PATIENT EXPOSURE IN GENERAL DENTAL PRACTICE IN THE NETHERLANDS.

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INTRODUCTION

Today radiology has become an important factor in dental diagnosis. Although the risk of a single radiograph is low if properly conducted, the frequency of these radiographs is rather high and still increasing.

To estimate the population risk due to dental radiography an investigation was started among 1200 dental practitioners. A questionnaire was set up to inventory commonly applied indications of X-ray examinations, the number of examinations and the organizational actions taken by the dentists to limit radiation doses to the patients. Information was gathered on the type of X-ray machines, the use of aiming devices, protective measurements for patients and dental staff, developing procedures as well as the type of films.

A number of practical tests was applied to obtain a quantitive impression of patient doses in accordance with special circumstances. For the practical tests films and lithium fluoride TLD-100 chips (Harshaw) were used to determine the beamdiameter, the exposure of the X-ray machine and the scatter at a set distance of the middle of the beam, developing circumstances as well as entrance and exit skindoses measured on the skin of a patient.

The results of 544 dental practices will be discussed. Finally an estimation of the possible extent of reduction in patient exposure in the Netherlands will be made.

RESULTS

Nearly 80% of the X-ray machines used were made by Philips, operating at 45, 50 or 65 kVp. Siemens X-ray machines were used in 7% of the dental offices while other manufactures were represented in less than 5% of the practices.

45% of the X-ray machines were operating at 65 kVp, 41% at 50 kVp. The kilovoltage used ranged from 45 to 90 kVp. X-ray machines of 65 kVp or more were all provided with open end cones. Still 30% of the X-ray machines were provided with circular pointed cones.

The mean exposure per radiograph of all X-ray machines was 142×10^{-6} C/kg. For X-ray machines operating at 50 kVp the exposure was 201×10^{-6} C/kg, for 65 kVp 81×10^{-6} C/kg. The mean entrance skin dose was 4.83 mGy, for X-ray machines of 50 kVp 6.70 mGy and of 65 kVp 2.80 mGy. X-ray machines provided with a circular pointed cone caused an exposure of 245×10^{-6} C/kg in comparison with 98×10^{-6} C/kg for open end cones. The entrance skin doses for these different types of cones were 8.35 mGy and 3.30 mGy.

At a fixed distance of the middle of the beam scatter was measured only when circular pointed cones were used. The mean scatter measered caused an additional entrance skindose of 0.20 mGy. No scatter was measured for open end cones.

Tabel 1: Mean exposure and entrance skindose for X-ray machines of 45 till 90 kVp.

kVp	Exposure C/kg	s.d.	s.e.	Skindose mGy	s.d.	s.e.
	$\times10^{-6}$					
Mean	142	147	7	4.83	4.83	0.24
45	394	174	71	16.22	7.41	3.02
50	201	180	14	6.71	5.71	0.44
56	278	160	80	9.16	6.37	3.19
60	200	211	56	6.17	4.66	1.25
65	81	59	4	2.80	2.18	0.16
70	73	62	10	2.53	1.82	0.29
90	51	-	-	2.27	-	-

In 48% of the dental practices Kodak Ektaspeed films were used. The mean exposure measured in those practices was 100×10^{-6} C/kg instead of 178×10^{-6} C/kg in the other practices. The entrance skin doses were 3.23 mGy and 6.14 mGy. Theoretically a reduction of 40% in exposure by using Ektaspeed films instead of Ultraspeed films was expected. The reduction was even higher because of other influences: dentists using Ektaspeed films had more often X-ray machines operating at higher kVp's and had more often X-ray machines provided with open end cones.

The mean number of patients was 2055 per practice. The mean number of X-rays taken was 748 each year during 427 X-ray examinations: 1.75 exposures per examination. Approximately 20% of the patients were examined radiographically each year.

65% of the dentists made 2 bitewing radiographs of new patients routinely. In nearly 60% of all practices these bitewing radiographs were repeated at set intervals, more than 90% within 3 years.

Most radiographs were made of patients between 20 an 30 years of age (35%) and between 11 and 20 years of age (32%).

In 81 % of the dental practices radiographs were automatically processed while in 18% films were developed manually. Dentists using automatic film processing procedures caused less exposure and skindoses than other dentists. The low mean exposure in this group was caused by other influences: dentists using automatic film processing procedures had more often X-ray machines operating at higher kVp's, more often X-ray machines provided with open end cones and they used more often automatic timers than was used in the total group. No differences were found between both procedures if the results were corrected for the influences as mentioned above .

The mean exposure was 135×10^{-6} C/kg for automatic film processing and 220×10^{-6} C/kg for all kinds of manually film processing. The mean entrance skin dose for both kinds of processing was 4.34 mGy and 6.90 mGy.

The films used to control film processing indicated that the mean density of the X-ray films was less than films developed in a standardized way. More than 60% of the dentists could improve their developing procedures.

Lead aprons and thyroid collars reduce the effective dose-equivalent. The influences of these protective measures couldn't be measured directly during bitewing radiography with the LiF TLD-100 on the cheek of the patient. In the sample 54% of the dentists had a lead apron, 15% a lead collar. In 38% of the dental practices these protective measures were used during all exposures for every patient.

The use of aiming devices can cause a reduction in patient exposure of 40% if the beam is shielded. These reductions can not be measured during bitewing radiography by the measuring technique used in this study. In 8 % of the dental practices aiming devices provided with an extra diafragm were used.

DISCUSSION AND CONCLUSIONS

If all X-ray machines operating at 50 kVp provided with circular pointed or open end cones are replaced by X-ray machines operating at 65 kVp, a reduction in exposure of 58% is possible in 41% of the dental practices reducing the mean exposure to:

$$(1 - 0.58 \times 0.41) \times 142 \times 10^{-6} = 108 \times 10^{-6} \text{ C/kg}$$

If Kodak Ektaspeed films are used in all practices a reduction in exposure of 40% in 52% of the dental practices will result in a decrease of exposure to:

$$(1 - 0.40 \times 0.52) \times 142 \times 10^{-6} = 112 \times 10^{-6} \text{ C/kg}$$

Filmprocessing can be improved in 60% of the dental practices. However no differences in exposure were found as far as "good" or "bad" developing procedures were compared. In 51% of the dental practices the exposure was at least 32% higher than expected to receive a good radiograph. If the over-exposure is reduced, the mean exposure will decrease to:

$$(1 - 0.32 \times 0.51) \times 142 \times 10^{-6} = 119 \times 10^{-6} \text{ C/kg}$$

Finally a total reduction in patient exposure can be estimated by multiplying all possible reduction factors:

$$0.76 \times 0.79 \times 0.84 = 0.50$$

The mean exposure for a bitewing radiograph can therefore be reduced by 50% to 71×10^{-6} C/kg. It is possible to reduce the risk due to dental radiography in the Netherlands by 50% if all measures as discussed before will be carried out.