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Custom mold applicator high-dose-rate brachytherapy for nonmelanoma skin cancer—An analysis of 273 lesions

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ABSTRACT

PURPOSE: Nonmelanoma skin cancer is the most commonly diagnosed malignancy in the United States. A modern version of surface brachytherapy, ''topographic applicator brachytherapy'' (TAB), can be used to treat early-stage nonmelanoma skin cancer (ES-NMSC). The purpose of this study was to evaluate the acute toxicity, chronic toxicity, and recurrence rates of patients with ES-NMSC treated with TAB.

METHODS AND MATERIALS: From 2010 to 2013, 172 patients with 273 ES-NMSC tumors were consecutively treated with TAB. A custom applicator was created using a thermoplastic mold with Harrison Anderson Mick applicators. Dose fractionation schemes included 40 Gy in eight fractions delivered twice per week or 48 Gy in 16 fractions delivered four times per week.

RESULTS: Of the 273 tumors treated, 23.8% were located on the nose, 54.2% were basal cell carcinoma, 76.2% were Stage I, 89.3% were treated definitively, 98.9% completed treatment, and 75.5% received 40 Gy in eight fractions. Median followup was 25.0 months (0.5−71.0 months). Maximum acute toxicity was G0, 0.4%; G1, 33.3%; G2, 48.7%; G3, 12.1%; and G4, 5.1%. Local recurrence was 4.8% at 25 months, with median time to recurrence being 9 months. There was no regional or distant metastasis documented during the followup. Chronic toxicities included erythema (4.4%), chronic ulceration (4.0%), telangiectasia (2.6%), and pigmentation changes (2.2%).

CONCLUSIONS: TAB was able to provide excellent local control (95.2%) with low rates of Grades 3 and 4 toxicities for treatment of ES-NMSC. TAB is a reasonable alternative to surgical resection when there is concern of poor cosmesis/wound healing.

Keywords: Skin; HDR brachytherapy

Introduction

Nonmelanoma skin cancer (NMSC) is the most commonly diagnosed malignancy in the United States. There is no current estimate on the incidence of NMSC nor is it tracked by the Surveillance, Epidemiology, and End Results Program database due to its low mortality and reputation for being easily detected and treated. In 2006, Rogers et al. estimated the incidence of NMSC within the United States by using population-based analysis claims and the U.S. Census Bureau. This analysis concluded that 3,507,693 cases of NMSC were diagnosed in 2006, with 2,152,500 patients being treated; furthermore, the analysis noted that the incidence of skin cancer was increasing annually (1).

Currently, the most commonly used method to treat early-stage nonmelanoma skin cancer (ES-NMSC) is surgical resection. Surgical options include Mohs micrographic surgery (skin sparing) and wide local excision. Invasive techniques, such as electrodessication and curettage, can also be used. Several nonsurgical treatments can be used, including topical chemotherapy, cryotherapy, and radiation therapy (2). Definitive radiation therapy is often recommended in situations where surgery can cause a cosmetic

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defect, when reconstruction is required, or when there is a concern of a delay in healing, thus risking ulcer formation.

In regard to radiation therapy, ES-NMSC can be treated with several techniques. Before the advent of Mohs, superficial x-rays and electron therapy were frequently used with reported 5-year local control rates of 80−93% (3−5). Dosimetrically, electron therapy can treat curved surfaces, but it penetrates past the skin's surface, so it may risk excessive toxicity. Superficial x-rays, however, have a better depth dose distribution than electrons but still have dosimetric challenges when treating curved surfaces, which makes treatment of the nose and ears difficult. Brachytherapy, however, can prescribe the dose to a small, shallow area while having a steep dose falloff underneath the skin's surface due to inverse square law while being able to treat a curved surface. Because of this, brachytherapy is preferred for being the most conformal and having low penetrability (6). Beginning in 2010, the author's institution implemented a modernized version of brachytherapy called ''topographic applicator brachytherapy'' (TAB) to treat ES-NMSC. This study analyzes the authors' 2010−2013 experience.

