Radiation Dosimetry for Cleft Palate Patients

LLOYD SHERWIN LANDA, D.D.S.
GERALD SHAPIRO, M.S.
SIDNEY I. SILVERMAN, D.D.S.
CHARLES B. STORCH, M.D.
New York, New York

Cleft palate patients receive a considerable x-ray exposure in the course of diagnosis of many of the problems related to speech, dental, and medical study of their congenital anomalies. The x-ray dosage is a result of still films and cineradiographic studies. In addition, specialized laminagraphic and tomographic procedures are now being used.

Additional radiation exposure occurs during and after cleft palate therapy. If the therapy is surgical in nature, postsurgical radiographic examinations are desirable to evaluate the efficacy of the procedure performed and to determine whether further surgery is indicated. When therapy is prosthetic in nature, cineradiographic examinations of the prosthesis are utilized (using television image orthicon fluoroscopy) during the impression-making and the fabrications stages and again after completion of treatment.

In general, however, radiation exposure should be kept to an absolute minimum, consistent with the objective of obtaining the required diagnostic information. To this end, we have established the following radiographic procedure which incorporates as many precautions and safeguards as possible.

Description of Equipment

As shown in Figure 1, the basic radiographic equipment consists of 150 kv x-ray generator, and a heavy duty x-ray tube which is mounted on a ceiling-hung C-arm. The opposite end of the C-arm holds a high gain image intensifier with a coupled television image orthicon camera. The radiation field is limited by an adjustable collimator. Directly in front of the collimator is a thin ionization chamber which covers the entire radiation field. This is connected by means of a cable to a measuring and recording instrument in the control room (Figure 2)

Dr. Landa is Assistant Professor, Dr. Shapiro is Instructor, Dr. Silverman is Professor and Chairman, and Dr. Storch is Associate Clinical Professor, Department of Graduate and Postgraduate Prosthodontics, New York University College of Dentistry.

This paper was presented at the 1965 annual meeting of the International Association for Dental Research in Toronto. The paper is based on research which was supported by PHS Research Grant DE-01244, National Institute of Dental Research, and VRA Grant 56-T-65.

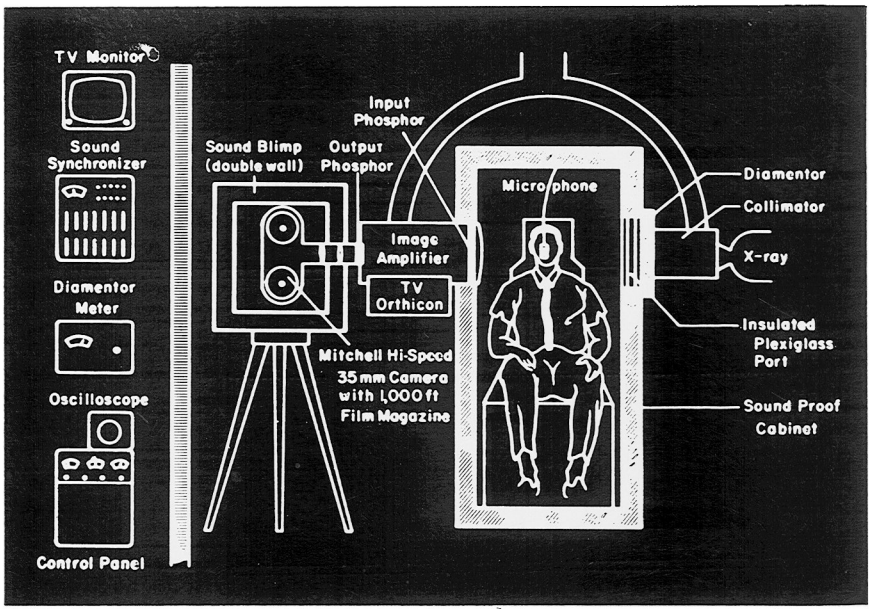

FIGURE 1. A schematic representation of the arrangement of the cineradiographic equipment: From right to left, the x-ray tube, collimator, monitor ionization chamber (Diamentor), sound-proofed booth, patient, image amplifier with coupled television orthicon, camera with sound-recording track, lead protected wall.

