Current Techniques and Principles in Dental Radiology: Part II

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This article is the second in a two-part series providing an overview of current principles in dental radiology. Although not new to medicine, the application of digital imaging in dental practice (as discussed in Part I, Jansen L, Overman V, Mauriello S. Current Techniques and Principles in Dental Radiology: Part I. J Pract Hyg 2002;11(4):19-22) has been slow to emerge. Consequently, many dental offices may still utilize traditional film-based imaging or a combination of both film-based and sensor-based imaging. This article reviews film characteristics, imaging geometry principles, and film-holding devices that can be applied to both imaging systems.

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Introduction

Currently, there are two image receptor systems available on the market—film-based and sensor-based. The following will discuss the film-based characteristics and qualities important in displaying a diagnostically acceptable radiograph. Specific characteristics to be reviewed include: speed, contrast, latitude, sharpness, resolution, and mottle.

Film Characteristics

Film-based systems are categorized into screen (indirect exposure) and nonscreen (direct exposure) imaging systems. Regardless of the type of film-based imaging system, the film is composed of two primary components—a base and an emulsion. The base is composed of a polyester material with a pale blue tint. The emulsion is a gelatin with suspended exposure crystals. Typically, the emulsion is coated on both sides of the polyester base and is termed double-emulsion film. Film construction is important in understanding characteristics inherent to the film.

Film Speed

Intraoral nonscreen film is currently available in three different speeds: Ultraspeed (D-speed) film has been on the market the longest and is the slowest speed film currently

Figure 1. A snap-on rectangular collimator inserted in a circular collimator.

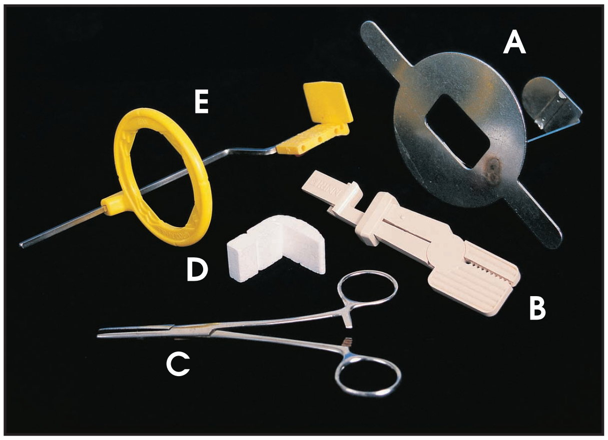

Figure 2. Examples of film-holding devices: (A) Precision, (B) Snap-A-Ray, (C) Hemostat, (D) Stabe, (E) XCP.

available; Ektaspeed plus (E+-speed) film became available in the mid-1990s; and Insight (F-speed) film is currently being tested in dental schools. Both E+- and F-speed films render low radiation doses to patients compared to D-speed film.[1-3] This occurs because of the different shape and larger size of the exposure crystals, which require fewer x-ray photons to acquire the proper film density. Thus, the shorter exposure time results in a lower patient dose. The clinician should be aware, however, that these faster film speeds are also more sensitive to processing variations (ie, poor darkroom quality control, film fog, pressure marks).[4] In addition, exposure time for F-speed film may need to be modified slightly depending on whether the film is processed manually or in a roller transport system. As a result, a regularly monitored quality assurance program is essential to ensuring competent diagnostic images.

Film Contrast

Film contrast describes the range of energies that the film emulsion is most sensitive to, or the ability of the film to discern different densities in the object being imaged (eg, it allows more shades of gray to be displayed). When D-speed film is compared to E+-speed, characteristic curves demonstrate that the film contrast is essentially the same.[1,2,5-8]

Film Latitude

Film latitude determines the number of densities that can be distinguished on the film. The greater the film latitude, the lower the contrast (ie, more shades of gray). When E+-speed film was compared to D-speed film, research demonstrated that the E+-speed film had a high inherent contrast and narrow exposure latitude similar to D-speed film.[3] Additional research demonstrated that in exhausted processing solutions, although contrast and latitude were affected in both films, E+-speed film outperformed D-speed film in regards to consistent latitude and contrast readings.[4]

