Proceedings of the Iowa Academy of Science

Volume 32 | Annual Issue Article 73

1925

Economical Filtration in Deep X-ray Therapy

Scott W. Smith Jr.
Coe College

ECONOMICAL FILTRATION IN DEEP X-RAY THERAPY

SCOTT W. SMITH, JR.

A problem in deep x-ray therapy is to deliver to a deep seated malignant tumor, a sufficiently large dose of x-rays to affect the malignancy without permanent injury to the skin and intervening tissue. To accomplish this it is necessary to obtain a very penetrating beam of x-rays.

Radiation from a Coolidge tube is decidedly heterogeneous as to wave length, although as the voltage is raised, the proportion of short penetrating wave lengths is increased. However, even with the high voltages now in use (as high as 240,000 volts) much undesirable soft radiation remains in the beam. In an effort to reduce the proportion of soft rays, filters are placed in the path of the beam.

The question now arises as to the best material for the filter, and the correct thickness of the selected material that should be used. The practice of using a millimeter or more of copper as a filter for x-rays produced at 200 Kv. has become rather common. It is our belief that such a filter thickness is excessive and with its use much time is wasted.

To investigate this problem, readings were made at the surface and at a depth of 10 cm. in a water phantom, by means of an ionization chamber and a gold leaf electroscope, of the time required for the shadow of the gold leaf to fall ten scale divisions in the microscope, when various thicknesses of several different materials were used as filters. From Fig. 1 it will be seen that the time required to discharge the electroscope ten units when the ionization chamber is at the surface of the water, increases with each additional layer of filter material. A similar graph might be constructed showing the increase in time when the ionization chamber is at the 10 cm. depth in the phantom. If for any particular filter thickness, the surface time be divided by the depth time, the percentage of the beam reaching a depth of 10 cm. is obtained. Fig. 2 shows these percentages plotted against their corresponding filter thicknesses.

It will be seen at once from this graph that with the addition

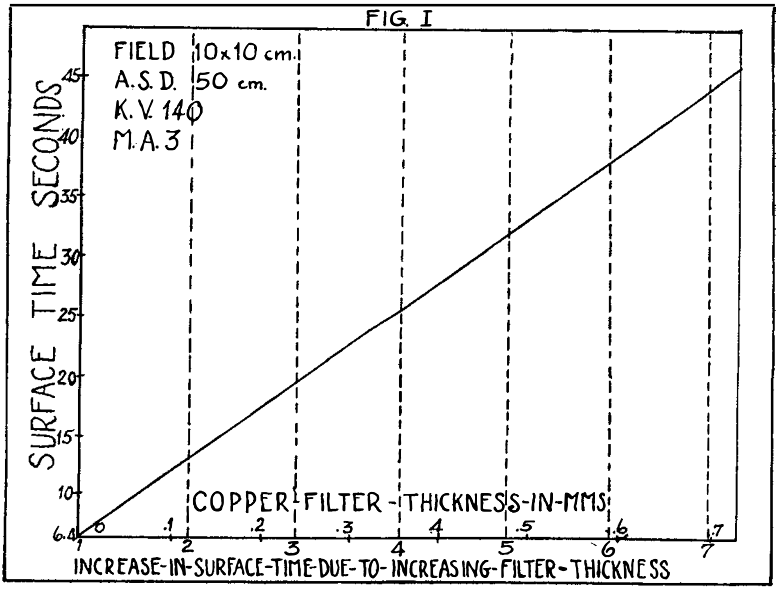

Fig. 1. Specimen graph showing the time in seconds required to discharge the electroscope with the ionization chamber at the surface of the water phantom, plotted against filter thickness expressed in millimeters, and also expressed as the thicknesses required to increase the surface time in equal multiples.

