High-Dose Rate Brachytherapy for Non-Melanoma Skin Cancer

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Non-Melanoma Skin Cancer Facts:

- Most common malignancies worldwide (Krzysztofiak et al., 2022) and within the United States (Devlin et al., 2016)
- Most cases have a good prognosis, however, early detection and treatment are vital (Han et al., 2022) as untreated lesions may infiltrate and cause damage to surrounding soft tissue, bone, and cartilage (Krzysztofiak et al., 2022)
- 80% of lesions are in the facial region (Krzysztofiak et al., 2022)
- Occurence and morbidity are both twice as high in men than in women (Hu et al., 2022)
- Incidence is rising at 2-3% annually (Hu et al., 2022) likely due to recreational exposure both outdoors and in tanning beds (Hu et al., 2022), an aging population, and an increase in UV exposure due to ozone layer depletion (Han et al., 2022)
- Main Risk Factors: frequent sun exposure and fair skin

Two Main Types:

Basal Cell Carcinoma (BCC) is the most common non-melanoma skin cancer (NMSC), making up approximately 80% of lesions (Devlin et al., 2016). BCC is associated with better prognoses and lower chances of spreading than other NMSCs (Krzysztofiak et al., 2022). Accoridng to the American Academy of Dermatology (AAD), lesions often appear as round, flesh-colored growths, pearl-like projections, or pinkish patches and are most commonly found on the head, neck, and arms (2023).

Squamous Cell Carcinoma (SCC) is the second most common NMSC and is generally more aggressive, with a greater chance of spreading to nearby structures (Devlin et al., 2016). SCC often presents as a red, scaly patch, a firm red bump, or a sore that repeatedly heals and reopens. SCC most commonly occurs on the rim of the ear, face, neck, arms, chest, and back. These lesions may arise from precancerous growths known as actinic keratoses (AAD, 2023).

Common appearance of BCC and SCC lesions (AAD, 2023) [IMAGE]

Radiation therapy is a form of treatment that exposes cancerous cells to ionizing radiation. The goal of this treatment is to cause lethal damage to target cells via DNA ionization and ultimately decrease cell population, while limiting exposure to adjacent healthy cells. The frequent mitotic activity of cancer cells, in comparison to normal tissue cells, makes these cells more susceptible to DNA mutation and therefore cellular malfunction and death. (Han et al., 2022).

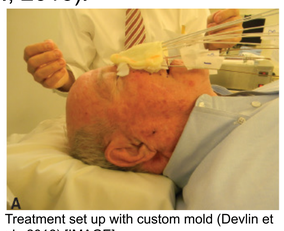
Brachytherapy is a type of radiation therapy that directly exposes areas of disease to ionizing radiation. Small radioactive devices are placed in contact with the lesion either interstitially or superficially. Low-dose rate (LDR) seeds stay in place and administer dose for 1 to 7 days, permanent implants are inserted and decay over time, but never removed, and high-dose rate (HDR) seeds are left in place for only a few minutes per treatment (National Cancer Institute, 2019).

Superficial Brachytherapy Applicators

Brachytherapy utilizes high energy sources that deliver doses up to 12 Gy per minute (Krzysztofiak et al., 2022). For the treatment of superficial skin lesions, custom surface molds, prefabricated multichannel flaps, and tungsten alloy cup-applicators are used (Devlin et al., 2016).

- The simplest way to deliver these treatments is with cup-shaped tungsten alloy applicators designed to secure the source to the skin while also shielding structures outside of the cup. These are ideal for flat lesions with clear margins. Two types of these are the Valencia and Leipzig applicators.
- Custom molds and flaps are designed and created to each patient, which makes them ideal for lesions otherwise too large or irregular to be treated. Common locations include ear, nose, and fingers. These applicators do not provide any form of shielding to nearby structures and therefore increase the need for shield implementation. Two common types are the Freiburg Flap and Harrison-Anderson-Mick applicator. (Devlin et al., 2016).

Treatment set up with tungsten alloy applicator (Devlin et al., 2016) [IMAGE].



Treatment set up with custom mold (Devlin et al., 2016) [IMAGE].

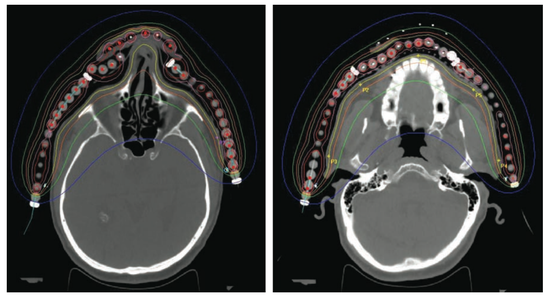


Image of treatment plan of dose distribution of brachytherapy with the use of a custom mold (Devlin et al., 2016) [IMAGE].

Treatment Process

Prior to receiving treatment, a patient will need to undergo a simulation process in which a CT scan is obtained. This provides visualization of the treatment area necessary for the medical dosimetrist or physicist to create the treatment plan. The plan includes the exact positions the source will be located throughout the course of the treatment delivery to create the desired dosage distribution of both the area of interest as well as surrounding tissues and structures.

- Once the treatment plan is developed, the physician, radiation therapist, and physicist will begin the setup and treatment process
- Immobilization devices such as masks, tape, and personalized head rests are created and set up. This ensures the patient is in the exact same position for each treatment
- Once the patient is precisely positioned, the physician will demonstrate the area of treatment
- The treatment team will position and secure the flap or applicator to the patient's skin and connect it to the radiation source with a catheter
- Due to the radioactivity of the source, it is constantly emitting ionizing radiation. It will move through the catheter in different dwell positions as indicated by the treatment plan in order to distribute dose exactly as desired
- After the treatment, therapists will obtain photographic documentation to ease future replication efforts

This process will be repeated for numerous days until the patient receives the entirety of the dose prescribed (Devlin et al., 2016).

Patients often receive treatments daily or every other day for a couple of weeks, with each treatment dosage adding up to the overall prescribed dose (Devlin et al., 2016).

Side Effects and Healing Process

- Acute side effects may appear during the treatment process, but are likely to fully develop a couple of weeks after the completion of the treatment.
- Common acute effects are: erythema, pruritis, dryness, and desquamation.
- These reactions often resolve 4 to 6 weeks after the completion of treatment.
- Late effects include alopecia, skin atrophy, and scarring. If any of these occur, they are often mild.

BCC before treatment (A), directly after the completion of treamtnet process (B), and 3 months after completion (Krzysztofiak et al., 2020). [IMAGE]

Patient Selection

For those diagnosed with NMSC, surgical excision is often the first line of treatment. However, there are numerous factors that patients and physicians must consider, such as type of NMSC, lesion size and location, clinical stage, and comorbidities. Those who have comorbidities, use anticoagulants, and/or have a lesion in a cosmetically or functionally critical area are considered poor surgical candidates and therefore often opt for HDR brachytherapy, instead (Devlin et al., 2016).

Other considerations in treatment selection include:

- Inconvenience of treatment regimens associated with HDR brachytherapy
- Patient willingness and physical ability to undergo invasive procedures
- Lower costs associated with surgical excision and Mohs microscopic surgery
- Resource availability (Lee et al., 2019).

Conclusion

- High-Dose Rate Brachytherapy is an excellent option in the treatment of non-melanoma skin cancers
- With modern immobilization, shielding, and treatment plan developments, this treatment type has the capability to rid of lesions on irregular and/or cosmetically sensitive areas of the skin

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