A digital radiographic artifact: A clinical report

Daniel M. Schweitzer, DDS,[a] and Robert W. Berg, DMD[b]
College of Dentistry, New York University, New York, NY

Digital dental radiographic imaging is considered to be as diagnostically accurate as conventional film-based radiography. In addition, many digital radiographic systems offer various image enhancements that may aid in image interpretation. However, neither type of radiographic imaging technique perfectly correlates radiographic diagnoses with clinical findings. Moreover, visual digital enhancements may provide information that is diagnostically misleading. This report presents a completed patient treatment evaluation with both enhanced and unenhanced digital radiography. The outcome suggests that clinicians should be careful with the interpretation of digital radiographic images, as this can potentially result in false-positive diagnoses. (J Prosthet Dent 2010;103:326-329)

Dental radiology is a valuable adjunct in diagnosis and treatment planning.[1,2] It also serves as a useful verification modality to aid in optimizing the quality of the treatment outcome. While considered to be as diagnostically accurate as conventional film-based radiography, digital dental radiographic imaging offers additional advantages such as decreased patient radiation exposure and faster image processing.[2-6] Digital radiographic images can also be adjusted to enhance information and suppress radiographic noise (unwanted variations within an image leading to potential misdiagnoses). Contrast, edge enhancement routines, magnification capabilities, and other enhancement features are routinely included in commercial digital systems to augment the clinician's diagnostic ability.[2,5,7] However, neither conventional nor digital radiographic examination imaging techniques enable the clinician to perfectly correlate the radiographic diagnoses with clinical findings. This clinical report describes a digital radiographic enhancement artifact that may potentially result in false-positive diagnoses.

CLINICAL REPORT

A 64-year-old white man presented for dental treatment with complaints concerning the extent of wear and sharpness of his teeth. Following a complete clinical and conventional radiographic examination and recording of dental history, the patient's diagnosis included the following: defective amalgam and composite resin restorations with secondary caries, multiple teeth with insufficient proximal contacts and evidence of food impaction, multiple teeth with primary caries, and generalized severe occlusal wear and erosion with likely decrease in occlusal vertical dimension.

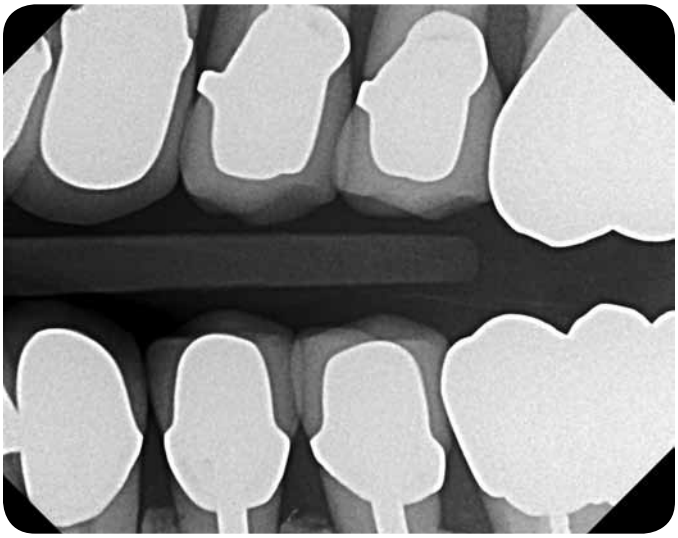
Complete-mouth rehabilitation proceeded with the fabrication and insertion of multiple cast posts and cores as foundation restorations and metal ceramic complete coverage restorations. The posts and cores were fabricated in type III gold alloy (Harmony Hard; Ivoclar Vivadent, Inc, Amherst, NY) from direct polymethyl methacrylate patterns (Pattern Resin LS; GC America, Inc, Alsip, Ill), fitted with a silicone disclosing medium (Fit Checker; GC America, Inc), and luted with a zinc phosphate luting agent (Fleck's; Mizzy, Inc, Cherry Hill, NJ). Definitive impressions for the metal ceramic crowns were made with medium- (Impregum; 3M ESPE, St. Paul, Minn) and light-body (Permadyne; 3M ESPE) polyether impression materials. The impressions were poured in type IV stone (Fujirock; GC America, Inc). High noble gold alloy (Golden Ceramic; Ivoclar Vivadent, Inc) was used to fabricate castings to which porcelain (Halo; Shofu Dental Corp, San Marcos, Calif) was subsequently added. The metal ceramic restorations were adjusted and fitted intraorally by use of shimstock foil (Artus Corp, Englewood, NJ) for proximal contacts and a silicone disclosing medium for internal fit. Digital radiographic evaluation (bitewing and periapical radiographs) and clinical evaluation (visual and tactile examination) for marginal fit were performed to ensure satisfactory seating of the restorations. The metal ceramic restorations were definitively luted with a resin-modified glass ionomer luting agent (Fuji Plus; GC America, Inc).

