Optimization of Radiation Doses and Patients' Risk in Dental Radiography

Ralph Alexandru ERDELYI[1, a)], Virgil-Florin DUMA[2, 3, b)]

[1] *West University of Timisoara, Romania*
[2] *3OM Optomechatronics Group, "Aurel Vlaicu" University of Arad, Romania*
[3] *Doctoral School, Polytechnic University of Timisoara, Romania*

[a)]Corresponding author: ralph.erdelyi93@gmail.com
[b)] duma.virgil@osamember.org

Abstract. The aim of this study is to present the patient's risk in dental radiography and to optimize the dose taken by patients during such an exposure. The development of technology led to the development of medical equipment and also to the improvement of medicine along all its fields. A major progress was made by dentistry because all dental radiographs (intraoral, panoramic, 3d CBCT – Cone-Beam Computed Tomography) offer high-quality images which are used to diagnose and make a treatment plan suitable for every patient's problem and also to check the result of the doctor's work during the treatment.

METHODS

A skull model (Fig. 1) was scanned using two types of exposure with a CBCT machine ProMax 3D Plus (Planmeca, Helsinki, Finland).

FIGURE 1. Skull Model.

Numerous combination of voltage [kV] and current intensity values [mA] of the X-ray tube were tested in order to obtain panoramic radiographs with a radiation dose which maximize the benefit-risk ratio. This means that the quality of the image is high enough for a medical purpose and the dose used for getting this quality of the image is as low as possible. The same method was used for 3D CBCT. From the machine settings the voxels dimensions were selected and the exposure was made at ULD (ultra-low-dose). Instead of ULD, the machine also can expose at normal radiation doses, which are twice bigger than ULD. After that, the skull model was exposed at different values of voltage [kV] and current [mA].

In order to obtain a high-quality image with a ULD, an image reconstruction software was utilized. This allowed for small image modifications like removing artefact, adjusting the brightness, the contrast, the sharpness or other image characteristics. These image modifications and the reconstruction software also reduce the radiation doses because there is no more needed a perfect raw image and the first image could be enhanced.

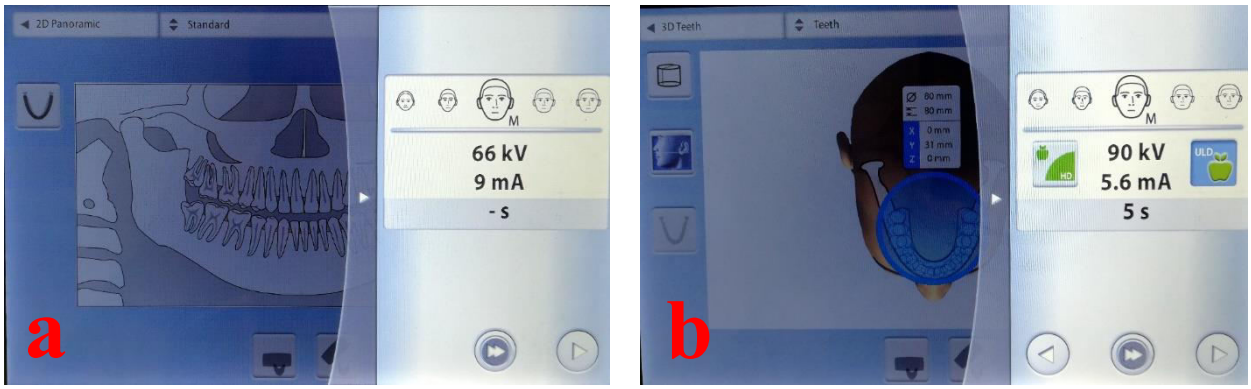

FIGURE 2. Machine settings, from volume and voxel size to current intensity and voltage for panoramic (a) and for 3D imaging (b).