Methods and materials

TAB is a version of surface and mold brachytherapy that uses materials commonly found in a radiation oncology department. An institutional review board-approved protocol for prospective data collection was created at the initiation of this treatment paradigm, allowing physicians to analyze patient outcomes. To be included in this analysis, patients had to have biopsy proven Stage I−II squamous cell carcinoma (SCC), basal cell carcinoma (BCC), or Bowen's disease of the skin. TAB could be used for (*1*) definitive treatment, (*2*) adjuvant treatment in cases with poor pathologic factors (e.g., positive margins or perineural invasion and location), or (*3*) salvage treatment for recurrence after previous surgery or radiation. In addition, patients had to have at least one followup with a radiation oncologist after treatment completion to assess acute toxicity as well as at least 1 year of followup in total between radiation oncology and dermatology to assess for local recurrence and chronic toxicity.

Identification of the tumor (or tumor bed) was determined based on the dermatologist's consultation and physical examination. A 5-mm radial expansion was made to account for microscopic disease spread (clinical target volume), and an additional 3- to 5-mm radial margin was added for planning target volume (PTV) based on the anatomical location and tumor size. The PTV was then demarcated on the skin with a marker. A slotted Harrison Anderson Mick (HAM) applicator (Eckert & Ziegler) was cut to a width that would encompass the PTV, and 6F catheters were threaded through the HAM. The median number of catheters required per tumor was four (range: 1−12). Depending on the location, a Freiberg Flap (Nucletron B.V.) could be used in place of the HAM applicator.

Four pieces of thermoplastic were then cut and placed in a heated water bath. The first piece was molded tightly around the PTV and surrounding anatomy. This was the base layer, which needed to be larger than the HAM piece. If the tumor was located on a flat surface, marks were placed on the skin around the base layer to aid in accurate repositioning.

The second piece of thermoplastic was also larger than the HAM; it was used to anchor the HAM to the base layer. The third and fourth pieces of thermoplastic were used to attach a hook and loop fastener to opposite sides of the base layer, which aided in keeping the base layer flush to the skin. Once the mold was created, a radioopaque wire was placed on top of the drawn PTV, and the thermoplastic mold was fastened back onto the patient. Radioopaque markers were then placed within each catheter, and the catheters were numbered. The patient then underwent a CT simulation. The scanned area needed to encompass the PTV and the blind ends of the catheters. Before treatment planning began, the CT simulation was evaluated to ensure the mold was flush against the skin and the HAM encompassed the PTV. The catheters were then digitally reconstructed in Oncentra (Elekta, Veenendaal, The Netherlands). The dwell positions within the PTV were the dwell positions used for treatment (Fig. 1).

In regard to treatment planning, ES-NMSC tumors were treated with one of two dose fractionation schemes: (*1*) 40 Gy at 5 Gy/fx two times per week, and (*2*) 48 Gy at 3 Gy/fx four times per week. The latter dose fractionation scheme was used primarily when: (*1*) the tumor was >5 cm, (*2*) the tumor was a recurrence, (*3*) the treatment was adjuvant, or (*4*) there were concerns of delayed healing after treatment. The CT simulation was examined to determine prescription depth. If the tumor's depth was visible, the authors would prescribe to that specified depth. If the tumor's depth could not be delineated, the prescription depth was 3 mm. The skin surface dose was constrained to receive a maximum of 135% of the prescribed dose. V_{90} of the PTV had to be >85% (Fig. 2). Shielding was used when treating tumors around the eye or on the cheek. Patients were evaluated at 2 weeks, then 6 weeks, and then every 3 months for the first year posttreatment. After completing 1 year of followup with radiation oncology, patients were strictly followed by dermatology. Dermatology evaluated patients at regular intervals of 3 to 6 months, depending on each patient's individualized skin conditions.

Endpoints

Treatment endpoints included acute skin toxicity, chronic toxicity, and recurrence rates. Acute toxicity was based on the Radiation Therapy Oncology Group grading criteria and graded weekly during treatments and at