In accordance with the guidelines for the certification process of the American Board of Prosthodontics, a complete series of posttreatment digital radiographs was made. Software

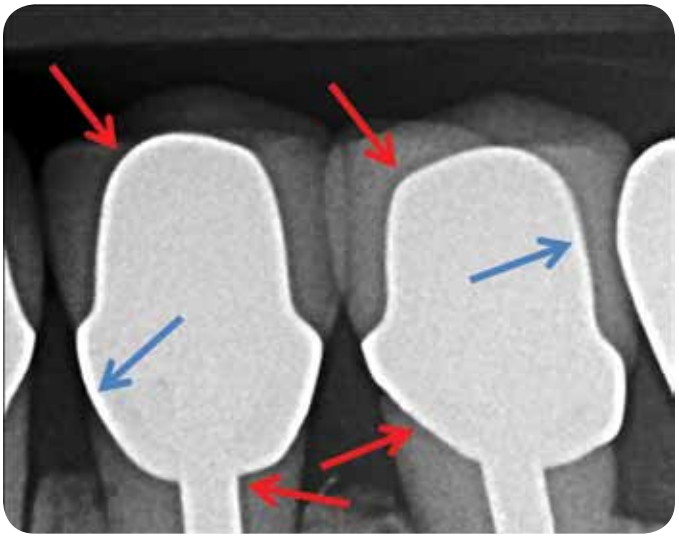
[a]Clinical Assistant Professor, The Jonathan and Maxine Ferencz Advanced Education Program in Prosthodontics.
[b]Clinical Assistant Professor, The Jonathan and Maxine Ferencz Advanced Education Program in Prosthodontics.

(Dexis Software Release 8; Dexis, LLC, Des Plaines, Ill) was used with an operating system (Windows XP; Microsoft Corp, Redmond, Wash) on a personal computer with a central processing unit (Intel Core2 Duo, 2.53 GHz; Intel Corp, Santa Clara, Calif) and a graphics processor (ATI Radeon HD 2400 XT; Advanced Micro Devices, Inc, Sunnyvale, Calif). This was used in conjunction with a radiographic sensor system (Dexis Model 601P Portable Digital X-Ray Sensor System; Dexis, LLC). Radiographic exposures were produced by an intraoral radiographic system (Acuray Model 071A; Takara Belmont USA, Inc, Somerset, NJ) at 70 kVp, 10 mA, with an exposure time of 8/60 second.

