Title	Tangential pendulum therapy using wedge filter
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Citation	日本医学放射線学会雑誌. 1961, 21(2), p. 114-118
Version Type	VoR
URL	https://hdl.handle.net/11094/17869
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Tangential Pendulum Therapy Using Wedge Filter

by

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楔状フィルターを用いた切線振子照射法

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（昭和36年3月20日受付）

病巣が比較的表在性のもので，しかもかなり広範囲に強力な照射を必要とする場合，例えば乳癌などに対する有力な照射法の一つとして，通常の200 kVp 程度のX線を用いた振子照射法に楔状フィルターを加味して用いることを提案する．今回はこの基礎実験の一つとして銅の楔状フィルターを用い，円柱状パラフィンファントム内に於る線量を測定した．その結果，病巣角内の外套域での線量分布は，通常のフィルターを用いたものに比較してかなり均等化され，外套域内縁部にも充分な線量を与え得ることが明らかになつた．

楔状フィルターの形，および材質を改良することによつて，更に合理的な線量分布が得られると考えられるので，上手に調節された電子線照射と同程度の成果を挙げ得ると信ずる．

Introduction

Many reports have been so far made on various methods of radiation therapy for comparatively superficial lesions which require rather extensive and intensive irradiation. Some of those methods mostly adopted are as follows:

(1) Medium deep therapy with 100-150 kVp x-rays
(2) Tangential fixed field irradiation with 200 kVp x-rays
(3) Tangential pendulum therapy
(4) Moving beam therapy with a lead sieve
(5) Ra or ^{60}Co mould therapy
(6) High-energy electron-beam irradiation

Each technique of irradiation has its advantages and disadvantages. For example, (1) does not seem adequate in delivering a cancero-cidal dose homogeneously to the lesion. In case of (2) or (3), the delivered dose reduces as it reaches down deeper tissues leaving cancer cells, which need higher dose than a skin tolerant dose such as adenocarcinoma cells, only insufficiently irradiated. (4) needs a massive radiation about the seventy per cent of which is at least to be wasted. Also it is too much complicated in setting-up for general use. So far as the delivery of a cancero-cidal dose within the limit of skin tolerance is concerned, (5) and (6) seem favorable. But they are not without handicaps. (5) is with a risk of over exposure on the part of the operator and (6) seems too expensive in practice.

To cover these handicaps, we propose a method in which a wedge filter is applied on a fixed tangential or rather tangential pendulum therapy. This newly introduced method seems very favorable in practical use in that positioning is accurate and the same conditions for irradiation can be kept.

Wedge Filter

Since Ellis and Miller first reported (1944)[5] the usage of a wedge filter, it has been used for various purposes and ways. The recent research was made by Cohen (1959, 1960)[2],[3], and Cohen and Burns (1959)[4].

We made several wedge filters. They are made of laminated thin copper sheets fixed to a thin aluminium plate 0.5 mm thick, which is fixed to a duralmin base-plate with a suitable aperture. Instead of a clinical copper filter, the base-plate is inserted into a filter slide which is at the end of a collimeter. The width of this wedge is determined by a field size at the position of 50 cm from the focus, and for a given wedge filter a field length is continuously variable. A representative wedge filter is described in Fig. 1.

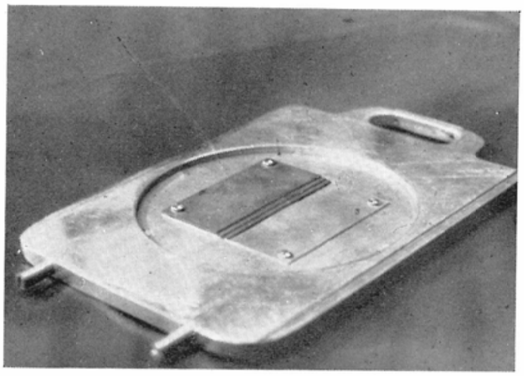

Fig. 1. Copper wedge filter

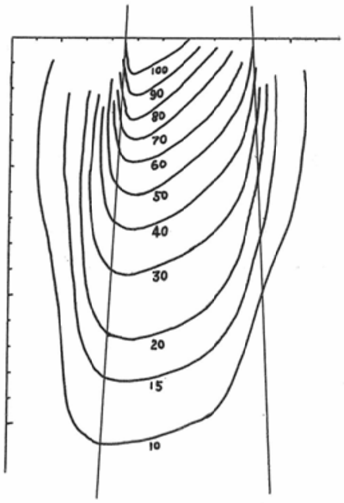

Fig. 2. Isodose curves for wedge field (in water phantom), FSD 50 cm, FS 5×10cm.

