Review Article

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Brachytherapy – Principles and Practice

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ABSTRACT

Radiation Therapy is one of the potent treatment modality in treating various cancers importantly oral cancers. Cells in Oral Cancers are sensitive to radiation which dictates exploration of various modalities of radiation therapy.Brachytherapy is one such modality which has a proven history of efficacy and future that needs exploration. This review details the past, present and future of Brachytherapy.

Keywords: *Brachytherapy, Curietherapy, Mould Therapy, Interstitial Therapy*

Introduction

Brachytherapy is synonymously described as Internal Radiation Therapy, Plesiotherapy, Curietherapy and Endocurietherapy. [1] It is described as a procedure that is related to the delivery of radiation therapy using sealed sources that are placed as close as possible to the site to be treated. [2] The word Brachytherapy is derived from the Greek word “Brachys” which means “short” or “short distance”. Forssell in 1931 coined the term brachytherapy. [1]

Radiation therapy is considered the major treatment modality of malignancies, as oral cancers are efficiently treated with this modality it is imperative that the types of radiation therapies with their past present and future should be known to the health care professionals. Brachytherapy is the clinical use of small encapsulated radioactive sources placed at short distances from the target volume to irradiate malignant tumor cells. It continues to play an important role in the management of cancers of several sites, including the head and neck, uterine cervix, and prostate. [2] Compared to conventional external beam therapy, the physical advantages of brachytherapy result from a superior localization of dose to the tumor volume.[1] In brachytherapy, since radiation is continuously delivered over a period of time, repair of sublethal and potentially lethal damage, proliferation and other cell kinetic effects modify the radiation response of tumor and normal tissues, resulting in complex dose rate effects that also influence the therapeutic ratio for brachytherapy.[2]

History

History of Brachytherapy dates back to 1901 when Pierre Curie suggested that a radioactive source could be used to treat tumors.[3] The early practice of brachytherapy was largely empirical and extended upto 1930s. Radium and Radon were the first radioactive sources to be used during this period. Radium was first used by Danlos and Robert Abbe.[1] Important developments in the field of newer radionuclides, design of sources, and radiation dosimetry were achieved from 1940s to 1970s. Tantalum, Caesium and Iridium were used during this era.[1]

Various modifications were evolved with an intent of increasing the efficacy with least possible radiation hazard. Afterloading technique, first introduced by Henschke and co-workers in New York in 1953, removed the hazard of radiation exposure to medical personnel and provided an impetus to the modern era of brachytherapy. Interstitial Radium therapy was common till mid-twentieth century. Gold seeds and Gold Shells were used to shield beta rays allowing gamma rays to pass.[1]Currently, Iridium is the most commonly used artificial source of brachytherapy.[3]

Principle of Brachytherapy

Brachytherapy technique involves the use of small radioactive sources placed inside the body cavity within the tumor or adjacent to it. It is applicable for treatment of tumors by placement of sources using needles or catheters. Most common brachytherapy sources emit ‘photons’, however ‘beta rays’ and ‘neutrons’ emitting sources are also used. [4]

Classification:

It can be classified as follows [5]

- With respect to source loading
  - Hot Loading- Preloaded and contains radioactive source at the time of placement of implant.
  - Afterloading- Applicator is placed first into the target position and radioactive sources are loaded later, either manually (Manual Afterloading) or using machines (Automatic Afterloading).
- With respect to dose rate
  - Low Dose Rate – 0.4-1 Gy/hr

- used for Oral and Prostate cancers
- Medium Dose Rate – 1-12 Gy/hr
- used for Cervix cancer
- High Dose Rate - >12 Gy/hr
- used for Breast, Skin Cervix and Prostate cancer.

• With respect to duration
- Temporary – implanted for specific duration (mostly used)
- Permanent - also called seed implants.

• With respect to source placement
- Interstitial – placed within tumor volume surgically
- used for Breast, Prostate cancers
- Intracavitary – placed in body cavities close to the tumor volume
- used for Trachea, Skin and Cervical cancers
- Intravascular – single source placed in small or large arteries
- Intraoperative – sources are implanted during surgery

Requirement of brachytherapy source:-

1) Gamma ray energy should be high enough to avoid increased energy deposition in bone by photoelectric effect and low enough to minimise radiation protection requirements. Optimum range of Gamma ray energy is 0.2-0.4 MeV [1]
2) Half life should be such that correction for decay during treatment is minimal [6]
3) Absence of charged particle emission.
4)` High specific activity and adequate photon yield. Mostly should be in powder form. [7]
5) Material should be available in insoluble and non-toxic form.

