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Specific Features and Physicotechnical Conditions of X-Ray Imaging Using the PARDUS-Stoma Apparatus

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The PARDUS-Stoma X-ray system is described. It is intended for diagnosis of various diseases of teeth and para- and periodontium in dentistry and maxillofacial surgery. The device design allows its use under conditions unconventional for X-ray equipment. Because of extremely low exposure dose of X-ray radiation, it also allows diagnostic examination in an unspecialized premise, for example, directly in the dentist's office. Because of small dimensions and weight, it allows dental photographing to be carried out manually, without use of a special floor or wall support. The results of this work show that manual photographing using the PARDUS-R X-ray device in a usual dentist's office is performed according to the operating instructions. It is safe not only for the personnel of group A, but also for the non-professional population.

The PARDUS-Stoma X-ray diagnostic system provides diagnosis of various diseases of teeth and periodontium in dentistry and maxillofacial surgery. The PARDUS-Stoma consists of the PARDUS-R portable X-ray diagnostic apparatus, digital X-ray image display based on X-ray-sensitive CCD-matrix RENTGENVIDEOGRAF, and a PC (Fig. 1). The PARDUS-Stoma system displays individual segments of the X-ray image of the patient's maxillofacial system obtained using target-oriented microfocal X-ray imaging [1].

In contrast to presently available foreign dental X-ray imaging devices (radiovisiographs), the PARDUS-Stoma system uses the first domestic portable microfocal X-ray apparatus PARDUS-R as a radiation source. The diagnostic system can be used under unconventional conditions:

1) directly in dental polyclinics (because of low X-ray exposure dose);

2) manual X-ray imaging without special rack (because of small size and weight) (Fig. 2).

The use of the PARDUS-Stoma system under unconventional conditions is based on two documents: 1) sanitation regulations SanPiN 2.6.1192-03 Hygienic Requirements for X-Ray Dental Rooms, Apparatuses, and X-Ray diagnostic examination [2]; 2) Methodological Recommendations MU 2.6.1.2043-06 Hygienic Requirements for Positioning of Radiovisiographs in Dental Rooms [3]. The first document specifies working load on the PARDUS-Stoma system outside X-ray dental diagnostic departments of hospitals or policlinics (dental or general purpose): dental digital X-ray image devices with working load 40 mA·min/week can be placed in dental departments situated in residential buildings provided that radiation safety requirements are observed (c. 9.2 [2]).

Fig. 1. PARDUS-Stoma portable digital X-ray diagnostic system: *1*) PARDUS-R microfocal X-ray apparatus; *2*) RENTGENVIDEOGRAF X-ray image display; *3*) PC.

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Fig. 2. Target-oriented X-ray imaging using the PARDUS-Stoma portable X-ray diagnostic system.

The second document defines the radiovisiograph. The radiovisiograph is defined as a dental X-ray diagnostic system containing X-ray apparatus and intraoral image detector. Therefore, photolaboratory image processing is not required (c. 3.1 [3]). The second document also specifies radiation safety requirements for the general population (cc. 4.3, 5.5 [3]) and medical personnel of group A (cc. 5.6, 5.11 [3]). According to c. 4.3 [3], effective dose power of X-ray radiation reduced to standard working load of a given X-ray apparatus is 0.3 μGy/h. This value is limiting annual effective radiation dose for the general population (1 mSv) at exposure time during this period of 3000 h (c. 2.19 [2]).

It should be noted that the medical regulations allow group A personnel to be near the patient if necessary (c. 5.11 [3]). The medical personnel should be protected using individual protective devises (apron and collar) (c. 9.11 [2]). The portable X-ray diagnostic system PARDUS-Stoma is appropriate for diagnostic examination in the field (e.g., military field conditions).

When a radiovisiograph is used in hospital, group A medical personnel should be protected using protective screen (c. 5.6 [3]). A protective screen should be positioned 1 m from the X-ray radiation source. Size, position, and Pb equivalent of the protective screen are determined by radiation safety requirements (limiting effective radiation dose for group A personnel). Limiting annual effective radiation dose for the whole body is accepted to be 20 mSv at exposure time during this period of 1700 h (150 or 500 mSv for some organs: eye lens or skin, hand, and foot, respectively).

