SURFACE MOULD
BRACHYTHERAPY

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RCC, JIPMER
Emil H. Grubbé

- Claimed to be the first to treat cancer with radiation (X-rays)
- Treated a Breast cancer patient with X-rays in Chicago in January, 1896 only 2 months after discovery of X-rays by Wilhelm Conrad Roentgen.

Many investigators then began testing the therapeutic potential of X-rays in several benign and malignant conditions.

By 1899, several physicians had successfully treated different types of malignancies particularly skin malignancies with X-rays.
Marie and Pierre Curie discovered Radium in 1898.

Was subsequently tested for radio‘therapy’.

Henri-Alexandre Danlos

- Successfully treated Lupus (skin) using Radium in 1901.

Radium was soon seen used to treat disorders where X-ray treatment was not feasible because it could be applied in a multitude of ways in which X-rays could not.
HISTORY

In the Early 1900s, Radium BRACHYTHERAPY was tested in malignancy.

Provided the advantage of more specific application to tissues as compared to X-rays.
The 1st Brachytherapy applications were Surface moulds & plaques. In these early applications, Radium was uniformly distributed in the applicator.

- It was later realized that this resulted in a non-homogeneous dose distribution.
Paterson & Parker later showed that:

“To achieve a homogeneous radiation dose distribution, a non-uniform distribution of Radium content is required”

They laid the Manchester Rules

**Ralston Paterson and H. M. Parker**

**A DOSAGE SYSTEM FOR GAMMA RAY THERAPY**

**PART I**

**By Ralston Paterson, M.D., F.R.C.S., D.M.R.E.**

*(Received June 7, 1934)*
HISTORY

But,

- The construction and use of brachytherapy surface moulds was associated with Radiation Hazard.

- Linear accelerators were introduced and high-energy electron beams became available, that began to be extensively used for skin and superficial treatment.

- This made surface mould brachytherapy become less popular.
HISTORY

However,

- With the development of after-loading techniques and in particular **HDR remote after-loading**, the issues associated with personnel radiation protection were overcome.

- HDR brachytherapy units became more widely used and this led to a **revived interest in surface moulds**.

- Radiation safety hazards associated with LDR moulds are no longer present and the treatment could be delivered safely over a short time as an outpatient procedure.
RADIATION MODALITIES FOR SKIN & SUPERFICIAL TUMOURS

- **kV X-Rays**
  - Useful for smaller tumours
  - Short Focus to Skin Distance (FSD) $\rightarrow$ High output & large influence of Inverse square law $\rightarrow$ Rapid dose fall-off.
  - Electron contamination
  - Calibration made difficult by the rapid dose gradient & Electron contamination
  - Dosimetric issues with curved treatment areas

![% Depth Dose for different modalities](image-url)
RADIATION MODALITIES FOR SKIN & SUPERFICIAL TUMOURS

- **High Energy Electrons**
  - Increasingly used.
  - Skin sparing.
  - Gives significant dose at depth (even with lower energies).
  - Therefore, beneficial for deeper tumours.
  - Can not account for curvature in treatment area.
  - Dosimetric planning uncertainties.
Mould Brachytherapy

- Can position source to precisely cover treatment area
- Conformal dose distribution
- Small effective penumbra
- Relative dose at depth can be controlled by adjusting height of source dwells above skin surface.
- Due to close source to skin distance, depth dose profile falls off quickly sparing tissue at depth.
- Can account for surface curvature
WHAT IS MOULD BRACHYTHERAPY?

- A technique of delivering brachytherapy by an **applicator** that is usually **custom** made and designed to provide a more **constant & reproducible** frame for **source positioning**.

- Can be used for flat surfaces as well as irregular shapes.

- Can be constructed from variety of material such as:
  - into which catheters are embedded

- They fit to the external patient surface & the catheters must remain in the exact position

- Intended to be as close as possible to tumour surface so as to provide adequate dose coverage of tumour and increase distance to normal surrounding structures.

- **Specialized polymers**
- **Acrylic resin**
- **Wax**
- **Thermoplastic material**

WHAT MAKES SURFACE MOULD BRACHY ATTRACTIVE?

