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Reference Doses for Dental Radiography

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INTRODUCTION & OBJECTIVES

The use of digital image systems (DS) has recently become increasingly popular in the field of dental radiography. These systems have substituted image systems based on radiographic film (RF) and have led to a change in working parameters in order to reduce patient dose without producing a detriment in image quality.

Most of the protocols and guides currently recommend a single reference dose value for any intraoral dental radiography. We believe it is important to distinguish between image systems used, in order to delimit working conditions for the more recent digital image systems. Along these lines, the Radiation Protection Service ACPRO, S.L. has performed a study on a sample of intraoral dental units for which quality controls were carried out. The study defined four groups of interest: standard adult and paediatric patients with radiographic film, and standard adult and paediatric patients with digital image system. A reference patient dose has been proposed for each group of interest.

METHODS

Data from quality controls at different centers within Catalonia performed by ACPRO (both within the private and public health system) to intraoral dental units during 2010 have been used. Data from dental units that dit not fulfil the minimum requirements established under the Spanish X-ray diagnosis quality control protocol [1] were discarded from the study. The final data set comprised information from about 400 sets of dental units and all data were automatically introduced into a data base. The maxillary molar projection was chosen, both for a standard adult and a paediatric patient (in units where paediatric mode is enabled), in order to obtain clinical working characteristics, as this projection involves the highest patient dose.

Data were classified according to the type of image system used at each dental facility. A second classification was done by taking into account tube voltage (<70 kV or 70 kV), emitted radiation wave form (single-phase (SPh) or high-frequency (HF)) and focus-to-skin distance, determined by the spacer cone length (20 cm or 30 cm).

The entrance surface dose (ESD) is determined by applying a backscattering factor of 1.1 to the entrance surface air kerma (ESAK) measured with a multimeter at the end of the spacer cone. The third quartile of the resulting ESD distributions was the value used to establish the reference dose levels.

RESULTS & DISCUSSION

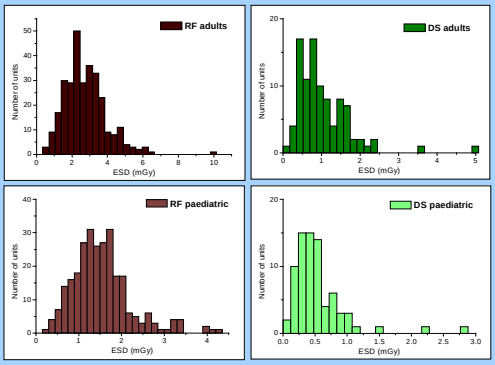

Figure 1. ESD distributions for each group of interest defined.

Type	Sample size	ENTRANCE SURFACE DOSE (mGy)				
		Lowest	Highest	Mean	Median	3rd quartile
RF adults	301	0.61	10.05	2.76	2.64	**3.39**
DS adults	96	0.17	4.92	1.03	0.86	**1.33**
RF paediatric	273	0.28	4.21	1.54	1.47	**1.81**
DS paediatric	76	0.12	2.86	0.54	0.46	**0.63**

Table 1. Statistical results from the ESD distributions of Figure 1. The 3rd quartile values are the proposed reference dose levels.

The 3rd quartile of the distributions of **Figure 1** was used to obtain the ESD reference levels shown in **Table 1**. **Figure 2** clearly shows that the use of digital image systems involves a reduction of the order of **60%** in ESD in comparison with the use of radiographic film. The reduction of ESD due to the use of the paediatric mode is of the order of **50%**.

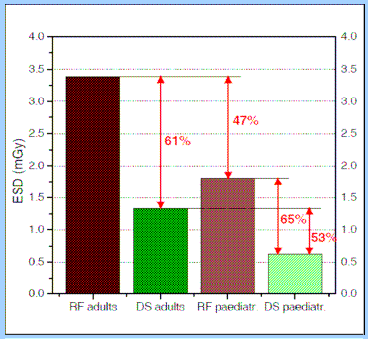

Figure 2. Comparison of reference dose levels and evaluation of the percentage of dose reduction by the use of digital image systems and the use of the paediatric mode.

