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Calculating and Evaluating Doses of Dental X-Rays CT Cone Beam

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Abstract

According to recent reports, there is an alarming reality in Vietnam today that about 90% of people have dental problems, mainly tooth decay. Dental diseases cause discomfort for patients and a loss of confidence in communication. Therefore, the demand for dental exams and treatments is increasing day by day.

X-rays have long been used to treat dental diseases and are playing an increasingly important role in dentistry. The creation of cone-beam computer tomography (CTCB) has brought many benefits to users. This thesis mainly presents how to calculate the DAP number (Dose Area Product) at CTCB Orthophos and convert the unit of DAP (Gy.cm2) to the unit of the effective dose (mSv).

The results obtained from nearly 100 CTCB scans show that the effective dose of the instrument Orthophos is about 0.2 mSv, which is satisfactory for the requirements for radiation safety even with the largest FOV.

The study was carried out under the supervision of Denstply Sirona for the purpose of warning before taking, helping doctors (technicians) to manage the problems related to the imaging process and to minimize the radiation dose radiation on the patient, and determine the radiation on the patient in practice at the same time.

1 Introduction

The CTCB system was born and developed over the years, the improvement of the CTCB equipment introduced new CTCB systems with better functionality than the next generation, serving better dental imaging. In addition, these new CTCB are beneficial, but they also need to be concerned that with new

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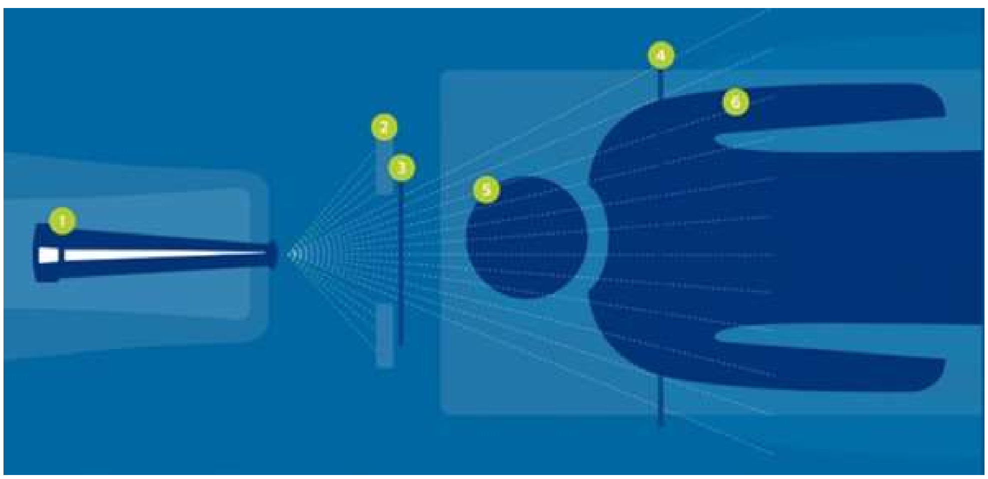
technologies, the radiation that people receive when taking pictures of CTCB has a effect on the health, so there will be methods to calculate and determine the effective dose of radiation.

Because it is impossible to measure the dosage of tests regularly, other measurements, such as dose-area-product value, are often used as the metric to calculate the dosage that patients receive. Dap (mGy x cm^2) says the dose in the beam and the area is irradiated. It depends on the device and the exposure parameters, whether the patient is photographed or exposed, while the effect is affected by the size of the patient and the area irradiated. Some CTCB units provide the dap index of each irradiation. The dentist and CTCB technician should know dap of different kinds of tests made by their CTCB device and how dap compares with alternative checks.

2 Method

The DAP value is a quantity used to assess radiation risk from x - ray use in dental diagnosis and dental radiography. It is defined as the dosage dose multiplied by the irradiated area, expressed as the Gy.cm2, sometimes the prefix unit mGy.cm^2 or cGy.cm^2 is used. DAP meter manufacturers often calibrate them based on the absorption of the air. Dap is not only reflecting the dose in the radiation field but also reflects the dose surrounding the irradiated tissue.