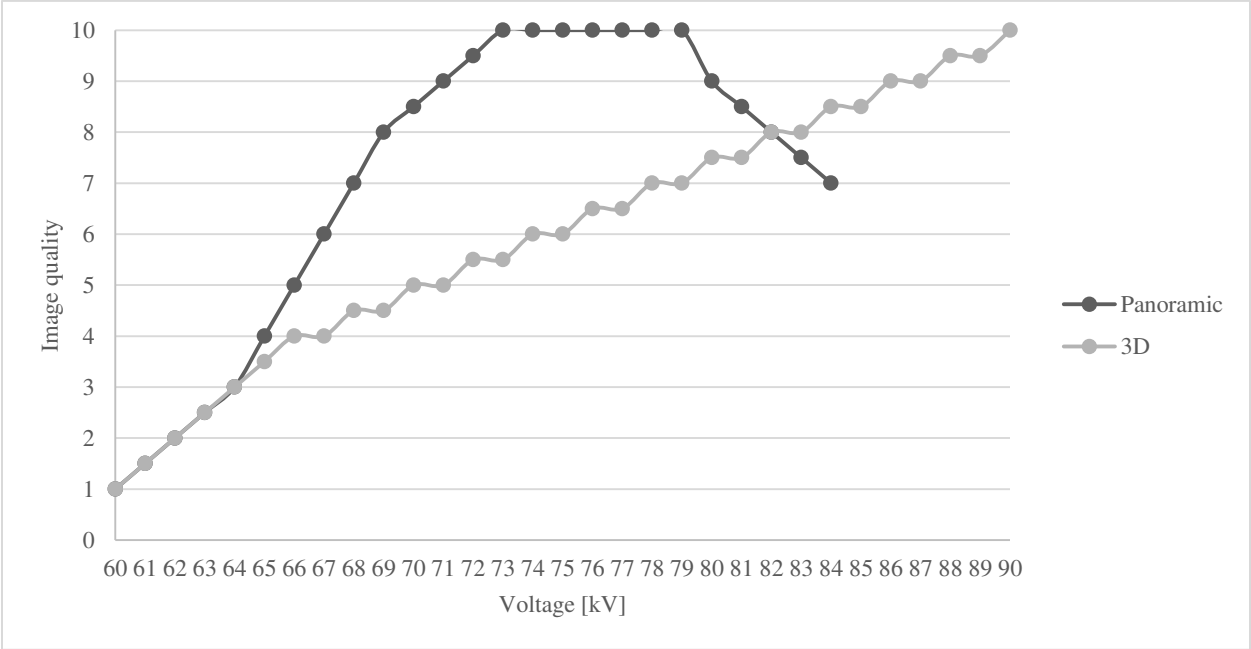

FIGURE 3. Quality for the best image from every value of voltage.

Table 1. Values of voltage and current.

2D		3D	
Voltage [kV]	**Current [mA]**	**Voltage [kV]**	**Current [mA]**
60	1	60	1
61	1.1	61	1.1
62	1.25	62	1.25
63	1.4	63	1.4
64	1.6	64	1.6
65	1.8	65	1.8
66	2	66	2
67	2.2	67	2.2
68	2.5	68	2.5
69	2.8	69	2.8
70	3.2	70	3.2
71	3.6	71	3.6
72	4	72	4
73	4.5	73	4.5
74	5	74	5
75	5.6	75	5.6
76	6.3	76	6.3
77	7.1	77	7.1
78	8	78	8
79	9	79	9
80	10	80	10
81	11	81	11
82	12.5	82	12.5
83	14	83	14
84	16	84	
		85	
		86	
		87	
		88	
		89	
		90	

Beside the technical part (i.e., the specifications of the machines), on which the quality of the image depends on, the patient's positioning, should also be taken into account. In this respect every millimeter counts so it is important for a good image that the patient is relaxed, well fixed into the machine according to his anatomical characteristics, and to stand still until the end of exposure. In the case of Planmeca ProMax 3D Plus (and also for other types of CBCT machines), the patient positioning is guided by lasers.

