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A Field Study for the Determination of Dose Values in Dental Radiology

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IV.7. A field study for the determination of dose values in dental radiology

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ABSTRACT

An inexpensive and simple test device was developed and used in a field study to evaluate entrance dose, dose to an intra-oral film, filtration and field size under routine conditions in more than 200 dental practices. The test device consists of two films of different speeds and a set of five thin copper filters for a filter-analytical determination of the radiation quality.

Dentists voluntarily participating in the study were asked to expose the test device (sent to them by mail) as they usually do when examining a molar tooth. Together with a short questionnaire, describing the respective conditions of film exposure and processing, the test device was returned for development and evaluation.

The main result was the evidence of a significant dose reduction compared to the findings of similar studies performed in 1970 and 1975. This reduction is due to a general shift to lower values and a complete disappearance of values above 45 mGy (5 R) which in 1970 were still more than 15%. In the same way the number of facilities showing insufficient filtration or collimation had decreased. Nevertheless, a large spread of dose values could still be observed, ranging from 2.5 mGy (290 mR) to more than 30 mGy (3.4 R) for the entrance dose. The most striking result, however, was that such an important parameter as the speed of the films used at the respective unit turned out to have no impact on the entrance dose.

TEST OBJECTIVE

In spite of the high frequencies of dental examinations and their comparatively high surface and film doses, their contribution to the overall radiological hazard is of minor importance. In terms of effective dose equivalent it is estimated to be about 1% of the total value for all medical X-ray examinations (Wall et al, 1983).

Unlike other examinations, however, the amount of radiation administered to patients under routine conditions can be easily evaluated by simple and inexpensive methods. In the past, field studies could be performed, providing reliable results which allow for

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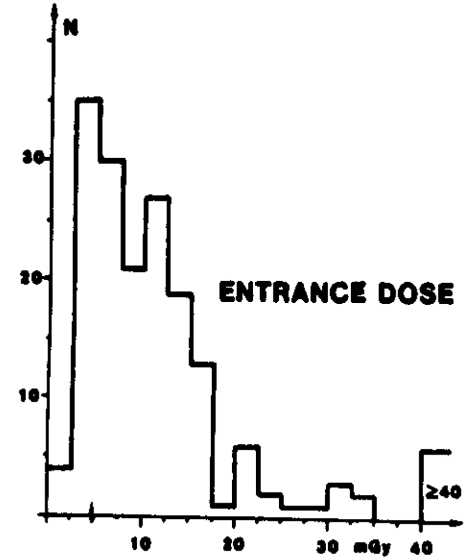

FIG. 1.
Distribution of entrance dose values (equal to dose on the test film).

comparisons with the present-day situation. Due to numerous efforts in recent times to reduce doses to patients and staff, resulting in legal recommendations and regulations, a significant improvement was to be expected. The main objective of this field study was to find out how the dose values for the examination of a molar tooth have changed since 1970.

TEST PROCEDURE

More than 200 dentists participating voluntarily in the field study were asked to expose the test device (sent to them by mail) as they do when examining a molar tooth. Together with a short questionnaire, describing the respective conditions of film exposure and processing, the test device was returned for development and evaluation.

The test device consisted of two films (Kodak MS and DR5) of different speeds and a set of thin copper filters from 0.01 to 0.2 mm thickness. Two films were necessary to cover the range of dose values expected to occur in routine work.

The purpose of the filters was a filter-analytical determination of radiation quality, the approximate knowledge of which is indispensable for the evaluation of dose to the test film and, calculated from that, the dose to the dental film.

The distribution of entrance doses (Fig. 1) is wide, ranging from 2.5 mGy (290 mR) up to more than 30 mGy (3.4 R). This is the more surprising since the choice of exposure conditions is quite restricted for this kind of examination.

Only the influence of tube voltage on entrance dose

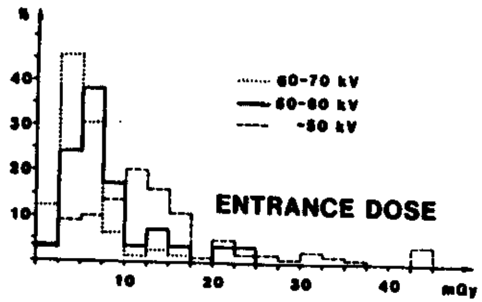

FIG. 2.
Effect of tube voltage on entrance dose.

