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Operator Exposure to Scatter Radiation from a Portable Hand-held Dental Radiation Emitting Device (Aribex™ NOMAD™) While Making 915 Intraoral Dental Radiographs*

ABSTRACT: Operator exposure to backscatter radiation while using an Aribex™ NOMAD™ radiation emitting device (a portable, self-contained, cordless, hand-held dental X-ray unit) was determined while the operator employed various *typical* and *atypical* use scenarios during the exposure of 715 digital and/or film-based dental radiographs and 200 study control exposures. Study data was compared to the radiation safety occupational exposure annual Maximum Permissive Dose (MPD) of 50 mSv (5000 mrem) to determine the possible exposure risk to an unprotected operator using this device. The results showed the reproductive organs received the highest dose and the thyroid the least. The average operator whole body dose for the study was determined to be 0.047 mSv (4.47 mrem) or 0.09% of the annual MPD. Extrapolating the data as an expression of averaged annual operator exposure resulted in a whole body dose of 0.4536 mSv (45.36 mrem) or 0.9% of the annual MPD, These results are well below established occupation exposure limits and are compatible with those published by the manufacturer.

KEYWORDS: forensic science, radiation exposure, radiation safety, portable radiation emitting device, maximum permissive dose

The Aribex™ NOMAD™ portable hand-held dental radiation emitting device was developed in 2004 and received FDA approval as a medical device in July, 2005 and has been used extensively and almost exclusively in the resolution of mass fatality incidents (MFIs) requiring forensic dental identification of numerous victims. The use of this device during the recovery and postmortem identification efforts following Hurricane Katrina and the Indian Ocean tsunami facilitated identification of the victims of these catastrophes. Units have become a standard component of the prepositioned armamentarium deployed by the federal disaster mortuary operational response teams (DMORTs) in the United States.

Despite the successful use of the NOMAD™ unit in the situations described previously, in the United States, use of the device in the private sector or by other professionals than dentists has been curtailed by individual state laws and regulatory agencies responsible for monitoring operator safety while employing radiation emitting devices. In 2006, the Nevada State Board of Health–State Health Division authorized a study to be conducted at the UNLV School of Dental Medicine to evaluate leakage and backscatter radiation to the operator while using the Aribex™ NOMAD™ unit in a variety of exposure scenarios.

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Study Design

Operator exposure to scatter radiation while using an Aribex™ NOMAD™ radiation emitting device (a portable, self-contained, cordless, hand-held dental X-ray unit) was determined while the operator employed various *typical* and *atypical* use scenarios during the exposure of 715 digital and/or film-based dental radiographs and 200 control exposures. As marketed, the protective shield of the device provides the optimum protection from backscatter radiation to the operator when the instrument is employed by an upright operator imaging a seated patient in the *typical* dental office setting (1,2).

The low dose operator exposure described by the manufacturer and others (2–4) when the NOMAD™ unit is used in this *typical* position represents this ideal situation and complies with National Council on Radiation Protection and Measurement (NCRP) guidelines (5). This is true regardless of whether the capturing device is an electronic sensor, phosphor plate, or silver-based film (6).

Conversely, there has been widespread forensic dental use of this device in recent MFIs requiring exposure of quality radiographs in the field or morgue setting (7,8). This fact, in addition to the potential use of this technology in anthropological field work and veterinary medical diagnosis, suggests that its greatest use to date and in future scenarios involves *atypical* situations. Findings have been reported for the use of the NOMAD™ portable X-ray system deployed in the temporary morgue facility at St. Gabriel, Louisiana following Hurricane Katrina (7). This study indicated that these units presented no significant scatter radiation risk to any member of the dental teams (operators, computer personnel, and assistants) deployed to that facility.

Operators of these devices, however, were instructed to "wear protective gear, because safety was an important issue with heavy use of this machine" (4). This issue was reinforced because "the supine position of the person being imaged required the operators standing near the gurney to be in an at risk position using a very new machine in a non-standard (*atypical*) configuration" (4).