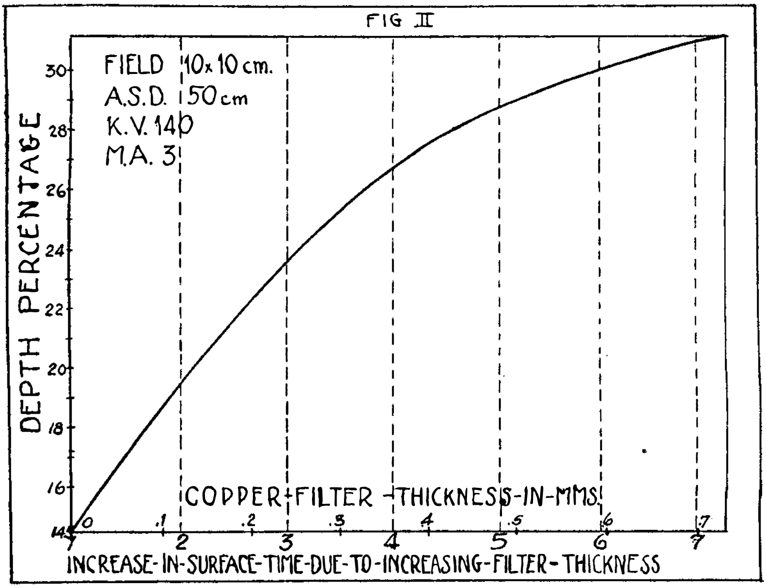

Fig. 2. Percentage of x-rays reaching a depth of 10 cm. in water, plotted against filter thickness required to increase the surface time in equal multiples of the time required by the unfiltered beam to discharge the electroscope.

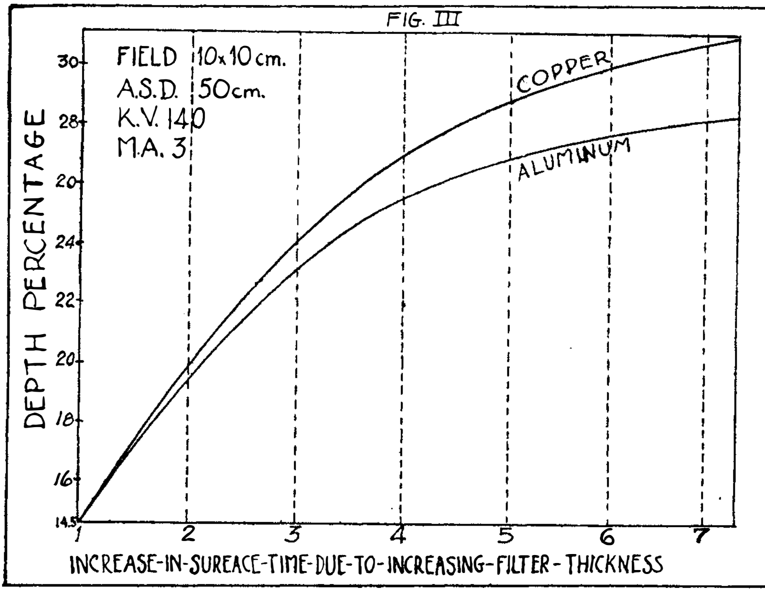

Fig. 3. Comparative depth-dose percentages of x-rays filtered through copper and aluminum, plotted against their absorption values expressed by the thickness required to increase the surface time in equal multiples.

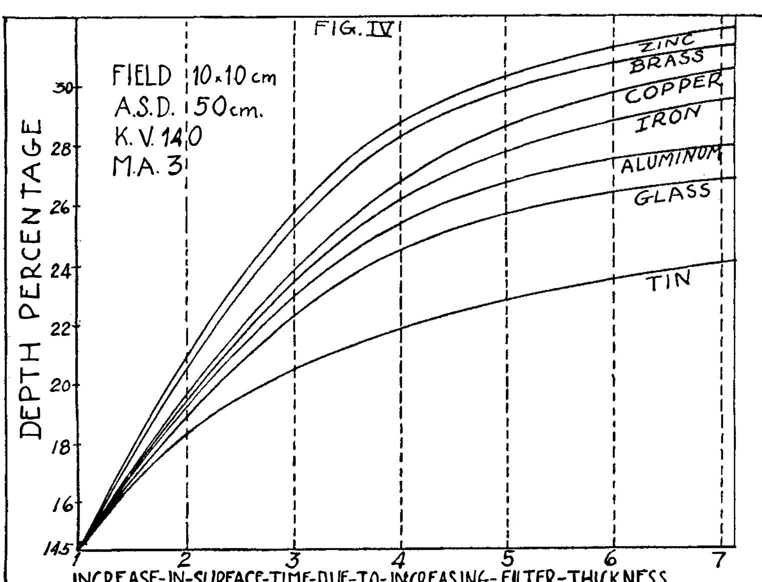

Fig. 4. Comparative depth-dose percentages with various filter materials, plotted against their absorption values.