The isodose curves for this single wedge field are given in Fig. 2. Dose distribution was measured in a water phantom about $70\times50\times40$ cm deep. The beam from the x-ray tube, the axis of which was kept vertical, entered horizontally through an acrylite wall 3 mm thick. The measurement was made on a horizontal plane with a thimble chamber 4 mm in internal diameter and 17.5 mm long (Type RCD-43101, Tokyo Shibaura Electric

Co., Ltd.), with remote control and automatic recording. The thimble chamber was used for the depth of 2—18 cm and a shallow chamber for the depth from the surface to 5 cm : for the depth of 2—5 cm both chambers were reasonably required.

Dose Measurement and Results

We used a cylindrical paraffin phantom 20 cm in diameter, which had several holes 2 cm in diameter and of 1,2,3,4,5, and 6 cm in depth (Fig. 3). Holes less than 4 cm in depth are used for measurement of the dose received mainly from direct beam, and other holes from scattering only. To avoid possible errors of measurement, we kept the widest distance as possible between one hole and another and stuffed these holes with paraffin except one into which the ionization chamber was set.

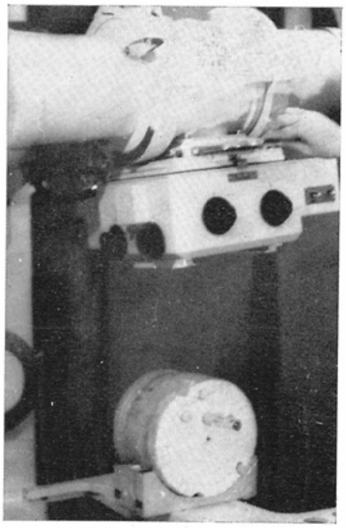

Fig. 3. Cylindrical paraffin phantom

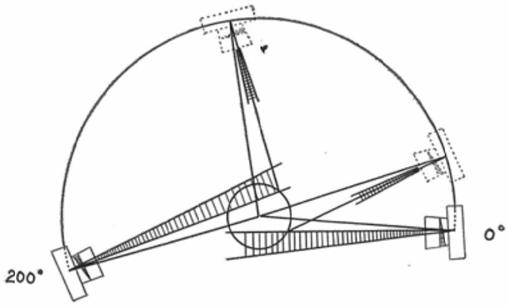

Fig. 4. Schematic representation of tangential pendulum irradiation with wedge filter

Following Kohler's method for a usual pendulum therapy, we adopted a focus-surface distance 50 cm, pendulum radius 60 cm (50 cm + axis depth 10 cm), field size 5×12 cm, tangential angle about 8°, and pendulum angle 200°. A wedge filter was inserted in such a way as its thick side came on the surface of the phantom (Fig. 4). We used a pendulum therapy unit, Type KXC-18-5, Tokyo Shibaura Electric Co., Ltd., operating at 200 kVp with 0.7 mm Cu+0.5mm Al filter (HVL 1.55 mm Cu, r.p.m. about 0.1 and 0.5).

Ionization chamber measurement was made in various points within and on the surface of the phantom. The radiation dose was determined with a Model 131 Victoreen condenser chamber.

The results of the measurements are shown in Fig. 5. The final isodose curves are shown in Fig. 6, in which the figures indicate the percentage of a maximum surface dose. How to determine the area of tissues to be irradiated in the tangential pendulum therapy

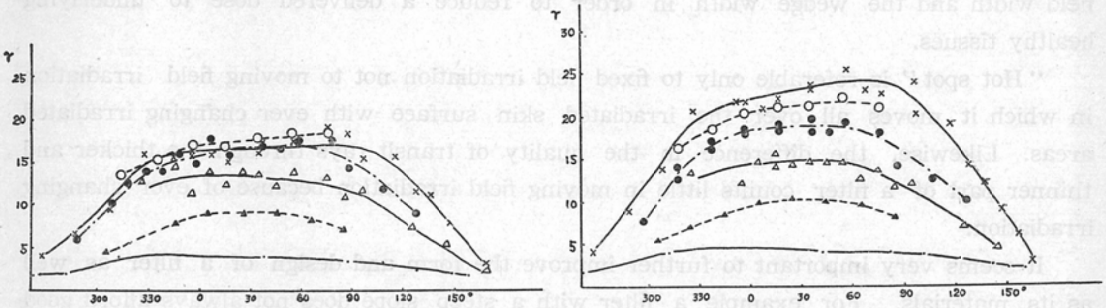

Fig. 5. Dose measured in paraffin phantom (left) with wedge filter, and (right) without wedge filter (×—× : surface, ○…○ : 1 cm, ●…● : 2 cm, △—△ : 3 cm, ▲…▲ : 4 cm, •—• : 5 cm in depth).

