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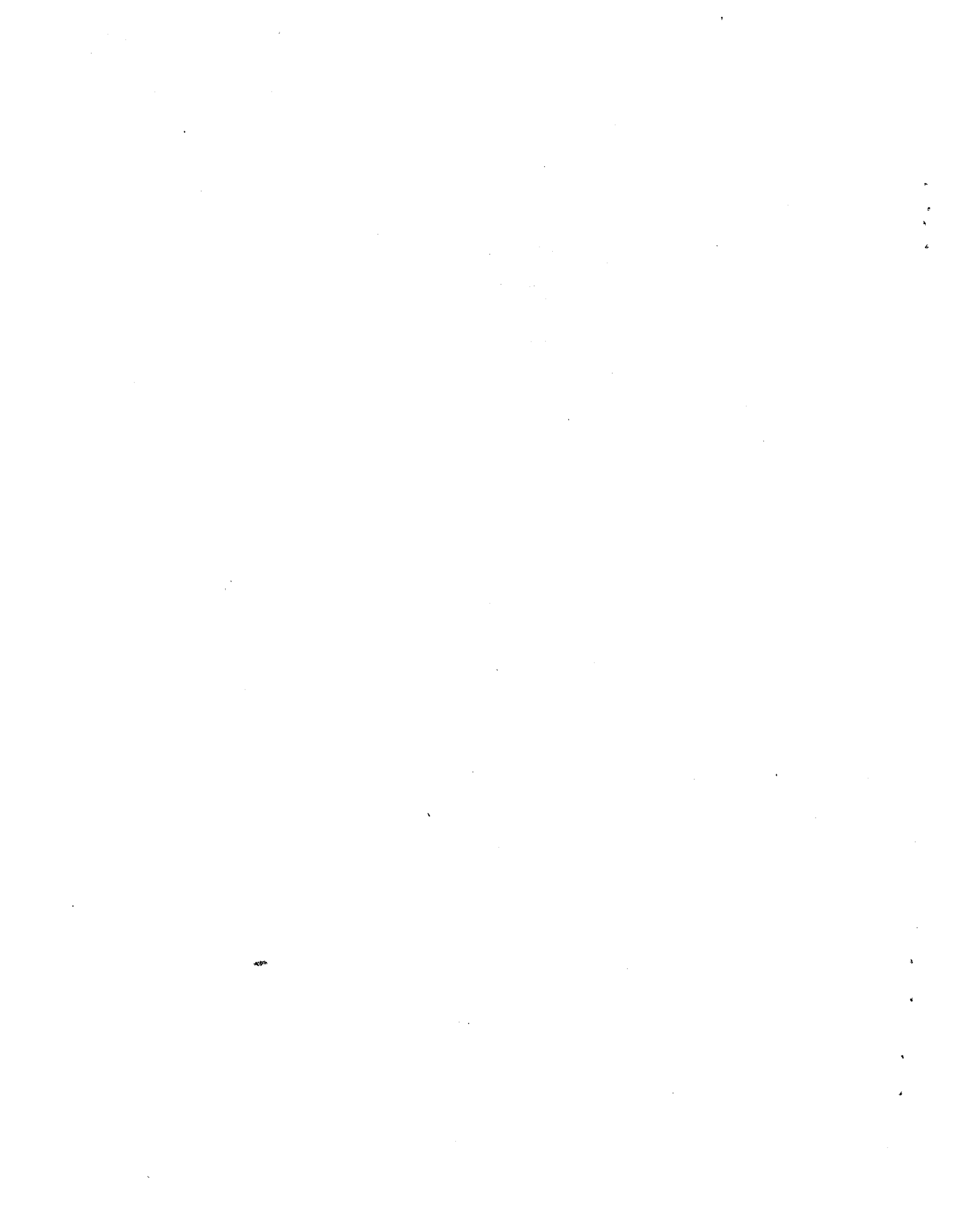
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W. E. Nolan

July 16, 1952

Berkeley, California



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University of California, Berkeley, California

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ABSTRACT

This report endeavors to point out the radiation hazards involved with respect to the patient undergoing oral roentgenography. The dose rate can be as high as 280 r/min. Very definite hematological changes have been observed and are being thoroughly investigated. Recommendations have been suggested to eliminate overexposures.