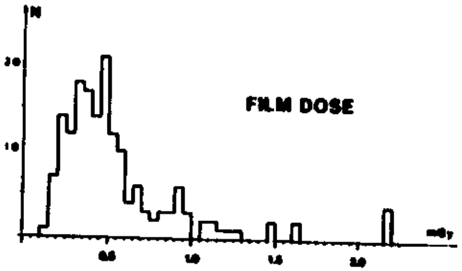

FIG. 3.
Distribution of film dose values.

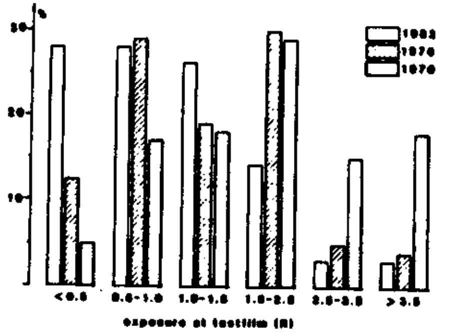

FIG. 4.
Comparison with results from former field study (for the sake of comparison the old unit, R, is used).

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could be shown (Fig. 2). The expected effects of other physical parameters like focus–skin distance, type of film used at the respective facility and conditions of film processing, as described in the questionnaire, could not be detected by any statistical means.

Even in the distribution of doses to the dental film (Fig. 3) the effects of film type used and of film processing were not perceptible. This indicates that the dose values are mainly determined by random and unrecognised deviations from the specified conditions.

Comparison with earlier results (Sonnabend, 1969; Sauter, 1978; Regulla & Sonnabend, 1980) shows a distinct reduction in entrance doses (Fig. 4). This is due to a general shift to lower values and a complete disappearance of values above 45 mGy (5 R), which in 1970 were still more than 15%. In terms of the median values of the distributions this results in an exposure decrease from 17 mGy (1.9 R) to 8 mGy (0.93 R).

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Evaluation of test films

1. The exposed and returned films were developed under standardized laboratory conditions and photometrically evaluated. By means of the H & D curves (Figure 1) of the test films, made available by irradiation with a standard radiation quality of 60 kV tube voltage and a filtration of 2 mm Al, the optical densities S_0 (that is the centre of the testfilm, without any filter) - S_5 were converted into "apparent" dose values D_{S0}-D_{S5}. The introduction of these "apparent" dose values was necessary to eliminate the non-linearity of the H & D curves.

2. To describe in a first step the radiation quality by which the film was exposed, the thickness of that copper layer was determined by linear interpolation along the absorption curve, which halves the "apparent" dose D_{S0}.

3. For 20 radiation qualities, from 40 kV/0.5 mm Al up to 70 kV/2.5 mm Al which are covering the range occuring in practice, the energy correction factor f_E of the test films was measured under laboratory conditions. Logarithmically plotted against the copper layers for achieving $D_{S0}/2$ (Figure 2) the distribution of f_E-values can be fairly approximated by a straight line. So without any other information on the spectral distribution f_E can be obtained via the copper layers for $D_{S0}/2$. The entrance dose D_E to the patient, equal to the dose to the testfilm, then follows the simple relation:

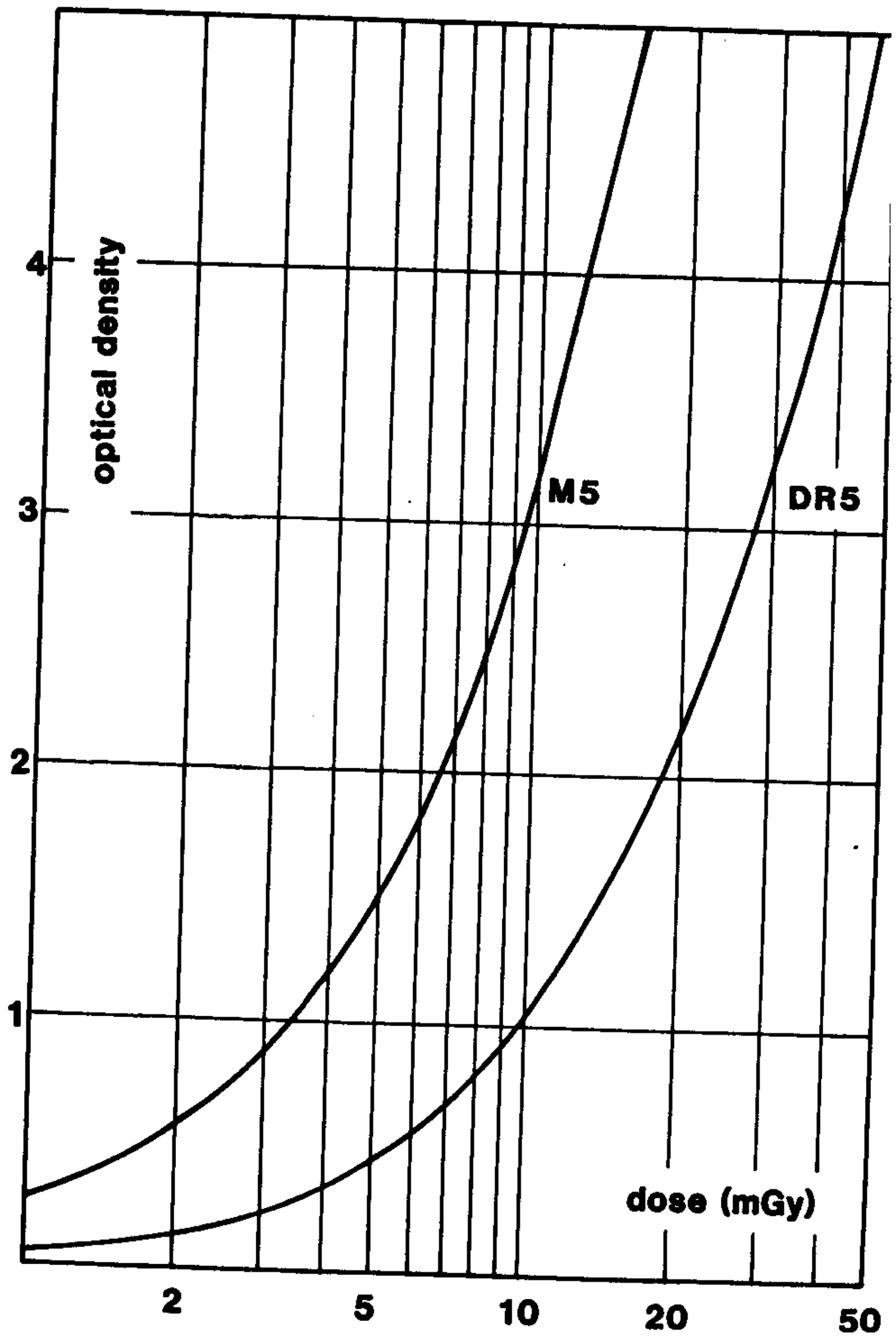
$$D_E = f_E \times D_{S0}$$

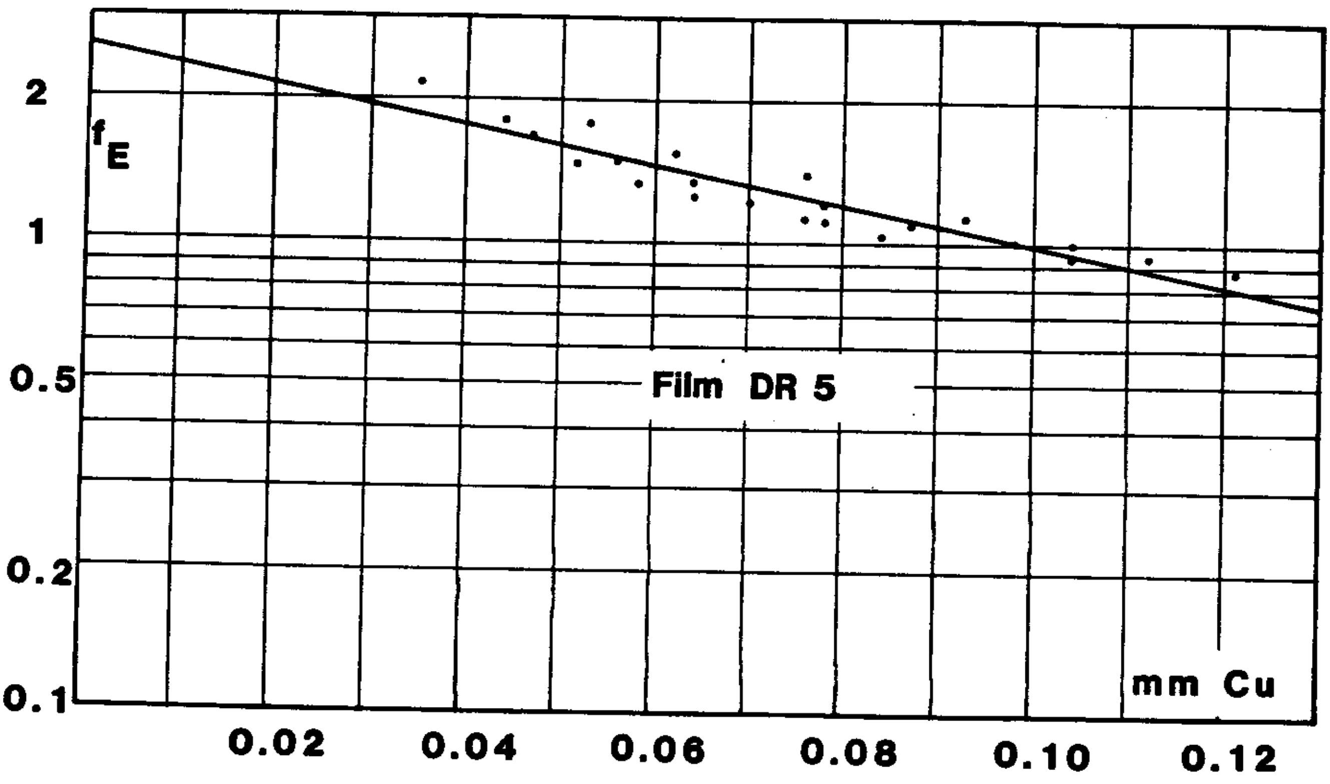
4. The corresponding dose D_F to an intra oral dental film was calculated according to:

$$D_F = D_E \times t \times f_a$$

t: Transmission through a phantom containing a mandible embedded in water and perspex. Values for t again were measured under laboratory conditions using the same set of radiations as mentioned under 3. Plotted over the copper layers for achieving $D_{50}/2$ the values for t are distributed along a straight line (Figure 3), thus allowing for the selection of t.

f_a: Distance factor correcting for thickness of the phantom (3 cm) at the respective focus to skin distance.




2
f_E
1
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Film DR 5
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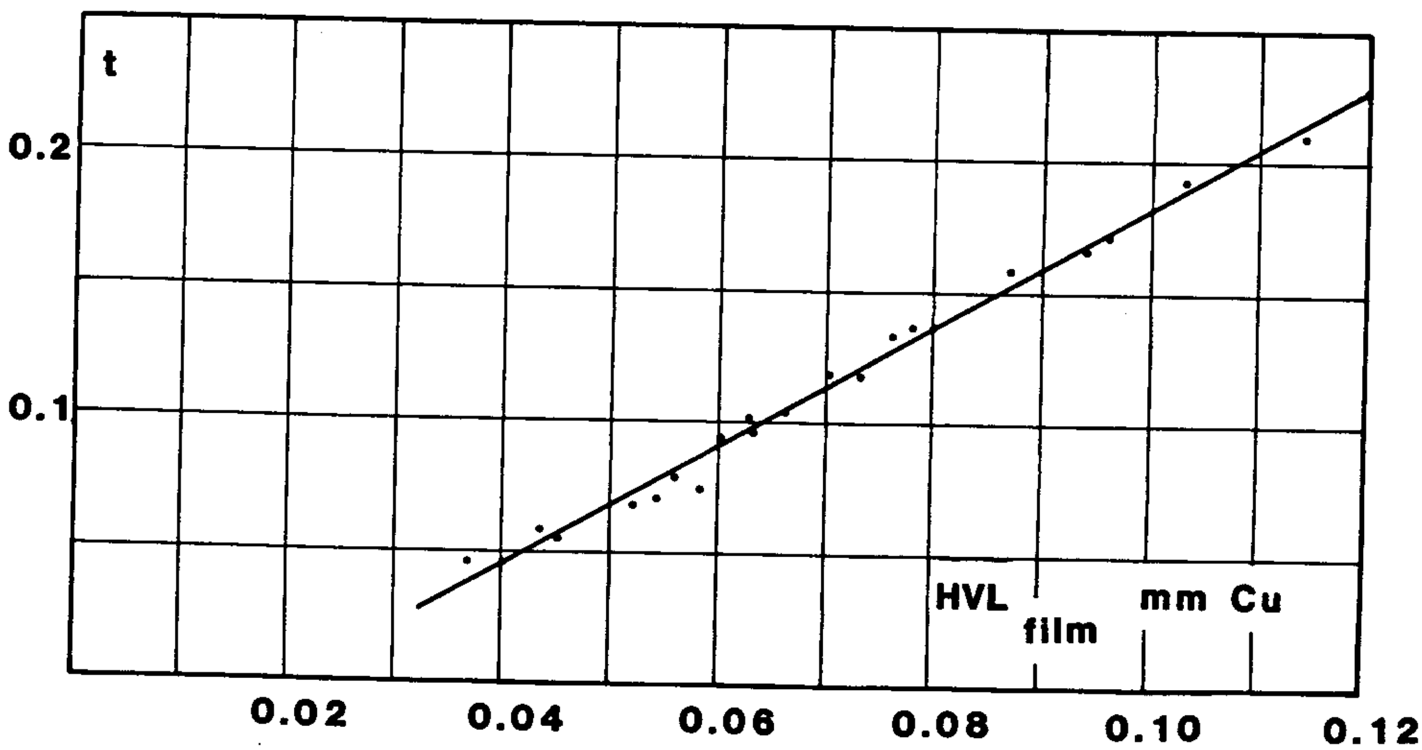
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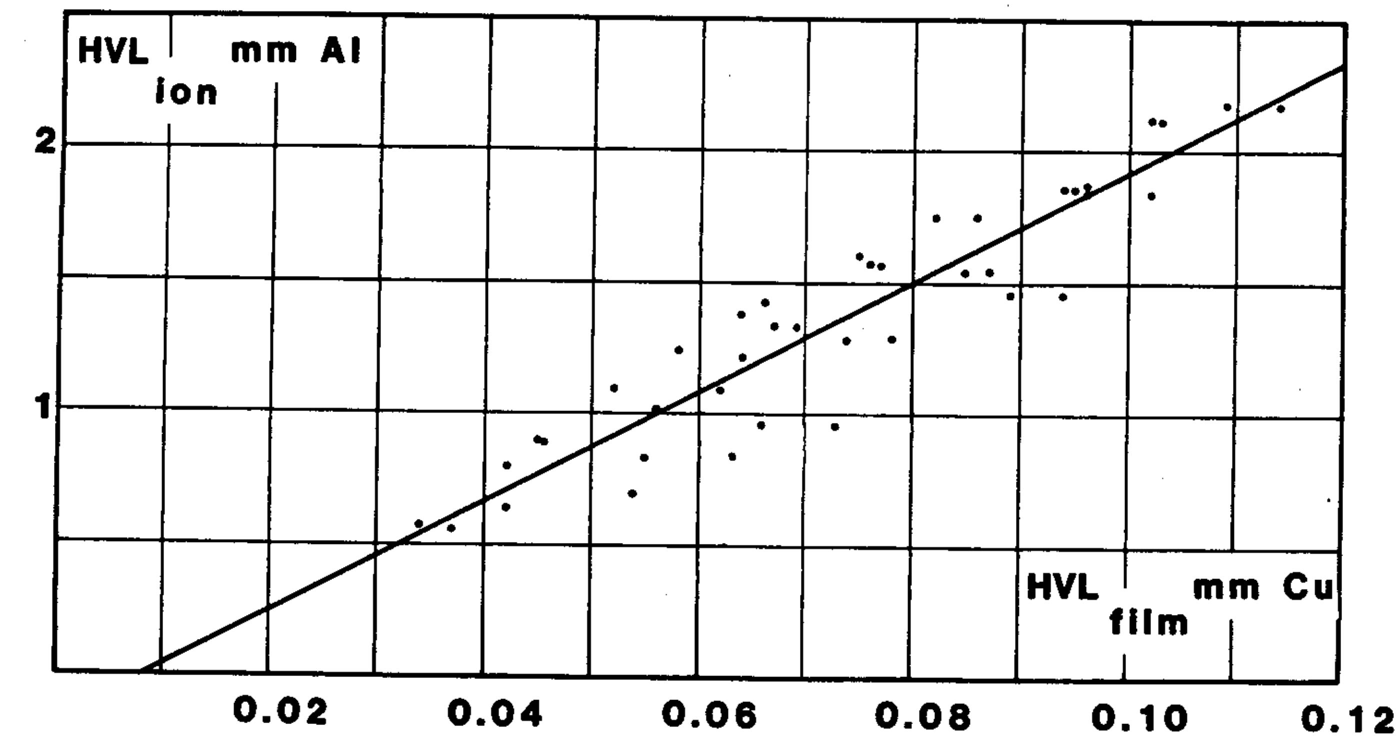
HVL ion mm Al
HVL film mm Cu
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