic bag sold in the market. However, before a cheaper plastic barrier can be used to replace a more expensive one, it must pass infection control qualifications. Therefore, this study aimed to (1) compare the efficacy of a commercially available hygienic sheath and an alternative plastic bag in preventing contamination of the image receptor during intraoral digital radiography and (2) compare the feeling of discomfort during intraoral digital radiography using the plastic bag *vs* the commercially available hygienic sheath as an imaging plate cover.

Methods and materials

The study protocol was approved by the Human Experimentation Committee (No. 20/2556) of the Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand.

61 Size 2 imaging plates (Kodak CS 7600, Carestream Health, Rochester, NY) sterilized by a 5.25% diluted solution of sodium hypochlorite (NaOCl) with distilled water with a ratio of 1 : 10, as suggested by the manufacturer, were used in this study.^{9,10} Positive and negative control groups were prepared as follows: (1) positive control group from saliva—an imaging plate was dipped in a petri dish containing trypticase soy broth mixed with the researcher saliva, the petri dish was inverted to allow the imaging plate to fall into another aseptic petri dish, an aseptic cotton roll stick was dipped in a test tube containing phosphate buffer solution (PBS) (a solution which is used to keep bacteria alive) and then, the cotton roll was smeared on both sides of the imaging plate. After that, the cotton roll stick was placed back in the same test tube of PBS. The PBS was then mixed using a vortex mixer and left for 15 min. An autopipette was used to obtain 100 μ l (0.1 ml) of solution to plate on the trypticase soy agar and then, it was incubated at 37 °C for 48 h in aerobic conditions. Finally, the growing bacterial colony was observed for colony characteristics, such as size, shape and colour. (2) Positive control group from the hand: the bacterial culturing method was performed similarly to that of the positive control group from the saliva, but a cotton roll stick swab was used on the researcher hand instead. (3) Positive control group from arm was also performed using a culturing method similar to that

of the positive control group with saliva, but a cotton roll stick was used to swab the researcher arm instead. (4) Negative control was also performed by culturing the bacteria the same way as the positive control group with saliva, but a cotton roll stick was used directly on a sterilized imaging plate.

Plastic bags (42 × 50 mm) and commercially available hygienic sheaths were randomly examined for any leakage using a water pressure test. 10 packs of barrier envelopes from each group were randomly selected. All of the barrier envelopes were filled with water and sealed, wiped with a dried cloth and placed on another dried cloth. A light finger pressure was applied on the barrier envelopes. The leakage of water was examined by visual inspection, while in addition trying to find scratches, crumpling or crinkling on both cover types. If any scratches, crumples or crinkles were found on any cover, it was discarded from the study. All of the plastic bags were sterilized with ethylene oxide gas.

The researcher wore sterilized gloves to place the imaging plate in commercially available hygienic sheaths (Kodak CS 7600, Carestream Health, Rochester, NY) and plastic bags (Figure 1), which were sized similarly to the imaging plate, 30 sets each, to prepare for intraoral periapical radiographic simulation by a radiological technician. Before the radiographic simulation, the researcher taught the radiological technician how to disinfect the barrier envelope after the radiographic simulation, as well as how to retrieve the imaging plate from the barrier envelope as suggested by the imaging plate manufacturer.

In the simulation of intraoral radiographic examination, the radiological technician wore gloves to assemble 60 sets of commercially available hygienic sheaths and plastic bags with a posterior Hanshin film holder (Figure 2). Written informed consent was given by 30 volunteer patients. The Hanshin film holder was placed in the volunteer mouth, letting the volunteer bite on the bite block to simulate a periapical radiographic technique in the mandibular molar region on each side. The

Figure 1 The commercially available hygienic sheath (a) and the plastic bag (b) used in this study.

