Pakistan Oral & Dent. Jr. 23 (1) June 2003

RADIATION DOSE-REDUCTION TECHNIQUES IN SAUDI DENTAL CLINICS

*RA'ED AL SADHAN, BDS, MS

ABSTRACT

Objective. *The purpose of this investigation was to describe the extent to which Saudi dental clinicians use materials, and equipment that reduce radiation exposure to patients and operators.*

Study Design. *Questionnaires soliciting information regarding intraoral radiographic practices were collected from a random sample of 259 dentists practicing at 11 major Saudi cities.*

Results. *The response rate was 64.75%. Dose-reducing techniques used were leaded aprons (79.1%), beam collimators (5.4%), and thyroid collars (8.5%). Patients held the films by their hands during exposure in 67% of clinics and by operator hand in 7%. E -speed film is used at 38.6% of clinics. Direct digital radiography is used at 5.7% of clinics for intraoral imaging. The most commonly used tube potential is 70-90 kVp (69.5%). A sunny window or the ceiling light were the method chosen to view the processed films by 10.7% of the surveyed dentists. Dentist made the radiographic exposure by themselves in 20.7% of clinics while dental assistants made the exposure in 41.7% of clinics. X-ray machines were located inside the clinic in 52.1% of clinics. 13.5% of operators remained inside the clinic during exposure. Only 19.3% of the clinics had a radiation exposure monitoring system*

Conclusions. *Some dose-reducing strategies are commonly used in Saudi dental clinics, while others have not gained wide acceptance.*

Key words: *Radiation Dose Reduction Techniques, Saudi Arabia Dentistry*

INTRODUCTION

The radiation exposure dose to dental patients from intraoral and extraoral radiographic procedures has been greatly reduced over the past several decades. The reduction in exposure time with the use of E-speed film[1-14] and direct digital radiography[15-19] compared with D-speed film is well known and is accomplished with no loss of diagnostic information. Significant decreases in radiation dose occur with the use of long, rectangular position indicating devices (PIDs) compared with round PIDs with a shorter source-film distance.[7, 20-24] Leaded rubber aprons and thyroid collars have been shown to minimize x-ray exposure to various parts ofthe body.[25,26] Research indicates that the use of the materials and techniques described earlier is not widespread among practicing dentists,[27-30] The purpose of this investigation was to determine the use of radiation-reducing materials and techniques by dentists practicing in a random group of dental clinics in Saudi Arabia.

MATERIALS AND METHODS

A questionnaire consisting of 11 questions in three sections was created (Fig. 1). A section concerning the place of practice (ministry of health, military, other civilian, or college of dentistry clinics) and the type of practice (single, group, or in a hospital or college of dentistry). In the second section, questions pertaining to the use of radiation dose-reduction techniques practiced at the time of radiographic exposure, such as covering the patient with leaded rubber aprons, thyroid collars, restricting the beam with collimators, and the use of PIDs. Information about the method of holding the films during exposure (by patient's finger, by operator or using a film holder) film speed, and

* Demonstrator, Dept. of Oral and Maxillofacial Surgery and Diagnostic Sciences, Cbllege of Dentistry, King Saud University, Riyadh, Saudi Arabia

ube potential settings. It also had questions about the type of illumination used to examine the processed films (viewing light, sunny window / ceiling light, or computer screen). In the third section, we solicited information about the type of operator performing the exposure (dentist, assistant, or radiographic technician), location of the x-ray unit and location of the operator during exposure (inside or outside the room) and if there was a system of monitoring x-ray exposure to the operator (e.g. film badges).

Most questions involved selection of the appropriate answer from listed options, but space was provided for respondents to make comments or explain their answers. An Arabic version of the survey was provided to non-English speaking Arabic dentists.

Questionnaires were mailed in September 2002 to 400 dentists practicing in 11 Saudi cities, Riyadh, Kharj , Jeddah, Dammam, Taif, Makkah, Arar, Buriedah, Najran, Abha and Wadi Al Doaser. The questionnaires were accompanied by an explanatory cover letter. After 6 weeks, 259 surveys had been returned, for a 64.75% response rate.