The postinsertion digital images were viewed by using software (Dexis Software Release 8; Dexis, LLC) with a 22-inch liquid crystal display monitor (Model no. 2208WFP; Dell, Inc, Round Rock, Tex) with the resolution set at 1680 x 1050 pixels. The images were viewed in an approximately 7 x 9-inch desktop window. Evaluation of the postinsertion digital images was performed in unenhanced and enhanced modes. The enhanced mode used a software feature that automatically alters image brightness and contrast to aid in the potential diagnoses of caries and tooth fractures (ClearVu; Dexis, LLC). Upon review of the enhanced images, a distinct marginal radiolucent halo was evident at all of the indirect restoration-tooth interfaces, possibly indicating a near uniform misfit of the luted definitive restorations or the presence of caries. Additionally, a radiolucent halo was evident at the metal ceramic interface of each restoration, possibly indicat-

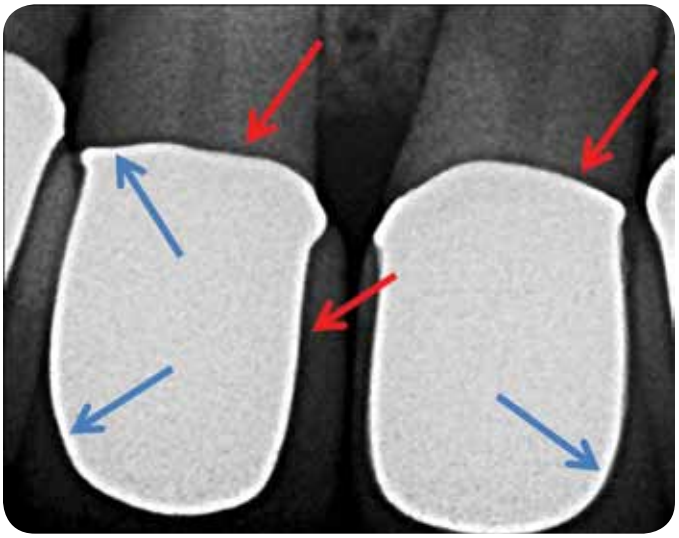


1 Posttreatment bitewing radiograph with ClearVu enhancement.

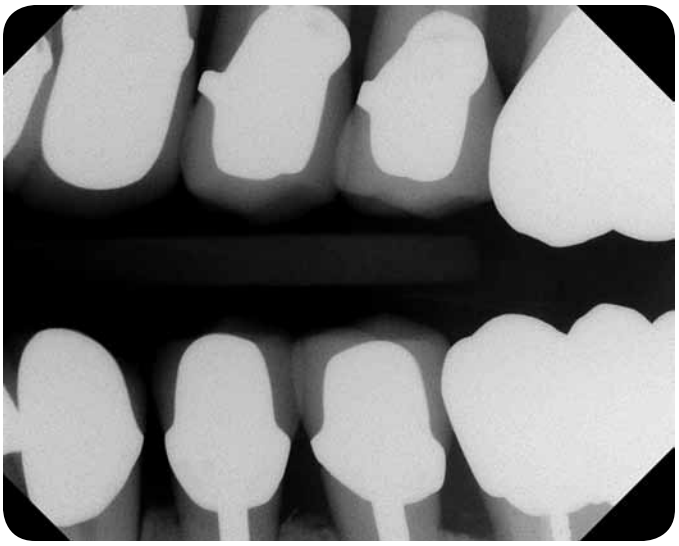


2 Closer view of posttreatment bitewing radiograph with ClearVu enhancement in Figure 1. Red arrows indicate radiolucent artifact. Blue arrows indicate radiopaque artifact.