(1)	X-ray Tube	(3)(4)	DAP Chamber
(2)	Collimator	(5)(6)	Air Kerma Chamber

Figure 1: The difference between DAP and AK (Air Kerma). [15]

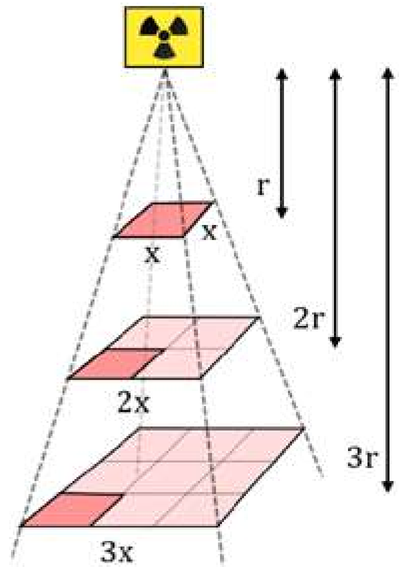


Figure 2: DAP value is independent of distance to X-ray Tube

The dap value does not depend on the (r) distance to the x - ray source, as the dose falls 1 / r2 while the area is irradiated with the distance, and dap is usually constant.

$$DAP_r = D_r \times x \times x$$

D_r: the dose emitted from the beginning of x - ray

r. distance from the beginning to detector

x: value one edge of FOV (cm)

2.1 The irradiation dose from Orthophos SL 3D

For any freely programmed parameter combinations, the technicians must calculate the value using the kV/DAP lists;

Calculation:

The values indicated below have been calculated for the parameter combinations proposed by Dentsply Sirona. If other settings are used, with the help of kV/DAP lists, proceed as follows:

1. Select the set kV level from the table of the respective X-ray system and note down the DAP factor.
2. Multiply the DAP factor by the actually used mA (as indicated on the X-ray system).
3. Multiply the result by the actual exposure time (see Multitimer or table).

To compensate for measuring errors as well as for system and instrument variations, a tolerance of 20 % must be taken into account.

kV	3D expo sure mode	DAP factor program VOL1 (mGy x cm2/mAs)		DAP factor program VOL2 (mGy x cm2/mAs)	DAP factor program VOL3 (mGy x cm2/mAs)	
		8 x 8	8 x 5.5	5 x 5.5	11 x 10	11 x 7.5/8
85	**SD**	9.459	6.583	4.191	15.401	11.790
85	**HD**	11.094	7.722	4.951	18.064	13.829
85	**Low Dose**	3.059	2.129	1.365	4.981	3.813

Table 1: DAP factor program for 3-D imaging (Provided by Densply Sirona).

Radiography	mSv/Gycm2
Head AP	0.058
Head PA	0.034
Head Lat	0.037
Cervin spine AP	0.19
Cervin spine Lat	0.12
Shoulder AP	0.064
Shoulder (axial)	0.046
Chest PA	0.16
Chest Lat	0.13
Thoracic spine AP	0.24
Thoracic spine PA	0.091
Lumbar spine AP	0.22
Lumbar spine Lat	0.092
Lumbo-sacral joint Lat	0.078
Abdoment AP	0.18
Pelvis AP	0.14
Single Hip AP	0.13
Both Hips AP	0.13
Femur AP	0.036
Femur Lat	0.0034
Knee AP	0.0034
Knee Lat	0.0030
Foot (dorsi-plantar)	0.0032
Foot (oblique)	0.0032
AP = Antero-posterior PA = Postero-anterior	

Table 2: Conversion factor of Effective Dose to DAP in radiography (2-D imaging).

For 3-D dental imaging, Batista et al. [22] suggested using formula for tube voltage >85 kVp.

$$E = [0.00145.(kV) + 0.0118].P_{KA}$$

In which:

E: effective dose (μSv)
(kV): tube voltage, tube voltage of Orthophos SL 3D is 85kV
$P_{KA:}$ DAP value (mGy.cm2)

2.2 Effective dose received by the patient during CTCB

Using the Python programming language to build an interface used to calculate the radiation dose received by the patient during CTCB. The algorithm uses the formula provided by Dentsply Sirona in the Orthophos SL 3D operating manual.

$$DFP = \frac{DAP}{mAs} * mA * s$$

In which,

DFP (DAP program factor): DAP index of each shooting program

DAP (Dose Area Product): dose value by scan sector (area)

mA: amperage of the X-ray tube

s: irradiation time.

The program is designed on demand, with the aim of predicting the effective dose of each scan. The results include the DAP index and the Effective Dose.