According to c. 5.7 [3], protective measures (screen or individual protective devices) and distance to protective screen is determined using calculations or dosimetric measurements.

The possibility of manual use of the PARDUS-Stoma system directly in dentist's office was assessed at St. Petersburg State Electrotechnical Technological University in collaboration with FGUN NIIRG (St. Petersburg). The X-ray radiation dose was measured within a circle with radius 0.5 and 1 m from the output window of the X-ray apparatus. The measurements were also performed at vertical (points V1-V8) and horizontal (points H1-H8) planes, as well as at points of location of X-ray technician hands and head (eye lens). The geometric pattern of X-ray imaging is shown in Figs. 3 and 4.

During measurements, the X-ray apparatus was in the room center (total room area, 20 m^2). According to c. 5.3 [4], a plastic container (filled with water; diameter, 150 mm; height, 200 mm) was used as a tissue-equivalent phantom. The working mode of the X-ray apparatus was determined in clinical tests at the Department of Maxillofacial Surgery and Dentistry, Military Medical Academy, St. Petersburg: maximal X-ray tube anode voltage, 60 kV; maximal exposure dose per frame, 0.03 mAsec [4]. The DKR-AT1123M dosimeter was used. The results of the tests are given in Table 1.

Maximal effective X-ray radiation dose was observed at points V1 and H1. The X-ray technician's hands are not at these points during X-ray examination.

In leading domestic dental medical organizations, up to 80-100 target-oriented dental photographs are taken per day (10 photographs per hour) in case of two-shift work of X-ray room. Each X-ray technician takes 40-50 photographs.

TABLE 1.

Point	Dose, nSv			
	Vertical plane (V)		Horizontal plane (H)	
	R = 1.5 m	R = 1.0 m	R = 1.5 m	R = 1.0 m
1	56	124	60	129
2		34		27
3	11	22		20
4		20		22
5	1	3	2	4
6		6		19
7		16		17
8		27		30
Hand		82		
Eye lens		25		

The maximal working load R of the PARDUS-R X-ray apparatus (product of one photograph exposure dose multiplied by total number of photographs per week) per X-ray technician (six-day working week) is:

$$R = 0.03 \text{ mA·sec} \times 50 \text{ photographs} \times 6 \text{ days} =$$

