

TRANSMISSION OF BUCKY (GRENZ) RAYS THROUGH HUMAN SCALP HAIR

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Abstract. The shielding effect of various types of human hair and the influence of a shampoo on the transmission of grenz rays were determined by ionization chamber measurements. The mean transmission proved to be 53.7% with clean hair and 48.1% with hair shampooed one week before. $P < 0.05$ ($n = 50$) (Pratt's test). A relationship was found between weight of hair layer and transmission. In clinical practice, the thickness of the hair should be assessed, and the normal skin dose multiplied by 1.5 for patients with a thin hair layer, by 2 in the case of a medium, and by 3 in the case of a thick hair layer.

Key words: Bucky rays; Grenz rays; Transmission through scalp hair

Bucky radiation or ultra soft X-radiation is generated at 6-12 kV. This radiation is used in the treatment of several skin diseases, e.g. psoriasis (1, 2, 4, 5, 6, 8). When psoriasis affects the scalp, it has been a clinical tradition to multiply the skin dose several times. An evaluation of the radiation dose delivered through scalp hair does not seem to have been reported in the literature.

MATERIAL

The material comprises 56 patients referred more than twice for Bucky therapy of the scalp. Three of the patients were excluded as they did not complete the treatment, two because their hair was greased by ointment at the second measurement, and one because he had in the meantime had his hair crewcut. This leaves 50 persons who completed the investigation.

METHOD

The radiation was produced with a Siemens Dermopan unit with a beryllium window. Radiation factors: 12 kV, 0-filter, HVL (half-value layer) 0.25 mm cello (0.02 mm Al). The measurements were performed with a thin-window ionization chamber having a diameter of 8 mm

and a height of 6 mm, in combination with a Baldwin-Farmer substandard dosimeter.

The ionization chamber was placed on the scalp at a distance of 20 cm from the focal spot, at right angles to the central beam. A reference value exposure time was determined without intervening hair, corresponding to a dose of 50-60 R. Thereafter, the hair was combed over the ionization chamber, re-establishing the normal hair style and without the patient moving the head, and the exposure time for the same dose delivered to the ionization chamber was determined. Each value presented is an average of two measurements. As the output of the X-ray unit was kept constant during the measurement, the transmission could be determined as the ratio between the exposure times at the two measurements,

$$\text{i.e. transmission} = \frac{\text{reference value (minutes)} \times 100}{\text{time (minutes) with hair}} \%$$

The investigation was carried out twice, the first time with clean, newly washed hair and the second time at least 3 days after the last shampoo.

Hair colour, weight per metre hair, and hair diameter were registered, and photos of the hair were taken for subsequent comparison. 21 of the patients permitted a haircut, and made it thereby possible to count the number of hairs per cm^2 in the radiated field. As many of the distributions are skew, medians and interquartile ranges are used. The statistical analysis included Pratt's one-sample rank sum test (9).

RESULTS

An average of 2.4 days after shampoo the mean transmission in the total group was 53.7%, and an average of 6.3 days after shampoo it was 48.1%. Thus, when the time since the last shampoo increases by 4 days, the mean transmission falls by 5.6%.

$P < 0.05$, Pratt's test ($n = 50$, number of zeros = 4, non-zeros = 46) (negative rank sum = 881, positive rank sum = 384).

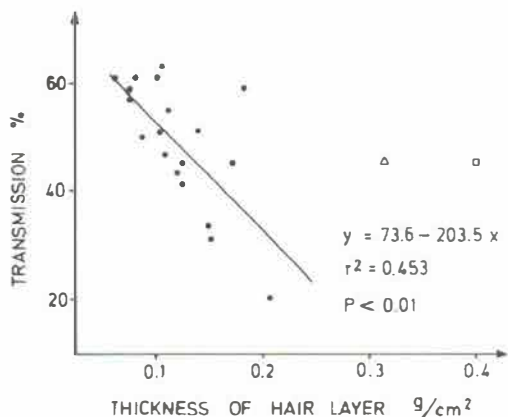


Fig. 1. Relationship between thickness of hair layer (g per cm²) and transmission rate. The points (□ △) are not included in the linear regression because very long hair (20 and 26 cm) gives a greater hair layer thickness only when calculated, and not in reality.

Hair weight per metre: Median 4.31 mg. Interquartile range 3.58–5.07 (*n*=50).

Hair diameter: Median 0.049 mm. Interquartile range 0.044–0.054 (*n*=50).