## X-RAY DOSAGE TO PATIENTS UNDERGOING ORAL ROENTGENOGRAPHY

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July 16, 1952

It is well known that for many years x-rays have been used in the dental profession as a potent diagnostic tool. Deprived of this means of exploration, the dentist would be at a great disadvantage. In spite of the necessity of x-rays in the dental field, very little has been done, however, to protect the patient from unnecessary overexposure.

Upon visiting a dentist for preliminary examination, the patient, in most instances, is subjected to a full mouth x-ray examination. This may entail the taking of 20 to 35 radiographs, depending on the technique used. In view of the fact that very little work has been done in this particular field, it was felt that an effort should be made to ascertain the danger of overexposure, if any, to the patient.

### Methods and Definitions

The amount of radiation delivered to the patient depends on several factors, which are as follows:

1. The energy of the x-rays used.
2. The focal distance (distance between tube target and skin).
3. The amount of filtration used.
4. The amount of current used.

5. The total time the patient is exposed.

The energy of the x-rays is important, as it is a major factor in determining the rate at which the radiation is being delivered and also in determining the depth of penetration. In most cases, the higher the energy, the greater the rate of delivery. Of course, the greater the energy, the greater the depth of penetration.

In general there are two focal distances used. One technique employs an 8 inch focal distance, the other technique uses a 16 inch focal distance. In using the 8 inch distance, the exposure time is shorter as compared to the 16 inch distance, but the total amount of radiation delivered to the patient can be as high as three to four times that which is delivered when the longer focal distance is used. One might think that the dosage delivered to the patient would be the same in both cases and that the exposure time using the 8 inch distance should be one-fourth that used in the 16 inch technique. However, this is not the case. In most cases the total exposure time using the 8 inch technique is only about 35 percent shorter than the time used with the 16 inch technique.

The amount of filtration used with dental machines is very important. In many instances no filtration is used. The failure to filter out all soft radiation increases the dosage tremendously. Most machines examined in this study were using a current of 10 M.A.

The total time of exposure varies, depending on the technique employed, which can be as short as 50 sec. and may be as long as 1 min. 35 sec. This is no doubt the most important factor in determining the total dose delivered to the patient.

Radiation dosages, in most cases, are expressed in roentgen units. The



word roentgen (or r as used hereafter) is defined as follows: That amount of x or gamma radiation producing in 1 cc of air ions carrying 1 e.s.v. of charge of either sign. The r is equivalent in energy to 83 ergs per gram average in tissue and results in  $1.615 \times 10^{12}$  ion pairs per gram tissue. At the present time the accepted weekly tolerance dose for x or gamma rays is 0.3 r per week. This of course pertains to total body exposure.

A Victoreen Nylon thimble chamber was used to determine the rate at which the radiation was being delivered. A special type of film (Dupont #558) was also used to determine the dose delivered to various anterior and lateral surfaces of the face, neck and chest. This was accomplished in the following manner. Films were placed in contact with the patient's neck, completely surrounding that portion of the body. In addition, films were also placed at twelve locations on the anterior surface of the body between the neck and the waist. This technique was used with three patients. These location films were read on a Photovolt Densitometer against a previously run set of film standards. The measurement pertaining to the rate at which the dose is delivered was repeated several times in all cases.

#### X-Ray Units Examined and Results Obtained

A number of dental units were examined in the San Francisco Bay Area. The following three units were used to collect this data. These machines were assumed to be typical, and as one can see, the results vary depending on the machine and the technique used.

Machine A This machine was operated at 65 K.V., 10 M.A., no filtration, and the technique used called for a 16 inch focal distance. The number of exposures for a full mouth examination averaged about 30. The total time of exposure

was about 90 sec. The rate of delivery was 75 r/min. or a total of 113 r delivered to the area during a full mouth examination.

Machine B This machine was operated at 45 K.V., 10 M.A., no filtration, and the technique called for an 8 inch focal distance. The number of exposures for a full mouth examination in this office was about 25. Total exposure time was about 70 sec. The rate of delivery was 270 r/min. or a total of about 315 r to the area during a full mouth examination.

Machine C This machine was operated at 65 K.V., 10 M.A., no filtration, and at an 8 inch focal distance. The number of exposures for a full mouth examination in this office was about 28. Total exposure time was about 75 sec. The rate of delivery was 190 r/min. or a total of about 238 r delivered to the area during a full mouth examination.

An examination of Machine B was made after a 2 M.M. Al filter had been installed, all other operating conditions remaining the same. The rate of delivery is now 40 r/min. as compared to 270 r/min. without filtration. The radiographs are of much finer quality owing to the fact that much of the softer radiation that tends to fog the film is now being eliminated.

