

## PHANTOM MEASUREMENTS OF ABSORBED DOSES IN DENTAL RADIOGRAPHY

TOR WØHNI

Dental radiography involves modest patient doses compared with most radiographic examinations, but they are, on the other hand, very frequent. In 1975 more than 4 millions of dental films were exposed in Norway, the bulk of which was conventional bite-wing exposures.

This report presents some phantom measurements of absorbed doses from dental radiography, focused on bone-marrow dose recordings. (In the following, 'dose' means absorbed dose.) Mean doses to the population are calculated as well.

The final report from the Adrian Committee (1966) presents bone-marrow doses from dental radiography. However, modified exposure parameters such as cone lengths and tube potential, as well as increased film sensitivity, necessitate fresh investigations.

The doses from a molar bite-wing projection, a conventional full mouth examination consisting of 10 exposures and an orthopantomogram are presented. Gonad doses from a molar bite-wing projection are also recorded.

### **Material and Methods**

Three different radiographic units were used throughout the experiment. The molar bite-wing exposure and the full mouth examination were performed with a Siemens Heliodent unit, tube potential 50 kV, total filtration 2 mmAl and focus-skin distance 10 cm. The mAs values chosen correspond to films of highest sensitivity

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Submitted for publication 4 May 1976.

*Acta Radiologica Therapy Physics Biology* 16 (1977) Fasc. 2 April

(ultraspeed). The gonad dose measurements were carried out on a Müller RT 200 therapy machine. Approximately 10 000 single exposures, each with a skin exposure of 0.5 R, were simulated. The tube potential was 60 kV and the total filtration 2 mmAl. The irradiated skin area was approximately 30 cm<sup>2</sup> on both units.

In the orthopantomographic exposure, a Siemens OP2 with tube potential 85 kV and total filtration 2 mmAl was used. During an orthopantomographic exposure, the dental arch is imaged by circling of the tube around the patient's head. The beam passes through a narrow slit at the tube exit, and traverses the dental arch during the rotation. The film cassette moves on the opposite side of the patient's head. Due to the changing curvature of the dental arch, the centre of rotation shifts twice during the exposure, thus making three separate dose maxima. The exposure lasts 15 seconds. The dose maxima were located by observing the blackening of films placed within the phantom. An orthopantomogram gives a general view of the dental arch, thus in many respects replacing a full mouth examination.

In these measurements an Alderson-Rando phantom was applied. The phantom contains a human skeleton and teeth of appropriate size, and otherwise consists of tissue equivalent plastic material. The density of this material is 0.985 g/cm<sup>3</sup> and the effective atomic number is 7.30. The phantom is divided into 2.5 cm thick layers with drilled holes for housing dosimeters. Some additional holes were drilled at various positions in order to record the bone-marrow doses.

The exposures were measured with small LiF crystals (TLD-100) from Harshaw chemical company. Their size is 3 mm × 3 mm × 0.9 mm. They have an effective atomic number close to that of soft tissue, and the change in sensitivity throughout the energy range considered is less than 5 per cent.

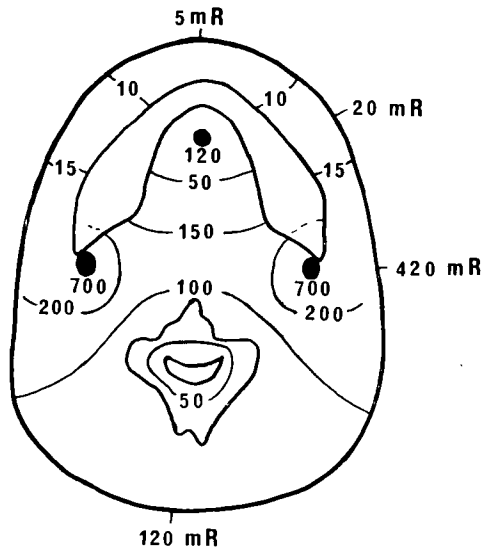
After exposure the crystals were heated to 240°C by a Harshaw 2000-A Thermoluminescence detector. The light yield from the crystals were recorded with an Harshaw automatic integrating picoammeter, Model 2000-B. The radiation intensities in the different structures containing red bone-marrow were partly measured and partly estimated from the exposure levels in the surrounding tissues.

The dose to red bone-marrow was calculated on the basis of a rad/R-value of 1.01 (JOHNS & CUNNINGHAM 1969), together with the distribution model of red bone-marrow in adults given by ELLIS (1961). In the soft tissues a rad/R-value of 0.92 (STORM & LIER 1972) was applied.

## Results

The recorded values for skin exposures were: molar bite-wing 600 mR, full mouth 2 520 mR, orthopantomography 420 mR, and for red bone-marrow 1.0 mrad, 7 mrad and 2 mrad, respectively. The dose distribution by an orthopantomographic exposure appears in the Figure.