Number of hairs per cm²: Median 226. Interquartile range 184–266 (*n*=21).

The relation between transmission and mass of hair in g per cm² (calculated from hair weight in g per metre × hair length in metres × number of hairs per cm²) is seen in Fig. 1. The transmission through a theoretical, arranged hairlayer net mesh will be a very flat exponential function. Our measurements make up such a small part of the curve that in practice it may be considered as a linear function. Owing to the large number of measurements required for determining the above quantity, this procedure is unwieldy in clinical practice, but from an assessment of the parameters and clinical judgement it was possible to deduce a simple rule which is directly applicable (Table I and Fig. 2). It was found that patients with a thick layer of hair or dense hair growth had a transmission of 40% or less. Individuals with normal hairgrowth had a

Table I. Penetration of Grenz rays (12 kV, unfiltered) through human scalp hair, and skin dose multiplication factors

Hair type	Transmission (%)	Multiplication factor
Thick hair cover or dense hair	≤40	3
Medium hair	40–60	2
Thin hair	≥60	1.5

transmission between 41 and 59%. Persons with rather thin or very thin hair had a transmission of 60% or more. An attempt to relate hair colour to transmission coefficient was without significance.

DISCUSSION

At a hair length ranging between 8 and 16 cm, we found a mean hair weight of 0.125 g per cm². This corresponds to a cellon layer of about 1.25 mm. Cellon and epidermis have approximately the same half-value layer in g/cm². If this also applies to hair, the weight will correspond to about 4 half-value layers. Thus, the transmission would be expected to be less than 10%, which also has been taken in consideration by Bucky (3). The main explanation why the transmission measured proved to be more than 5 times greater must be that hair is not a homogeneous layer. There will be a net mesh phenomenon, the radiation passing in places through the frames of the individual hairs so that the mesh holes give rise to the unexpected greater radiation. This effect was observed in persons with very greasy hair which was at times parted where the teeth of the comb had passed through; the result was a high transmission value in such areas.

Possibilities of error in the measuring procedure

1. a variation in the standard distance of 20 cm from the focal spot to the scalp will give rise to errors which accord largely with the inverse—



Fig. 2. Illustration of the clinical judgement; from the left: thin, medium, and thick hair.

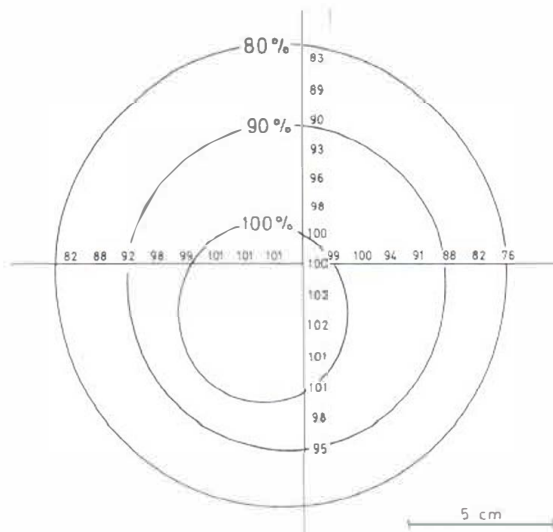


Fig. 3. Dose distribution of the Dermopan unit used, 20 cm from the focus, perpendicular to the central beam.

square law. Thus, when the distance is increased from 20 to 21 cm the dose has to be multiplied by $20^2 - 21^2 = 0.91$; at 22 cm, 0.83, etc.

2. if the ionization chamber is not placed at right angles to the direction of the beam, the measured dose will be too low.
3. outside the central beam, the dose will differ, as is apparent from Fig. 3.

These possible errors are avoided by introducing the measurement of a reference value, as mentioned previously. In the treatment of psoriasis, Bucky dosages to the skin of 100–450 R have been recommended, with a maximum of 600–800 R weekly (1, 2, 4, 5, 7). Skin radiation experiments in the treatment of psoriasis have shown that 100 R 12 kV weekly is an effective dose. The same clinical effect may be obtained with 50 R twice a week (6, 7).

As psoriasis of the scalp does not differ from psoriatic lesions of the skin, the weekly dose administered to the scalp, according to the above findings, should be 150–300 R. 200 R to medium-

haired individuals, 150 R to persons with rather thin or very thin hair, and 300 R to patients with thick hair layer or a dense hairgrowth (Table I and Fig. 2). Doses higher than these must be considered to be over-treatment.

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