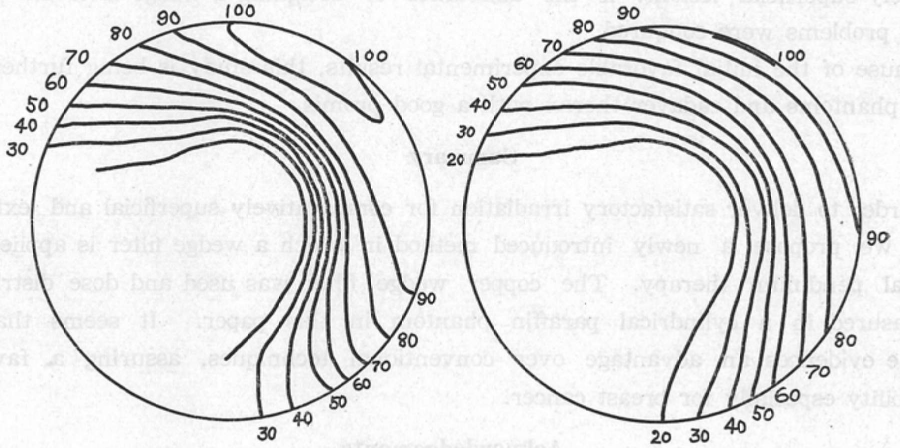

Fig. 6. Isodose curves for tangential pendulum irradiation in paraffin phantom (left) with wedge filter, and (right) wtihout wedge filter.

is a difficult problem as discussed by Rossmann (1954, 1955)[7,8], and Baerwolff (1954)[1]. The dose distribution for the wedge filter technique is lower on the surface and even from the surface to the depth of cm than that for a non-wedge technique.

Discussions

It seems that the wedge filter technique in tangential pendulum therapy evidences an advantage over conventional techniques, assuring a favorable practicability for moderately superficial lesions, especially breast cancer, its metastases to regional lymph nodes, and its chest wall recurrences which require a skilful management. The above mentioned experiments, although they are only part of the basic experiments that should be carried out, lead to an encouraging possibility that the use of various kinds of the wedge filter will result in better dose distribution for treating individual lesion.

It is understood that the depth of penetration may be regulated by varying the field width and the wedge width in order to reduce a delivered dose to underlying healthy tissues.

"Hot spot" is referable only to fixed field irradiation not to moving field irradiation in which it moves all over the irradiated skin surface with ever changing irradiated areas. Likewise, the difference in the quality of transit rays through the thicker and thinner part of a filter counts little in moving field irradiation because of ever changing irradiation.

It seems very important to further improve the form and design of a filter as well as its materials. For example a filter with a steep slope does not always afford good results. Besides copper which has been rather customarily used, a combined usage of tin and graphite was introduced by Cohen (1960)[3]. Therefore a tangential pendulum irradiation with a wedge filter would be one of the most useful methods in treating moderately superficial lesions. if the difficulties of designing a wedge filter and related physical problems were conqured.

Because of the initial favorable experimental results, this study is being furthered on various phantoms and cadaver thorax with a good promis.

Summary

In order to deliver satisfactory irradiation for comparatively superficial and extensive lesions, we propose a newly introduced method in which a wedge filter is applied on a tangential pendulum therapy. The copper wedge filter was used and dose distribution was measured in a cylindrical paraffin phantom in this paper. It seems that this technique evidences an advantage over conventional techniques, assuring a favorable practicability especially for breast cancer.

Acknowledgements

The authors would like to express their heartfelt thanks to Prof. Hiromu Tachiiri for his advices and suggestions in completing this paper. Acknowledgment is also due Mr. Katsumi Nagai and Mr. Shigeyasu Kurihara of Tokyo Shibaura Electric Co., Ltd. for their co-operation.

An outline of this paper was presented at the Nineteenth Annual Meeting of Nippon Societas Radiologica, Sapporo, Japan, July, 1-3, 1960.

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