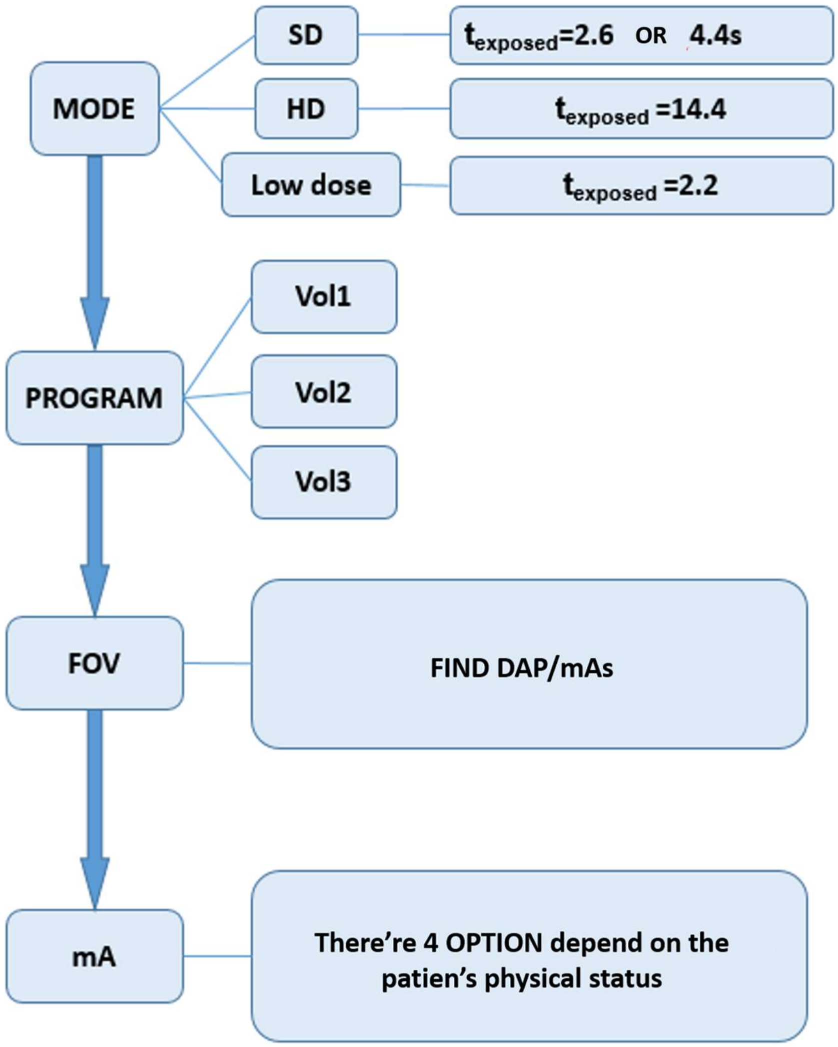


Figure 3: Python Program workflow

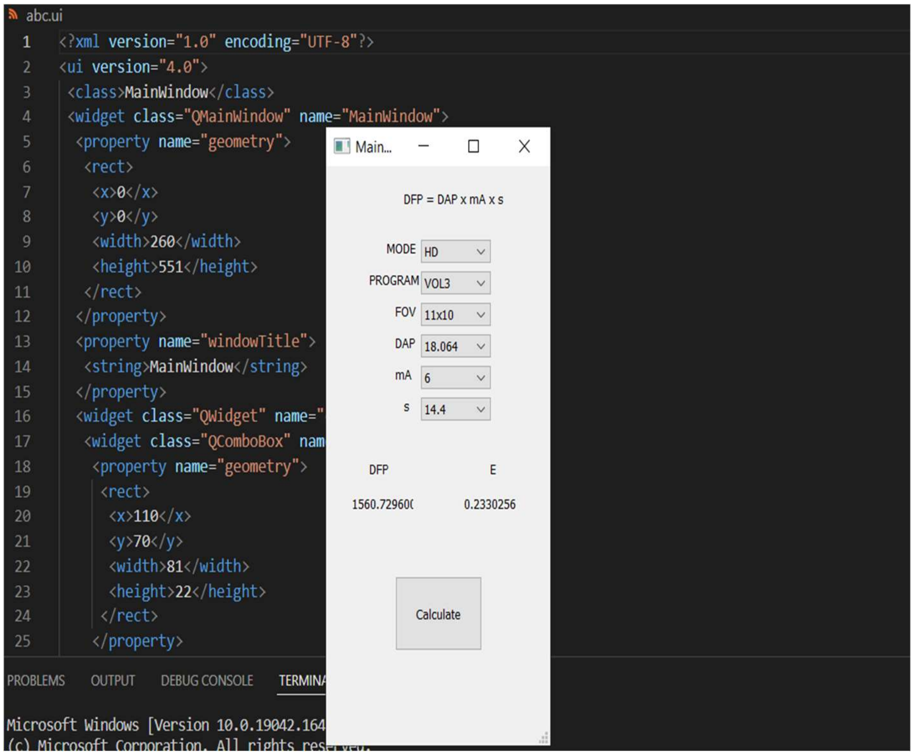


Figure 4: Software interface

The process of calculating

Step 1: Select Mode to choose the quality for the image, including 3 modes: SD, HD, Low Dose.