RESULTS

Place and type of practice

Most of the survived dentists practiced in Ministry of Health (MOH) dental clinics (n=99, 34.3%), 81(28%) worked in dental clinics operated by military sector , 76 (26.3%) worked in a college of dentistry (COD) and 21 (7.3%) practiced in private clinics.

Only 31 (11.6%) worked in single clinics as solo practitioners, 48 (18%) worked in group practices and 188 (70.4%) in hospitals or COD.

Use of radiation dose-reduction techniques

Radiation protective parries and beam restrictors: patients were covered with leaded rubber aprons by most of the surveyed dentists (n=204, 79.1%) and lead thyroid collars were used by 22 (8.5%) dentists. Only 14 (5.4%) used collimators and 21(8.1%) used position indicating devices. (Fig. 2).

Film holding during x-ray exposure: 154 (67%) reported that they used patient fingers to hold films inside the mouth during x-ray exposure. 16 (7%) operators used their own fingers sometimes to hold the film inside the mouth during exposure. 75 (32.6%) used film holders. (Fig. 3).

Film speed and tube potential: D-speed dental films were the most common used films (n=95, 54%) followed by E-speed (n=68, 38.6%). Only 5 dentists (2.8%) used the fastest films, F-speed. Digital radiography was employed in 10 clinics (5.7%) thus eliminating the need for films. (Fig. 4). The most commonly used tube potential was between 70 and 90 kilovoltage peak (kVp) (n=91, 69.5%) and the remaining (n=41, 31.3%) used tube current less than 70 kVp. (Fig. 5).

Film viewing conditions: Viewing boxes were used by most respondents (n=203, 80.6%). Suboptimal viewing methods, such as a sunny window or the ceiling light, were used by 27 dentists (10.7%). Computer monitors were used by 7 dentists (2.8%). (Fig. 6)

Operator performing the x-ray exposure: Dentists performed the radiographic exposure only in 61 clinics (20.7%) while dental assistant made the examination in 123 of clinics (41.7%) and dedicated dental radiographic technicians in 111 clinics (37.6%). (Fig. 7)

Location of x-ray unit and operator: The x-ray machines were located inside the dental clinic in 151 (52.1%) clinics and outside the clinic in 139 (47.9%) clinics. The operator making the exposure was outside the clinic in 219 of the clinics (86.9%) and remained inside the clinic in 34 clinics (13.5%).

Monitoring radiation exposure: Systems for monitoring radiation exposure to personnel (such as film badges) were used by 42 dentists (19.3%).

DISCUSSION

Al-Shamary et al estimated the number of dentists working in Saudi Arabia at 3845 dentists .[31] Thus, the participants in this study represent 6.73% of dentists in Saudi Arabia.

Place and type of practice

In this study 64.6% of the respondents worked in civilian clinics (MOH, Universities ...etc) and 28.1% in clinics operated by a military sector (Armed Forces, National Guard, Security Forces... etc). This is in agreement with Al Hamidi and Al Shamrani[32] who reported that 77.7% of dentists in Saudi Arabia practiced in civilian clinics and 39% practiced in clinics operated by a military sector. With the exception of private dental sector (only 7.3%), the surveyed sample appears to present the dental practice in Saudi Arabia in general. Possible explanations for the low response from the private dentists could be concern with confidentiality of practice management and concern of governmental oversee resulting from the response to this study.

Fig. 1 The Mailed Survey

1- Where do you practice dentistry:

- ❍ Ministry of Health.
- ❍ Other government civilian clinics.
- ❍ Military, National Guard, Security forces, or other non-civilian sectors.
- ❍ College of Dentistry.
- ❍ Private Practice.

2- How many dentist work with you in the same location:

- ❍ You practice in a single clinic by yourself.
- ❍ You practice in a in group practice with others.
- ❍ You practice in a Hospital or a Dental College.

