

*A brief report is presented on a follow-up study of 1,908 irradiated cases of tinea capitis and of 1,801 cases of the same condition that were not irradiated. So far the irradiated group appears to have a larger number of cases of cancer, mental illness, and permanent damage of the scalp hair than the controls. The investigation is being continued.*

## **FOLLOW-UP STUDY OF PATIENTS TREATED BY X-RAY FOR TINEA CAPITIS**

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HIS report summarizes the findings to date of a follow-up study of 1,908 cases of tinea capitis (ringworm of scalp) who were treated by x-ray epilation and 1,801 cases of tinea capitis who did not receive x-ray therapy. Both groups were treated at the Skin and Cancer Unit of the New York University Hospital between 1940 and 1958.

The purpose of the study is to characterize the nature and magnitude of chronic radiation injury due to x-ray epilation. It was motivated by the current need in the field of radiological health protection for quantitative data on the relationship of radiation dose to chronic injury.

Although x-ray epilation has been used for many decades and involves substantial doses of ionizing radiation to the scalp, brain, and associated head structures of children, only a few follow-up studies of a limited nature have been done.<sup>1,2</sup>

The opportunity for a long-term follow-up study at this institution seemed favorable for the following reasons: (1) a registry which included 2,500 irradiated cases had been maintained

for many years, and (2) the distribution of radiation dose in the head could be defined with considerable accuracy since the x-ray equipment was always carefully calibrated, the treatment procedure was well standardized and virtually all of the x-ray epilations were done by one technician or under her supervision.

At the present time there are several facets to the program: (1) an evaluation of the medical experience of the irradiated and control populations by means of a health questionnaire, (2) a clinical and laboratory examination of a representative sample of the irradiated and control populations, and (3) a study of the x-ray dose to the various head structures associated with the Adamson-Keinbock technic.

### **Adamson-Keinbock Irradiation Technic**

The x-ray epilation technic involved exposure of five overlapping areas of the scalp to the x-ray beam in order to irradiate the scalp as uniformly as possible. The air dose from the 100 kv unfiltered beam for each field was 350 r.

Figure 1 demonstrates the arrangement of the head and x-ray tube for one of the exposure positions and the leaded rubber shielding used for the rest of the body.

Dosimetric studies of this irradiation technic have been done, using a head phantom built around the skull of a seven-year-old child. X-ray doses have been measured with lithium fluoride powder in small fluorocarbon plastic tubes placed at various sites in the

phantom. These measurements indicate that the dose to the scalp ranged from 500 to 800 rads and that the surface dose to the brain was 140 rads.

#### Population Characteristics

As indicated in Table 1, 81 per cent of the 1,908 irradiated cases and 76 per cent of the 1,801 nonirradiated cases have so far been located. The average age at treatment was seven years in both groups. The located irradiated

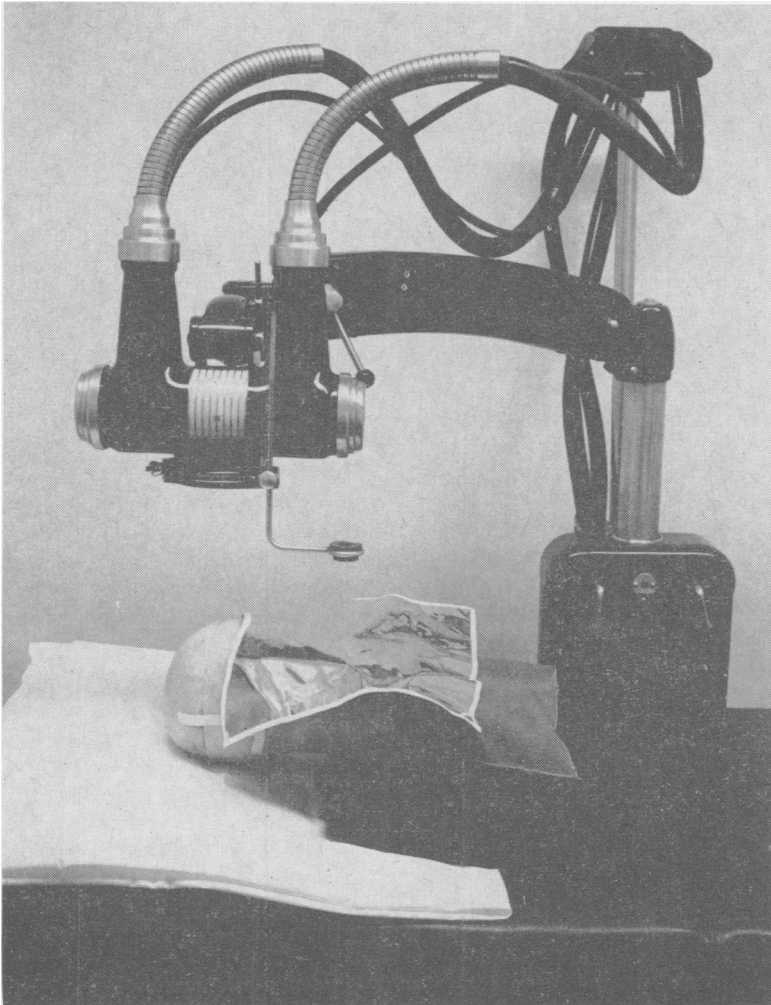


Figure 1—Arrangement of head and x-ray tube for an exposure position, and leaded rubber shielding used for rest of body.