	3rd quartile quantities	DENTAL UNIT CHARACTERISTICS						
		Total	< 70 kV	70 kV	SPh	HF	20 cm	30 cm
RF adults	ESD (mGy)	3.39	3.84	3.21	3.25	3.74	3.47	2.11
	tube output[a] (mGy/mAs)	0.041	0.045	0.040	0.039	0.055	0.041	0.038
	mAs-value[b] (mAs)	3.84	3.75	3.84	3.84	3.50	3.68	5.04
DS adults	ESD (mGy)	1.33	1.51	1.29	1.44	1.12	1.43	0.99
	tube output[a] (mGy/mAs)	0.043	0.048	0.039	0.037	0.060	0.044	0.039
	mAs-value[b] (mAs)	1.64	1.33	1.76	1.76	0.80	1.60	2.28

(a) Measured at 1 meter from focal spot.
(b) Fixed dental unit intensity multiplied by selected exposure time.

Table 2. Comparison of the main dental unit parameters and the resultant patient ESD depending on the tube-voltage, the wave form and the spacer cone length.

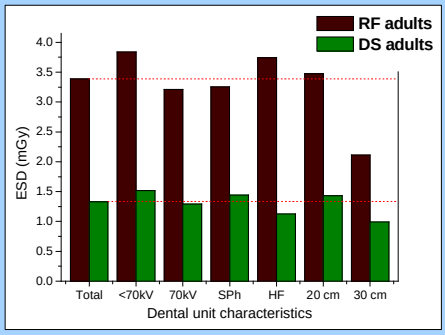

Figure 3. Graphical comparison of ESD depending on dental unit characteristics and image system.

Table 2 and **Figure 3** give the influence of different dental unit characteristics on ESD.

Dental units with a cone length of 30 cm inherently imply a 55% lower dose than units with a cone length of 20 cm, when only considering the distance factor. To compensate for this effect, higher mAs-values are needed. The statistics in **Table 2** show that 30-cm cone units imply substantially lower patient doses than 20-cm cone units, in spite of the higher mAs-values generally used by them.

Table 2 indicates that HF dental units present higher tube-output values than SPh units. To compensate for this effect, HF units work at lower mAs-values. In the case of DS we have seen a substantial mAs reduction, which implies a patient dose decrease. However, in the case of RF, the mAs reduction is insufficient and the patient doses for HF units are even higher than those for SPh units. DS devices are able to work at lower exposure times and provide good quality images. The heating time inherent to SPh units makes them not optimal for working at low exposure times (large time deviations are shown in the quality controls) and, therefore, they require longer exposure times than HF units. This could be the explanation for the substantially lower ESD achieved by HF DS units in comparison with SPh DS units. However, in the case of RF, there are no technical reasons in order to explain higher ESD values for HF units than for SPh units.

Table 3. Dose reference levels comparison between the results of the present study and those of protocols, guides and other published studies.

	REFERENCE DOSE LEVEL (mGy)				
	present study (2012)	EC [2] (2004)	AAPM [3] (1999)	NRPB [4] (1999)	Napier [5] (1999)
RF adults	3.4[a]	4.0[a]	3.5[b]	4.0[c]	3.9[c]
DS adults	1.3[a]				
RF paediatrics	1.8[a]				
DS paediatrics	0.6[a]				

(a) Maxillary molar projection.
(b) Bitewing projection, 70 kV dental units with D speed radiographic film.
(c) Mandibular molar projection.

Table 3 shows that the result obtained in the present study for the maxillary molar projection ESD for a standard adult patient using an image system based on radiographic film is in agreement with more relevant reference dose levels that have been previously established. In addition, the present study proposes new reference dose levels for which no previous values were available, as for the use of digital image systems and for paediatric patients.

CONCLUSIONS

The present study shows that a single reference dose value for intraoral dental examinations is insufficient, due to the increasing use of digital image systems which involves a substantial dose reduction (60%). Likewise, we also can conclude that it is needed to establish new reference dose levels for paediatric patients, as a significant dose reduction is also observed (50%).

For the above reasons, the present study proposes some new reference dose levels to ensure patient dose reduction: for standard adult patients, 3.4 mGy with radiographic film and 1.3 mGy with digital image system; for paediatric patients, 1.8 mGy with radiographic film and 0.6 mGy with digital image system. The reference dose levels proposed by the present study for standard adult patients is in agreement with the most relevant current reference dose levels.

From the above discussion, we would also like to point out that for dental units which present an entrance surface dose higher than the reference values proposed (meanly 20 cm spacer cone units and high-frequency units with radiographic film) it should be possible to reduce the clinical exposure time. This time reduction could not be possible for single-phase units with digital image system, also presenting higher entrance surface dose values, because of their technical restriction to work at low-time values.

REFERENCES

[1] *Protocolo Español de Control de Calidad en Radiodiagnóstico* (2002), SEFM-SEPR
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