3- Where is the intraoral x-ray machine located:

- ❍ Inside the clinic.
- ❍ Outside the clinic.

4- Who is in charge of taking intraoral x-rays in your clinic:

- ❍ Dentists.
- ❍ Dental Assistants.
- ❍ Dental radiology technicians.

5- When taking an intraoral radiograph on a patient, Do you use:

- **O** Lead apron.
- **O** Lead thyroid collar.
- **O** Collimator or beam restrictors.
- **O** Position indicating device.

6- When taking an intraoral radiograph on a patient:

- ❍ Patients hold the films inside the mouth by their fingers most of the time.
- ❍ The operator taking the radiograph sometimes has to hold the film.
- ❍ You use a film holder.

7- What type of films do you use for intraoral x-rays at your clinic:

- **O** No films (digital radiography).
- **O** D speed (Kodak Ultra-Speed).
- **O** E speed (Kodak Ektaspeed or Ektaspeed plus).
- **O** F speed (Kodak Insight).

8- What is the kilovoltage peak (kVp) of the intraoral x-ray machine you use in your clinic:

- **0** Less than 70 kVp.
- **O** 70-90 kVp.
- **O** Over 90 kVp.

9- In the place where you practice dentistry, where does the operator stand during intraoral x-ray exposures:

- **O** Outside the room.
- **O** Inside the room at a distance from the patient.
- **O** Beside the patient.

10- When you examine a periapical radiograph, do you use:

- ❍ A special x-ray viewing light attached to the dental chair.
- ❍ A viewing light box placed beside the dental chair on a bench.
- ❍ A sunny window.
- ❍ The ceiling light.
- ❍ A computer screen (digital radiography).

11- Do you have a system of monitoring radiation exposure (film badges): O No O Yes