**Table 1—Population characteristics of the irradiated and nonirradiated cases of tinea capitis**

Characteristics	Irradiated		Nonirradiated	
	Total	Located	Total	Located
Population	1,908	1,548 (81.1%)	1,801	1,363 (75.7%)
Year of treatment: median	1949	1950	1946	1947
Age at treatment:				
mean	7.4 yrs.	7.4 yrs.	7.2 yrs.	7.2 yrs.
standard deviation	2.6 yrs.	2.6 yrs.	3.1 yrs.	3.1 yrs.
Posttreatment elapsed time:				
mean	13.1 yrs.	12.2 yrs.	15.5 yrs.	14.8 yrs.
standard deviation	5.0 yrs.	4.8 yrs.	5.3 yrs.	5.2 yrs.
Age at contact:				
mean	20.8 yrs.	19.9 yrs.	22.7 yrs.	22.2 yrs.
standard deviation	5.9 yrs.	5.6 yrs.	6.6 yrs.	6.5 yrs.
Per cent male	86.3%	86.9%	78.9%	79.1%
Per cent white	74.1%	72.9%	75.7%	75.7%
Per cent due to <i>M. audouinii</i>	91.3%	90.2%	58.0%	58.4%

cases and the located nonirradiated cases were comparable in terms of race and sex composition, with white males predominating in both groups. The post-irradiation elapsed time was 12 and 15 years, respectively, for the irradiated and nonirradiated cases and consequently the control cases were a few years older than the irradiated cases at the time of contact.

As indicated in Table 1a, *Microsporum audouinii* was identified on culture in 90 per cent of the irradiated cases. In the controls, the same organism was recovered in 58 per cent, while 20 per cent had *Microsporum lanosum*. A small proportion of both groups had other fungi as causative agents.

#### Health Questionnaire Survey

A health questionnaire patterned on one used at Rochester University for

the follow-up study of thymus irradiation<sup>3</sup> was sent to each patient upon location. The questionnaire included personal data and illness experience since the time of treatment for tinea capitis. The patients were asked to provide the names of hospitals and physicians responsible for their care. Physi-

**Table 1a—Distribution of fungus diagnosis in the irradiated and nonirradiated cases of tinea capitis who responded to the health questionnaire**

Fungus Diagnosis	Irradiated		Nonirradiated	
	No.	%	No.	%
<i>M. audouinii</i>	1,397	90.2	801	58.0
<i>M. lanosum</i>	34	2.2	287	21.1
Misc.	117	7.6	147	10.8
Unknown	—	—	128	9.2
Total	1,548	100.0	1,363	100.1

cians and institutions were contacted whenever indicated in order to obtain accurate diagnoses.

### Mortality Experience

Mortality findings are summarized in Table 2. In each group 14 cases died during the period of follow-up. In the irradiated group, three cases died of leukemia, one of aplastic anemia, five from violent causes (including three traffic accidents, a drowning and a suicide) and five from other diseases. In the controls, no deaths occurred from leukemia or aplastic anemia. Seven cases died of traffic accidents, two cases were killed while resisting arrest, one was a homicide, one was accidentally shot and three died of disease. The average age at death in the irradiated cases was 15.5 years and in the nonirradiated cases, 19 years.

### Leukemia and Cancer

In addition to the three leukemia deaths there were six cases of cancer for a total of nine cases in the irradiated group (Table 3). Of these cancers, four were in the head (two brain tumors, one fibrosarcoma of the mandible and one lymphosarcoma of a submandibular gland). There was also a case of Hodgkin's disease and a case of rectal cancer. The average age at x-ray treatment for the nine cancer cases was seven years, the average age at diagnosis was 15 years and the average posttreatment elapsed time from x-ray treatment to the diagnosis of cancer was eight years. In the nonirradiated cases there was only one cancer, a case of Hodgkin's disease who had been treated for ringworm at the age of six and developed the disease 11 years later.

### Mental Disorders

The number of cases of mental illness, including psychosis, personality dis-

orders, and psychoneurosis was higher in the irradiated group than in the nonirradiated controls, as indicated in Table 4. The total number of cases of mental disorders was 45 in the irradiated group and 13 in the nonirradiated group. Of these, 29 cases of major mental disorders (psychosis and personality disorders) occurred in the irradiated group compared to nine cases in the nonirradiated group. The remaining 16 cases in the irradiated and four cases in the nonirradiated were psychoneurosis.

