

A Comparison of Technique Errors using Two Radiographic Intra-oral Receptor-holding Devices

Sally M. Mauriello, RDH, EdD; Qun Tang, RDH, MSDH; K. Brandon Johnson, RDH, MS; Holly H. Hadgraft, RDH, BS; Enrique Platin, RT, EdD

Abstract

Purpose: Technological advances in intra-oral receptors have resulted in film-holding devices that may or may not be interchangeable with photostimulable phosphor receptors. This study evaluated the number and types of technique errors that occurred when using PSP receptors with a standard film-holding device and a dual PSP/film-designed device.

Methods: The Rinn XCP-ORA® (Standard) and the Rinn Flip-Ray® PA device (Test) were compared using rectangular collimation. DenOptix® imaging plates (sizes 1 and 2) were used as receptors. Fourteen periapical (10-size 2 and 4-size 1) projections were exposed per full mouth series on each Dental X-ray Teaching and Training Replica with both devices. Five Dental X-ray Teaching and Training Replicas were exposed by 3 experienced radiographers. Data were analyzed using a paired t-test to determine differences in the performance scores between the 2 devices. Technique errors (receptor placement, vertical angulation, horizontal angulation and cone centering) were reported using frequencies. An experienced evaluator critiqued each projection.

Results: A total of 15 full mouth series (210 projections) were taken per device. The mean performance scores per device were 88.4 (standard device) and 88.1 (test device) and were not statistically different ($p=0.88$). Cone centering errors were the most common error observed in both the standard (36%) and test (43%) devices. Receptor placement errors occurred when using the standard (12%) and test (9%) devices. Vertical and horizontal errors were <2% for both devices.

Conclusion: Devices designed for use with film may be used interchangeably with photostimulable phosphor receptors. Some difference was noticed between devices regarding error type and occurrence.

Keywords: intraoral radiographic technique errors, intraoral radiographic device, image quality, dentistry

This study supports the NDHRA priority area, **Clinical Dental Hygiene Care:** Assess the use of evidence-based treatment recommendations in dental hygiene practice.

INTRODUCTION

The earliest reported use of intraoral film-holding devices was by William H. Rollins in 1896.¹ Improvements have been made throughout the years on intraoral film devices in order to standardize variable factors, such as film position and X-ray focus. In addition, these devices have been designed to produce optimally comparable radiographs (size and accuracy of object).² Evolution has included the introduction of bite blocks, film support and backing plates, film-holding and beam-aiming devices.³⁻⁹ These devices were designed to be used with film and many are still on the market today.

The American Dental Association (ADA) recommended the use of a beam alignment device and rectangular collimation when exposing intraoral radiographs.¹⁰ In order to adhere to this recommendation, radiographers have continued to use paralleling devices originally designed for film even though many have transitioned to using digital photostimulable phosphor receptors. Since receptors have

varying dimensions, film-holding devices may not be interchangeable with photostimulable phosphor receptors. Anecdotal reports suggest that the photostimulable phosphor receptors are not secured tightly in the film-holding device and thus result in more technique errors. Common technique errors seen with film holders include receptor placement, vertical angulation, horizontal angulation and cone centering.

Technological advances in radiographic intra-oral receptors have promoted the development of new receptor-holding devices. More recently, a receptor-holding device commercially marketed for use with photostimulable phosphor and film receptors has been introduced in dentistry. The dual receptor designed device (Dentsply Rinn Flip-Ray® PA) was developed as a paralleling technique system that does not require changing parts for exposing horizontal and vertical periapical projections.¹¹ No studies evaluating or comparing technique performance of this

device to others have been reported in the literature. The purpose of this study was to compare the number and types of technique errors that occurred when using photostimulable phosphor receptors with a standard film-holding device and a dual photostimulable phosphor/Film-designed device.

