COMPARISON OF PHANTOM AND IN VIVO DOSAGE MEASUREMENTS IN DENTAL RADIOGRAPHY

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SUMMARY

For the assessment of doses in diagnostic radiography often phantoms are used, made of tissue equivalent material. The literature about dosimetry in dental radiodiagnosis shows a large divergence of results. This divergence can partly be explained by the application of different projection techniques and other technical parameters. The anatomical variations in the head and neck region contribute to the variance as well. It is necessary to compare phantom measurements and patient measurements when using phantom measurements for the prediction of patient doses. In this study dose measurements were carried out in an Alderson-Rando phantom with LiF-chips. Corresponding measurements were done in patients.

The patient measurements showed a larger variance. The entrance doses were lower, the exit doses higher to the patients as compared to the phantom. The study reveals that phantom measurements cannot simply be used for the determination or prediction of doses to patients.

INTRODUCTION

For the assessment of doses in diagnostic radiography often phantoms are used, made of tissue equivalent material. Many publications have appeared, concerning dose measurements and risk estimations in dental radiography based on such phantom studies. The literature about dose measurements in dental radiography shows a large divergence of the results. This divergence can partly be explained by the application of different projection techniques and other technical parameters. Another source of this divergence however are the patients themselves. The anatomical structures in the maxillo-facial region are very complicated. Slightly different radiographic techniques may result in highly varying measurements as a result of the influence of the anatomical structures on the dose distribution in the applied technique. This applies the more for the anatomical variance in the population as a whole and its influence on dose measurements. These effects can not be determined by means of phantom measurements only. Particularly in dental radiography the absorbed dose within a limited area may be rather high. The dose distribution is often very complicated by the complex anatomical structures in the head region and the small beam geometry. This makes it important to have a better understanding of the significance of phantom measurements in dosimetry for dental radiodiagnosis for the determination of patient doses.

AIM OF THIS STUDY

An investigation is being undertaken in our department aiming at the determination and comparison of doses in a number of radiographic techniques as used in dentistry (granted by the Dutch Government and the Foundation for Health Prevention). This investigation consists of two parts. The first part is based on phantom measurements for the determination of the dose distribution in several radiographic techniques [1,2]. In continuation an investigation is undertaken in a number of dental practices in order to find the frequence and variance of the applied techniques.

In order to rate the results of the phantom measurements of the first part of this investigation at its true value for predicting patient doses, a comparative study has been caried out. The objective of this study was to determine the agreement of in vivo and in vitro dose measurements in dental radiography.

METHODS

Phantom dose measurements were carried out in an Alderson-Rando phantom. Selected LiF-chips (Harshaw, TLD-100) have been used for the dose registration. The X-ray source was a General Electric 1000 dental X-ray apparatus at 15 mA and 75 kVp. The first half value layer was determined at 3.2 mm Aluminium. The field diameter was 6 cm at the entrance site of the patient. The focus-skin distance was about 32 cm.

The phantom measurements were done ten times. The positioning of the X-ray beam was adjusted before each measurement in order to simulate the conditions in daily practice. Corresponding measurements were done in ten patients in places of the head and neck region accessible for TLD chips. The patient measurements were done during routine X-ray examinations.

The first part of the study was concerning entrance and exit doses consequent on the radiation of two bite-wing radiographs taken unilateral in the molar and the bicuspid region. Bite-wing radiographs give diagnostic information about the crown and upper part of the root of teeth and about the bone level of the supporting bone.

The second part was concerning measurements of doses consequent on the radiation burden of a full mouth x-ray survey. A complete full mouth survey consists of 16 to 20 X-ray pictures and gives diagnostic information about all teeth and the supporting bone structures. Chips were placed on fifteen locations on the skin surface in the head and neck region and in the region of the gonads.

The study was based on (the simulation of) a half full mouth survey of nine X-ray pictures in order to obtain information about the contribution of both primary and secundary radiation to the dose. Some regions are situated in the primary beam and receive primary radiation and the secundary radiation of subse-

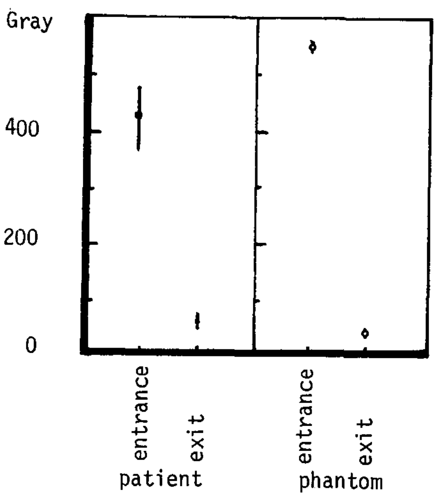

figure 1, Dose measurements in patients and phantom for bite-wing radiographs.

quent radiographs; opposite regions are located outside the primary beam of one or more X-rays and receive secondary radiation only.