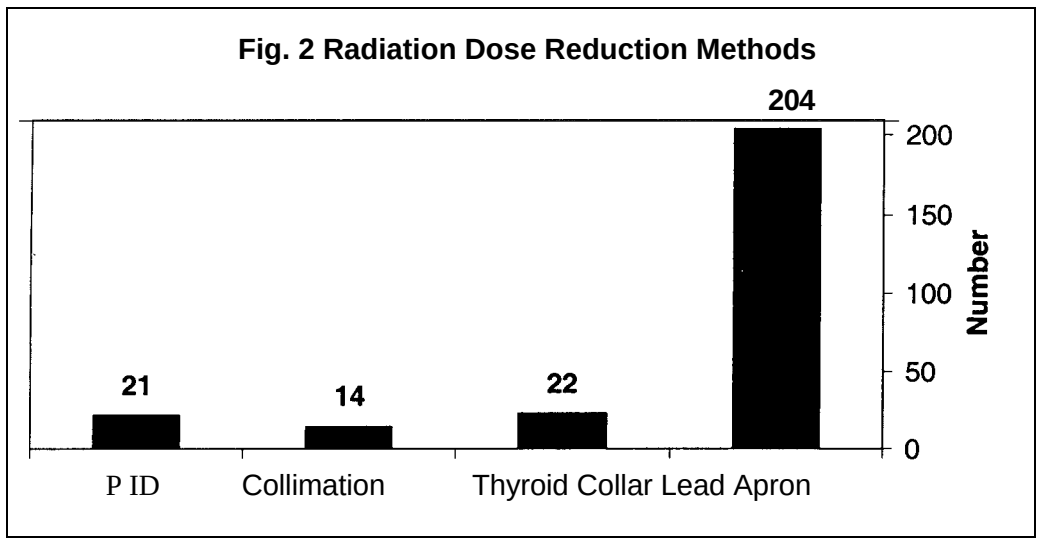


Fig. 3 Film Holding During Exposure

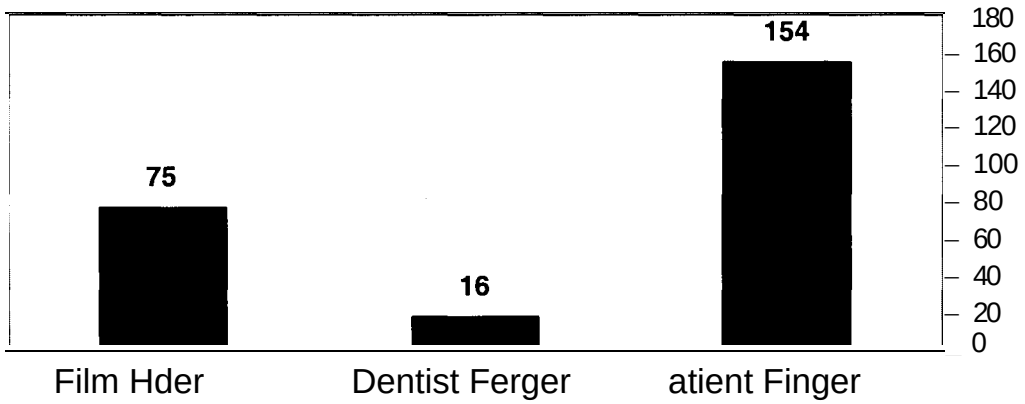


Fig. 4 Type of Film

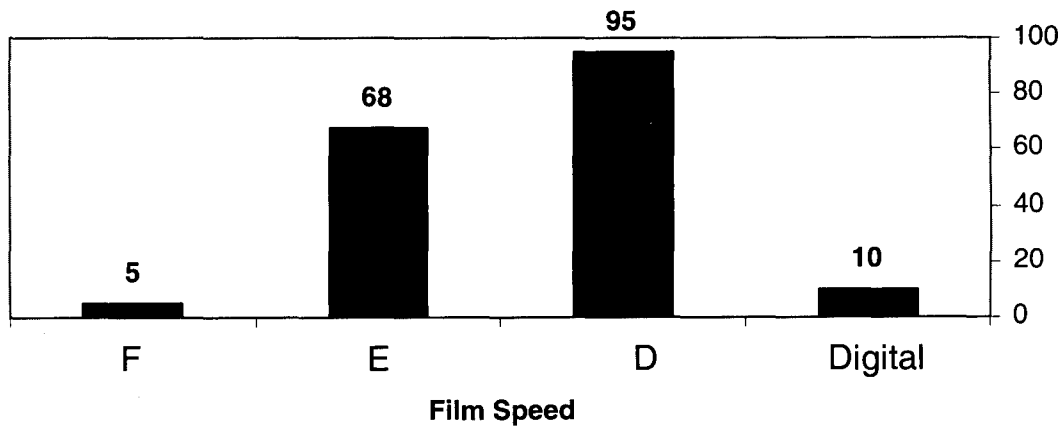
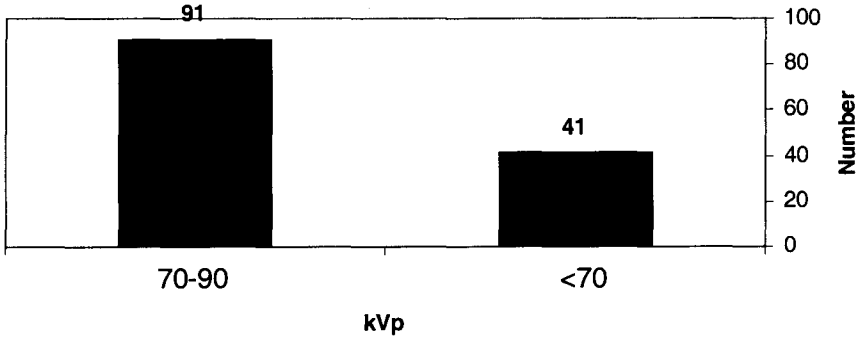
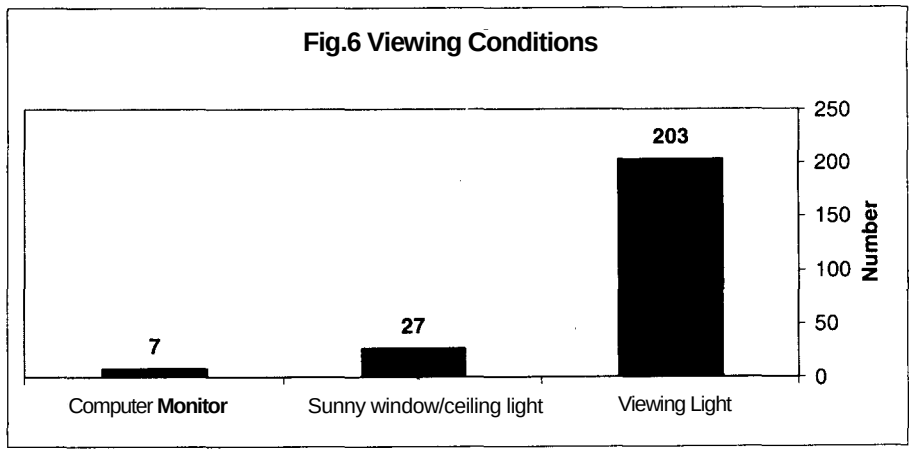
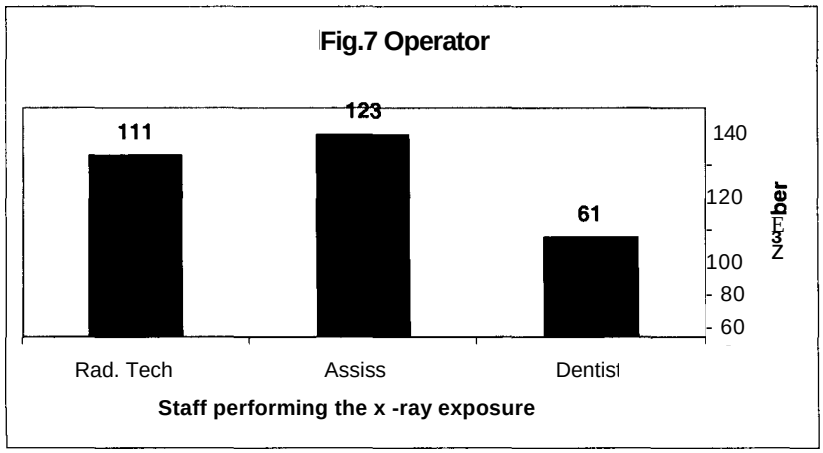