- No associated pain or discomfort
- No invasive surgical procedure involved
- Does not require anaesthesia
- No risk of tissue injury or infection
- No risk of transplanting tumour cells
- Doesn’t restrict the patient to bed
- No post-procedure effects
- Good cosmesis
- Conformal dose distribution & Sparing of deeper tissues
- Surface curvature can be accounted for
- Fewer treatment visits (compared to External RT)
IDEAL CASE FOR SURFACE MOULD?

- Accessible site
- Superficial tumour
- Well defined margins.
- No regional or distant spread

Suitable sites for mould therapy include:

- Skin
- Scalp
- Face
- Pinna
- Lip
- Buccal mucosa
- Hard palate
- Oral cavity
- Maxillary antrum
- External auditory canal
- Orbital cavity after exenteration.

WORKFLOW

Selection of patient

- Selection of patient after discussion in tumour board after relevant investigations
- Evaluation of patient by radiation oncologist, medical physicist and radiotherapy technician (and dental department)

Preparation of mould

- Preparation of the carrier material in the mould room
- Preparation of the dental carrier when required
- Fixation of the nylon catheters

RT planning

- Check CT to confirm absence of air gap
- CT stimulation with the mould in situ (1-1.25 mm slice thickness)

RT planning and evaluation

- Planning with stepping source dosimetry
- Dose point optimisation and prescription at specified depth (based on clinical evaluation)
- Plan evaluation: slice by slice evaluation of the dose distribution and dose volume indices

Treatment

- Ensuring proper fitting of carrier before delivery of each fraction by radiation oncologist
- Treatment delivery with HDR brachytherapy $^{192}$Ir source
- Follow up at 2 weeks of completion, then 3 monthly for 2 years and subsequently 6 monthly
PLANNING

- MANCHESTER SYSTEM
- IMAGE GUIDED PLANNING
MANCHESTER SYSTEM

Showed the amount of radium in milligram-hours (mg-h) required to give a dose of 1000R to the treatment area which is at a distance ‘h’ from the surface of the applicator, while achieving a +/-10% dose uniformity.

Answered:

1. How much radium will be required?

2. How radium must it be arranged? (to achieve a homogeneous dose +/- 10% across skin surface)
MANCHESTER SYSTEM

1. How much radium will be required?

Depends on the

- Area to be treated
- Treating distance
- Filtration

If filtration other than 0.5 mm Platinum used

<table>
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<th>1.5</th>
<th>2</th>
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<td>10%</td>
<td>20%</td>
<td>35%</td>
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Gold ... ... ... ... As platinum.

Lead and Silver ... ... ... ... As half their thickness in platinum.

Monel, Brass, etc. ... ... ... ... As one-third their thickness in platinum.

TABLE A. 12.1 A

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Filtration = 0.5 mm platinum.
Area is in centimeters squared.
Treating distance is in centimeters.

MANCHESTER SYSTEM

I. How much radium will be required?

Depends on the

- Area to be treated
- Treating distance
- Filtration

Example:

To treat a 10 cm² area at a distance of 0.5 cm to a dose of 1000 R, 235 mg-hrs of Radium is required (0.5 mm Platinum)

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</tbody>
</table>

*Filtration = 0.5 mm platinum.
*Area is in centimeters squared.
*Treating distance is in centimeters.
2. How Radium must be arranged?

Why is it important?

Diagram illustrating the extreme importance of correct arrangement.
Intensity produced at 1 cm. by two different radium distributions over the same area.
2. How Radium must be arranged?

- After determining the amount of Radium to be used, that amount is to be arranged in the following ways.

  - **Use CIRCLES** arrangement wherever possible
    - If diameter < 3x distance → Single circle sufficient
    - If diameter >3x and <6x distance → 5% radium at the centre; remaining 95% in the circle
    - If diameter > 6x distance → 3% radium at the centre; use 2 concentric circles (inner circle = \( \frac{1}{2} \) dia of outer)

  - Use other arrangements if required → Separate rules exist for Square / Rectangle / Irregular fields.

*Distance* (h) refers to the distance separating the plane on which the radium is mounted, and the plane at which the dose is assessed (i.e., the treated area).