In all three cases where film was used to measure the dosage to various lateral and anterior surfaces of the body, it can be said that the dose delivered to any area below the shoulder line did not exceed 2 r. In the region of the face and neck the dose delivered was much greater, and in the cases studied exceeded 75 r to both lateral surfaces and somewhat less to the anterior surface. This measurement was obtained with film.

In the region of the neck there is a very large concentration of lymphatic tissue. This tissue is most sensitive to radiation<sup>1</sup> and it was thought that with

such high dose rates one might observe changes in the blood picture of patients undergoing such examinations.

At the present writing five patients have been observed in the following manner. When it was possible a W.B.C. and differential was done every hour beginning at 8:00 A.M. and running in some cases until 10:00 P.M. on the day before exposure to a full mouth x-ray examination. This allowed observation of the normal diurnal variation of the particular patient. On the day of examination the same procedure was followed with but one exception. The first three counts were taken at two hour intervals and hourly thereafter. The patient was observed daily after the first day for several days and will be observed weekly for several weeks.

The five patients who received full mouth x-ray examinations were exposed to the following amounts: 35 r, 115 r, 135 r, 315 r, 315 r. In all cases a significant change in the blood picture was observed to a greater or lesser degree depending on the dose delivered. With the exception of the patient who received only 35 r, all others showed an apparent depression in lymphocytes<sup>2</sup>. This depression was noted as early as the 7th hour after the x-ray examination, and in some cases did not occur until about 12 hours after x-ray examination. The lymphocyte count remained depressed for a period varying from two hours to 30 hours. In one case when the patient received 315 r, the depression seemed to be close to 45 percent. Other hematological changes were observed and are being further investigated.

### Discussion of Results

It can be seen from the above data that a considerable amount of radiation is absorbed by the patient. The exposure is not confined entirely to the

area being radiographed but extends over a much larger area. It can also be seen that very good radiographs can be obtained without exposing the patient to an unnecessary dose of radiation. It should be pointed out that the total amount of radiation delivered to the patient is delivered to an area embracing the entire jaw and neck area. To any 1 c.c. of skin surface the dose will in most cases not exceed 100 r. However, it should also be pointed out that there are many intersecting lines of radiation within the neck and oral cavity due to the angle at which the radiographs are taken. These points of intersection are definitely points of higher ionization.

The results of the hematological studies will be discussed in a future report. For the present it can be said that significant blood changes have been observed in patients exposed to full mouth x-ray examinations to a greater or lesser degree, depending on the total exposure.

Other points that should be mentioned are the following: A patient could conceivably be exposed several times to a full mouth x-ray examination within a very short period of time. In many cases, the entire upper portion of the body is bathed in radiation to a greater or lesser degree.

#### Recommendations

In the future the use of x-rays as a diagnostic tool will certainly increase rather than decrease, both in the medical as well as the dental profession. In view of this trend it would seem logical that the dentist give careful consideration to all factors involved before ordering full mouth radiography. The patient should be questioned with respect to prior x-ray examinations of any nature. It might be well to bear in mind that the present thinking is that ionizing radiation of all types has a cumulative effect biologically.

Personnel who presumably will be engaged for many years in a profession necessitating their working with various types of radiation and radioactive materials should avoid full mouth radiography as a routine procedure.

It is entirely possible that a patient could be undergoing a radiographic examination of some other portion of the body during the same period oral roentgenography is being performed. In many cases this could be very objectionable.

A record of exposure should be kept of all persons undergoing x-ray examination of any type.

All personnel whose profession requires them to use x-ray equipment of any kind should be completely familiar with the equipment they use with respect to the K.V. used, the currents used, what filtration is employed, if any, and of course the r output of the unit.

Several recommendations are in order at this point with respect to the dental unit itself. (1) All dental units should be equipped with proper filtration. (2) The x-ray beam should be collimated so as to cover precisely the area to be radiographed. (3) A long focal distance should be used at all times. (4) The shell housing the tube should be x-ray proof. (Many in use at the present time are not.) (5) It might be profitable to investigate some new film techniques, such as impregnating the emulsion with a material that would fluoresce upon being irradiated. One might use a piece of calcium tungstate to be included as an integral part of the film packet. (6) It might also be worthwhile to consider a shield of some sort to protect the patient's neck from secondary and scattered radiation.

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