Fig.5 Tube Potential







Use of radiation dose-reduction techniques

Radiation protective parries and beam restrictors: The widespread use of leaded rubber aprons for intraoral radiography (79.1%) is a positive finding, similar to the results obtained in a survey of US dental schools in 1986[33] and US dental hygiene programs in 1990.[3]4 However, in this study only 8.5% used a thyroid collar. Use of thyroid shielding in North American educational institutions is more common than in private practices, where less than half of dentists used the collars in a 1992 survey.[27] Research indicates that thyroid shielding can reduce the dose to the thyroid gland by at least one third.[20, 25, 26, 35] Evidence suggests that leaded aprons should also cover the thorax, since radiation dose reductions of 20% to the breast have been recorded with their use.[20o] However, some dentists may dispense with the apron because of the extremely small radiation exposure to the gonads.[22]

Long beam-limiting devices, producing a 12-in or 16-in source-film distance (SFD), are used by 5.4% of dentists. This should be encouraged, since the radiation dose reduction with longer PIDs is significant when compared with shorter cones. Cederberg et a1[23] reported a difference of 30% in the effective dose when comparing full-mouth radiographic surveys performed with a 19.6 cm SFD round cone to the same procedure using a 29.8 cm SFD round PID. Gibbs et a1[22] recorded reductions in effective dose ranging from 13% in the salivary glands to 38% in the thyroid gland when using a 16-in instead of an 8-in round cone. Kircos et a1[20] described a reduction in irradiated tissue volume of approximately 30% when changing from an 8-in to a 16-in PID.