---

<table>
<thead>
<tr>
<th>Diameter divided by “distance”</th>
<th>( \text{Per cent Radium outer circle} )</th>
<th>( \text{Per cent Radium inner circle} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{in cm} )</td>
<td>( \text{in cm} )</td>
<td>( \text{in cm} )</td>
</tr>
<tr>
<td>6</td>
<td>80%</td>
<td>17%</td>
</tr>
<tr>
<td>( \frac{7}{2} )</td>
<td>75%</td>
<td>22%</td>
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<tr>
<td>10</td>
<td>70%</td>
<td>27%</td>
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---

2. How Radium must be arranged?

- **CIRCLES** arrangement
  - If diameter < 3x distance
  - If diameter >3x and <6x distance
  - If diameter > 6x distance

MANCHESTER SYSTEM

Various arrangements

Diagram illustrating the “Rules for Distribution,” depicting typical arrangements to produce homogeneity at 1 cm.

Fig. 2.
MANCHESTER SYSTEM

EXAMPLE:
Treat this lesion of 3.5 cm diameter by 1 cm mould
With 1 mm filtration to a dose of 6000 R in 20 days
(16 hrs per day)
• We’ll treat 5 cm area (for margin) with circles
• Area of treatment = $\pi d^2/4 \sim 20 \text{ cm}^2$
• Distance (h) = 1 cm
• Total Treatment time = 20×16 = 320 hrs
EXAMPLE:

Treat this lesion of 3.5 cm diameter by 1 cm mould with 1 mm filtration to a dose of 6000 R in 20 days (16 hrs per day)

- We'll treat 5 cm area (for margin) with circles

\[
\text{Area of treatment} = \frac{\pi d^2}{4} \approx 20 \text{ cm}^2
\]

- Distance (h) = 1 cm

- Total Treatment time = 20x16 = 320 hrs

RADIUM REQUIREMENT

- Radium required for 1000R = 641 mg-hrs

- Radium required for 6000R = 641x6 ~ 3,850 mg-hrs + 10% (fil)~ 4200 mg-hrs

- Total Radium required = 13 mg (given for 320 hrs)
MANCHESTER SYSTEM

EXAMPLE:

Treat this lesion of 3.5 cm diameter by 1 cm mould
With 1 mm filtration to a dose of 6000 R in 20 days
(16 hrs per day)

- We’ll treat 5 cm area (for margin) with circles
- Area of treatment = $\pi \frac{d^2}{4} \approx 20 \, \text{cm}^2$
- Distance (h) = 1 cm
- Total Treatment time = 20x16 = 320 hrs

RADIUM ARRANGEMENT

- Diameter is 5X distance i.e. >3x and <6x distance.
- Therefore, 5% radium at the centre $\rightarrow$ 0.05 x 12 = 0.65 $\approx$ 1 mg at centre
- Remaining 95% in the circle $\sim$ 12 mg in the circle (use 6 ‘2mg’ tubes)
MANCHESTER SYSTEM

How to choose thickness of applicator or ‘h’:

- Determined by the treatment depth required
- Governed by the Inverse Square Law
- If greater depths are to be treated, source are kept at a greater height

<table>
<thead>
<tr>
<th>Distance, h, to surface, in mm</th>
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<td>3.5</td>
<td>3.7</td>
<td>4.2</td>
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</tr>
</tbody>
</table>
Dose is prescribed to 3–5mm under the skin surface. A distance from the source to the skin of 5mm is recommended to obtain homogeneity on the surface of the skin, & avoid an overdosage.

Ideal for superficial tumours (<5mm)

Recommended BT schedules for surface moulds:

- 3Gy per fraction, 17–18 fractions, 3 times a week, total dose 51–54Gy.
- 4Gy per fraction, 10–12 fractions, 3 times a week, total dose 40–48Gy.
- 5Gy per fraction, 10–12 fractions, twice a week, total dose 50–60Gy.
- 5Gy per fraction, 8 fractions, twice a day, daily, total dose 40Gy.
- Higher doses per fraction, once a week

IAEA Human Health 12 - The Transition from 2-D Brachytherapy to 3-D High Dose Rate Brachytherapy
THANK YOU