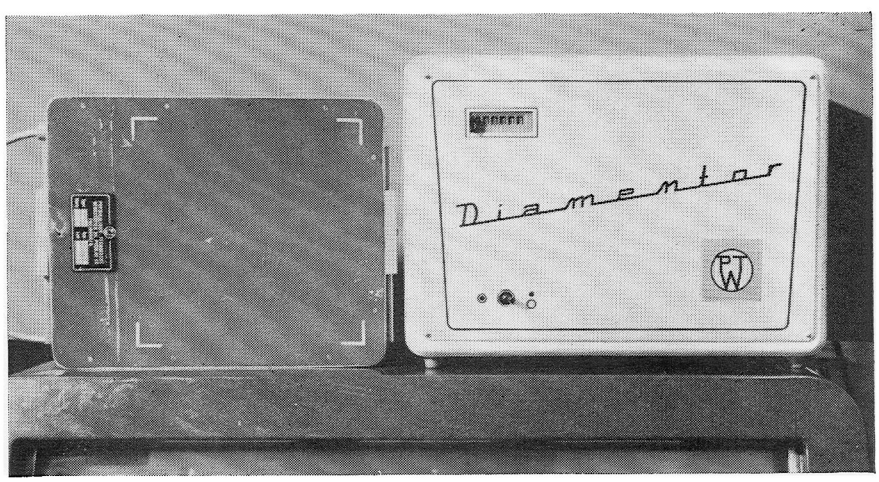

FIGURE 2. The flat field monitor ionization chamber, left, is placed in front of the collimator and attached by a cable to the measuring and recording instrument, the Diamentor on the right.

RADIATION DOSIMETRY EXAMINATION CHART

Name: Age:

Chart # Date:

Examination Part		Projection	K. V.	M. A. or M. A. S.	Cine Time and frames/sec.
T. F. D. (target film distance)	T. S. D. (target skin distance)	Field Size Film Size	Chart # Diamentor Reading r cm^2	Skin Dose at Point	Clinical Diag. Total Skin Dose
Gonadal Dose (Dosimeter)	Protection Equip. Used	Film Type	Grid Used	Cassette Type	No. & type of Still Films

FIGURE 3. A personal radiation dosage chart, entries are made for each radiographic examination.

which continually records the total radiation flux in units of roentgens cm^2. This is of particular importance because it enables us to know the total radiant energy delivered.

The camera used for cineradiography is an Eastman Kodak Cine Special driven by a synchronous motor with a speed capability of 7.5, 15, 30, and 60 frames per second. The camera shutter opening and film transport are synchronized with the x-ray beam by means of a pulsing device so that x-rays are produced only when the film is in proper position to be exposed. There are no x-rays emitted while film is being transported from one frame to the other. Throughout the examination, the patient is protected from stray radiation by means of a lead apron which covers the body and shoulders. A lead

RADIATION DOSIMETRY EXAMINATION CHART

Name: John Doe Age: 14
Chart # H1421 Date: 6/10/65

Examination Part		Projection	K. V.	M. A. or M. A. S.	Cine Time and frames/sec.
Head		Lat.	65	20	15 f/p/s
T. F. D. (target film distance)	**T. S. D. (target skin distance)**	**Field Size Film Size**	**Chart # Diamentor Reading r cm²**	**Skin Dose at Point**	**Clinical Diag. Total Skin Dose**
36"	30"	2½x1½	233	5.8 rads	Cleft palate 5.8 R
Gonadal Dose (Dosimeter)	**Protection Equip. Used**	**Film Type**	**Grid Used**	**Cassette Type**	**No. & type of Still Films**
0 rads	lead apron eye shield	16mm EK. Lina-Shell.			

FIGURE 4. Entries in the diary for a typical examination with cineradiography. A lateral projection of the head at 65 kv and 20 ma, 15 fps, at 36 inch target-film-distance and 30 inch target-skin-distance, and a field size (at the collimator) of 2½ x 1½ inches resulted in an integral radiation flux reading of 233 roentgens cm². Gonadal dose was less than 1 mr, recorded by a thimble ionization chamber. The calculated skin dose was 5.8 rads.

shield is used to protect the eyes during lateral head examinations. When hypopharyngeal tissues are not being examined, a lead protector is placed to shield the thyroid gland. The use of these protective shields reduces the dosage to the critical regions (gonads, eyes, thyroid, and blood-forming organs) to very low levels.

A personal radiation diary (Figure 3) was established to record all radiographic exposures for cleft palate patients. In addition, a radiation exposure history is obtained for every cleft palate patient.

It is suggested that a formal radiation registry be established, similar to that established for the New York City Fire Department. The dosage

history might indicate the patient's name, chart number, date of examination and age. Radiographic technical factors such as type of examination, and recorded dosimetry readings (including gonadal dose measurements) should be noted. Skin dose can be calculated from a knowledge of the incident radiation flux obtained from the monitor chamber and the technical factors used.

