Biomedical Engineering, Vol. 46, No. 5, January, 2013, pp. 183-185. Translated from Meditsinskaya Tekhnika, Vol. 46, No. 5, Sep.-Oct., 2012, pp. 8-10.
Original article submitted March 25, 2012.

Portable X-Ray Apparatuses for Dentistry and Maxillofacial Surgery

N. N. Potrakhov[1]*, E. N. Potrakhov[1], A. Yu. Gryaznov[1], A. Yu. Vasilyev[2], N. V. Balitsky[2], and D. V. Boychak[2]

Portable X-ray apparatuses for dentistry and maxillofacial surgery have entered the list of medical X-ray equipment in recent years. The construction of a portable X-ray diagnostic apparatus allows the use of the apparatus without a tripod. The specifications and features of the portable dental apparatuses available on the domestic market are described. The results of measurements of the radiation dose at the workplace of the medical assistant performing manual dental photography using the first domestic portable device of the PARDUS family are presented.

In recent years, the domestic market of medical X-ray equipment has been supplied with portable X-ray apparatuses for dentistry and maxillofacial surgery. Such devices provide X-ray photography without a tripod. The reasons for their introduction into domestic medical practice are:

1) rapid progress in domestic private dentistry;

2) implementation of techniques of intra-operation monitoring in adult or pediatric patients subjected to maxillofacial surgery [1].

Intra-operation microfocal roentgenograhy provides monitoring for foreign body extraction, osteoplastic material use, and bone tissue regeneration in cystectomy and cystotomy. This procedure is the method of choice for patients with deficiency of bone tissue or in the presence of a foreign body at the implantation site [2].

The small size of the majority of dental rooms excludes the use of a full-size dental X-ray apparatus. Besides, use of a long-tube X-ray apparatus is not appropriate for an anesthetized patient.

It should be noted that in the USSR in the late 1980s the first attempts at application of portable X-ray apparatuses developed at OKB RP (Leningrad) and LETI (now St. Petersburg State Electrotechnical University) in dental practice were made [3, 4]. However, being developed ahead of time, the portable X-ray apparatuses were found to be incompatible with the general infrastructure of the clinical practice and the contemporary normative base.

Materials and Methods

At present, more than ten models of portable X-ray dental apparatuses and digital X-ray systems (mainly of foreign manufacture) are used in domestic medical practice (Table 1).

The X-ray dose is an important factor in the case of manual photography. Special studies were performed at the Research Institute of Radiation Hygiene to evaluate the X-ray dose received by medical personnel. The X-ray dose was measured near the technician's head and hand. The most commonly used typical models of X-ray apparatuses were tested: PARDUS-R (Russia), PORT-XII (Korea), and AXD-4000 (Korea). The results of the performed using a water-filled head phantom are given in Table 2.

Table 2 shows that the level of X-ray dose power for PARDUS is several times lower. This is due to a smaller focal spot size as compared to PORT-XII. Therefore, the PORT-XII apparatus should be used at skin–focus distance (SFD) of at least 200 mm. To facilitate focusing of the PORT-XII, the technician holds the apparatus near the head using both hands. This method of X-ray photography is sometimes called the video camera method. Other specifications of this mode of X-ray photography are: X-ray tube current, 2 mA; maximal exposure time, 0.5 sec; exposure time per photograph, 1 mAsec [5].

[1] St. Petersburg State Electrotechnical University, St. Petersburg, Russia; E-mail: KZhamova@gmail.com
[2] Moscow State University of Medicine and Dentistry, Moscow, Russia.
* To whom correspondence should be addressed.

TABLE 1. Specifications of Portable Dental X-Ray Apparatuses and Digital Dental X-Ray Systems

