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Review Article

Aspects of dosimetry and clinical practice of skin brachytherapy: The American Brachytherapy Society working group report

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ABSTRACT

PURPOSE: Nonmelanoma skin cancers (NMSCs) are the most common type of human malignancy. Although surgical techniques are the standard treatment, radiation therapy using photons, electrons, and brachytherapy (BT) (radionuclide-based and electronic) has been an important mode of treatment in specific clinical situations. The purpose of this work is to provide a clinical and dosimetric summary of the use of BT for the treatment of NMSC and to describe the different BT approaches used in treating cutaneous malignancies.

METHODS AND MATERIALS: A group of experts from the fields of radiation oncology, medical physics, and dermatology, who specialize in managing cutaneous malignancies reviewed the literature and compiled their clinical experience regarding the clinical and dosimetric aspects of skin BT.

RESULTS: A dosimetric and clinical review of both high dose rate (^{192}Ir) and electronic BT treatment including surface, interstitial, and custom mold applicators is given. Patient evaluation tools such as staging, imaging, and patient selection criteria are discussed. Guidelines for clinical and dosimetric planning, appropriate margin delineation, and applicator selection are suggested. Dose prescription and dose fractionation schedules, as well as prescription depth are discussed. Commissioning and quality assurance requirements are also outlined.

CONCLUSIONS: Given the limited published data for skin BT, this article is a summary of the limited literature and best practices currently in use for the treatment of NMSC.

Keywords: Ir-192; Electronic brachytherapy; Nonmelanoma skin cancer; Basal cell carcinoma; Squamous cell carcinoma; High dose rate; Planning target volume; Clinical target volume; Gross target volume; Biological equivalent dose

Introduction

Nonmelanoma skin cancer (NMSC) is the most common malignancy and affects 2−3 million people each year in the United States (1−3). Although NMSC has a low mortality rate, its incidence continues to rise and it significantly affects quality of life. The most common histology of NMSC is basal cell carcinoma (BCC) and squamous cell carcinoma (SCC).

The primary goals of any treatment of NMSC are to cure the lesion with preservation of function and to optimize cosmesis. Treatment options include surgery, radiation therapy, and topical agents, with surgical techniques such as Mohs micrographic surgery, electrodessication, and curettage being the most frequently used. Historically and at present, radiation therapy has an important role in the management of NMSC as outlined in the following sections, especially in functional preservation.

A variety of radiation therapy techniques have been used to treat NMSC. These techniques include superficial x-rays

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(which have largely been supplanted by more advance techniques), orthovoltage x-rays, megavoltage x-rays, electron beam irradiation, and radionuclide-based brachytherapy (BT). Electronic brachytherapy (eBT) is a newer technology administering high-dose-rate (HDR) BT with the use of a low energy x-ray source and therefore requires minimal shielding (4–26).

The goal of this report is to provide a review of the dosimetry and clinical aspects of NMSC skin BT. It provides an overview of the typical BT modalities for NMSC including a standard reference for treatment planning and prescription. Skin BT including eBT should be performed only by authorized users (AUs) and qualified medical physicists (QMPs) as defined by agreement states and federal regulatory agencies. These regulations may vary from one state to another, and it is the responsibility of the institution to adhere to the local requirements. Individuals without such training, credentials, or with jurisdictional scope of practice limitations should not be performing this procedure.

Surface applicators have been used in radiotherapy because the turn of the 20th century. Applicators such as wax and paraffin skin custom molds were developed and used with radium needles or radon seeds to cure skin cancer (27). Interstitial irradiation was used in many clinics, as well (28–31).

The introduction of teletherapy and concerns over radiation exposure from BT had a negative impact on the use of BT, and a generation of radiation oncologists had limited exposure to BT in managing skin cancer.

Over the past 40 years, radiotherapy for NMSC has largely consisted of superficial and orthovoltage x-rays and electron beam therapy. Electron beam therapy often requires templates and lead cutouts, the construction of which can be messy and uncomfortable for the patient when using skin collimation for a better dose coverage. When using this modality, output factors and percent depth dose (PDD) measurements need to be performed. This entire process can be time consuming and cumbersome for the department. Moreover, if collimation is done at a distance from the skin, penumbra should be considered. Typically, additional collimation at skin with lead inserts is required to improve penumbra. In the treatment of small fields, electron dosimetry requires special attention because the PDD and output change significantly according to the specific block shape and size. HDR BT, despite the more heterogeneous dose distribution, presents several advantages, particularly for irregular surfaces and challenging setups.

With the incorporation of HDR BT and remote afterloaders in the 1960s, there has been a renewed interest in BT for cutaneous malignancies. Reports of older published series mainly done in European facilities with wide experience in BT showing efficacy in treating skin cancer (29–31) has led to recent interest and growth in new techniques. Several innovative applicators have been introduced to the BT community, and the use of skin BT has significantly increased (32).

Patient evaluation

The primary tools available to evaluate NMSC lesions are (*1*) clinical history, (*2*) clinical examination, and (*3*) histopathologic classification.

1. Clinical history: Clinical history should include prior treatment of the area or other cutaneous malignancies, medical conditions rendering a relative (such as collagen vascular disease), or absolute (genodermatoses such as basal cell nevus syndrome or xeroderma pigmentosum) contraindication.
2. Clinical examination: Clinical examination should be performed to choose the correct treatment option for the lesion. In lesions in which boundaries are not well defined, additional scouting skin biopsies (usually shave or punch) are useful methods to gauge lateral extent. The lesion should be palpated and moved to determine if there is significant extension into the subcutaneous fat or if the tumor is fixed to deeper structures. Palpitation of the regional lymph node drainage sites should be performed. Also critical is the evaluation of the surface to be treated (flat or curved, regular, or irregular) and measurement of the lesion in the case of macroscopic tumor or the scar in patients after surgery (Fig. 1). Pretreatment and posttreatment photographs should be part of the medical records.
3. Histopathologic classification: It is essential to have a definitive pathology report. The report classifies the tumor in specific terms including the relevant subtypes. Understanding the biologic behavior of subtypes will guide treatment. The goal is to estimate the risk for significant subclinical extension (33).

Staging

BCC and SCC of the skin are usually found while still small and with little potential of metastatic spread. For this reason, patients usually do not require staging, blood work, or imaging tests. In the presence of high-risk features, including tumor thickness of greater than 4 mm, diameter greater than 20 mm, tumor invasion into the lower dermis, perineural invasion, lymphovascular invasion, aggressive histology such as moderate or poor differentiation, or tumor involving high-risk sites such as the scalp, lip, ear, eyelids, and nose, staging may be done. The American Joint Committee on Cancer and TNM (Table 1) system is generally used (33, 34).

Imaging tools

The selection of the appropriate applicator for adequate dose coverage depends on the dimensions of the planning target volume (PTV), and therefore, appropriate imaging, as described in the following sections, may be helpful. During the last decade, advances in noninvasive skin imaging techniques have produced new cutaneous imaging