FROM THE RADIUM CENTRE FOR JUTLAND (DIRECTOR: PROF. S. KAAE) AND THE RADIOPHYSICAL LABORATORY (DIRECTOR: C. B. MADSEN), ÅRHUS, DENMARK.

IMMOBILISATION, COMPENSATION AND FIELD SHAPING IN MEGAVOLT THERAPY

by

N. E. SØRENSEN and A. SELL

This communication deals with attempts made to overcome problems that arise in ensuring that the absorbed dose within the patient is in agreement with the calculated dose plan. The introduction of megavolt apparatus has increased the demand for precision so that the fields may be well defined with consequent reduction both in the integral and unwanted absorbed doses to particularly radiosensitive organs such as the eyes, brain and kidneys.

The reasons for a deviation between the planned and the true absorbed dose may be: (1) The position of the patient changing from treatment to treatment. (2) The body surface not being the same as that of the phantom, which is plane and used for measuring the depth dose and isodose curves that form the basis of the calculations. (3) With the field limitation marked directly on the skin, variation during the treatment may still occur from breathing as well as from treatment to treatment because of loss of weight or small differences in the set-up. (4) Inhomogeneous tissue (bone, air cavities, etc.).

Positioning of the patient. The most stable and reproducible positions of the patient during treatment are supine and prone, the former being normally preferred. This position permits irradiation of the patient from the front and from the sides and, where the treatment unit can be fully rotated and sections of the couch

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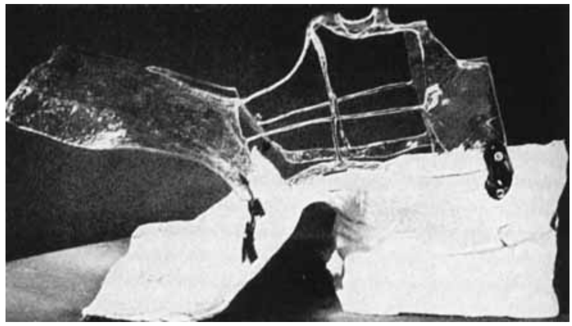


Fig. 1. Treatment shell for irradiation of the oral cavity with parallel opposing fields.

removed or changed to very thin sheets (e.g. mylar folium), from the back as well.

Uniform positioning from treatment to treatment may even be difficult with the patient supine, especially in head and neck conditions. Different technical remedies may be used. Shells of plastic or plaster of Paris and tailored for the individual patient are considered to form the most effective immobilisation unit. The cost in money and technician's time in connection with their production has however proved a handicap. Partly individual shells such as front shells in connection with standard back support kits have been employed in some centres. The authors have found these useful, for instance in the treatment of bladder and prostate tumours.

The experimental manufacture of fully individual shells was started in 1964, particularly for the treatment of the head and neck region. A front shell of plastic, and a back shell of plaster were connected by straps with press-studs (Fig. 1). The plastic part was produced in the same way as described by other centres. An impression was taken of the patient with plaster bandages and from this a plaster model was produced. This enabled a plastic shell to be manufactured by a vacuum process on an industrial machine. A difficulty arose in making a suitable back shell of sufficient stability. After several experiments with unsatisfactory results such a shell was produced from plaster bandages. This combination is still in use.

The back shell is made as follows. The patient is placed on a couch with a surface similar to the treatment couches and pieces of foam rubber of different shapes are used to position the head and arms; this is done with due regard to the treatment and comfort of the patient. A convenient position having been found, the patient, if possible, sits up. Plaster bandages are then applied from the top of the head down to the scapulae. Before the plaster hardens, the patient is returned to his original position so that the bandages may be held and moulded by hand as necessary until they harden; the hardening process takes about five minutes.

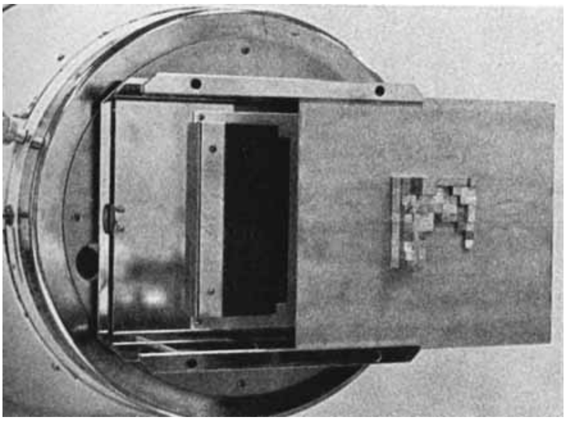


Fig. 2. Filter holder for wedge and compensating filters with the wedge filter in its correct position and the compensating filter drawn halfway out.

