

## Teaching Case

# Water Bath Radiation for Extensive, Extremity-Based Cutaneous Disease of Mycosis Fungoides

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## Introduction

Mycosis fungoides (MF) is a type of non-Hodgkin T-cell lymphoma presenting with cutaneous patches, plaques, and tumors.<sup>1</sup> Early-stage MF is typically managed with skin-directed therapies, including phototherapy, topical corticosteroids, and radiation therapy, of which serial use may be administered for long-term disease control. Because MF is sensitive to ionizing radiation, radiation therapy is widely used to alleviate symptoms and improve local disease control.<sup>2,3</sup> Among various radiation therapy modalities such as electron, high-dose-rate (HDR) brachytherapy, and kilovoltage and megavoltage (MV) photons, electron external beam therapy has been one of the most used treatments for MF as it can effectively treat superficial tissue and spare deep tissues and organs.

Electron beam therapy is, however, not optimal in accounting for possible dose nonuniformity due to irregular surface and the inconvenience of custom field-shaping devices. HDR using surface applicators can deliver a conformal dose to such regions, but setup can be difficult for large, circumferential surfaces necessitating extended treatment time. HDR also requires additional attention to field junctions to avoid hot or cold spots. A megavoltage

photon beam with tissue compensation could be useful to deliver a highly uniform dose to the region in a shorter treatment time than HDR and without a custom cutout.

Cases have been reported for megavoltage photon irradiation with various tissue compensation methods involving superficial tumors located in extremities<sup>4-10</sup> such as MF,<sup>4,5</sup> Bowen's disease,<sup>6,7</sup> and Kaposi Sarcoma.<sup>8-10</sup> In addition to water,<sup>6-9</sup> alternative methods have also been used, including rice,<sup>4</sup> 3-dimensional printed bolus,<sup>5</sup> and sand bags.<sup>10</sup> However, the cases reported with the alternative methods were limited only to a relatively smaller patch of skin.<sup>4,5,10</sup> Furthermore, treating a large area of extremity-based MF has not been reported. In this paper, we report a use of megavoltage photon irradiation with water for tissue compensation in a patient with MF with extensive disease of upper extremities including digits to achieve dose homogeneity and short treatment time.

## Case Presentation

The patient is a 66-year-old man with a history of stage IB mycosis fungoides diagnosed in 2007 involving left upper arm and left posterior calf. After diagnosis, he underwent multiple therapies including nitrogen mustard, Imiquimod, bexarotene, photochemotherapy, and narrowband ultraviolet B phototherapy and also received HDR brachytherapy in a total of 8 Gy in 2 fractions to a right posterior thigh plaque. He was referred to radiation oncology by his dermatologist for progression on the proximal right upper extremity, axilla, and right posterior thigh.