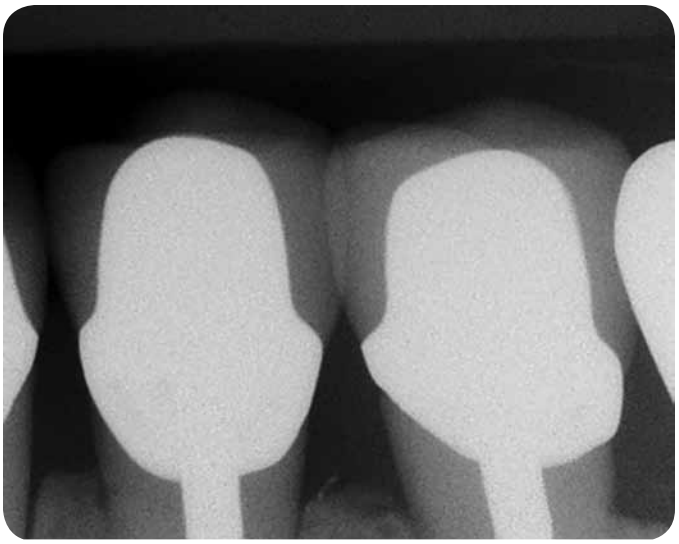
3 Posttreatment periapical radiograph with ClearVu enhancement.



4 Closer view of posttreatment periapical radiograph with ClearVu enhancement in Figure 3. Red arrows indicate radiolucent artifact. Blue arrows indicate radiopaque artifact.

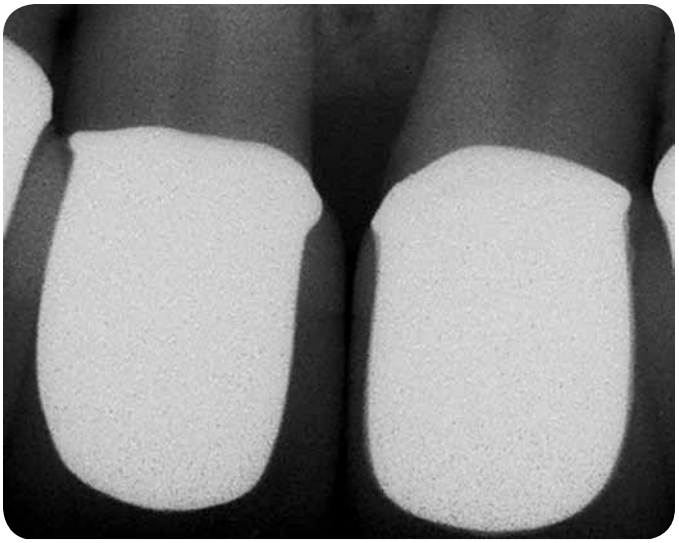


5 Posttreatment bitewing radiograph without image enhancement.



6 Closer view of posttreatment bitewing radiograph without image enhancement in Figure 5.

7 Posttreatment periapical radiograph without image enhancement.



8 Closer view of posttreatment periapical radiograph without image enhancement in Figure 7.

ing structural imperfections within the prostheses. Uniformly paired with the radiolucent halos were radiopaque halos within the counterpart opaque structures in each digital image (Figs. 1 through 4). However, the original digital images, viewed without the enhancement feature, showed no radiolucent indication of restoration misfit, nor did they exhibit any of the other interface artifacts observed in the previously described enhanced images (Figs. 5 through 8). This change in visual information, on the identical radiographic image, can potentially result in interpretive confusion and, hence, increase the chance for diagnostic error.

DISCUSSION

Inaccurate interpretation of diagnostic data can result in failure to diagnose and treat dental disease or can potentially generate unnecessary treatment. Radiographic imaging provides important diagnostic data that aid the clinician in developing an accurate treatment plan for each patient. Digital radiographic imaging has made the acquisition of radiographic information easier for the clinician. Additionally, digital imaging systems provide numerous software packages that impact the ability to accurately interpret a radiographic image.

The interpretation of digital images differs from that of conventional film. Primarily, digital images are often scaled much larger than conventional film images due to computer monitor screen size. Currently avail-

able digital radiographic systems and software packages use algorithms that allow the user to manipulate the captured radiographic data. These include measurement of density and histogram analysis of density values, spatial image filtering (noise reduction and edge enhancement), pseudocolor and negative display, zooming in on an area of interest, and electronic millimeter grids and rulers for superimposition on captured images. A feature that aids in the diagnosis for one condition may not necessarily aid in the diagnosis of another condition.