METHODS AND MATERIALS

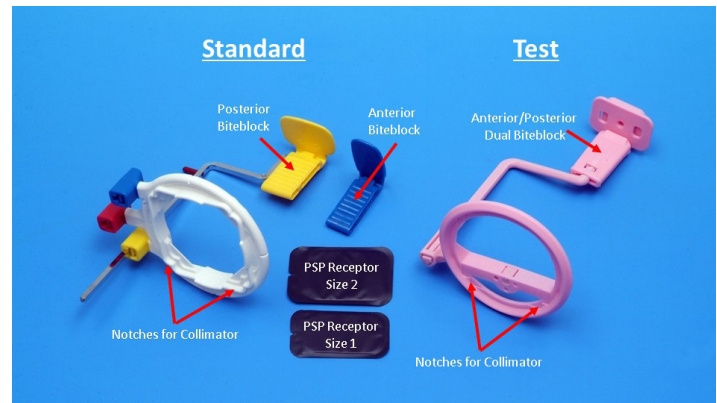
This study was designed to compare the technique quality of 2 intra-oral radiographic receptor-holding devices. Both devices were designed for use with the paralleling technique and rectangular collimation. The Dentsply Rinn XCP-ORA® (Standard) (Model # 550771, Elgin, Ill) and the Dentsply Rinn Flip-Ray® PA (Test) (Model # 552600, Elgin, Ill) devices are shown in Figure 1. The Standard device (XCP-ORA) was originally designed to be used with dental film. Two color-coded biteblocks, blue for anterior projections and yellow for posterior projections, are used with the corresponding color-coded knob on the aiming ring. Figure 1 demonstrates the Standard (XCP-ORA) device set up for use with a posterior projection. The Test device (Flip-Ray®) was originally designed for use with photostimulable phosphor receptors, but more recently has been marketed to be compatible with film or photostimulable phosphor receptors (dual-use device). Both the aiming ring and biteblock were adjustable for anterior and posterior projections by rotating them on the bar. Figure 1 shows the test device set up to be used for a posterior projection.

To standardize the receptor type, all projections were exposed using DenOptix® photostimulable phosphor (Gendex, Hatfield, Penn) receptors (displayed in Figure 1). Size 1 receptors were used for the lateral/canine periapical projections (n=4) and Size 2 receptors were used for the central (n=2), premolar (n=4) and molar (n=4) periapical projections. A total of 14 periapical projections constituted a full mouth series for purposes of this project.

Five Dentsply Rinn Dental X-Ray Technique and Training Replica (Model #546002, Elgin, Ill) manikins were used for the radiographic projections. Each manikin was constructed with a human skull and natural teeth which provided unique inherent characteristics. The manikins were designed to allow high reproducibility of projections which allowed for comparison of techniques. For this study, manikins were selected for use based on acceptable functioning of components (i.e. opens easily, locks securely on biteblock), reasonably aligned teeth (i.e. no missing teeth, extremely overlapped teeth) and normal anatomic structures (i.e. no shallow palate).

Each room was equipped with a Planmeca Prostyle Intraoral X-ray unit (Roselle, Ill) with a rectangular collimator insert. The kilovoltage peak (kVp) for each

Figure 1: Examples of Radiographic Devices and Photostimulable Phosphor Receptors



This figure displays an example of each intra-oral radiographic device used in the study. Positioned on the left is the XCP-ORA™ positioning system (standard) with Rinn XCP® anterior and posterior biteblocks. On the right is the XCP Rinn Flip-Ray™ PA positioning system. Centered are size 1 and 2 Photostimulable phosphor (photostimulable phosphor) receptors with barrier covers.

projection was 70. The exposure time for anterior projections was set at 0.20 seconds and a posterior projection was 0.32 seconds.

Each projection was evaluated based on predefined criteria assessing receptor placement, horizontal angulation, vertical angulation and cone centering. Specific criteria are stated in Table I. In addition, each projection was evaluated based on diagnostic acceptability such that the projection displayed the intended radiographic information. For example, the entire lateral and canine teeth were displayed in the lateral/canine projection. Criteria were defined as the presence or absence of technique error. Performance scores were calculated based on diagnostically acceptable and diagnostically unacceptable radiographs. On diagnostically acceptable radiographs, 1 point (-1) was deducted for errors present in each projection and 4 points (-4) were deducted for unacceptable projections for each full mouth series. Four points constituted the maximum number of points deducted per projection with a maximum number of points achievable per full mouth series is 56 (14 projections). Table II describes the application of point values per technique error.

Three qualified radiographers (licensed dental hygienists) exposed two full mouth series per Dentsply Rinn Dental X-Ray Technique and Training Replica. The years of experience of the 3 qualified licensed dental hygienists exposing intraoral radiographs totaling from 10 to 40 years. The radiographers were experienced using the paralleling technique with a beam alignment device. Both the Standard and Test intraoral receptor-holding devices were devices that used the paralleling technique and align the beam to the receptor. The Dentsply Rinn Dental X-Ray Tech-