The plaster shell is then extended around the shoulders and the top of the head. A bandage is also applied from the back of the head down over the foam rubber support to the surface of the couch, to fix the head at the correct distance. The patient is then removed from the shell and the foam rubber replaced by plaster to form a solid, reproducible support.

This type of back shell has proved to be so effective that where the field size has proved too large to be cut out of the front shell, it has been possible to remove the latter during the treatment and only use it during the set-up procedure.

The front shell could of course also be of plaster but it was found best to proceed to a plastic shell for the following reasons: (1) It is much more convenient for the patient. (2) If a treatment programme is changed, either immediately or later during the treatment, a new plastic shell may be made quickly and without inconvenience to the patient. (3) The positive model may be used later for the design of compensating filters and for obtaining exact measurements and contours of the patient. (4) The plastic shell is transparent.

The immobilisation of the patient during treatment is more secure with the shell system. The latter also saves time in the daily set-up and thus increases the capacity of the treatment apparatus. Furthermore, compensating filters demand that the planning and treatment positions be as nearly the same as possible.

Compensating filters. Without compensation for missing tissue, problems in the planning of the treatment will always arise. Even with complicated set-ups and by making calculations of the dose distribution at several levels, it may be impossible to obtain a sufficiently homogeneous absorbed dose within the tumour volume. Individually designed compensating filters make both the set-up and the calculation easier.

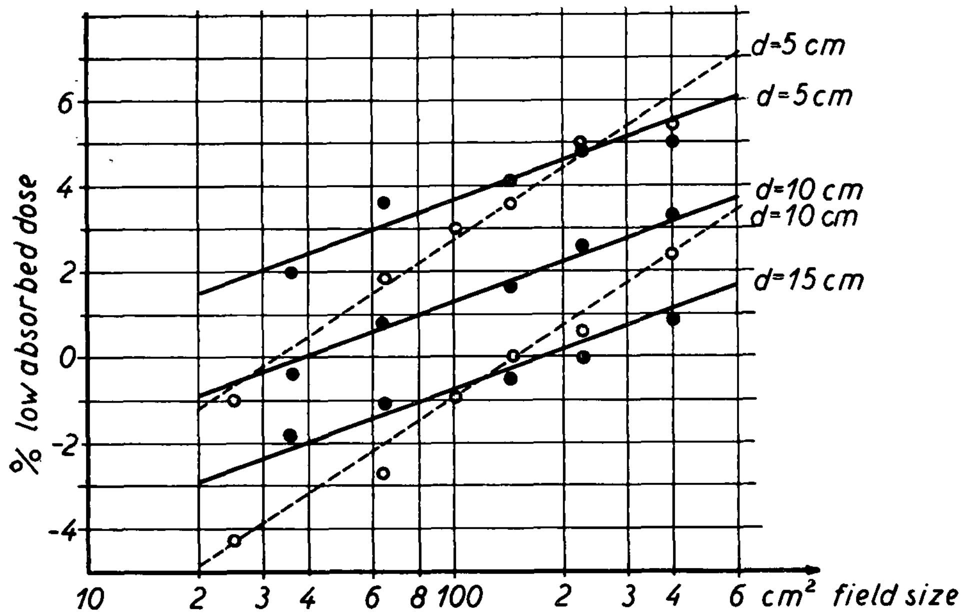
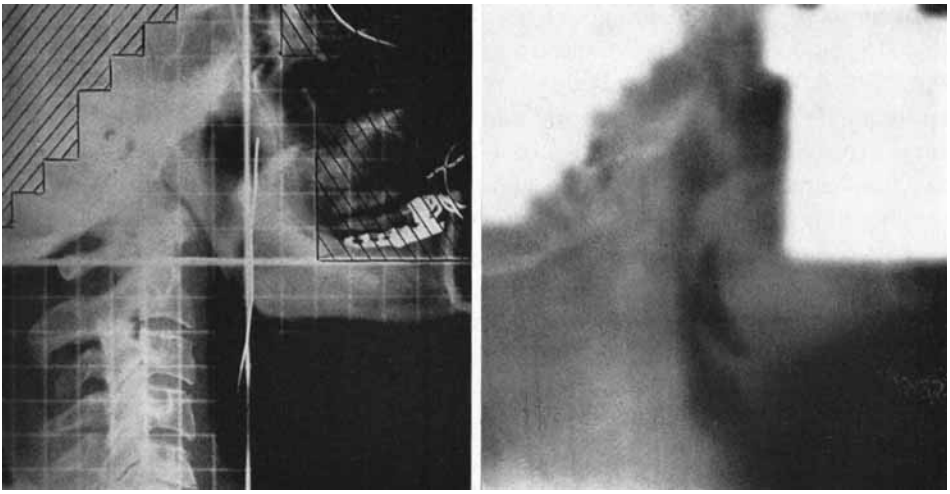


Fig. 3. Measured error when compensating for 5 cm missing tissue with $\frac{5}{\varrho \text{Al}} = 1.85$ cm Al. ○- - -○ for ^{60}Co γ-rays and ●——● for 6 MeV roentgen rays for different field sizes and depths (d) in the water phantom. A low absorbed dose means over-compensation.