Even greater radiation dose reduction is accomplished with the use of PIDs with rectangular openings that are roughly the size of a #2 dental film. The tissue area exposed with rectangular beam limitation is approximately one third of the area exposed with the circular cone of 2.75-in diameter. Reductions in overall patient dose of 70% to 75% have been reported,[20-24] with decreases of more than 80% to certain organs.[22-24] PIDs were used only in 8.1% of clinics. Similar low accep-

ance of rectangular beam limiters was found in the practicing dental community in both North America[27,28] and Sweden.[30,36]

Film holding during x-ray exposure: Practitioners should use film holders that position the film to coincide with the collimation. They should not hold films in place for patients[37,38]. Although this was not common among the surveyed dentists (only 7%), this practice should be severely discouraged. The dental film or digital detector should only be held by the patient when it cannot otherwise be kept in position. It should not normally be hand-held by anyone else. Exceptionally it may be held by someone other than the patient using a pair of forceps, or other appropriate holder, to avoid direct irradiation of their fingers, for example, when a child or a handicapped person cannot hold it themselves. Film holders should be promoted instead of patient fingers (used by most dentists in this sample 67%), as a significant reduction in the number of unacceptable periapical films was found when film holders were used instead of patient manual support[39].

Film speed and tube potential: D-speed radiographic film is used by 54% of dentists and E -speed was used by only 38.6%. This is much lower than what have been reported in other studies in other countries, for example E-speed films are used in 86% of North American Dental schools.° However, this finding is higher than that reported in a study on private dentists which showed that 73% used D-speed film[27] and similar to what have been reported in Sweden where 52% used D-speed films and 47% used E-speed films.[36] The reason for this may stem in part from the original E-speed film (Kodak Ektaspeed) that appeared on the market in 1981. Although it was found in objective research to be comparable with D-speed film in diagnosing caries and periodontal bone loss [,2, 4-6,12-14] and permitted a reduction in exposure time of at least 40%,[1-14] Ektaspeed exhibited poor contrast in darker parts of the image.[1, 3' 8,11] Research demonstrates that dentists prefer greater contrast in radiographs,[41,42] which could explain the unfavorable opinion of Ektaspeed, leading to its removal from the market in favor of Ektaspeed Plus. It may be that some dental faculty members are not aware of the improvement of Ektaspeed Plus, thereby rejecting E-speed film on the basis of the performance of the original Ektaspeed.

Recently, F-speed films were introduced to the Saudi market. Research indicates that this film has contrast equal to or greater than Ektaspeed Plus, with an exposure dose reduction of at least 20%.[43, 44] Only 2.8% of dentists used it in this study. Dentists should be encouraged to shift from D and E-speed films to the faster F-speed film to reduce the radiation dose to their patients.

Direct digital radiography (DDR) is used in patient care by 5.7% of the surveyed dentists. Usually it is most frequently used in endodontics, where the rapid production of an image is an appealing feature when instrumenting a canal. When used with a charge-coupled device or complementary metal-oxide semiconductor sensor, DDR allows a reduction of at least 50% in exposure time compared with E -speed film.[15,16, 19] This is a significant decrease in the radiation burden placed on patients during root canal procedures. DDR has been available since 1989, so the fact that it is not used at all in patient care by 97.2% of the sample was unexpected.

Dental x-ray machines have been marketed for intraoral radiography with operating kVp ranging from less than 50 to more than 100. Published data show no significant relationship between beam energy and effective dose to the patient with beams ranging from 70 to 90 kVp.[22] There is little to be gained from higher energies, greater than 80 kVp. Many contemporary machines operate at a fixed voltage which, if in the 60 to 80 kVp range, is generally acceptable. Most of the dentists in this study used a kVp ranging from 70 to 90 (69.5%) while some used lower than 70 (31.3%), possibly those are dentists using more sensitive films or mostly treating children.