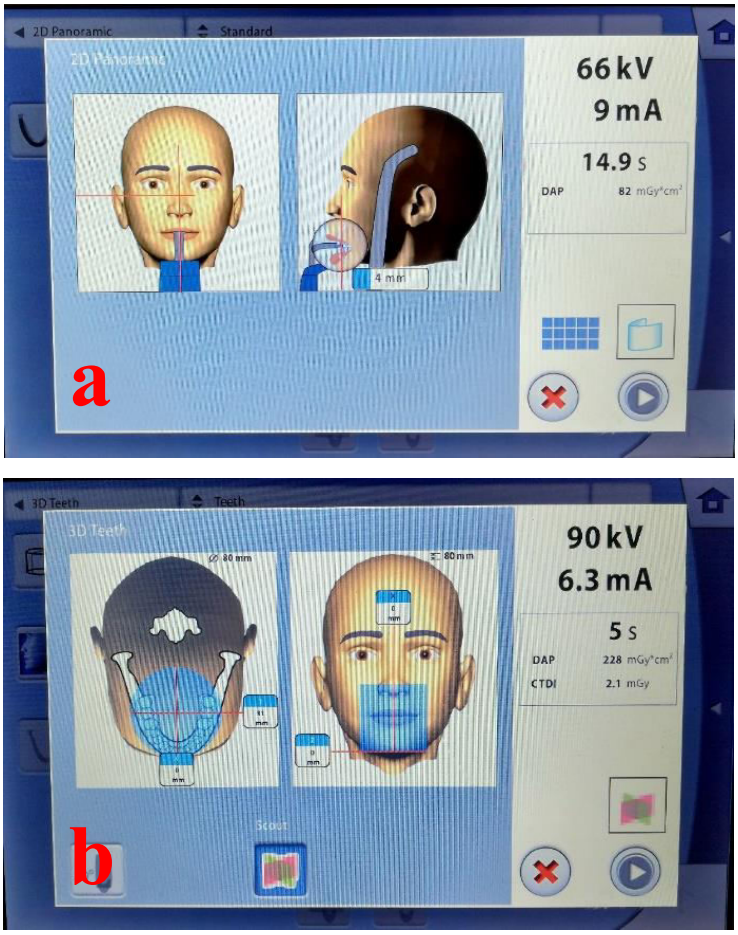

FIGURE 4. Panel with the appropriate position of the patient for panoramic (a) and for 3D imaging (b).

RESULTS

The radiation dose taken by a patient during the exposure is the smallest possible, while still assuring the quality of the image to offer all the information needed by the doctor, both for diagnosis and intra (or post) treatment. Effective doses for intraoral radiographs are around 1.5 µSv, for panoramic radiographs between 9 and 10 µSv, and for CBCT it varies between 30 and 100 µSv, depending on what volume is needed, from 5 x 5 to 8 x 8 cm. Table 2 shows better the effective doses calculated for every kind of exposure. The equation 1 was used for calculating all the effective doses from the DAP given by the machine.

$$E_D = C * DAP \quad (1)$$

From that formula, E_D means effective dose, C is a specific tissue coeficient and DAP is the dose absorbed in the area we examined. In figure 3 is represented the relation betwin the radiation dose and image quality and it shows that from 72 to 79 KV it is achieved the best image quality for panoramic exposures and the best 3D reconstruction is given at maximum voltage and ULD settings.