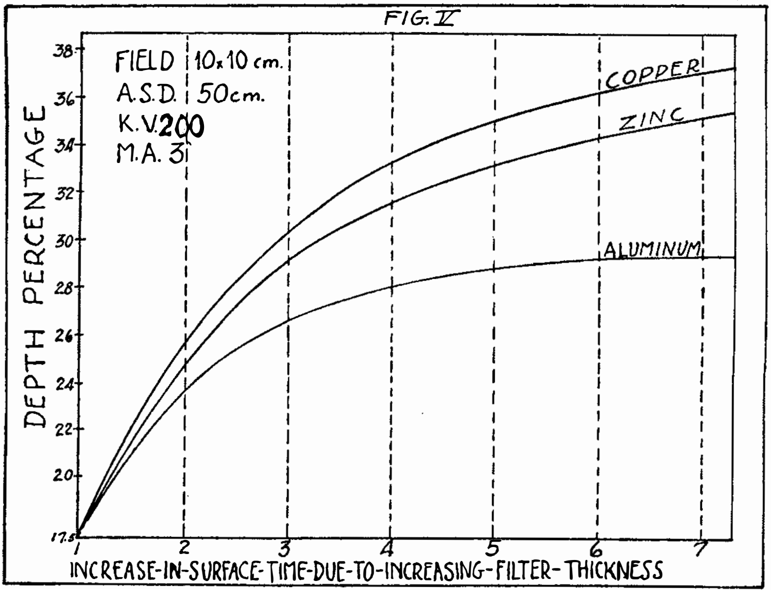

Fig. 5. Comparative depth-dose percentages of x-rays produced at 200 Kv., filtered through copper, zinc, and aluminum.

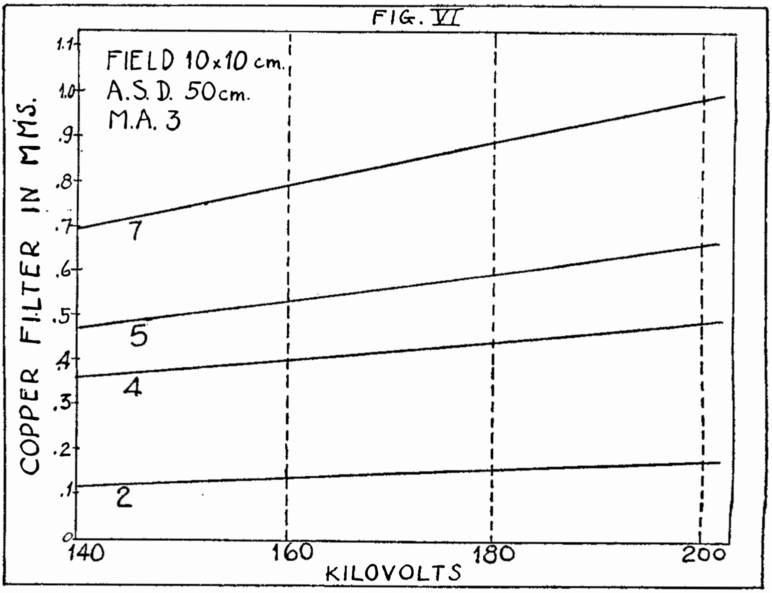

Fig. 6. Thickness of copper required at various voltages to increase the time of the surface-dose 2, 4, 5, and 7 times, or to absorb 50, 75, 80, and 85 percent of the unfiltered beam of x-rays.

of the first few thicknesses of filter, the penetration of the beam is greatly increased, but that after a certain amount has been added a further increase in filter thickness does not bring about a very great increase in penetration, while the decrease in intensity of the beam goes on steadily. There is, then, a point beyond which increase in filter thickness may no longer be considered as profitable because the slight increase in penetration is outbalanced by the increase in time required to deliver a certain dose of radiation. This point we have termed the "limit of economical filtration." It may be considered as attained when sufficient filter has been added to increase the surface time to five times the value with no filter.

In order to determine the best material to use as a filter, a study was made of various filter materials including zinc, brass, copper, iron, glass, aluminum, and tin. Fig. 3 shows the method of comparing the efficiency of the filters. With both copper and aluminum the penetration is increased as the filter thickness is increased, but with equal absorption of the beam, the beam filtered through copper is slightly more penetrating than that filtered through aluminum. Therefore copper may be considered a more efficient filter material than aluminum. Fig. 4 shows a comparison of the various materials investigated, and shows that copper, zinc, and brass are good filter materials, while tin is a poor filter material.

Fig. 5 shows the thickness of copper filter at various voltages required to increase the surface time in equal multiples. From this graph it is seen that as the voltage is increased the filter thickness required to filter out a certain percentage of the beam is likewise increased. Therefore the limit of economical filtration should be expressed in terms of absorption rather than filter thickness.

My thanks is due Dr. A. W. Erskine of Cedar Rapids, Ia., for his guidance and help in this and work previously reported in the Proceedings of the Iowa Academy of Science.

Coe College,
Cedar Rapids, Iowa.