Table I: Intraoral Radiography Performance Criteria for Periapical Examinations

| | |
|---|--|
| A. General Consideration - All periapical views should demonstrate: | |
| <ol style="list-style-type: none"> 1/4 inch (5mm) of alveolar bone visible beyond the apex of each tooth. 1/16 - 1/8 inch (1 - 2mm) margin between the crowns of the teeth and edge of the receptor. The occlusal plane should parallel the occlusal edge of the receptor. | |
| B. Specific Views | |
| <p>1. Central Projection (#2 receptor vertically placed) The central/central interspace is centered on the receptor. Demonstrate the central incisors, lateral incisors, and proximal portion of canines, incisive foramen and nasal fosse. Interproximal spaces open with emphasis between central incisors.</p> <p>2. Lateral Incisor/Canine Projection (#1 receptor vertically placed) The lateral/canine interproximal space is centered on the receptor. Demonstrate the entire lateral incisor; entire canine; distal portion of central incisor and mesial portion of premolar. Interproximal spaces open with emphasis between the lateral incisor and canine (the canine and the premolar will appear overlapped; this is a result of the transition to a double row of cusps and the normal curvature of the arch).</p> <p>3. Premolar Projection (#2 receptor Horizontally placed) Demonstrate no less than the distal third of the canine; the entire first premolar, second premolar and first molar; and the mesial portion of the second molar. Interproximal spaces open with emphasis on the canine/first premolar and first premolar/second premolar.</p> <p>4. Molar Projection (#2 receptor Horizontally placed) Demonstrate the first, second and third molars. Interproximal spaces open with emphasis between the first and second molar. This can be achieved by placing the anterior portion of the detector no further forward than the distal portion of the second premolar or by centering the second molar on the receptor.</p> | |

Table II: Point Values to Determine Performance Scores per Full Mouth Series

| Error Type | Error Severity | Point Value |
|--|---|-----------------------------|
| Receptor placement error or Horizontal overlap error or Vertical distortion error or Cone centering error | Error present but image is diagnostically acceptable | -1 out of 4 possible points |
| Receptor placement error and Horizontal overlap error | Both errors present but image is diagnostically acceptable | -2 out of 4 possible points |
| Receptor placement error and Horizontal overlap error and Cone centering error | Three errors present but image is diagnostically acceptable | -3 out of 4 possible points |
| Receptor placement error and Horizontal overlap error and Vertical distortion error and Cone centering error | Four errors present but image is diagnostically acceptable | -4 out of 4 possible points |
| Receptor placement error or Horizontal overlap error or Vertical distortion error or Cone centering error | Error present but image is not diagnostically acceptable | -4 out of 4 possible points |

nique and Training Replica sequence and device used first were randomly assigned. The evaluator was knowledgeable about the performance criteria and has evaluated radiographic technique errors for 35 years. During the image assessment, the evaluator was blinded to the devices used and the radiographers.

The study procedure was composed of the following steps:

- Five DXTTR manikins were assembled in 5 operatories
- Each radiographer was randomly assigned a Dentsply Rinn Dental X-Ray Technique and Training Replica and device

- Upon completion of the full mouth series, the exposed receptors were assigned a unique code number, scanned and stored in the School of Dentistry electronic patient record
- The radiographer progressed to the next assigned Dentsply Rinn Dental X-Ray Technique and Training Replica and device. This procedure continued until each radiographer exposed all 5 Dentsply Rinn Dental X-Ray Technique and Training Replicas using both devices.
- The radiographic images were accessed from the electronic patient record and evaluated on a 22 in. desktop monitor with 1024x768 pixels resolution in a low lit room. No enhancement features were used to alter the display of the image.
- Ten full mouth series (5 exposed with the standard device and 5 exposed using the test device) were randomly selected to be reread by the evaluator in order to determine intra-rater reliability. The rereading occurred approximately 4 hours after the initial evaluation of the images.

The outcome measure for the study was a full mouth series (14 periapicals) performance score. This score was determined by evaluating each image within the full mouth series. Thus, each projection within a FMX was assessed for the presence or absence of a technique error. Once the 14 images within the FMX were evaluated, a performance score was calculated. Fourteen images were worth a maximum of 56 points. The number of points calculated for the presence of an error was subtracted from 56 and then that number was divided by the maximum possible points to derive a percent score. For example, if five points were deducted due to 5 horizontal errors, then 51 would be divided by 56 for a percent score of 91.1 for the full mouth series.

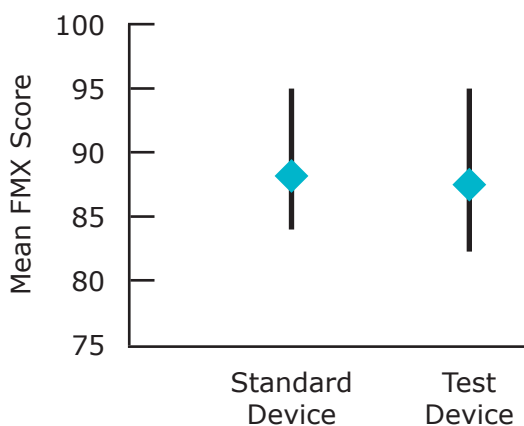
Data were entered into an Excel spreadsheet and analyzed. Technique errors (receptor placement, vertical angulation, horizontal angulation and cone centering) were reported using frequencies. A paired t-test was used to compare full mouth series mean performance scores between devices. Intra-rater reliability was assessed using an intra-class correlation.