Film Sharpness and Resolution

The ability of the film to distinguish edges clearly (ie, sharpness) and the ability to identify one structure from another (ie, resolution) are important factors in radiographic interpretation. Studies that have compared the diagnostic performance of D- and E+-speed films have demonstrated that there is no significant difference in caries detection and endodontic use.[9-12]

Mottle

The last factor that is inherent in film and influences the diagnostic quality of the film is mottling or radiographic noise. Similar to television snow, radiographic mottling is the result of uneven densities on the film. Due to the larger crystal size in the faster speed film and/or high-processing temperature, the film may appear grainier.[5] Although anecdotal comments suggest slower speed films have better diagnostic quality, research has shown the diagnostic quality of the films to be comparable.[10,13]

Because screen films are designed to be sensitive to light, they are utilized in combination with intensifying screens. Calcium tungstate was utilized customarily untilrare earth film/screen combinations became available in the late 1980s.[14] There are many types of rare earth materials (eg, samarium, gadolinium oxysulfide) that

Table 1

Shadow Casting Principles

Principle	Results
Small focal spot	The beam is more parallel and thus more consistent in nature
Proper beam angle (beam perpendicular to the long axis of the tooth and film)	The resultant image has less distortion
Extended source-to-object distance	The beam is less divergent and the resultant image is sharper and has less magnification
Maintaining parallel object and film	Decreases the chance of distortion of the image
Shortened object-to-film distance*	Decreases magnification

*Often in paralleling, the film must be moved away from the object in order to maintain parallelism between the object and the film.[21]

provide a substantial reduction in dose due to the quasi-monochromatic beam.[15] Contrast with the rare earth screen combinations has been shown to be equal to or better than the calcium tungstate screen film combinations.[16] Radiographic mottling when utilizing extraoral film is due to the fast film-screen combinations. The graininess is a result of photon fluctuations in the x-ray beam or unevenness in the display of light from the intensifying screen phosphors.

Imaging Geometry Principles

Whenever new products are being considered for use in dental radiology, it is always important to consider both patient safety and the diagnostic quality of the film. Some of the techniques to achieve this goal include: the utilization of fast speed film and film-screen combinations, film-holding devices that align the beam to the film, digital imaging, rectangular collimation, and rare earth filters.

Rectangular Collimation

Rectangular collimation is an effective means of reducing the dose to the patient. Historically, a circular collimator has been used to expose rectangular film. As a result, additional skin surface (approximately 60%) is exposed that is greater than the size of the film.[5] Thus, an easy way to reduce the dose to the patient is to use a collimator shaped like the film (Figure 1). The only caveat to using a rectangular collimator is that a film-holding device that aligns the beam to the film must be utilized; otherwise, the radiograph will probably have cone cuts. Rectangular collimation can be achieved through the use of Precision Instruments (Isaac Masel, Philadelphia, PA) with a circular collimator, a rectangular collimator, or snap-in collimators.[16]

Rare Earth Filters

Although several studies have demonstrated the effectiveness of dose reduction with rare earth filters, dentistry has been slow to incorporate them into everyday practice.[15,17,18]

Table 2

Film-holding Devices

Stabe	Rinn Corporation, Elgin, IL
XCP (Extension Cone Paralleling)	Rinn Corporation, Elgin, IL
Precision Instruments	Isaac Masel, Philadelphia, PA
Hemostat	This can be purchased from any medical supply company
Snap-A-Ray	Rinn Corporation, Elgin, IL

The most practical application appears to be through the use of compound filters (ie, aluminum plus samarium, aluminum plus gadolinium oxysulfide).[19] Almost 50% dose reduction with minimal loss of image contrast can be achieved depending on the material and kilovoltage utilized.[19] Furthermore, the ADA recommends that "Beam filtration should comply with federal and state regulations. The most judicious use of filtration involves selective filtration of excessively high-energy as well as excessively low-energy radiation."[20]

By selectively filtering the high and low energy photons from the x-ray beam with a rare earth filter, one can decrease the dose to the patient as well as improve the image quality by removing x-ray photons that do not add any diagnostic value to the film. Previous limitations, such as increased exposure time and tube loading, are now manageable with the faster speed films that are available on the market.