Salient features of few isotopes used in Brachytherapy (table 1)

Different types of treatment modalities in Brachytherapy [9,10,11]

Mould Therapy

Earliest technique involved a surface applicator with which Radium can be applied over the body for treatment. The base on which Radium needles or tubes are mounted are made up of Wax or Plaster o Paris. Treatment was then given, spread over few fractions, by fixing the mould in correct position and leaving it fixed for a couple of hours. [1,9]

Moulds are customised to allow the applicator to be seated accurately and fixed, in close proximity to the tumor, thus allowing less loss of source.

Intercavitary Therapy

In Intercavitary therapy treatment is given by placement of radioactive source inside natural body cavities. Gynaecological malignancies are most commonly treated using this therapy. Advantage of Intercavitary therapy is that very high doses can be delivered to the tumor as the source is placed in close vicinity to it. Additionally very loss dose will be delivered to the normal structures by Inverse Square Law.

Intraluminal Therapy

Technological and surgical advancements have led to the development of this technique in the last 20 years. In this technique radioactive source train is inserted into the lumen through a suitable applicator and the dose is delivered at a precise point below the mucosa, usually at 0.5-1 cm depth. [8]This technique is commonly used for oesophagus and bronchus tumors. It has got the advantage of giving palliative treatment in 1 or 2 sittings in advanced cases of tumors. [12]

Interstitial Therapy

In this technique radioactive sources are implanted into the tumor and surrounding tissues and allowed to remain there for a definitive period (temporary implants) or indefinitely (permanent implants). The sources that are used can be in the form of needles, wires or seeds. It is most commonly used for Squamous Cell Carcinoma of Head and Neck

Table 1: Some commonly used radioactive sources.

Source	Maximum Energy	Available Forms	Uses
Radium 226	2.4 MeV	Needles and tubes	Not used now
Caesium 137	0.662 MeV	Needles and Tubes	As a substitute of Radium in Manual Afterloading
Cobalt 60	1.25 Mev	Spherical plates and Needles	As a substitute of Radium Ophthalmic Applicators
Iridium 192	1.5 MeV	Flexible Wire and Tubes (Ribbon Source)	Head and Neck, Uterine, Cervix and Breast Malignancies

region, Skin cancers, Breast Tumors and Soft Tissue Sarcomas. [1]

Techniques of Brachytherapy

Depending on the loading technique it is classified as :-

1) Pre-load technique
   - The radioactive sources (previously live Radium) were loaded directly into the applicator and inserted into the patients.
   - Caesium has now replaced Radium as the radioactive source.
   - It causes significant radiation exposure to radiation personnel.

2) After-load Technique
   - It was introduced in 1953 by Henschke in New York, to overcome the disadvantages of Pre-load technique.
   - On the basis of loading, it is of two types: Conventional or Manual Loading

Remote or Automatic Loading

Advantages of Brachytherapy [13]

High dose of radiation can be given directly to the tumor sparring the surrounding normal tissues.

Treatment time in brachytherapy is short as compared to

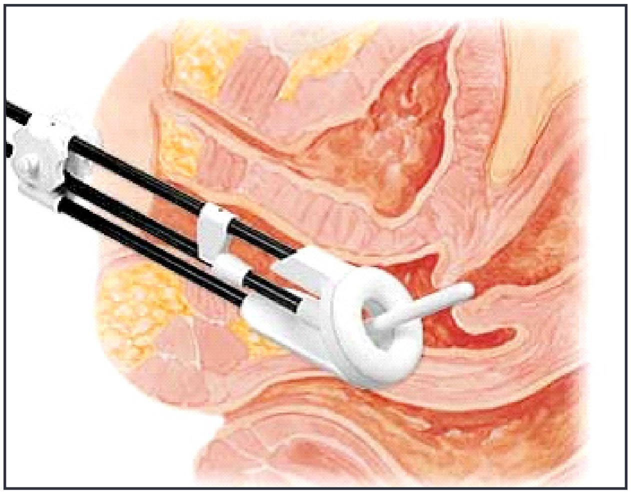


Fig. 1: Showing the placement of radioactive source by Intercavitary Therapy.