Film viewing conditions: In order to extract full diagnostic information from the films it is essential to have dedicated viewing facilities. A specially designed light-box should be installed in an area where the ambient lighting can be adjusted to appropriate levels. Suitable film masking should be used to optimize the viewing conditions by cutting out stray light.

For viewing dense areas of a radiograph the incorporation of a high intensity light source in the light-box is recommended. Some of the respondents (10.7%) reported using inappropriate viewing conditions (sunny window and/or ceiling light). Cathode Ray Tubes (CRT) computer monitors were used by only 7 dentists (2.8%). The fact that a higher number reported using DDR (n=10) might be explained by assuming that the remaining might viewed the images in printed format rather than on a CRT computer monitor. It would be interesting to investigate the quality of these printed images and compare it to the regular films and those displayed on CRT computer monitors.

Operator performing the x-ray exposure: In most dental facilities surveyed (41.7%) the staff involved in radiologic procedures were dental assistants who may or may not be certified. Certified assistants are trained and credentialed to perform radiologic exposures, process the films and evaluate them for quality. Assistants may be credentialed for these procedures upon completion of approved training. Only dentists and legally-qualified and credentialed auxiliary personnel shall be authorized to perform dental radiographic exposures.[38]

Location of x-ray unit and operator: More than half of the dentists in this study reported having the x-ray units inside the clinic (52.1%) and 13.5% of operators stayed inside the clinic during exposure. It is a fundamental principle of radiation protection that no one other than the patient undergoing the procedure is permitted in the room at the time of radiation exposure. Fixed barriers, generally walls, provide the most economical, effective, and convenient means of excluding office staff from the primary x-ray beam as it exits the patient or from radiation scattered from the patient or other objects in the primary beam. The operator should be positioned behind a protective barrier at the time of x-ray exposure. The barrier should be constructed so the operator can maintain visual contact and communication with the patient throughout the procedure. If the facility design is such that a protective barrier is not feasible, then the operator shall be positioned as far as possible from the tubehead (at least 2 m) the time of exposure. If the 2 m distance cannot be maintained, then a barrier shall be provided. If the facility design requires that the operator be in the room at the time of exposure, then the operator should be positioned not only at maximum distance (at least 2 m) from the tubehead, but also at the location of minimum exposure. Maximum exposure will generally be in the direction of the primary beam as it exits the patient. Maximum scatter will be backwards, i.e., 90 to 180 degrees from the primary beam as it enters the patient. Generally the position of minimum exposure will be at 45 degrees from the primary beam as it exits the patient.[45]

Monitoring radiation exposure: Radiation monitoring was reported by19.3% in this study. Monitoring of individual occupational exposures is generally required if it can be reasonably expected that any individual will receive a significant dose, usually defined as greater than 10 to 25 percent of the occupational dose limit. The most recent available data indicate that the average annual occupational dose in dentistry in 1980 was 0.2 mSv.[46] Few dental workers received more than 1 mSv and 68 percent received exposures below the threshold of detection. These data suggest that dental personnel should not be reasonably expected to receive occupational exposures greater than the 10 to 25 percent of the annual dose limit of 50 mSv y^{-1}. However, the cumulative dose limit in mSv of 10 times the age, and the limit for pregnant workers of 0.5 mSv per month once pregnancy is known, suggest that personnel dosimetry may be a prudent practice. Personnel dosimeters shall be provided for known pregnant occupationally-exposed personnel.

One of the limitations of an investigation of this nature is the possibility of bias. It is possible that some answers may represent the ideal situations intended by the respondents, but adherence to these standards may be lax in other times or areas of the practice. Thus, variation in standards may occur within dental clinics that are not reflected in our results.

Several investigations over the past years have documented increasing compliance on the part of dentists with the concept of selection criteria in prescribing radiographs.[47-49] The present investigation indicates that radiation burden to patients is also being reduced through the use of faster film and leaded rubber aprons. However, other dose-reducing mechanisms such as direct digital imaging, PIDs, and rectangular beam limitation are not as widely used.

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