For example, a typical examination involving cineradiographic examination of a cleft palate patient during phonation and swallowing would result in entries shown in Figure 4. Lateral projection of the head, (65 kv, 20 ma, 15 frames per second, at 36″ target film distance, a 30″ target skin distance, and a field size at the collimator of 2½ x 1½ inches) gave a reading at the measuring instrument of 233 r cm^2. Gonadal dose was zero, as recorded by a thimble ionization chamber. The calculated skin dose is 5.8 rads.

In order to obtain the skin dose, the Diamentor[1], which measures and records the emitted flux through the collimator jaws is calibrated against a standard free air ionization chamber. In addition, skin dose measurements have been recorded with the thimble chamber of the Farmer-Baldwin instrument at known collimator openings, target skin distances, and tube currents. The monitor ionization chamber readings can be linearly related to skin dose, that is, they are independent of energy (kv) or x-ray intensity (ma) in the range employed for patient's studies.

Thus the value of 5.8 rads given in Figure 4 is arrived at by the following equation, experimentally determined for our physical facility.

$$\text{Skin dose (rads)} = \frac{K \times \text{Ionization chamber reading (r cm}^2\text{)}}{\text{A Area (in}^2\text{)}} \times \frac{30 \text{ inches}^2}{\text{TSD}^2}$$

Where A is the area of the collimator opening (2½ x 1½ in.),
TSD (Target Skin Distance) = 30″,
Diamentor reading in r cm^2 = 233, and
K = 9.4 x 10^2 (a constant, in rads, for conversion of Diamentor readings in r cm^2 to skin dose at a standard 30″ target skin distance).

The conventional cleft palate x-ray examination consists of cinefluorographic films of phonation of a group of vowels and consonants, sentences of connected speech, and a barium swallow, and lateral films taken at rest and during the prolonged phonation of *e*. The cineradiographic examination consists of fluoroscopy at a very low ma for the positioning of the patient and filming described above. The major dosage is from the cine filming. The additional dosage from the two still films is approximately 1.5 rads to the skin. Hence, the total skin dose is 7.3 rads. Calculation of critical organ dosage to the head and neck

[1] PTW Diamentor—George T. Mellon, Inc., New York 38, New York.

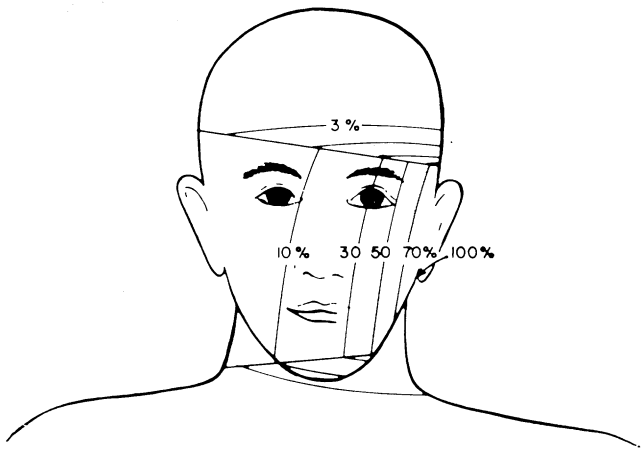

FIGURE 5. An illustration of the isodose distribution curve for estimating dosage at a given depth in the head region.

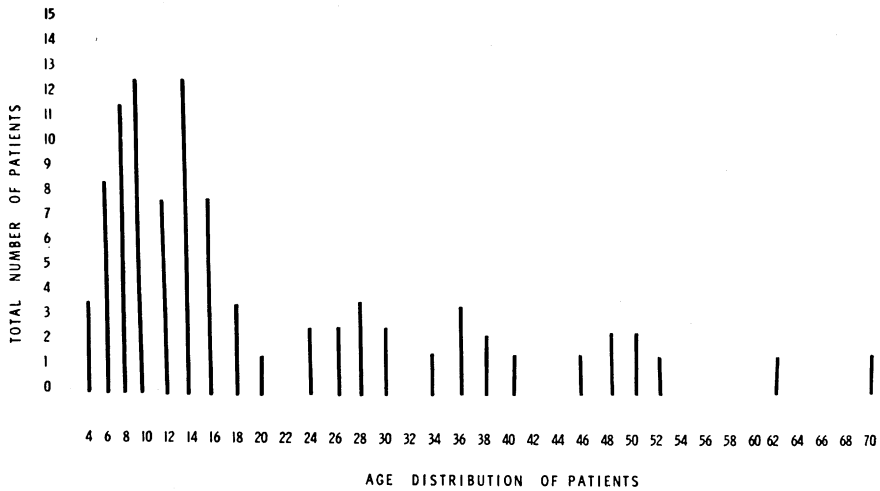

FIGURE 6. Age distribution of cleft palate patients undergoing radiographic examination.

regions may best be visualized by Figure 5 in which isodose distribution patterns are overlayed over a normal cranial outline. In this manner, the dose throughout the head can be determined relative to the surface dose. Thus, the dose at midline (at the pituitary gland) is 30% of the skin dose, or, in this case, 2.2 rads. Dosage would be higher at the eye were it not for the lead shield.