$$= 0.15 \text{ mA·min/week}.$$

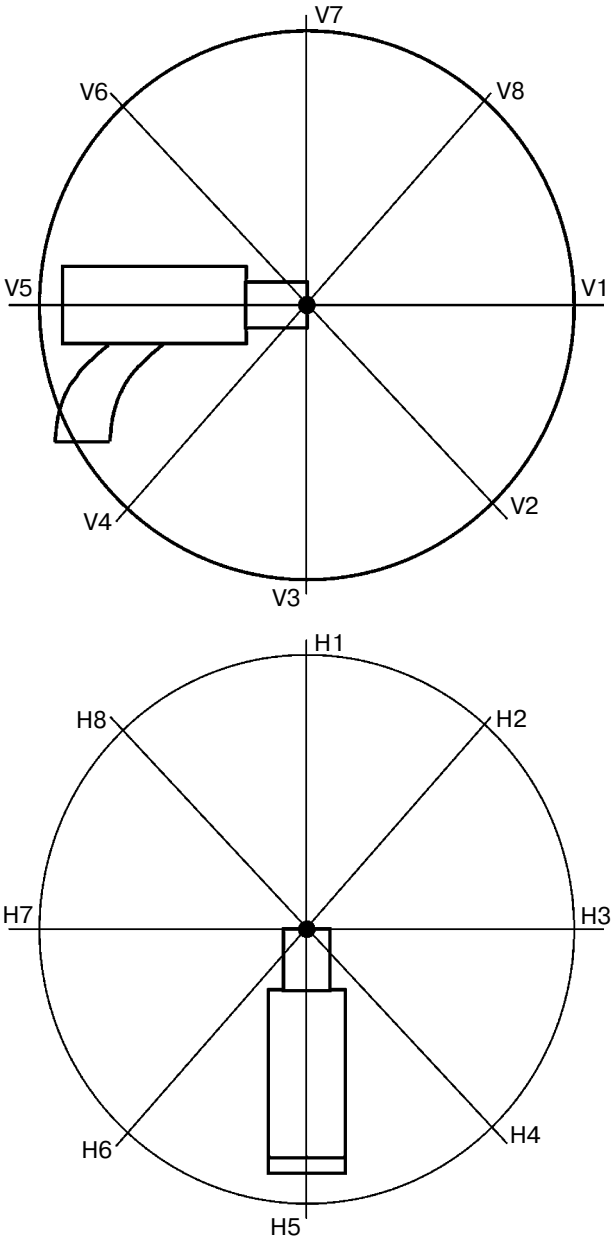

Fig. 3. Geometric pattern of measurement of X-ray radiation dose.

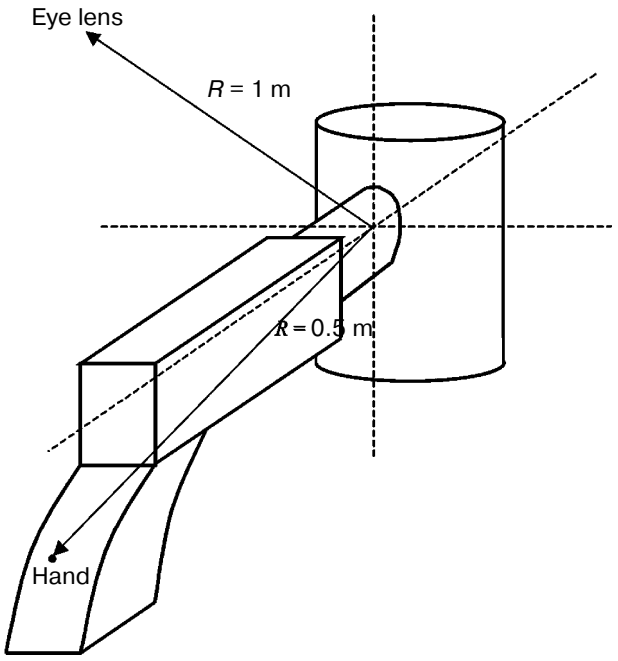

Fig. 4. Geometric pattern of measurement of X-ray radiation dose.

Equivalent X-ray radiation dose D received annually by an X-ray technician is the product of measured dose at point D_{xy} multiplied by total number of photographs per year. In case of 50 working weeks per year, annual dose for hand and eye lens is:

$$D_{\text{hand}} = D_{xy} \times 50 \text{ weeks} \times 300 \text{ photographs} =$$

$$= 82 \times 15000 = 1.23 \text{ mSv};$$

$$D_{\text{eye lens}} = D_{xy} \times 50 \text{ weeks} \times 300 \text{ photographs} =$$

$$= 25 \times 15000 = 0.38 \text{ mSv}.$$

These values are less than 1/300 of the limiting X-ray radiation dose for group A medical personnel (for hand and eye lens).

Effective dose power P of X-ray radiation at point V1 (H1) for maximal number of photographs per hour at maximal exposure time (0.3 sec) per photograph is:

$$P = D_{xy} \cdot (10 \text{ photographs/h}) = 1.3 \text{ μSv/h}.$$

This value is also less than the limiting dose determined by c. 5.14 [5] for group A medical personnel.

It should also be noted that at distance >1.5 m the effective dose power of X-ray radiation reduced to the same number of photographs is less than limiting value for the general population (0.3 μGy/h [5]).

The results of this work indicate that manual X-ray imaging using the X-ray apparatus PARDUS-R is safe not only for group A medical personnel, but also for the general population.

Therefore, the PARDUS-Stoma X-ray diagnostic system can be used for dental diagnosis directly in the dental chair.

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