Apparatus, manufacturer	View	Voltage, kV	Current, mA	Exposure time, sec	Focal spot diameter, mm	Maximal X-ray dose power at the site of technician's hand, mSv/h	Weight, kg	Cost, thousands of rubles	Available documentation	Type of photography**
Port-XII X-ray apparatus (Unident, Korea)		60	2	0.03-2.0	0.8	1.0	2.35	180	Sanitary-and-epidemiologic report	Video camera
AnyRay X-ray apparatus (Vatech, Korea)		60	2	0.03-2.0	0.8	–	2.6	170	–	Video camera
DX-3000 X-ray apparatus (Dexowin, Korea)		60	1	0.05-1.35	0.8	–	1.5	170	–	Video camera
AXD-4000 X-ray diagnostic system (Dexowin, Korea)		60	1	0.05-1.35	0.8	1.1	1.8	450	Sanitary-and-epidemiologic report	Video camera
NOMAD X-ray apparatus (Aribex, USA)		60	2.3	0.01-0.99	0.4	3.6*	4.0	250	–	Gun
PARDUS-Stoma X-ray diagnostic system (ELTEKh-Med, Russia)		50-70	0.1	0.05-5	< 0.1	0.03	3.8	430	Registration certificate	Gun
PARDUS-R X-ray apparatus (ELTEKh-Med, Russia)		55-65	0.1	0.05-5	< 0.1	0.03	2	190	Registration certificate	Gun
REXTER X-ray apparatus (Dental X-ray, Korea)		70	2	0.05-1.35	0.4	–	2.7	190	–	Video camera
BPD-I X-ray apparatus (Pothrone Series, Korea)		60	2	0.01-2.0	0.8	–	2.3	180	–	Video camera
Diox portable X-ray apparatus (DigiMed, Korea)		60	2	0.01-0.60	0.4	–	2	127	–	Video camera
REXTAR LCD portable X-ray apparatus (Korea)		70	2	–	0.4	–	1.7	180	–	Video camera
REXTAR portable X-ray apparatus (Korea)		70	2	–	0.4	–	2.7	171	–	Video camera

* Dose power per whole body of technician.

** Video camera type: technician holds the apparatus in both hands (one hand) near the face; gun type: technician holds the apparatus at the arm's distance.

At the same imaging quality, the SFD value for the PARDUS apparatus is 50 mm. The X-ray tube current in this case is 0.1 mA; maximal exposure time is 0.045 mAsec. These values are considerably lower than for any other commercially available X-ray dental apparatus.

During photography, the flat end of the cone of the PARDUS device is brought in contact with the zone of interest. The contrast of the resulting image is sufficiently high, which facilitates targeting. This method of photography is sometimes called the gun method.

The results given in Table 2 with regard to the actual working mode of the PARDUS device allow the annual dose D received by the technician and environment to be estimated using the following equation:

$$D = P_{\text{eq meas}} \cdot N \cdot t_{\text{exp}} / 3600 \ [\mu\text{Sv}],$$

where $P_{\text{eq meas}}$ is the equivalent dose power at the place, μSv/h; N is the number of X-ray photographs per year; t_{exp} is the maximal exposure time of a single photograph, sec; 3600 is the number of seconds in one hour.

Maximal performance values of the PARDUS X-ray apparatus used in combination with the digital visual system RENTGENOVISIOGRAF are: voltage, 65 kV; current, 0.15 mA; exposure time, 0.3 sec [6]. The annual X-ray dose D_{h} received by technician's hand in case of 100 photographs per day (50 weeks per year) is:

$$D_{\text{h}} = 30 \cdot 600 \cdot 50 \cdot 0.3 / 3600 = 75 \ \mu\text{Sv} = 0.075 \ \text{mSv}.$$

The annual dose D_{head} for the head is:

$$D_{\text{head}} = 70 \cdot 600 \cdot 50 \cdot 0.3 \ / \ 3600 = 175 \ \mu\text{Sv} = 0.175 \ \text{mSv}.$$

The annual X-ray dose D_{hp} at distance 2 m behind the head phantom for a direct beam is:

$$D_{\text{hp}} = 290 \cdot 600 \cdot 50 \cdot 0.3 / 3600 = 725 \ \mu\text{Sv} = 0.725 \ \text{mSv}.$$

In accordance with the following equation derived in [7]:

$$R = I \cdot t_{\text{exp}} \cdot n \ [\text{mA} \cdot \text{min/week}],$$

where I is the maximal tube current and n is the number of photographs per week, the maximal working load R is:

$$R = 0.15 \cdot 0.3 / 60 \cdot 100 \cdot 6 = 0.45 \ \text{mA} \cdot \text{min/week}.$$

TABLE 2. Equivalent X-Ray Dose Power of Portable Dental X-Ray Apparatuses

Device name, manufacturer	P_{eq}, μSv/h		
	Hand	Head	Direct beam (distance, 2 m)
PARDUS-R, Russia	30	70	290
Port-XII, Korea	1000	143	–
ADX-4000, Korea	1100	160	–

According to the Radiation Safety Standards NRB-2009, the levels of exposure of group A personnel and patients are 20 and 1 mSv, respectively. Thus, the PARDUS X-ray apparatus is safe both for medical personnel and patients (located at a distance >2 m).

Conclusions

1. Domestic and foreign portable dental apparatuses have different values of the focal spot size and X-ray tube current. The mean values of these parameters in the domestic PARDUS X-ray apparatus are an order of magnitude lower than in its foreign counterparts. This makes the PARDUS family of apparatuses superior to similar devices.

2. The results of this work demonstrate that the microfocal PARDUS X-ray apparatuses can be safe both in outpatient and inpatient settings (for example, when used in a dental room or at home).

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