Figure 2 The posterior Hanshin film holder with a commercially available hygienic sheath (a) and a plastic bag (b) containing an imaging plate.

patient bit on the bite block for 1 min each time and a different type of barrier envelope was used for each side. After each barrier type was used, the Hanshin film holder was taken out of the mouth and the barrier envelope with the imaging plate inside was taken out of the Hanshin film holder; then, both barrier types were sterilized using the same method as for sterilizing the imaging plate. To retrieve the imaging plate out of the plastic bag, the seal was unzipped and the imaging plate was pushed out and allowed to fall onto a clean and sterilized cloth. In the commercially available hygienic sheath group, the imaging plate was removed from the sheath by tearing along the patch and then, pushing the imaging plate to allow it to fall onto a clean and sterilized cloth. Later, the researcher used a cotton roll stick to swab on both sides of the imaging plate. The swabbed medium was then plated on trypticase soy agar and incubated for bacterial growth using the same method as the positive control group. The characteristics, shape and colour of bacterial colonies on the media were observed. The amount of bacterial colonies was counted in colony-forming unit per millilitre units.

Patient volunteers were asked to evaluate the discomfort from using each type of barrier envelope by indicating their feeling of discomfort on a visual analogue scale (VAS) score of 0–10, with 0 being not painful at all and 10 being very painful. In addition, the patient volunteers filled in a prepared form to provide further information regarding the discomfort experienced while biting the Hanshin film holder in each side.

The differences in the number of bacterial colonies and the differences in patient discomfort on the VAS between groups (the commercially available hygienic sheath group *vs* the plastic bag group) were analyzed using the paired *t*-test, with a confidence level of 95%. Descriptive statistics were used to show the percentage of bacterial colonies on the media plates, separated by barrier type.

Results

The characteristics, shape and colour of bacterial colonies found on the trypticase soy agar of the three positive

control groups are shown in Figure 3–5. There was no bacterial colony in the negative control group (Figure 6).

The plastic bag group showed bacterial colonies on 3 (10%) out of 30 media plates with a colony number of about 10 CFU/ml; the commercially available hygienic sheath group also showed bacterial colonies on 3 out of 30 media plates with a colony number of about 10–20 CFU/ml, as shown in Table 1 and Figure 7. No statistically significant difference in bacterial colony numbers between both groups was found ($p = 0.745$).

The VAS score of patient discomfort in the plastic bag group ranged from 0 to 8 (Mean = 5.33), whereas in the commercially available hygienic sheath group, it ranged from 0 to 10 (Mean = 3.03), as shown in Table 2. A statistically significant difference in the discomfort score was found between both groups ($p = 0.000$).

Figure 3 Positive control group showing bacterial colonies incubated from saliva on the trypticase soy agar.

Figure 4 Positive control group showing bacterial colonies incubated from the researcher hand on the trypticase soy agar.

Discussion

This study found that the number of bacterial colonies in the plastic bag group vs the commercially available hygienic sheath group was not significantly different, indicating that the plastic bag and the commercially available hygienic sheath had equal effectiveness for preventing contamination on an imaging plate. The average number of bacterial colonies found was

Figure 5 Positive control group showing bacterial colonies incubated from the researcher arm on the trypticase soy agar.

Figure 6 Negative control group showing no bacterial colony found on the trypticase soy agar.

considered low similar to the study by Wenzel *et al.*³ However, the average VAS score for patient discomfort in the plastic bag group (5.33) was significantly higher than that in the commercially available hygienic sheath group (3.03).

In our study, the existence of bacterial colonies in the media for both groups implies the possibility that the imaging plate was contaminated from saliva. The cross-contamination may have occurred while removing the imaging plate from the barrier envelope, exposing it to saliva from the surface of the envelope. Besides exposure to saliva, the imaging plate can be contaminated from bacterial flora found in the air⁶ or from skin.³ However, to determine whether or not the bacteria are from an intraoral source, typically oral streptococci, one must proceed with the Gram-staining technique or one may culture the bacteria on salivarius agar.²

The method of wiping the imaging plate barrier envelope is another possible factor that can cause the imaging plate to be exposed to saliva. Studies have reported that unpacking the imaging plate barrier envelope after wiping it with an antiseptic solution and allowing it to dry was considered a good way to decrease the amount of bacteria on the exposed imaging plate barrier envelope.^{7,11–13} In our study, after simulation of digital periapical radiography, the imaging plate barrier envelope was wiped with a gauze dipped in diluted sodium hypochlorite followed by a gauze dipped in water, and then with dried gauze. This was considered an effective method to decrease bacterial contamination of the imaging plate; however, it is complicated in clinical practice, especially in clinics with many patients and a lot of staff, where staff may neglect to wipe the barrier

Table 1 Bacterial contamination on imaging plates of the two test groups

Test group	Number of samples	Number (%) contaminated	Amount of bacterial contamination (CFU ml ⁻¹)
Plastic bag	30	3 (10)	10
Commercially available hygienic sheath	30	3 (10)	10–20

envelope causing the imaging plate to become easily contaminated.