RESULTS

A total of 15 full mouth series were taken using both devices (420 total projections) which resulted in 210 paired images that were assessed for technical quality. Intra-rater reliability was 0.87 (intra-class correlation).

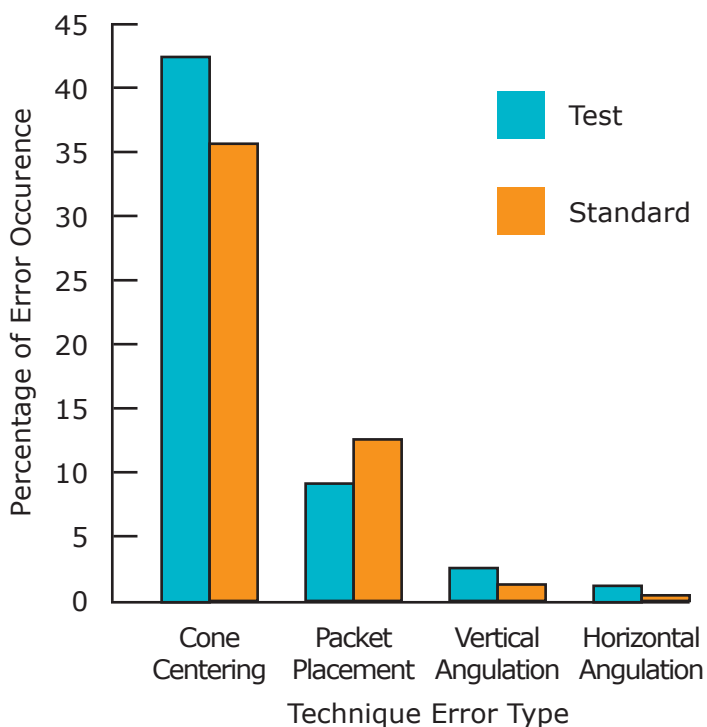
Figure 2 displays the mean performance full mouth series scores by device. The 15 full mouth series exposed by all radiographers using the standard device had an average score of 88.4 (range 84 to 97, standard deviation 5.5). In the same manner,

Figure 2: Mean Performance Scores by Device



The mean full mouth series performance scores per device were 88.4 (standard device) and 88.1 (test device) and were not statistically different ($p=0.88$).

Figure 3: Frequency of Technique Errors by Device



Cone centering was the most common error observed in both the standard (36%) and test (43%) devices. Receptor placement errors occurred in projections using the standard (12%) and test (9%) devices. Vertical and horizontal errors were <2% for both devices.

the average performance score for the full mouth series exposed with the test device was 88.1 (range 84 to 95, standard deviation 4.6). The scores were not statistically different with a p-value of 0.88.

Figure 3 presents the percent of technique errors by device. The percentage of technique errors was determined by dividing the number of times an error occurred by the maximum number of possible times the error could occur for each device. For example,

cone centering errors using the test device occurred in 90 images out of a possible 210 images. Cone centering and receptor placement errors were the most frequently observed errors that occurred. More cone centering errors were seen when using the test device (43%) compared to the standard device (36%). A similar percent of errors between devices were seen for receptor placement with the standard device displaying a slightly higher occurrence (12%) compared to the test device (9%). Vertical and horizontal errors were almost non-existent regardless of the device used. Diagnostically unacceptable images occurred in less than 1% of the projections with both devices.

DISCUSSION

No studies have evaluated the performance of the new device designed for use with film or digital photostimulable phosphor receptors. This study assessed both the number and types of technique errors that occurred with the test device as well as a comparison between the 2 devices. No statistical difference was seen between the 2 devices based on overall performance. A similar finding was reported in a study by Tang et al when comparing different beam alignment aiming rings used with paralleling devices.¹² One explanation for the findings of this study was that both devices were paralleling devices that aligned the beam to the receptor which allowed the projection geometry of the devices to compensate for minor alignment errors. Another reason for no performance difference may be that experienced radiographers were able to identify and problem-solve technical issues prior to making the exposure.