A photographic method that simplifies the design of compensating filters has been described earlier (Sørensen 1968). The method may be used both for the system with aluminium columns described by Ellis et coll. (1959) and Hall & Oliver (1961), and the system with lead sheets described by Wilks & Casebow (1969). We employ the former system. A filter holder with two frames is mounted on each treatment unit so that it is possible to insert wedge and compensation filters at the same time (Fig. 2). The mounting plate for both filters has a slot near one of the corners, with which a spring-loaded ball in the filter holder engages. This arrangement ensures that the plate is correctly located and at the same time the filter is properly orientated.

To simplify the system it has been decided to use the same columns independent of the machine and the energy. The spectrum of energies includes ^{60}Co γ-rays and 6 and 32 MeV roentgen rays. The cross section of the columns is 0.74 cm × 0.74 cm. (For ^{60}Co this corresponds to 1 cm × 1 cm at the normal treatment distance of 80 cm.) By selecting the length of the columns as $\frac{1}{\varrho} = \frac{1}{2.7} = 0.37$ cm



a b

Fig. 4. An example of field shaping in the neck region. a) Film obtained on the simulator with hatching of the areas to be covered with lead. b) Control film taken on the therapy unit with the compensating filter mounted.

per cm missing tissue, where ϱ indicates the density in g/cm^3, the system is further simplified as the lengths and sides of the columns then have the same module of 0.37 cm. Hall & Oliver (1961) gave the best length for ^{60}Co γ-rays as $\frac{0.88}{\varrho}$.

The error in using $\frac{1}{\varrho}$ cm was measured by an arrangement described by Sundbom (1964). A Mix D block, 5 cm thick, was placed in front of a water phantom (50 cm $\times$ 50 cm $\times$ 60 cm). The absorbed dose was measured at different depths and with various field sizes. The same measurements were taken without the Mix D block, but with one of aluminium corresponding to 5 cm tissue (1.85 cm) placed in the position used for the compensating filters on each machine.

The results for the ^{60}Co γ-rays and 6 MeV roentgen rays appear in Fig. 3. For field sizes from 5 cm $\times$ 5 cm to 20 cm $\times$ 20 cm, and depth in the water phantom varying from 5 to 15 cm, the absorbed dose varies from 4 per cent high to 6 per cent low. For the 32 MeV roentgen rays the technique is used only for field sizes varying between 10 cm $\times$ 10 cm and 14 cm $\times$ 14 cm. The absorbed dose was then 5 per cent low at 5 cm phantom depth and between 1 and 2 per cent low at 10 cm and 15 cm depth. This has been considered a satisfactory compromise and is used routinely in this department.

Field shaping. An advantage of the column system for compensating filters is that it provides the ability to deviate from the normal rectangular fields by field shaping. A film is first obtained with a simulator. A network is placed between the focus of the roentgen tube and the patient; this is made of metal wires arranged in squares and set in a 5 mm sheet of plexiglass. One square in the film corresponds to the cross section of an aluminium column. It is thus possible to replace any number of aluminium columns in the compensating filter by columns of 5 cm of lead. Fig. 4 a presents an image of a head neck field taken with the network and represents by hatching the areas that will be covered by lead shielding. Fig. 4 b is a corresponding representation obtained with the treatment unit for control of the shielding.

SUMMARY

A method of producing fully individual treatment shells is described. A system is also presented for controlling the dose distribution of ^{60}Co γ rays and 6 and 32 MeV roentgen rays by individually designed compensating filters with which field shaping by means of lead columns is possible.

ZUSAMMENFASSUNG

Eine Methode, vollständig individuelle Behandlungspläne herzustellen, wird beschrieben. Es wird ferner ein System gezeigt, um die Dosisverteilung von ^{60}Co γ-Strahlen und 6 und 32 MeV Röntgenstrahlen durch individuell hergestellte Kompensationsfilter zu kontrollieren, mit deren Hilfe es möglich ist, durch Bleisäulen das Feld zu formen.

RÉSUMÉ

Les auteurs décrivent un procédé de fabrication de coquilles de traitement complètement sur mesure. Ils présentent aussi une technique de modification de la distribution de dose des rayons γ du ^{60}Co et des rayons de roentgen de 6 et 32 MeV au moyen de filtres compensateurs faits sur mesure; cette technique permet de modifier la forme du champ au moyen de colonnes de plomb.

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