### Clinical and Laboratory Studies

A representative sample of 319 irradiated cases and 286 controls were

**Table 2—Deaths by cause in the irradiated and nonirradiated cases of tinea capitis**

Cause of Death	Irradiated	Nonirradiated
Violence		
Motor vehicle or train	3	7
Drowning	1	0
Suicide (schizophrenia)	1	0
Shot by policeman	0	2
Shot accidentally	0	1
Homicide	0	1
	—	—
Total	5	11
Disease		
Leukemia	3	0
Aplastic anemia	1	0
Pneumonia	1	0
Rheumatic fever	1	1
Cardiac insufficiency	1	0
Ulcerative colitis	1	0
Meningococcal meningitis	0	1
Tuberculosis	0	1
Nephritis	1	0
	—	—
Total	9	3
Total deaths	14	14
Population located	1,548	1,363

**Table 3—Cancer and leukemia in the irradiated and nonirradiated cases of tinea capitis**

Irradiated Patients							
Race	Sex	Diagnosis	Year of Treatment	Age at Treatment	Age at Diagnosis	Elapsed Time to Diagnosis	Age at Contact
W	M	Astrocytoma left optic nerve chiasma	1950	4	8	4	18
W	M	Brain tumor—astrocytoma	1953	10	11	<1	21
W	M	Fibrosarcoma of tissue of mandible	1947	3	18	15	18
N	M	Lymphosarcoma of submandibular node with focus of lymphocytic infiltration of submaxillary gland, right	1953	6	16	10	16
W	M	Hodgkin's disease	1957	10	14	4	16
W	M	Adeno-carcinoma of right valve of rectum	1944	8	23	15	27
W	M	Acute myeloblastic leukemia (died)	1944	8	27	19	Died at 27 yrs.
W	M	Chronic myelogenous leukemia (died)	1944	10	12	2	Died at 12 yrs.
W	M	Acute lymphatic leukemia (died)	1956	6	9	3	Died at 10 yrs.
		Average	1950	7	15	8	19
Nonirradiated Patients							
W	M	Hodgkin's disease	1947	6	17	11	23

subjected to a battery of clinical and laboratory studies. Included in the clinical examinations were: (1) medical history, (2) general physical examination, (3) dermatologic studies of hair and scalp, (4) audiometry, and (5) ophthalmologic and slit lamp examinations. Laboratory studies included: (1) white blood counts (total and differential) and hematocrit, (2) hair counts and anagen/telogen ratios, and (3) chromosomal studies on peripheral blood. The principal abnormal findings of the clinical examination program are summarized in Table 5. Twenty-three per cent of the irradiated individuals showed generalized loss of hair over the entire surface of the scalp compared to 0.7 per cent (two cases) in the non-

irradiated group. As shown in Figure 2, the generalized hair loss is easily distinguishable from the usual patterns of baldness in males. Significant dif-

**Table 4—Mental disorders in the irradiated and nonirradiated cases of tinea capitis**

Mental Disorders	Irradiated	Nonirradiated
Psychotic disorders	15	7
Personality disorders	14	2
Psychoneurotic disorders	16	4
Total mental disorders	45*	13*
Population located	1,548	1,363

\* P<0.01.

**Table 5—Summary of the main findings in the clinical examination of 319 irradiated cases of tinea capitis and 286 nonirradiated controls (1962-1965)**

Clinical Findings	Number Examined	Number Positive	Per cent Positive
Generalized			
hair thinning:			
irradiated	317	74	23.3*
nonirradiated	284	2	0.7
Cysts and nevi of scalp:			
(in males)			
irradiated	286	21	7.3†
nonirradiated	223	5	2.2
Balding (all grades):			
irradiated	317	61	19.2‡
nonirradiated	285	24	8.4
Greying:			
irradiated	317	23	7.2†
nonirradiated	284	8	2.8

\*  $P < 0.001$ .

†  $P < 0.02$ .

‡  $P < 0.01$ .

ferences between the irradiated and non-irradiated cases were also noted for several other dermatologic abnormalities. Male baldness of Grades IV through VII (Hamilton's classification)<sup>4</sup> was more common in the irradiated cases (19.2 per cent) than in the nonir-

radiated cases (8.4 per cent). However, most of these cases were of Grade IV which is minimal baldness.

There were 23 irradiated cases with cysts and nevi of the scalp compared to five cases in the controls, all of which were found in males. Although marked



**Figure 2—Generalized hair loss.**

greying of hair was not observed in either group, there were more cases with minor degrees of greying in the irradiated group than the controls.

In the audiometric examinations the irradiated cases showed an elevated incidence of high frequency hearing loss which was of borderline statistical significance.

In the eye examinations, no difference in the incidence of frank cataracts was found in either group, although the irradiated cases showed a significantly larger number of minor lens defects on slit lamp examination than the nonirradiated cases.

Studies of chromosomal abnormalities in the peripheral blood are currently under way. At present the data suggest that there is a higher incidence of stable and unstable forms of chromosomal aberrations in the irradiated group compared to the controls.

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## Summary

Of necessity, the data have been presented here in a summary fashion and will be described in greater detail elsewhere. Although the research project is still in progress, this follow-up study of 1,908 irradiated cases of tinea capitis and 1,801 nonirradiated cases of tinea capitis has thus far shown a substantially larger number of cases of cancer, mental disease, permanent damage of the scalp hair in the irradiated group compared to the controls.

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