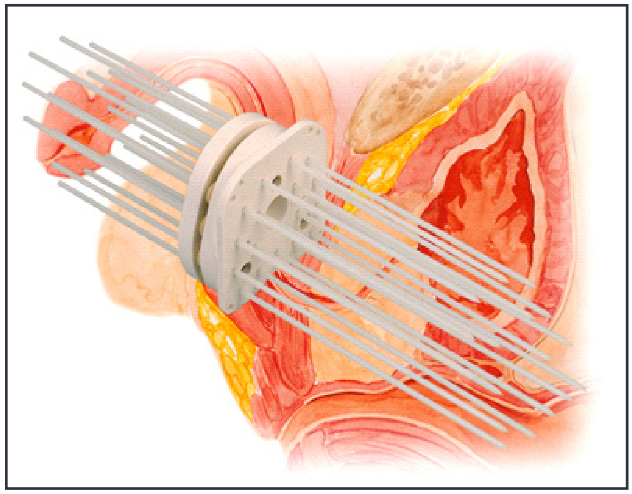


Fig. 2: Radioactive sources being introduced by Interstitial Brachytherapy Method.

Fig. 3: Manual Afterloading where the person is standing behind lead barrier.

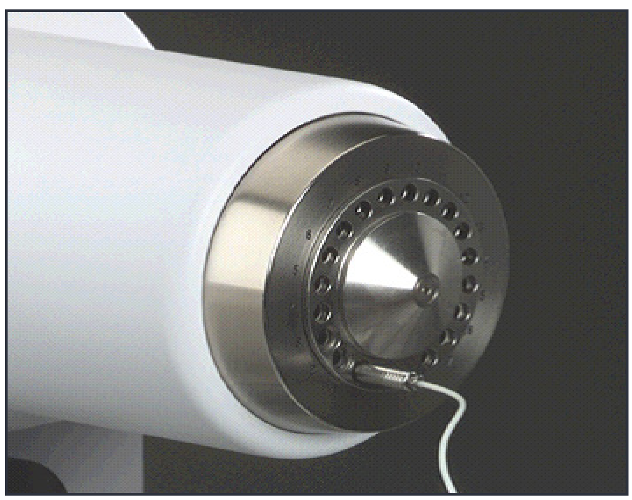
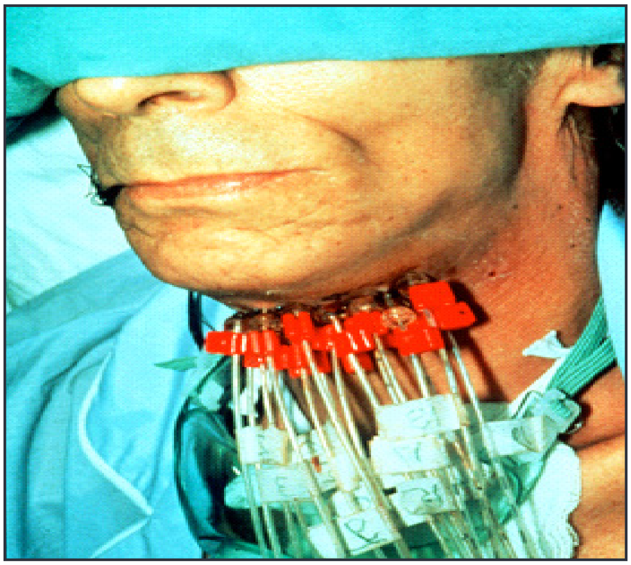


Fig. 4: Automatic Afterloading Machine.



External Radiation Therapy.

Disadvantages of Brachytherapy [13]

- It can be used only in selected cases especially in early stage of disease and at accessible sites.
- It is an invasive procedure and requires expertise.
- There is no long term record documented. So side effects are poorly understood. [14] Future Scope of Brachytherapy

Brachytherapy as a treatment modality needs to evolve. With the technological advancements such as 3D planning, real time dosimetry, fluoroscopy guided implants, the precision of implant placement has improved. The increased knowledge of radiation physics and hazards has added to the long list of indications in which brachytherapy can be used.

Brachytherapy, prime exponent of adaptive radiation therapy, will incorporate many of these advances in the management of suitable patients. Other more exotic area with potential application in clinical Radiation Oncology is the use of nano-particles with specific target radiotracers for imaging or radiopharmaceuticals for therapeutic purposes [15]

Conclusion

This review attempts to highlight the past, present and future of the novel radiation therapy, brachytherapy. An intricate analysis and consistent efforts from the practioners will definitely succeed in improvising and increasing its use in oral cancer.

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