According to the manufacturer of Dexis software (Dexis, LLC), the enhancement features used in its digital radiographic imaging software system do not alter the original image files, but instead extract different information from the image files and accentuate elements of the original image. More specifically, enhancement of the contrast in digital images is frequently done to increase image sharpness and aid in the diagnoses of dental pathology, such as proximal caries, ill-fitting restorations, or fractures.[5] ClearVu is an enhancement feature in Dexis that clarifies and sharpens the image by increasing the image's contrast. Contrast refers to the difference between the light and dark shades of grey in a digital image. When contrast is increased in a digital image, all pixel values are stretched; the dark shades become darker and the light shades become lighter.[8,9]

Controversy exists concerning the diagnostic efficacy of enhancement features used for digital radiographic imaging.[8-11] In this clinical report, the radiolucent artifacts observed in the enhanced postoperative digital radiographic images could have suggested restoration misfit and/or caries associated with the completed treatment. Similarly, the radiolucent intrarestorative artifacts could have suggested that there were imperfections or voids at the exhibited metal ceramic interfaces. However, when compared to the original, unenhanced images, these potential treatment concerns seemed invalid. Enhancements used in packaged digital radiographic imaging systems should be used cautiously as a diagnostic adjunct, and only in conjunction with unenhanced images to attain accurate radiographic diagnoses.

SUMMARY

Contemporary dental digital radiographic software packages often include enhancement features that can alter the visual information presented to a clinician. Careful interpretation of these images is needed as they can potentially result in false-positive diagnoses of dental pathology, prosthesis misfit, and/or structural imperfections within a prosthesis.

REFERENCES

1. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 3rd ed. Chicago: Quintessence; 1997. p. 8.
2. American Dental Association Council on Scientific Affairs. The use of dental radiographs: update and recommendations. J Am Dent Assoc 2006;137:1304-12.
3. Versteeg CH, Sanderink GC, van der Stelt PF. Efficacy of digital intra-oral radiography in clinical dentistry. J Dent 1997;25:215-24.
4. Wenzel A. Digital radiography and caries diagnosis. Dentomaxillofac Radiol 1998;27:3-11.
5. Haak R, Wicht MJ, Noack MJ. Conventional, digital and contrast-enhanced bitewing radiographs in the decision to restore approximal carious lesions. Caries Res 2001;35:193-9.
6. Hadley DL, Replogle KJ, Kirkam JC, Best AM. A comparison of five radiographic systems to D-speed film in the detection of artificial bone lesions. J Endod 2008;34:1111-4.
7. Kitagawa H, Farman AG. Effect of beam energy and filtration on the signal-to-noise ratio of the Dexis intraoral X-ray detector. Dentomaxillofac Radiol 2004;33:21-4.
8. Gotfredsen E, Wenzel A, Gröndahl HG. Observers' use of image enhancement in assessing caries in radiographs taken by four intra-oral digital systems. Dentomaxillofac Radiol 1996;25:34-8.
9. Güneri P, Lomçali G, Boyacioglu H, Kendir S. The effects of incremental brightness and contrast adjustments on radiographic data: a quantitative study. Dentomaxillofac Radiol 2005;34:20-7.
10. Tyndall DA, Ludlow JB, Platin E, Nair M. A comparison of Kodak Ektaspeed Plus film and the Seimans Sidexis digital imaging system for caries detection using receiver operating characteristic analysis. Oral Surg Oral Med Oral Path Oral Radiol Endod 1998;85:113-8.
11. Meier AW, Brown CE, Miles DA, Analoui M. Interpretation of chemically created periapical lesions using direct digital imaging. J Endod 1996;22:516-20.

Corresponding author:
Dr Daniel Schweitzer
133 East 58th St, #803
New York, NY 10022
Fax: 646-735-1843
E-mail: dmschweitzer@gmail.com