Measurements were corrected for back scatter. The primary aim of this study was not the calculation of dose values, but rather the evaluation of the relative tissue equivalence of the phantom material as compared with human tissue material. Therefore, results are given in Gray, but they have no absolute value for dose estimations as such.

RESULTS

a. Bite-wing Radiographs

The back-scatter factor for the phantom material proved to be 1.20, which agrees with data from literature for human tissue material [3]. In this study back scatter for human tissue material was less than expected.

The results of the bite-wing study are shown in figure 1. The entrance doses in patient measurements prove to be lower than those of the phantom measurements. The inverted relation exists with regard to the exit doses. The standard deviation for the patient measurements is much higher, both for entrance and for exit doses, as compared to the phantom measurements.

b. Full Mouth Survey Radiographs

Results of the study of full mouth survey radiographs are given in figure 2. It is clear that the standard deviation of the patient measurements is larger as

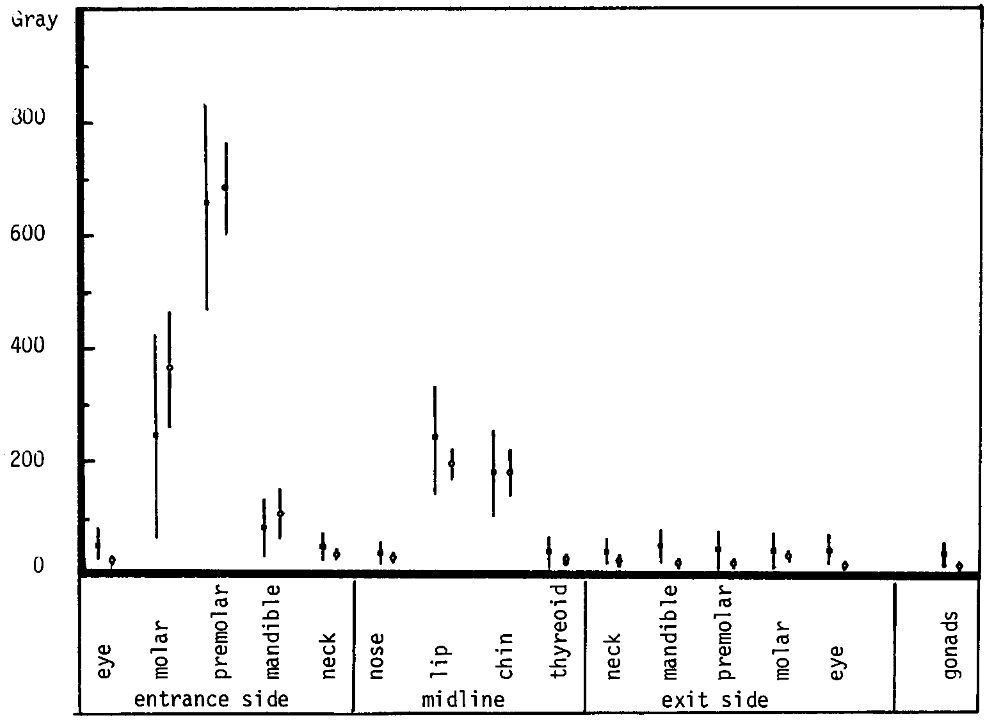

figure 2, Dose measurements in patients (■) and in phantom (●). Full mouth survey.

compared to the results of the phantom measurements. Phantom values are equal or exceed patient values when situated in areas which can be supposed to have received primary radiation of one or more X-rays of the survey.

Phantom values decrease after attenuation of the primary beam and in regions which have received only secondary radiation.

CONCLUSIONS

The bite-wing study and the study concerning the radiation dose of a full mouth survey show the same results. In the bite-wing study the entrance doses of the phantom measurements exceed the patient measurements. This fact can be explained from the production of the different amount of back scatter radiation in the phantom material and patient tissue material. This means that the phantom material is not fully tissue equivalent in the energy range used in this study.

The results of the full mouth survey study are partly masked by the fact that some regions receive both primary and secundary radiation in succesive radiographs. It is clear that the effects are more strength for regions far from primary radiation and in the center of the exposed field of one or more radiographs. Regions in the midline of head and neck show a more moderate effect.

As can be expected the variance of the patient measurements is larger than those of the phantom measurements. The influence of the anatomical structures comes into play strongly.

DISCUSSION

Especially in the low-energy range (50-100 kVp) of the radiation as applied in dental radiography the effects of secundary radiation may be enormous. The difference of the results of phantom and patient measurements can be the result of the slightly different composition of the phantom material as compared to human tissue material. The difference between entrance and exit doses in patient and phantom material makes it desirable to have more data between entrance and exit sites. Further investigation deals with this problem and is intended to give more information about the distribution of radiation within the head and neck region by measurements within the mouth. For this aim equipment has been developed for placement of TLD-chips within the mouth cavity.

The study reveals that the prediction of doses and risk estimations based on phantom measurements must be corected with in vivo measurements in the population in question, both for the assessment of the variability and for the magnitude of the average doses.

LITERATURE

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