Step 2: Select Program to choose the area of the FOV (field of view): including 3 programs: Vol1, Vol2, Vol3.

Step 3: Select FOV. Depending on the selected Program, each Program will have different FOV values.

Step 4: Select mA value. Each Mode offers 4 options of mA depending on the patient's condition.

Step 5: Select the shooting time. Shooting time depends on Mode.

A. Dataset

The data was taken from the Orthophos SL 3D machine of Dentsply Sirona at 3 dental clinics in Ho Chi Minh City. Ho Chi Minh City: Gia Dinh People Hospital, My Thien Hospital of Odonto-Stomatology and Pegadent Cosmetic Dentistry Center.

B. Data processing

Uses the formula (2.3), provided by Dentsply Sirona in the Orthophos SL 3D operating manual to calculate the DAP value for each case

$$DFP = \frac{DAP}{mAs} * mA * s$$

Then, uses the formula (2.2) to calculate the Effective dose

$$E = [0.00145.(kV) + 0.0118].P_{KA}$$

3 Result

FOV	**11x10**
Number of samples	**80**
Average effective dose value	**0.203236819**
Standard deviation	**0.017647687**
Average effective dose value	**1.505**
Standard deviation	**0.130675**

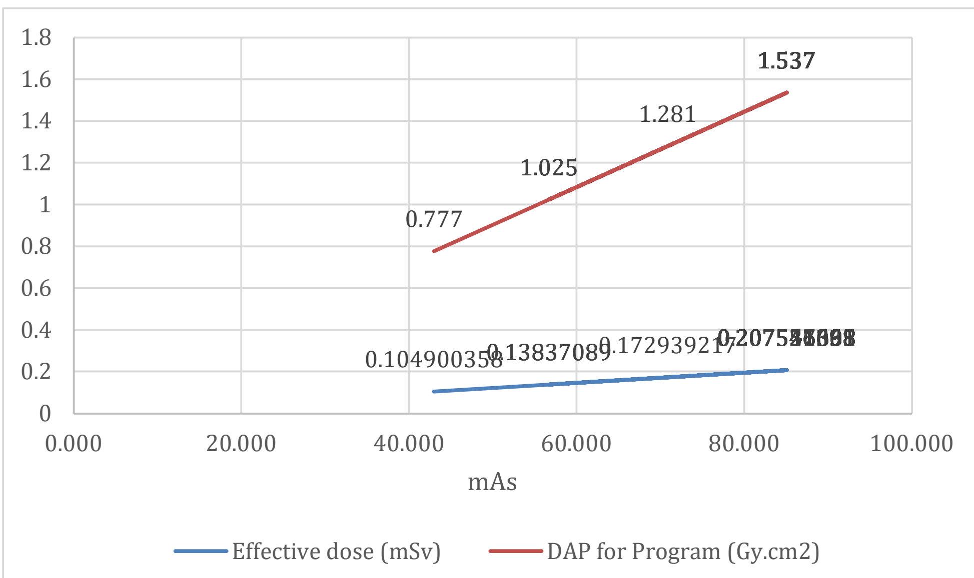


Figure 5: Linear plot of Effective Dose and DAP AS a function of mAs

4 Discusstion

CTCB is often used for functional survey, for editing purposes. Therefore, the FOV is usually very large, in nearly 100 data collected, there are 80 full-function scans with FOV of 11x10.

When the FOV is large, the technician usually reduces the current in the tube to minimize the irradiation dose and vice versa, when it is necessary to check the small FOV, the technician will increase the current to increase the image sharpness.

The average effective dose value is similar to the average common dose in dental CT.

The effective dose and DAP are a linear function of the product of mAs at 85 kVp.

The Orthophos SL 3D CTCB X-ray device provide a low dose, ensuring safety criteria radiation according to international standards.

CTCB machines are increasingly making an important contribution in the field of Odonto Stomatology. Therefore, the study of radiation dose of CTCB machine is also increasingly interested. The radiation dose from CTCB needs to be calculated, followed and closely overseed, although there are no clear reports on the effects of low dose levels.

5 Conclusion

In this paper, we have calculated the amount of radiation dose emitted from the CTCB machine of Dentsply Sirona with the desire to build a reference base for the dap value in CTCB. Besides, we also built a software to predict the radiation dose before conducting the irradiation process to help the technician adjust the parameters to minimize the radiation dose to the patient.

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The authors declare that they have no conflict of interest.

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