Thus, it has already been recognized that under these adverse conditions, the operator of the device is most likely to not be positioned within the "ideal safe-zone" provided by the protective shield of the unit. Despite the *atypical* situations created in forensic and other casework, radiation hygiene must be maintained in all situations to ensure that the use of these devices under any conditions results in minimal scatter radiation exposure to the operator. In this study, all potential *typical* and *atypical* use scenarios were included to represent the "worst-case" backscatter radiation exposure outcomes for the operator of this hand-held radiation emitting device under a variety of possible conditions.

Materials and Methods

The Aribex^{TM} NOMAD^{TM} hand-held, self-contained, portable, cordless X-ray generating device operates at 60 kV, 2.3 mA with an exposure range of 0.01–0.99 sec. The focal spot is 0.4 mm, inherent filtration is 1.5 mm Al equivalent, X-ray beam collimation is 60 mm, and the source to skin distance is 20 cm (Figs. 1*A* and 1*C*) (1,2).

Imaging subjects consisted of radiology training manikins, dry skulls, endodontic tooth models, anthropological specimens, and forensic specimens at the UNLV School of Dental Medicine, UNLV Department of Anthropology, and the Clark County Coroner's Office, respectively. Except for the initial imaging scenario which employed the manikins in clinical settings, all other image settings were considered *atypical* for the shield design (Figs. 1*A* and 1*D*).

Initial, *typical* images were made using training manikins routinely employed in dental school clinical simulation teaching programs. They have human teeth and near equivalent tissue material and produce comparable images to those obtained with live patients (Figs. 2*A* and 2*D*).

By exposing these images, mock patient doses were determined. Such exposure knowledge facilitated adjustments incorporated into