Film-holding Devices

Many practicing dental hygienists choose a radiographic technique based on either the predominant technique they utilized in school or by the choice made in the office in which they practice. Most dental hygiene programs teach the paralleling and the bisecting angle techniques. Yet, the utilization of the paralleling technique alone allows for the application of four of the five shadow casting principles that govern imaging. Shadow casting principles are defined as five basic rules that allow an object to be radiographed accurately and eliminate magnification and distortion (Table 1).

Film-holding devices eliminate the need for patients to hold the film with their hands, as well as help the clinician to align the position indicating device (PID), object, and film correctly. There are many variations of film holding devices on the market today (Table 2) (Figure 2). Only two film-holding devices [XCP and Precision Instruments (or generic variations on these name brands)] allow for the proper utilization of the paralleling technique, align the beam to the object and the film, and follow the recommendations by the ADA for rectangular collimation and positioning of the receptor to coincide with the collimation.[21]

When the film-holding device is aligning the film, beam, and object, there is a reduction of radiation exposure and number of retakes. The main disadvantages of using film-holding devices include: decreased patient comfort, expense, and inability to accommodate some patient conditions, such as a small mouth, malaligned teeth, and severe gag reflex. Some of these disadvantages can be eliminated through the use of adjunctive aids. In extreme

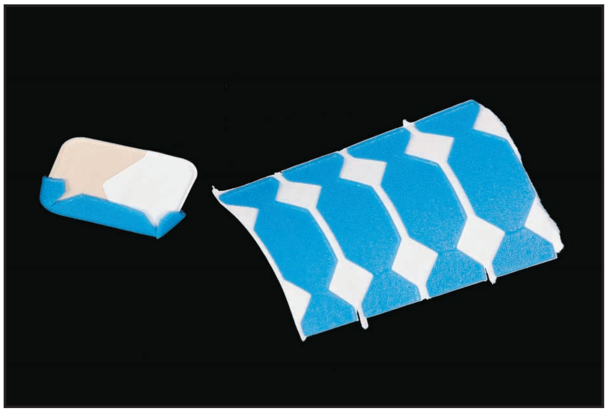

Figure 3. This is an example of an Edge-E-Z placed on a size 2 film pocket.

cases, topical anesthetic can relieve severe gag reflexes. In addition, small cushions (Edge-E-Z, Strong Dental Products, Inc, Corona, CA) can be placed on the edges of the film and utilized in order to prevent the edges of the film from impinging on soft intraoral tissues (Figure 3).

Film-holding devices such as the hemostat and the bent-film technique have specific functions. Although the hemostat can be utilized in any area of the mouth, it does not provide for beam alignment and should be utilized only when a small and maneuverable instrument is needed. Bending the film to form a ledge on which the patient can occlude is an excellent way to minimize the amount of materials that are placed in the mouth of a patient. This technique involves bending one side of the film over (approximately 1/3 of the surface of the film) and allowing the patient to occlude on that bent portion of the film in order to stabilize it in the mouth. This technique works well with patients who have an extreme gag reflex or cannot open their mouths in order to accommodate a film-holding device. The bent-film technique, however, will distort or decrease the film imaging area; therefore, its only practical use is with children where a smaller imaging area is needed.

Although film-holding devices are a means of helping to decrease exposure errors, they do still occur at times. The main technique errors that occur with the use of film-holding devices include such things as cone cuts and overlapping contacts between the dentition. The cone cuts are mainly due to noncentering of the primary beam with the film-holding device. The overlapped contacts in the posterior areas are due to the inability of the instrument to accommodate changing the horizontal angulation without changing the film alignment. In addition, one other unusual error can occur when utilizing a snap-on rectangular collimator for a cylindrical PID. These collimators can be inadvertently pushed out of the cone, or can slide out on one side, when aligning the collimator to the film-holding device. This error results in the beam being obstructed by the collimator, thus appearing as a severe cone cut on the processed film.

Conclusion

The primary goal of radiology is to produce a diagnostically acceptable image while keeping the radiation dose to the patient as low as possible. This can be achieved by utilizing film-holding devices that follow the paralleling principles and an appropriate image receptor system. Both film-based and sensor-based imaging require high-quality assurance in order to acquire good diagnostic images. Radiographic practices can be improved by following the current imaging techniques and principles discussed in this article.

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