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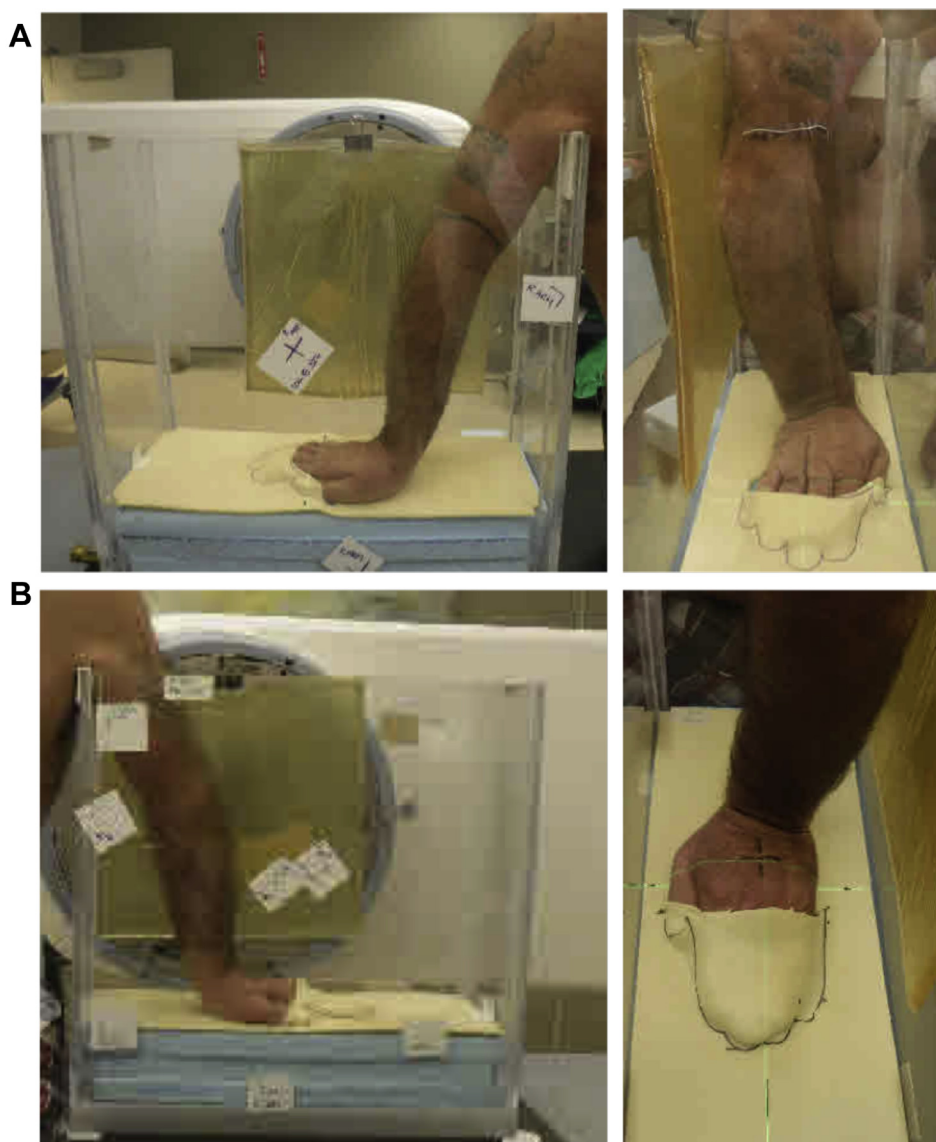
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At the initial radiation oncology consultation, the patient reported progression of disease on the proximal right upper extremity and right posterior thigh, the latter for which he had had prior HDR 8 Gy in 2 fractions using a surface applicator in 2016. Detailed skin assessment did not reveal any other skin involvement. As such, HDR treatment of the proximal right upper extremity and axilla using a custom plaque applicator with a dose of 8 Gy in 2 fractions and retreatment of the right posterior thigh with en face electron therapy with a dose of 8 Gy in 2 fractions was proposed given the long interval to locally recurrent disease.

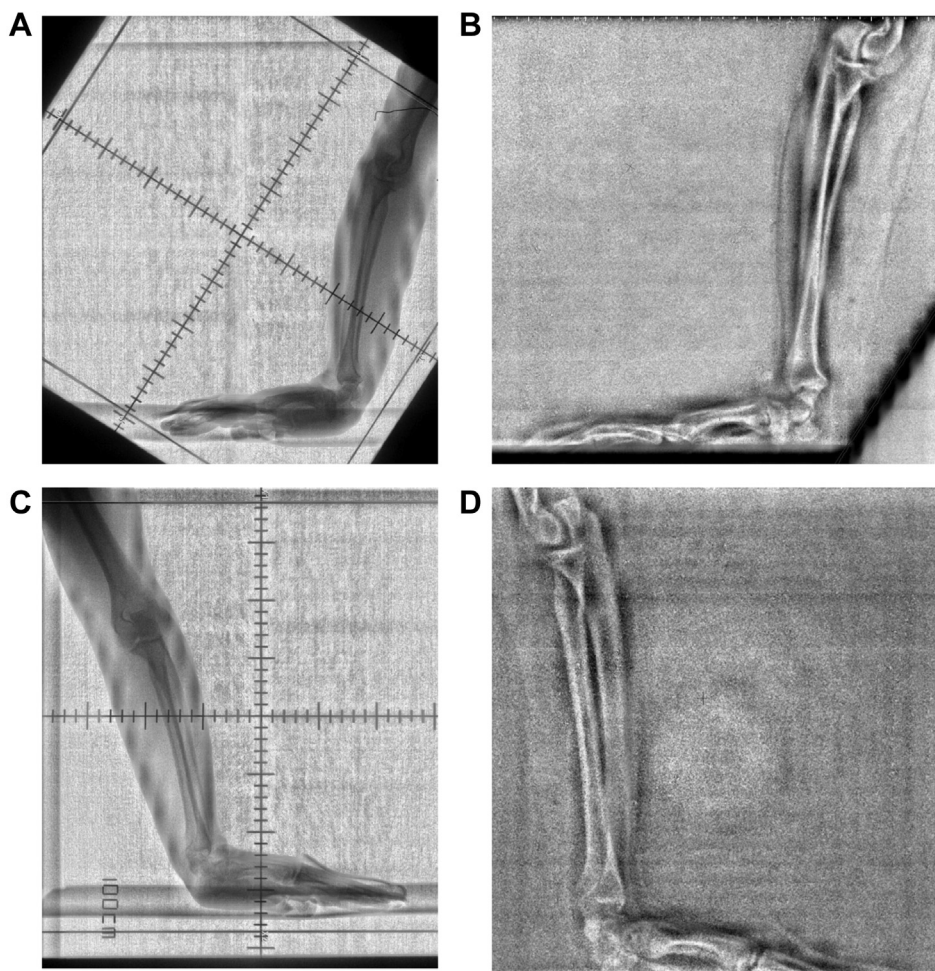
The patient had a complete response to this therapy at a 6-week follow-up visit. However, he had new regions of involvement, including the right upper extremity distal to the prior HDR treatment and left upper extremity. There was no other disease present, including no truncal