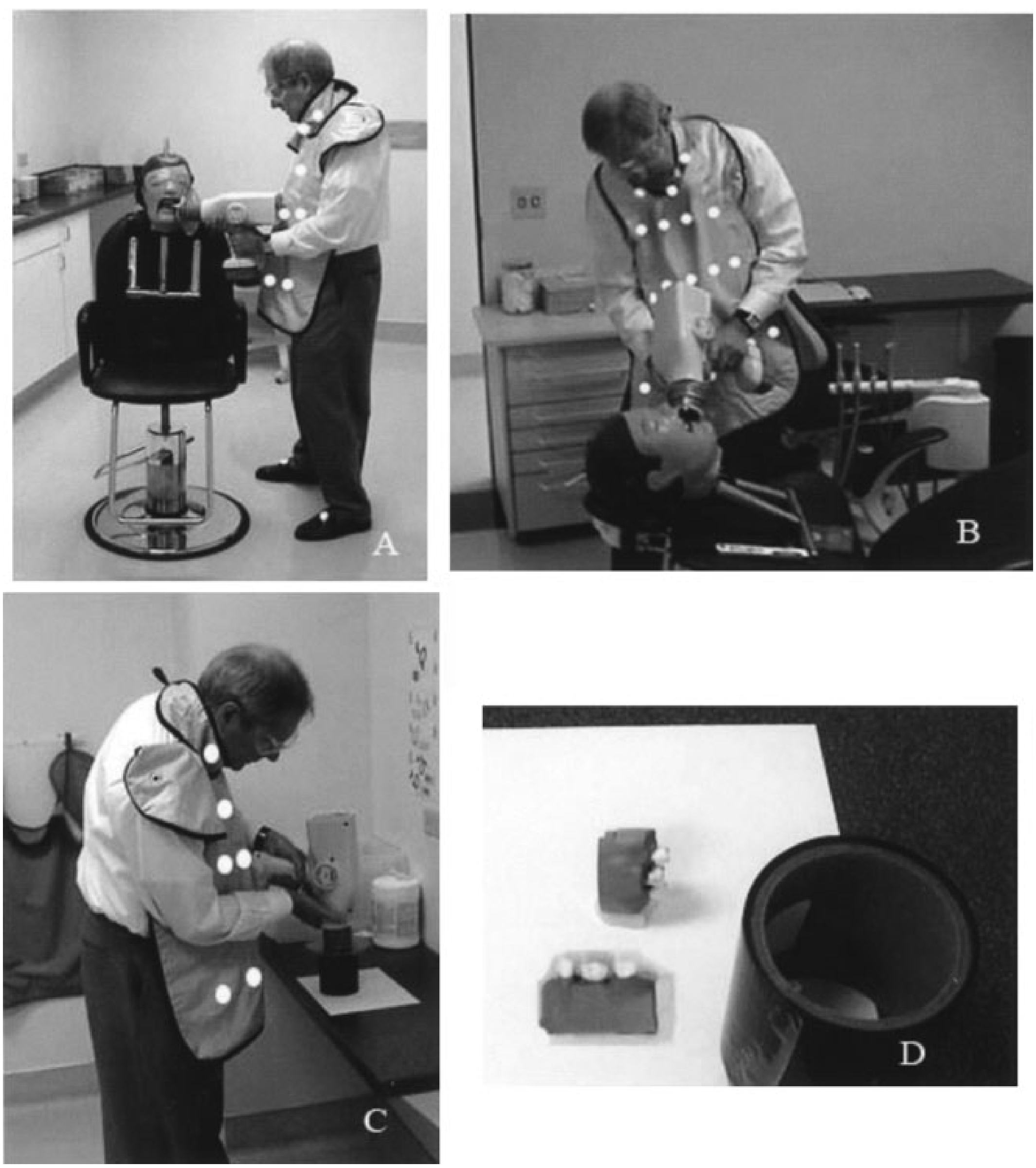

FIG. 1—Typical *(A) and* atypical *(B, C, and D) use positions for NOMAD exposures.*

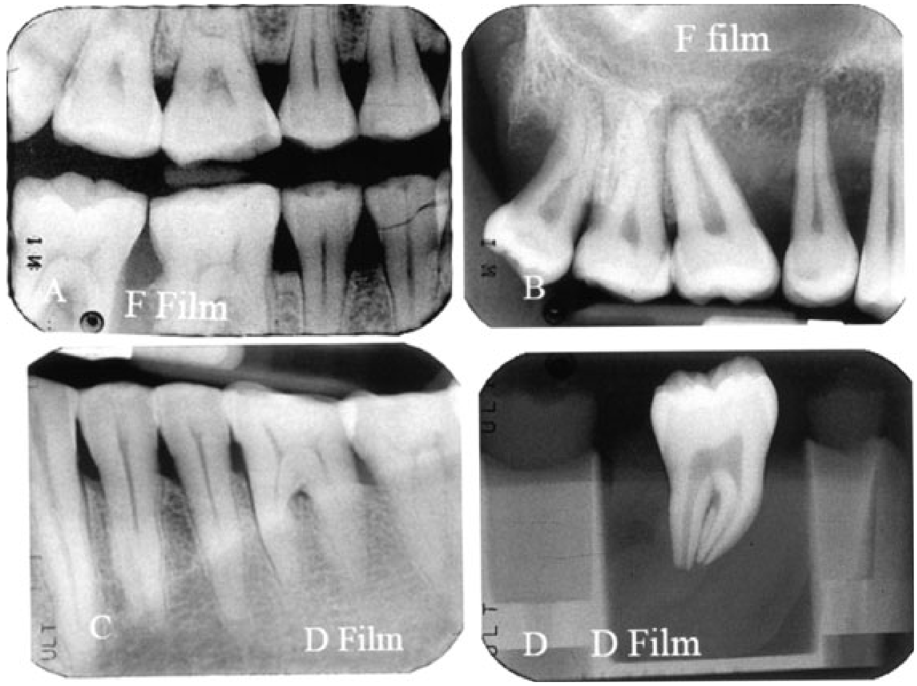

FIG. 2—*Representative film and digital intraoral study images made with the NOMAD™ X-ray device.*

the exposure of images in the *atypical* use scenarios. Exposure settings varied with use of film (D or F speed), digital sensors (CCD Dexis or PSP Scan X), and type of imaging subject (manikin "patient," skull, or forensic specimen). Except for specimen imaging, these settings were all compatible with those published by Aribex™ in the NOMAD™ User Manual (2) as guidelines for patient exposure (Table 1).

Operator protection for the study consisted of a lead apron with an attached thyroid collar which was worn by the respective operators during all exposure procedures. Luxel dosimetry badges, which are sensitive to X-rays, gamma rays, and higher energy beta particles, were affixed to the lead apron and collar over strategic areas identified as critical for radiation exposure. Additional Luxel dosimeters were affixed to the tops of the shoes of the operator.

