DOSIMETRIC CONSIDERATIONS IN DENTAL APPLICATIONS

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The use of intraoral sealed sources in conjunction with the micro-channel plate technology may provide increased diagnostic information with decreased radiation dose compared to conventional dental radiographic techniques. These reductions in radiation dose are a result of several factors, some specific to the prototype NIH device, and others more generally applicable. These advantages include:

1) Reduced depth dose
2) Reduced volume of irradiated tissue
3) Real-time operator feedback

In addition to these specific advantages, the integration of the Lixiscope into dental procedures may reduce the total number of normal radiographic exposures required.

Reduced Depth Dose

Due to the spectral distribution of energies produced by bremsstrahlung in the target of an X-ray machine, some of the photons emitted from the tube head approach the applied accelerating potential. In general, dental radiographic exposures are made at 80-90 kVp. Since these high energy photons penetrate both bone and soft tissue quite readily, they provide little radiographic contrast yet penetrate deeply into the irradiated tissue.

In using isotopic sources of photons, the problem of high energy contamination of the beam is eliminated. Since the photons are emitted at discrete energies, beam energy may be optimized for a particular application by selection of the appropriate radionuclide.

Reduced Volume of Irradiated Tissue

A collimated intraoral source provides many advantages with respect to volume of irradiated tissue (whether the image receptor is a microchannel plate device or not). In the normal dental techniques, at least two factors contribute to the large volume of tissue irradiated.

Since there is considerable uncertainty in the positioning of the film within the patient's mouth, the beam must be wide enough to ensure that the structures of interest will be imaged. In a more narrowly defined beam, the incidence of retakes will be much higher. This geometry produces irradiation of tissues that are not of interest to the dentist, and which are outside of the image receptor. By rigidly coupling the image receptor to the source, and collimating the beam size to the diameter of the input phosphor, needless irradiation of tissue is reduced. The effects of depth dose and of limited beam geometry are compared for the NIH prototype device and an 80 kVp unit commonly used for endodontic procedures. Doses are normalized to 1.0 rad at 1 cm on the beam centerline (Figures 1 and 2).

A second major advantage stems from the fact that radiation dose to the tissue beyond the film is eliminated. The volume of tissue irradiated during the normal radiographic exposure includes not only those structures between the source and the film, but those tissues in the "shadow" of the film as well. In the intraoral geometry, only the tissues of interest are irradiated.

Real-time Operator Feedback

The real-time imaging technique permits the dentist to examine the structures of interest at an angle that optimizes their visibility. In the normal radiograph, patient movement, poor film placement, improper techniques, and many other factors may contribute to the necessity of a retake. By receiving real-time feedback, the dentist optimizes the information available from the minimum number of exposures.

Specific Design Considerations in the NIH Prototype Device

With the practical nature of this conference in mind, a few comments on design considerations in

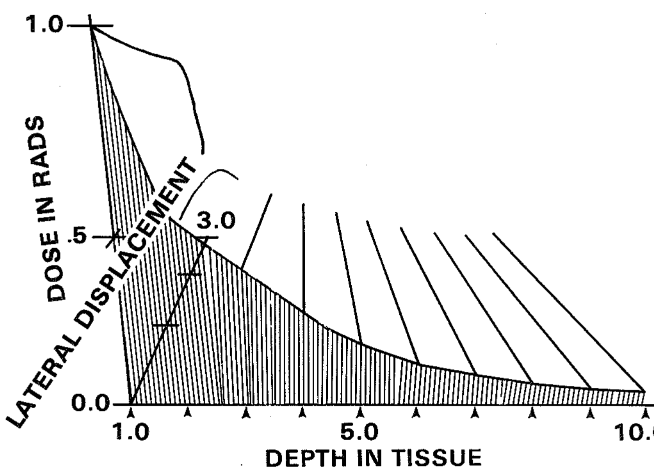

Figure 1. Effects of Depth Dose using 80 kVp X-rays

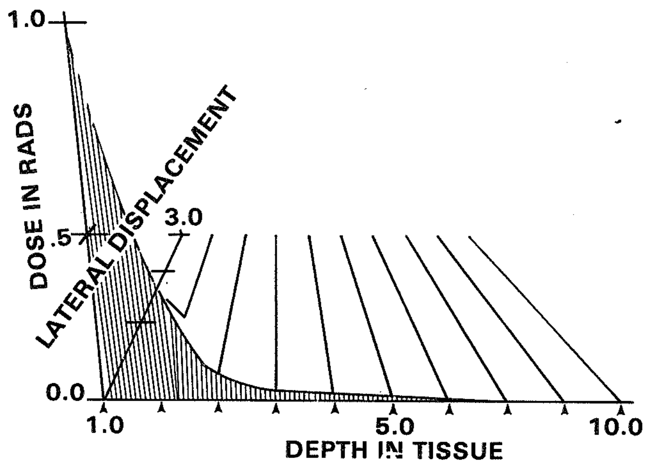

Figure 2. Effects of Depth Dose using I-125 Lixiscope Source

the NIH device are probably appropriate. Although no specific standards for the device exist, the NIH Prototype was designed to meet or exceed requirements for diagnostic type units. Some specific design goals of the device include:

1) Maximum Exposure Rate: 1.0 R/min
2) Maximum Leakage Radiation: .1 mR/hr at 1 meter
3) Beam Collimation: Rate at edge of input phosphor to be less than 10% of center-line rate
4) Shielding of Operator: Less than .1 mR/hr to eyes

Although these considerations are quite conservative and are specific to the NIH device, they are at least a starting point in making the Lixiscope a practical clinical tool. Many of the advantages seen in this design follow from the intraoral geometry and from the rigid coupling of source and image receptor. Similar improvements in radiation dosimetry might well be made in devices not using the microchannel plate technology. Because of the unique advantages of this particular configuration, however, it seems likely that the Lixiscope can provide adequate diagnostic information for a great many tasks with decreased radiation dose to the patient.