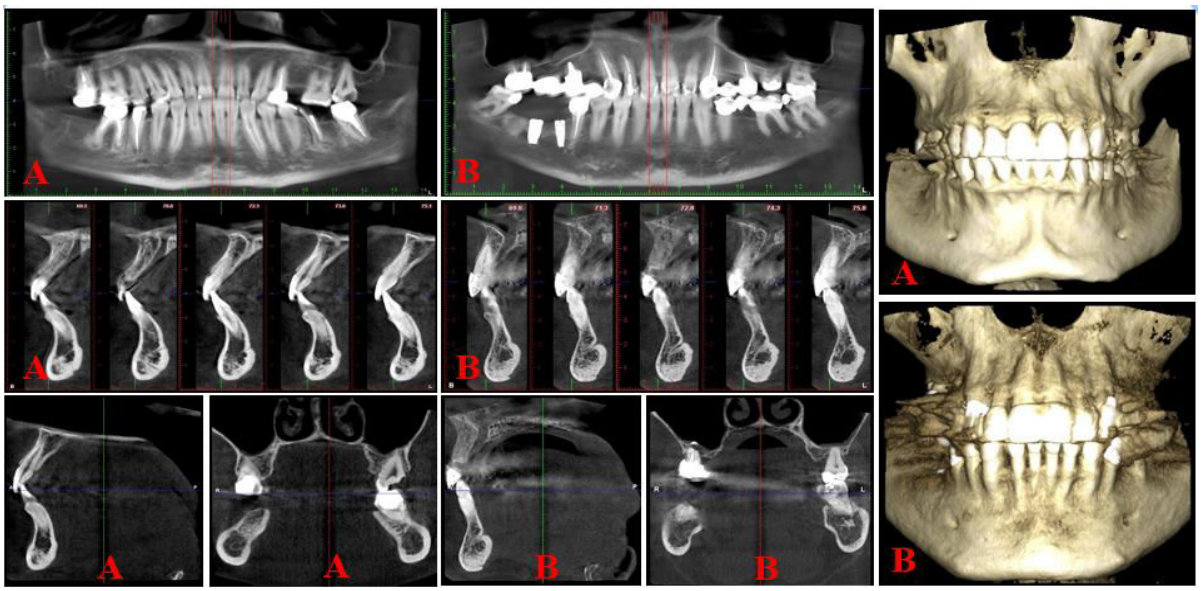

FIGURE 5. All A pictures are from a 3D CBCT with optimized doses and protocol and all B pictures are from a 3D CBCT with non-optimized doses and protocol.

TABLE 2. Effective dose calculated for every dental radiograph.

Procedure	Formula	Voxel size (µm)	DAP (mGy* cm^2)	Effective dose (µSv)
RX Panoramic	E_D=0.08*DAP		117.5	9.4
3D CBCT (8X8)	E_D=0.125*DAP	150	566	70.75
3D MAXILLARY (8X5)	E_D=0.1*DAP	150	368	36.8
3D MAXILLARY (5X5)	E_D=0.1*DAP	150	323	32.3
3D MAXILLARY (5X5)	E_D=0.1*DAP	75	709	70.9
3D MANDIBULA (8X5)	E_D=0.15*DAP	150	368	55.2
3D MANDIBULA (5X5)	E_D=0.15*DAP	150	323	48.45
3D MANDIBULA (5X5)	E_D=0.15*DAP	75	709	106.35
RX intraoral	E_D=0.07*DAP		21.42	1.5

Considering that the maximum dose allowed for a human during a year is 20 mSv and the dose taken from the natural background radiation is around 3000 µSv (depending on the location), patients could take doses around 16000 µSv whitout any problems. Usually, during dental treatments, doses taken by patients are around 600 µSv which include several panoramic and intraoral radiographs and a few 3D CBCT radiographs.

CONCLUSION

Effective doses are between 1.5 and 100 µSv, small radiation doses even if during the treatment there are many exposures needed. Considering the fact that the maximum dose allowed for a human during one year is 20 mSv which is 20000 µSv and the dose taken from the natural background radiation is somwhere around 3000 µSv depending on location, patients could take doses gathered around 16000 µSv whitout any problems. Usually, during dental treatments, doses taken by patients are somwhere around 600 µSv. So, patients could make dental radiographs any time the doctor need one whitout a signifiant risk of iradiation. In addition, if the machine is used in optimal condition and the protocol (from the preparation of the patient to final image) is optimised in order to get maximum image quality with an as low as possible dose of radiation, patients risk is almost nonexistent in the dental radiographs.

ACKNOWLEDGEMENTS

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