The findings also resulted in cone centering errors occurring at a higher frequency using the test device compared to the standard device. This finding was most likely attributed to the flexible nature of the device and not due to receptor dislodgment. Although the test device firmly secured the receptor in the biteblock portion of the device, the radiographers reported that the flexible design of the aiming ring to the swivel biteblock section allowed the geometry of the beam to the receptor to easily change. Another variable to note was the use of a rectangular collimator. It has been reported that a higher number of cone centering errors occur with the use of a rectangular collimator.¹³ Any cone centering errors that resulted due to use of the rectangular collimator would have occurred with both devices. The second most common technique error was receptor placement which occurred at a slightly higher frequency when using

the standard device. Receptor placement errors occurred primarily due to the increased flexibility of the photostimulable phosphor receptor or the receptor being dislodged from the biteblock. Since the photostimulable phosphor receptor was used with both devices, the most likely explanation for the slightly higher occurrence of receptor placement errors was a result of the receptor not being secured firmly in the biteblock.

A potential limitation of the study was the use of only 1 evaluator. The reason the authors chose to use one evaluator was to minimize error variance that would occur from the use of multiple evaluators. This was acceptable due to the specific performance criteria requiring the evaluator to identify the presence or absence of a technique error per projection. Intra-rater reliability was assessed to determine the amount of error due to this potential source of variance. Intra-class correlations determined intra-rater reliability to be good at 0.87.

CONCLUSION

It appears as though either device would be suitable for use with a photostimulable phosphor receptor. When using the photostimulable phosphor receptor with the standard device, extra precautions may be indicated to help secure the receptor in the biteblock and prevent inadvertent receptor placement errors. Radiographers should also take caution when aligning the collimator to the aiming ring of the test device. In addition, consideration should be given to manufacturing the test device with a sturdier material. It is important to remember that this study was conducted in a preclinical setting with a manikin. A clinical environment that involves tongue movement and tissue resistance may result in a different conclusion.

Sally M. Mauriello, RDH, EdD, is a Professor at the Department of Dental Ecology, School of Dentistry, at the University of North Carolina-Chapel Hill. Qun Tang, RDH, MSDH, is a full-time teacher at Milwaukee Area Technical College. K. Brandon Johnson, RDH, MS, is a Clinical Assistant Professor in the Department of Diagnostic Sciences, School of Dentistry, at the University of North Carolina – Chapel Hill. Holly H. Hadgraft, RDH, BS, is a project manager at Rho, Inc., Durham, NC. Enrique Platin, RT, EdD, is Enrique Platin, RT, EdD is a Clinical Professor in the Department of Diagnostic Sciences, School of Dentistry, at the University of North Carolina – Chapel Hill.

REFERENCES

1. Mauriello SM, Overman VP, Platin E. Radiographic imaging for the dental team. Philadelphia: JB Lippincott Co. 1995. p. 3.
2. Pitts NB. Film-holding, beam-aiming and collimating devices as an aid to standardization in intra-oral radiography: a review. *J Dentistry*. 1984;12:36-46.
3. Benkow HH. A new principle and appliance for radiographic tooth measurements. *J Dent Res*. 1957; 36:641-643.
4. Wege WR. A technique for sequentially reproducing intra-oral film. *Oral Surg*. 1967;23:454-458.
5. Colyer S. Some technical points in dental radiography. *Br J Radiol*. 1936;9:615-619.
6. Kells CE. Roentgen rays. *Dental Cosmos*. 1899;41:1014-1029.
7. McCormack FW. A plea for standardized oral radiography. *J Dent Res*. 1920;11:467-501.
8. Updegrave WJ. The paralleling extension-cone technique in intraoral dental radiography. *Oral Surg*. 1951;4:1250-1261.
9. Medwedeff FM, Knox WH, Latimer P. A new device to reduce patient irradiation and improve dental film quality. *Oral Surg*. 1962;15:1079-1088.
10. American Dental Association Council on Scientific Affairs. The use of dental radiographs. Update and recommendations. *J Am Dent Assoc*. 2006;137(9):1304-1312.
11. 2014 Product Catalogue. Dentsply Rinn [Internet]. 2014 [cited 2014 August 11]. Available from: <http://www.rinncorp.com>. Elgin, IL, USA or http://www.rinncorp.com/Pdf/MK287_FlipRay-PA_2.pdf
12. Tang Q, Mauriello SM, Platin E, Ludlow JB. Three intraoral radiographic receptor-positioning systems: a comparative study. *J Dent Res*. 2012;91(Special Issue A):Abstract number 1397.
13. Parrott LA, Ng SY. A comparison between bite-wing radiographs taken with rectangular and circular collimators in UK military dental practices: a retrospective study. *Dentomaxillofac Radiol*. 2011;40(2):102-109.