involvement, and the patient wished to avoid total skin electron beam therapy. A treatment was suggested of photon external beam radiation therapy using 2 opposed lateral beams with a water bath for tissue compensation to provide a uniform dose distribution and avoid problems caused by field-matching.

A dose of 2.5 Gy per fraction (total dose, 10 Gy) was prescribed with 2 opposed lateral beams to midline and 6-MV photons. Although the patient had prior complete response to 8 Gy in 2 fractions, there were concerns raised among team members with regard to hypofractionation. As such, hypofractionation dose was moderated, and a dose of 10 Gy in 4 fractions was prescribed out of an abundance of caution to achieve similar biological effectiveness to 8 Gy in 2 fractions. The patient was simulated using Acuity (Varian Medical Systems, Palo Alto, CA), and each upper extremity was immersed in a



**Figure 1** Photos of clinical setups: (A) right extremity, (B) left extremity.



**Figure 2** Images of right arms: (A) acuity simulation films, (B) MV portal film; and left arms: (C) acuity simulation films, (D) MV portal film.

water bath (20 cm thick, 45 cm tall, and 45 cm wide). As shown in [Figure 1](#), the isocenter was determined during the simulation and was marked on the skin and the water tank. Inside of the tank, layers of Styrofoam were added to adjust the height of a hand immobilization device and fit the ipsilateral armpit on the top corner of the water tank so each treatment field can include the entire treatment lesion under water. A superior border of the treatment area was made 2.5 cm superior to an anterior tattoo on each upper extremity, and the tank was filled with water to include each field. To minimize the edge effect (or lateral tissue damage), a 1.0-cm thick bolus was added on the water tank surface as a spacer behind the elbow in the path of each posterior beam because each elbow was bent in the posterior direction.

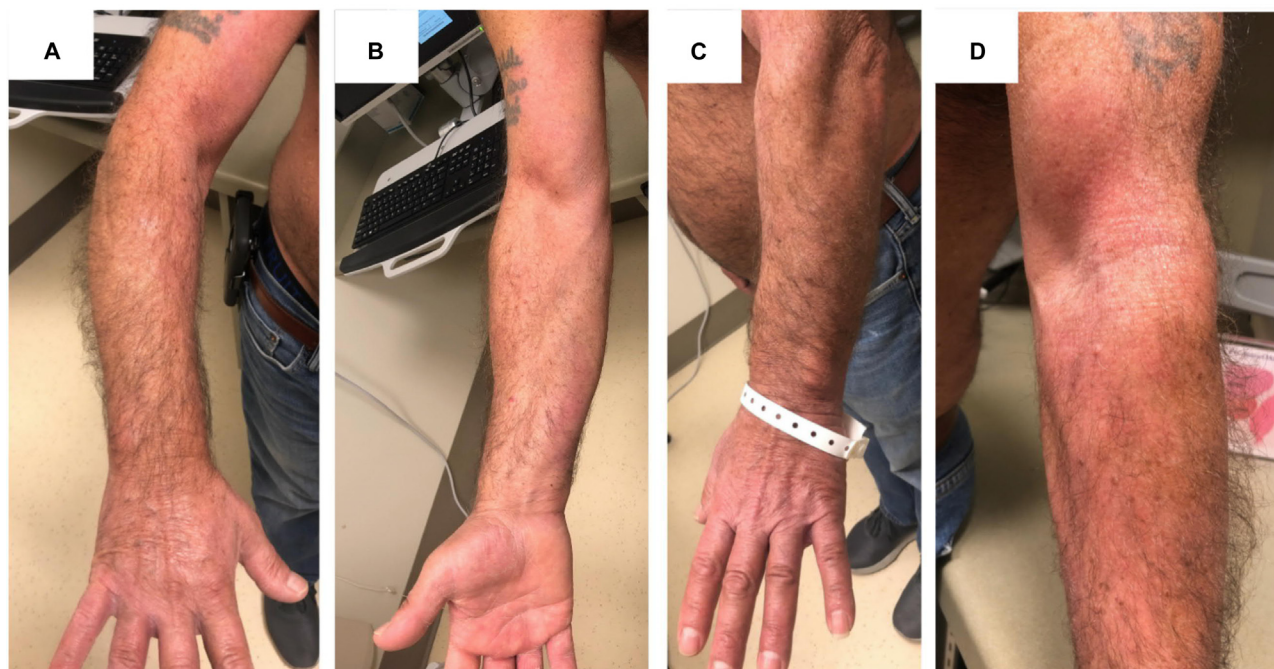
For each treatment, MV portal images were taken, and bony anatomy was verified to match the treatment fields for 6-MV photon beams as shown in [Figure 2](#). Monitor Units were calculated accounting for the prescription depth, dose, field sizes, and setup distance. The field size for each treatment was 38 cm × 39 cm without any multileaf collimator use.