Extremities (hands and fingers) and eyes were monitored with TLD dosimeter rings attached to eyewear and worn on the fingers of both hands. A total of 22 dosimeters were employed for measurements of the anatomical areas and six served as controls for anatomical areas and dosimetry coverage (Fig. 3). Dosimeters were supplied, read and exposure results provided by Landauer Inc., Glenwood, IL.

Results

The variables in the 715 study exposure scenarios included exposures made at digital settings for 56% (397), D speed film was next at 35% (252) followed by F film at 9% (67). Exposure times for D speed film were two to three and a half times greater than those for digital settings. Film, including D and F speeds, accounted for 319 (44%) of the total exposures. For purposes of the study, *atypical exposure* situations included the following:

- Bench specimens from the Clark County Coroner's Office,
- Anthropology specimens from the specimen collection at the UNLV Anthropology Department,
- Supine positioned manikin "patient" exposures obtained during the UNLV School of Dental Medicine clinical simulation exercise.

In these *atypical* exposure situations, areas of the operator's body including feet and reproductive regions fell outside of the hand-held radiation device's lead shield zone of protection. These *atypical* image exposures (digital or film) comprised 560 (78%) of the total exposures in the study. In contrast, the 200 control exposures were made in an upright position as shown in the manufacturer's training material. One hundred exposures were made at the D film exposure settings and the others at the PSP Scan X settings.

Comparison between the radiation dosage exposures to the operators of the portable radiation emitting device and the Maximum Permissive Dose (MPD) for an occupational radiation worker was the method employed to evaluate operator safety in this study. In the United States, the MPD is determined for three areas (whole body, eye, and extremities). For the whole body, the annual MPD is 50 mSv (5000 mrem). For the eye, it is three time greater at 150 mSV (1.5×10^4 mrem) and for the extremities (including skin, hands, and feet) it is ten times greater at 500 mSv (5.0×10^4 mrem) (1,9).

Landauer dosimetry results were reported in mrem as deep, eye, and shallow dose for the identified anatomical areas. Most

TABLE 1—*NOMAD™ exposure parameters at preset 60 kVp and 2.3 mA.*

Method	Endo Lab Film: Ultra D	Forensic Lab Digital: Dexis	Anthro Lab Film: Insight F	Clinic Manikin Digital: Scan X	Clinic Manikin Film: Insight F
Time/sec	0.34 0.70	0.20	0.15	0.15 0.20	0.15 0.20

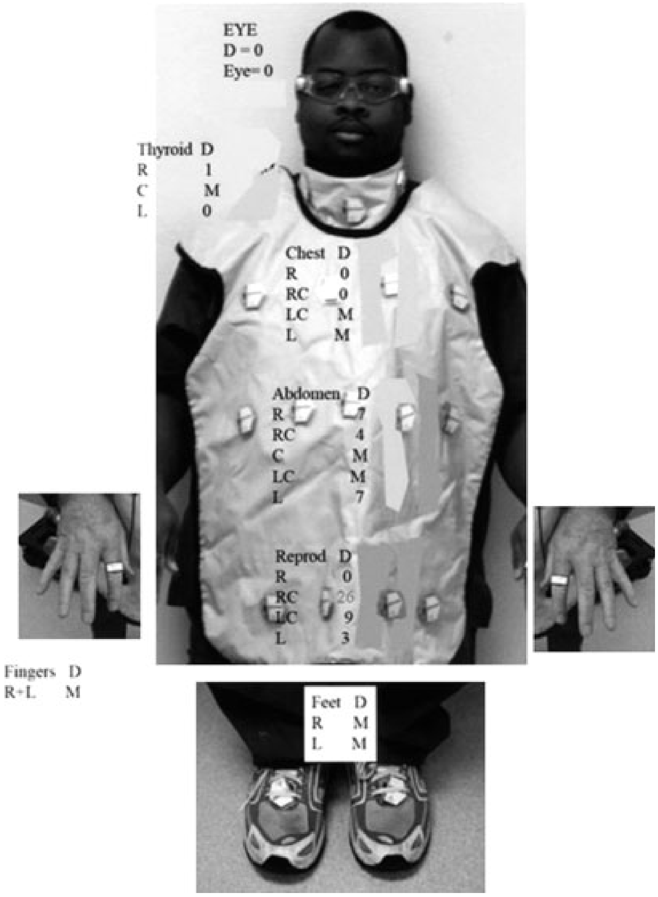

FIG. 3—*Distribution of operator deep dose (D) data. Refer to Table 3.*

dosimeters received <1 mrem and the dose values were recorded in Table 2 for the 715 study and 200 control exposures.