In our study, all of the plastic bags were sterilized with ethylene oxide gas before use in the simulation of intraoral radiographic examinations. Although one study¹⁴ has reported that ethylene oxide could change plastic structures, sterilization of plastic materials with ethylene oxide gas is generally accepted as a standard sterilization procedure in healthcare facilities.^{10,15}

The average VAS score for patient discomfort in our study in the plastic bag group (5.33) was significantly higher than that in the commercially available hygienic sheath group (3.03). A possible reason is that the plastic bag may have a hard and sharp edge which can poke the patient gingiva or intraoral mucosa when the patient bites on the film holder, causing pain and irritation and consequently, increased salivation. Contrastingly, the commercially available hygienic sheath has a softer texture with a round/curved edge giving the patient more comfort while biting on the film holder. However, this study performed simulation of periapical radiography at only the mandibular molar area, where it may be easy to place the imaging plate while a patient feels comfortable. In real clinical situations, intraoral radiography is performed in different areas using different techniques and in some areas, owing to a variation of a patient anatomy, difficulty may occur while placing the film or imaging plate. Some intraoral anatomical characteristics, such as a shallow palate, a narrow and small dental arch, torus mandibularis or torus palatinus, can result in pressure of the imaging plate against the tissues and, ultimately, affect patient discomfort as evaluated by the patient on the VAS. In addition, the pressure of the imaging plate against the tissues may cause the barrier

envelope to be scratched or torn and finally lead to imaging plate contamination. Wenzel *et al*³ evaluated the patient discomfort on the VAS scores after bitewing radiography using Size 2 imaging plates and using a commercially available hygienic sheath. They discovered that the average patient discomfort on the VAS scores was <2 (Scale 0–10), which is less than the VAS scores in our study. One of the reasons could be the location of the imaging plate between the maxillary and mandibular teeth for bitewing radiography; thus, the imaging plate is not pressed into either the floor of the mouth or the hard palate, bringing the patient comfort.

This is the first study to test the effectiveness of using a plastic bag available in the market to prevent contamination on the imaging plate while evaluating the patient discomfort during the intraoral radiographic examination. The use of a plastic bag as an imaging plate barrier envelope must take into consideration the issues of convenience in use, comfort, expense and prevention of contamination as well as whether or not it is better than the commercially available hygienic sheath. However, no recent study has used other types of plastic bags to test their effectiveness in preventing cross-contamination of the imaging plate in the real clinical practice. Therefore, further study in such topics should be undertaken prior to applying other types of inexpensive imaging plate barrier envelopes, with qualifications similar to those of the commercially available hygienic sheath, to clinical situations.

Based on the design of this study, it can be concluded that the plastic bag is effective in preventing contamination of the imaging plate when compared with the commercially available hygienic sheath in intraoral digital radiography, whereas the patient feels more

Figure 7 Characteristics, shape and colour of the bacterial colonies obtained from both kinds of barrier envelope groups.

Table 2 The visual analogue scale (VAS) scores of patient discomfort in the two test groups

Test group	Number of patients	Range of VAS scores	Mean VAS scores
Plastic bag	30	0–8	5.33
Commercially available hygienic sheath	30	0–10	3.03

satisfied with the use of the commercially available hygienic sheath than with the plastic bag. This study along with other previous studies,^{1–3,5–7} however, shows that the contamination of imaging plates during intraoral digital radiography still occurs frequently and is also a difficult issue to solve. Therefore, strictly following infection control guidelines during intraoral digital radiography is highly recommended.

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