## Results

During the treatment period, the setups were found to be reproducible. The patient did not present any acute toxicity. With the opposed lateral fields, the calculated dose at  $\pm 5$  cm (considering the uncertainties of the arm placement) from the midline was 3% higher than at the midline. The total treatment time for each fraction was scheduled for 45 minutes including setting the patient up and imaging daily, and the total radiation time was approximately 1 minute. At 6- and 12-week follow-up appointments, the patient had complete response in the area treated using this method. [Figure 3](#) shows treatment responses, with photos taken 6 weeks after treatment completion. The data used in this article are not available for reuse.

## Discussion and Conclusion

We report an effective treatment case of megavoltage photon radiation for extensive, extremity-based mycosis



**Figure 3** (A) Dorsal and (B) ventral surfaces of the right arm and (C) dorsal and (D) ventral surfaces of the left arm 6 weeks after treatment completion.

fungoides with a water bath as tissue compensator. This method is easier when providing a uniform dose distribution in a large and irregular target and is less sensitive to the treatment setup compared with conventional approaches such as electron beam therapy and HDR. Furthermore, this technique can be easily used in any clinic if a water tank of appropriate size is available.

The multidisciplinary team including the radiation oncologist and the physicists discussed various radiation therapy modalities and compared their advantages and disadvantages to efficiently treat the disease in the left lower arm and right upper extremity including hands and

digits. Electron beam therapy is often used for patients with MF involving extremities, and this patient also received en face electron therapy on his right posterior thigh; however, it was considered less optimal in this case because the patient had multiple semicontiguous, circumferential patches. Electron therapy in this case could be used by abutting multiple electron fields but would cause hot and cold spots in the junctions. The curved surface exacerbates this problem.<sup>11</sup> As a next option, HDR brachytherapy was considered for this case. The main disadvantage was that interdigital spaces would need to be treated with a custom plaque applicator.

**Table 1** Comparisons for large and irregular extremity-based MF treatment options

	MV water bath	Electron	HDR brachytherapy
Custom device for dose distribution	No	yes	yes
Advantage	Uniform dose in large and highly irregular surface Setup uncertainty has less impact on dose distribution		Deep-tissue sparing
Disadvantage	No deep-tissue sparing	Decreased dose at depth in the sloping surface	The size of the applicators is limited. Multiple applicators are required to cover large surface area.
Simulation	Possible skin infection risk with water immersion kV imaging on simulator	Hard to treat large areas and interdigital spaces	CT

Abbreviations: CT = computed tomography; HDR = high dose rate.

Finally, the option of photon external beam radiation therapy using 2 opposed lateral beams was suggested with a water bath for tissue compensation to provide a uniform dose distribution and avoid problems caused by field-matching, although the technique does not spare deep tissue and could cause a skin infection from the water immersion.<sup>4</sup> The advantages and disadvantages of each discussed modality are summarized in Table 1.

In this study, we presented a case that megavoltage photon radiation with a water bath as tissue compensator offers an efficient and reproducible method for treating extensive, extremity-based mycosis fungoides. This is a time-efficient method, and the treatment outcome of the patient was successful.

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