Deep dose equivalent as defined in the Landauer radiation dosimetry report is the dose that applies to external whole body exposure at a tissue depth of 1 cm (1000 mg/cm^2). Shallow dose is similar; however, it is measured at 0.007 cm (7 mg/cm^2) (10). Only the deep dose measurements, as representative of operator exposure, were used for further evaluations. The decision to eliminate the eye and extremity doses from further calculations was based upon the following:

- The eye and extremity annual MPD limits far exceeded any of the recorded doses for these sites as measured by this study (see Landauer reported data in Table 2).
- There was a possibility that an artificial exposure to the dosimeters could have occurred as a result of low energy backscatter radiation from the operator lead apron.

Table 2 shows that the only recorded measurable deep doses for the 715 study exposures occurred in the thyroid, abdomen, and reproductive regions. Additionally, Table 2 provides the specific deep dosimetry results for the 200 control exposures using film and digital sensors. These results indicate that the only measurable deep dose occurred in the left central reproductive area during film exposure and was recorded at 0.01 mSv (1 mrem). All other 200 control deep dose measurements for both film and digital exposures were reported as $M \leq 1$ mrem, which is below the sensitivity of the dosimetry badge.

Table 3 provides the average deep dose data for the 715 study and 200 control exposures obtained from dosimetry results recorded in Table 2 for the thyroid, abdomen, and reproductive regions. This approach follows protocols used in previous dosimetry studies (11–13). The values in Table 3 represent data displayed in both milliSievert (mSv) and millirem (mrem) units in accordance with radiation biology and safety reporting formats.

For the 715 study exposures, Table 3 shows the average operator deep doses ranged, respectively, from the lowest value to the highest for the thyroid at 0.0033 mSv (0.33 mrem), the abdomen at 0.036 mSv (3.6 mrem), and the reproductive area at 0.095 mSv (9.5 mrem). For the 200 control exposures, Table 3 also indicates that when the measured 1.0 mrem for the reproductive film exposure as recorded in Table 2 is averaged over the eight film and digital reproductive region sites the dose is 1.25×10^{-3} mSv (0.125 mrem).

Table 4, using data obtained from Tables 2 and 3, represents three analyses:

- A comparison of the average tissue deep dose from the 715 study dental radiographic exposures to the 200 controls.
- The dose at specific anatomic locations expressed as a percentage of the MPD (50 mSv [5000 mrem]).
- Determination of the average whole body exposure for the operators in the study and controls and expresses these figures as a percentage of the MPD.

Relative to the annual permitted MPD, for the study, the reproductive dose was the highest at 0.19%, this was followed by the abdomen at 0.072% and the thyroid dose was lowest at 0.0066%. For comparison, the 200 control exposures resulted in a dose of 0.0025% of the MPD. A similar determination for the average whole body exposure was 0.047 mSv (4.47 mrem) or 0.09% of the annual MPD. For comparison, for the 200 control exposures, the whole body exposure was 0.00041 mSv (0.041 mrem) and 0.00082% of the annual MPD.

Table 5 using data obtained from Table 4:

- Expresses the per exposure dose for each anatomical location and the average whole body dose for both the 715 study and the 200 control exposures.
- Extrapolates the results for *each anatomical location dose* of the study (based on 715 exposure doses and 200 control doses) to a projected annual NOMAD™ tissue dose of 7200 exposures.
- Extrapolates the results of the *average whole body dose* of the study (based on 715 exposure doses and 200 control doses) to a projected annual NOMAD™ tissue dose of 7200 exposures.
- Expresses the annual dose for *each anatomical location* and *average whole body* as a percentage of the annual MPD (50 mSv [5000 mrem]).