The dose maxima in the rotational axis are evident and very demarcated. The measurements are in accordance with values found by CASEBOW (1973) and ALTHONEN



Cross section of the head through the lower jaw. Skin exposures and dose distribution by an orthopantomographic exposure. The figures represent absorbed doses in mrad in soft tissue. Black dots: the rotational axis.

et coll. (1974), though doses up to 1 100 mrad in the lateral maxilla are reported. The presented value for bone-marrow dose per bite-wing exposure agrees well with HYLTHÉN (1975), who estimated the bone-marrow dose to 2 mrad, corresponding to a skin exposure of 1 R.

The doses represent absorption in soft tissue. The doses to solid bone may be considerably higher (KOREN 1972).

The uncertainty in the reported bone-marrow doses is  $\pm 20$  per cent, and in the remaining dose and exposure values  $\pm 10$  per cent. The gonad dose measurements were performed with the dosimeters placed in the interstice between the legs and in the anatomic position of the ovaries. The gonad dose to a full-grown man resulting from a single molar bite-wing exposure amounted to  $2 \mu\text{R}$  and to a full-grown woman to  $0.4 \mu\text{R}$ . The gonad dose from other projections may differ, depending on the direction of the beam. The genetic dose to children was not measured. In previous measurements (FLATBY & PHARM 1962), the genetic dose to children was assessed to 4 to 5 times that of adults.

The present value of  $2 \mu\text{R}/\text{exposure}$  is considerably lower than previous estimations. The Adrian Committee (1960) and LARSON (1958) indicated 0.06 to 0.1 mrad/exposure. A more recent report from Sweden (HYLTHÉN) indicates gonad doses around  $5 \mu\text{rad}/\text{exposure}$  when ultraspeed film is used.

Patient measurements of gonad doses from dental radiography in Norway have not been done in recent years. Due to increased film sensitivity and improved radiation hygiene, previous values (KOREN et coll. 1967) are not representative.

It may be questioned as to what extent a solid phantom really is able to simulate a patient, especially when long absorption paths are involved.

With the risk of over-estimating the population doses, the following values for gonad doses were applied:

Dose/exposure to men	5 $\mu$ rad
Dose/exposure to women	1 $\mu$ rad
Dose/exposure to boys	25 $\mu$ rad
Dose/exposure to girls	5 $\mu$ rad.

Questionnaires were sent to a number of dentists, and data concerning exposure frequency versus age distribution of patients collected. The number of individuals in the population in terms of age and sex and the corresponding child expectancy factor were obtained from the official statistics. The following population doses were calculated: mean bone-marrow dose per individual was 1 mrad/year and genetically significant dose per individual 0.012 mrad/year.

### Conclusion

Dental radiography contributes very little to the total population dose from diagnostic radiology. In 1967 the genetically significant dose in Norway was estimated to 10 mrad per year and subject (KOREN et coll. 1967). Orthopantomographic exposures involve lower radiation doses to the patients than conventional full mouth examinations.

### SUMMARY

Some phantom measurements of absorbed doses from Norwegian dental radiography are presented. The mean bone-marrow dose from a single molar bite-wing projection was assessed to 1 mrad, a conventional full mouth examination (10 exposures) 7 mrad and an orthopantomographic exposure 2 mrad. The population dose from Norwegian dental radiography was estimated to be: mean bone-marrow dose 1 mrad and genetically significant dose 0.012 mrad.

### ZUSAMMENFASSUNG

Die Ergebnisse einiger Phantommessungen für die absorbierten Dosen von norwegischen zahnärztlichen Röntgenuntersuchungen werden vorgelegt. Die mittlere Knochenmarksdosis für eine einzelne molare Projektion wurde auf 1 mrad geschätzt, eine konventionelle Ganz-Zahnuntersuchung (10 Expositionen) auf 7 mrad und eine orthopantomographische Untersuchung auf 2 mrad. Die berechnete Populationsdosis von den norwegischen zahnärztlichen Röntgenuntersuchungen ist: mittlere Knochenmarksdosis 1 mrad und genetisch signifikante Dosis 0,012 mrad.

### RÉSUMÉ

L'auteur présente des mesures sur fantôme de doses absorbées au cours de la radiographie dentaire en Norvège. La dose moyenne à la moelle osseuse fournie par une seule projection interproximale (bite-wing) a été trouvée égale à 1 mrad, un examen classique de toute la

bouche (10 films) donne 7 mrad et un film orthopantomographique donne 2 mrad. La dose à la population provenant en Norvège de la radiographie dentaire a été estimée : dose moyenne à la moelle osseuse 1 mrad et dose génétiquement significative 0,012 mrad.

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