To date, 96 patients have been examined (Figures 6 and 7). The dosage has ranged from 96 r cm^2 (2.4 r skin dose) to 4052 r cm^2 (48 r skin dose).

The average examination has resulted in a reading of 982 r cm^2 or

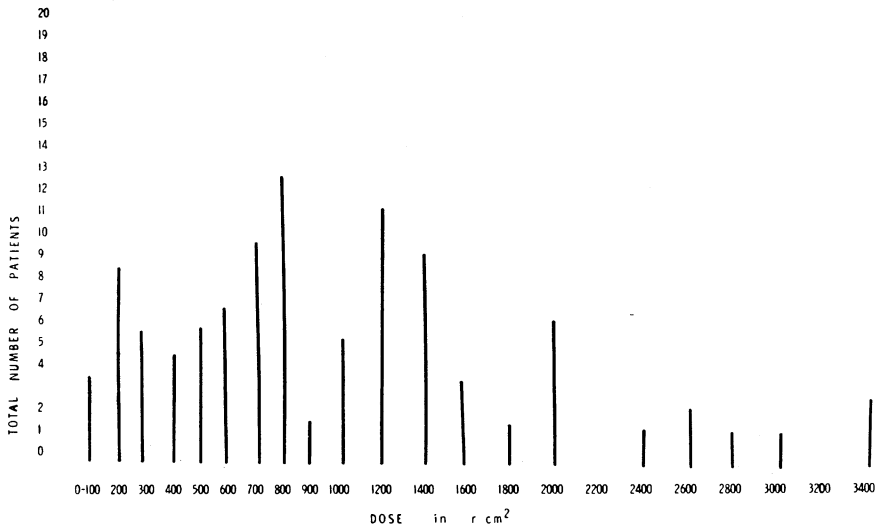

FIGURE 7. The range of total radiation flux resulting from examinations of cleft palate patients.

an average of 14.7 rads to the skin. However, this includes a number of re-examinations and additional special studies during the early stages of our clinical program. An evaluation of data for routine cleft palate examination would give a value of approximately 560 r cm^2 or 8.3 rads to the skin.

In reviewing the data, it became apparent that the length and scope of radiographic examinations increased as our studies progressed and, as a consequence, the total radiation dosage per examination per patient also increased markedly. As a result, the entire speech protocol used in the radiographic examination was re-evaluated and the following suggestions are proposed to keep dosage at the lowest level: a) a high gain image amplifier, properly adjusted for optimum film quality and brightness, b) freshly mixed developing solutions, c) high resolution, high speed film (that is, linagraph Shellburst EK), d) adequate protective devices (that is, full covering lead apron, eye shield, thyroid shield and small field size, e) image orthicon television system for positioning of patient, f) periodic systematic re-evaluation of the speech protocol, g) constant monitoring of the dosage, h) proper patient radiation history, i) complete patient dosage control records, and j) establishment of a maximum limit for total dosage for cleft palate examination in children (10 r to critical areas).

Summary

A discussion of the radiation problems associated with diagnostic x-ray studies of cleft palate patients has been presented. Methods of measuring, recording and limiting radiation exposure are described.

The authors wish to acknowledge with thanks the valuable scientific contribution of Mr. Harry Harvey, Jr., R.T., to this study.

reprints: *Dr. Lloyd Sherwin Landa*
New York University
421 First Avenue
New York, New York 10010

References

1. ARDRAN, G. M., and CROOKS, H. E., Routine dose recording in diagnostic radiology. *Brit. J. Radiol., 36,* 689–693, 1963.
2. ARDRAN, G. M., and CROOKS, H. E., The measurement of patient dose. *Brit. J. Radiol., 38,* 766–770, 1965.
3. JANOWER, M. L., ed., "Technological Needs for Reduction of Patient Dosage from Diagnostic Radiology", Thomas, 1963.
4. MORGAN, R. H., GEHRET, J. C., The radiant energy received by patients in diagnostic x-ray practice. *Am. J. Roentgen., 97,* 793–810, 1966.
5. POPPEL, M. H., SORRENTINO, J., and JACOBSON, A. G., *J. Amer. med. Assoc, 147,* 630–632, 1951.