The dose per exposure for each anatomical location and the average whole body was determined by dividing the average deep dose expressed for these locations in Table 4 by the number of exposures in the study (715) and controls (200). This resulted in per exposure dose values for the thyroid region at 4.6×10^{-6} mSv (4.6×10^{-4} mrem), abdomen at 5×10^{-5} mSv (5×10^{-3} mrem), reproductive region at 1.3×10^{-4} mSv (1.3×10^{-2} mrem), and average whole body at 6.3×10^{-5} mSv (6.3×10^{-3} mrem). The 200 study control exposure for the reproductive location was 6.2×10^{-6} mSv (6.2×10^{-4} mrem) and for the average whole body 2.0×10^{-6} mSv (2.0×10^{-4} mrem). These per exposure dosages are recorded in Table 5 data columns one and three.

The annual number of exposures was calculated after the manner published in the NOMAD™ User Manual (2). This approach predicts that an operator will make 150 exposures/work week (30 exposures/workday). For the purposes of this study, the number

TABLE 2—*Landauer reported dose in mrem for 715 dental X-ray exposures and 200 study control dental X-ray exposures.**

	Deep			Eye			Shallow		
	715	100 Control Film	100 Control Digital	715	100 Control Film	100 Control Digital	715	100 Control Film	100 Control Digital
Eye	0	M*	M	0	M	M	M	M	M
Thyroid:									
Right	1	M	M	1	M	M	M	M	M
Center	M	M	M	M	M	M	M	M	M
Left	0	M	M	0	M	M	M	M	M
Chest									
Right	0	M	M	0	M	M	M	M	M
R Center	0	M	M	0	M	M	M	M	M
L Center	M	M	M	M	M	M	M	M	M
Left	M	M	M	M	M	M	M	M	M
Abdomen									
Right	7	M	M	7	M	M	6	M	M
R Center	4	M	M	4	M	M	4	M	M
Center	M	M	M	5	M	M	8	M	M
L Center	M	M	M	M	M	M	M	M	M
Left	7	M	M	8	M	M	9	M	M
Reproductive									
Right	0	M	M	0	M	M	1	2	M
R Center	26	M	M	27	M	M	28	M	M
L Center	9	1	M	25	1	M	33	2	M
Left	3	M	M	31	M	M	46	M	M
Fingers									
Right	M	M	M	M	M	M	M	M	M
Left	M	M	M	M	M	M	M	M	M
Feet									
Right	M	M	M	7	M	M	11	M	M
Left	M	M	M	8	M	M	14	M	M
Background Dosimeter Control Dose	NMR			NMR			NMR		

*M ≤ 1 mrem (this is below the sensitivity of the dosimetry badge).
NMR, no measurable result.

TABLE 3—*Average operator deep dose dosimetry data for 715 dental X-ray exposures and 200 study control dental X-ray exposures* using a NOMAD^{TM} hand-held X-ray device.*

	Dose†	
Location	mSV Average	mrem Average
Thyroid (neck): (Three sites)	0.0033	0.33
Abdomen: (Five sites)	0.036	3.6
Reproductive: (Four sites)	0.095	9.5
Study control/200 exposures: (Eight sites—digital and film)	0.00125	0.125

*Radiation dosimetry report calculated by Landauer® Inc.—Table 2.
†Recorded dosages are calculated averages for all readings for each anatomical site as indicated in Table 2.

TABLE 4—*Average NOMAD^{TM} study dose from 715* and 200 control exposures expressed as average whole body dose compared to annual MPD 50 mSv (5000 mrem).*

	Dose		
Location	mSv	mrem	% Annual MPD 50 mSv (5000 mrem)
A. Thyroid	0.0033	0.33	0.0066
study control†	M‡	M	M
B. Abdomen	0.036	3.6	0.072
study control	M	M	M
C. Reproductive	0.095	9.5	0.19
study control	0.00125	0.125	0.0025
Average whole body dose	0.0447	4.47	0.09
Study control whole body dose	0.00041 (A+B+C/3)	0.041 (A+B+C/3)	0.00082 (mSv or mrem/5000)

*See Table 3: Total for 715 exposures.
†See Tables 2 and 3: Totals for 200 exposures.
‡M ≤ 1 mrem (this is below the sensitivity of the dosimetry badge).

of working days in a year was determined to be 240 when vacations, health leaves, and holidays were considered as factors. Thus, using these figures, making 30 radiographic exposures/workday × 240 days yields an annual radiographic exposure total of 7200 radiographs when employing this device.

These values were used to extrapolate potential annual occupational exposure dose by multiplying them by 7200 projected annual exposures to obtain the annual dose for each anatomical location and the average whole body annual dose. The results show that annual/7200 projected dose for the thyroid region was determined to be 0.033 mSv (3.3 mrem), abdomen at 0.36 mSv (36 mrem), reproductive region at 0.936 mSv (93 mrem), and average whole body at 0.4536 mSv (45.36 mrem). The 200 study control exposure for the reproductive location was 0.0446 mSv (4.46 mrem) and for the average whole body 0.0144 mSv (1.44 mrem). These per exposure dosages are recorded in Table 5 data columns two and four.

The extrapolated study data for 7200 annual exposures compared to the annual MPD indicates that the reproductive dose had the highest levels at 1.9%, the abdomen at 0.72%, and the thyroid with the least at 0.066%. The 200 controls were 0.09% of the MPD. The extrapolated values for the average whole body dose and study control whole body dose represent 0.9% and 0.028% respectively of the annual MPD. These percentages of the annual MPD are recorded in Table 5 data column five.

TABLE 5—*NOMAD™ study per exposure dose extrapolated to 7200 annual exposures* compared to annual MPD 50 mSV (5000 mrem).*

	Annual Dose				
	mSv		mrem		% of Annual MPD 50 mSv (5000 mrem)
Location	Per Exposure†	(Annual 7200)	Per Exposure†	(Annual 7200)	(Annual 7200)
A. Thyroid	4.6×10^{-6}	0.033	4.6×10^{-4}	3.3	0.066
B. Abdomen	5×10^{-5}	0.36	0.005	36	0.72
C. Reproductive	1.3×10^{-4}	0.936	0.013	93.6	1.9
Study control (reproductive value)	6.2×10^{-6}	0.0446	0.00062	4.46	0.09
Average whole body dose	6.3×10^{-5}	0.4536	0.0063	45.36	0.9
Study control‡ whole body dose	2×10^{-6}	0.0144	0.0002	1.44	0.028

*Annual NOMAD™ dose based upon 30 exposures/day × 240 working days/year = 7200 exposures. See Table 4: Average NOMAD Study Dose per anatomical location.
†Per exposure: Average NOMAD™ study dose per anatomical location/715 study exposures.
‡Per exposure: Average NOMAD™ study dose per anatomical location/200 control exposures.

Discussion

The Aribex™ NOMAD™ portable hand-held dental X-ray device provides an operator safe zone, protecting the operator from backscatter radiation. This is designed to work best when exposing radiographs on a *typically* seated dental patient (2). Although the unit's manufacturer has promoted universal application of this device, its use may be required in situations in which *atypical* imaging positions for the operator may be involved. These may include situations in which the use of wall mounted fixed radiographic units are impractical or not accessible.

In this study, *atypical* use is defined as an imaging situation where operator positions are not completely covered by the "safe zone" provided by the circular lead acrylic shield which is mounted over the end of the primary beam collimator. *Atypical* operator positions may occur in forensic dental casework, anthropological field work, veterinary situations, and dental procedures involving sedated patients. This study intended to present outcome data that would primarily be gathered from and represent *atypical* use of the unit while utilizing various imaging modalities (e.g., slow and fast speed films and different methods of digital technology).

MPD Comparisons

The annual MPD is a radiation safety concept directed toward workers occupationally exposed to radiation to determine potential work related exposure. These individuals are required to undergo training in the procedures for appropriate management and use of radiation generating material (isotopes) and devices. Because of the knowledge-base gained by this training, radiation exposure to the worker is theoretically minimized.

Use of a hand-held radiation emitting device presents a different situation for the operator since they could potentially become the subject exposed to backscatter radiation. This is similar to a patient's exposure to radiation except that, in a *typical* scenario, the patient is exposed to a limited number of radiographs (i.e., full mouth series, bite wing images, endodontic radiographs). The dental healthcare worker, anthropologist, pathologist, or morgue attendant using a hand-held radiation emitting device in an MFI environment could potentially be subjected to increased backscatter radiation by exposing numerous radiographs in an *atypical* manner during a shift at a disaster sight.

The Aribex™ NOMAD™ manufacturer's publications (1,2) indicate an annual dose of 0.65 mSv (65 mrem) when using settings on the device for film exposure. The use of digital radiographic procedures results in annual dosage levels of 0.13 mSv (13 mrem). As presented by the manufacturer, when using this hand-held radiation emitting device the operator's backscatter exposure is less than 1% of the annual occupational MPD. The manufacturer's method of calculation of this dose is not stated in their marketing documents.

If the annual dose extrapolated from the results of this study is determined as an average rather than reported values for specific anatomical sites, this would result in an annual study average whole body dose of 0.4536 mSv (45.36 mrem) as shown in Table 5. These results are approximately 30% less than those reported by the manufacturer for film, despite the fact that 78% of the exposures in this study were conducted *atypically*. Such a difference could be explained by the varying methods of measuring dose and the numbers and locations of the dosimeter devices that occur with different studies. The approach for this study was to provide broad area coverage so that averaged data would be most representative of tissue exposure.

The annual extrapolated whole body dose exposure (Table 5) can also be represented as 0.9% of the annual MPD. This approach provides validation of the Aribex™ NOMAD™ published data (1,2). This implies that *atypical* imaging scenarios have no detrimental impact upon the overall operator whole body annual dose.

The ALARA concept is an important principle in radiation protection and indicates that any exposure should be kept "*A*s *L*ow *A*s *R*easonably *A*chievable" (14,15). An operator using this hand-held radiation emitting device in an *atypical* situation will most likely have to make an individual determination as to what is reasonable or unreasonable in regard to their potential exposure to backscatter radiation. In this case, risk and benefit are not exclusive to the diagnostic process.

Risk and benefit can also be applied to an understanding and appreciation of the convenience and efficiency enjoyed by using a hand-held, portable radiation emitting device when confronted with overwhelming radiographic imaging tasks. These task requirements commonly occur in MFI disaster scenarios or in other situations requiring *atypical* configurations for the device (4).

Certainly, nothing prevents the use of protective lead aprons, personal dosimetry badge monitoring, and alternative shielding configurations by operators concerned about any additional radiation exposure. Additional reduction in radiation exposure to the operator can also be achieved by eliminating the use of ultra D speed radiographic film (requiring approximately 3.5 times the digital dose) and using digital imaging receptors (Table 1). This approach to reduction of operator radiation exposure dose is based upon the results of the control group in which the 100 digital exposures resulted in no measurable dose, whereas those for the ultra D speed radiographic film resulted in minimal, but, measurable dose.

Conclusions

Used in a *typical* manner, the manufacturer of the NOMAD™ hand-held radiation emitting device acknowledges that the unprotected operator will sustain a small additional amount of radiation (<1% of the MPD) (1,2). This additional radiation exposure is directly related to the operator position within the ''safe zone'' provided by the acrylic/lead shield on the end of the primary beam collimator.

This study documented operator backscatter exposure in *atypical* situations in which the operator was not positioned according to complete compliance with the ''safe-zone'' recommendations of the manufacturer. Despite this fact, the results of this *atypical* use study for this device are similar to those of the manufacturer. The additional whole body exposure of 0.0447 mSv (4.47 mrem) in this study (Table 4) as well as the annual whole body extrapolated exposure dose (Table 5) of 0.4536 mSv (45.36 mrem) are <1% of the 50 mSv (5000 mrem) occupational limit at which dosimeter monitoring is required for dental personnel in Nevada (16,17). As specified in Nevada Administrative Code (NAC) sections 459.325 and 459.339.1(a), ''Each licensee and registrant shall monitor occupational exposure to radiation from licensed and unlicensed sources under the control of the licensee or registrant and shall supply and require the use of personnel monitoring equipment by:

- Adults who are likely to receive in 1 year, from sources of radiation external to the body, a dose in excess of 10% of the 50 mSv (500 mrem) occupational limit.''

Although the additional backscatter dose contribution to the operator has been shown to be well below accepted occupational levels, any operator concerned about additional exposure when using the NOMAD™ device can choose to take appropriate shielding precautions, use monitoring devices, and/or exclusively use digital radiography.

Acknowledgment

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