CASE REPORT

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High-dose-rate surface mold with tumor translucency brachytherapy for a 103-year-old patient with skin cancer, dementia, tremor, and kyphosis: a case report

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ABSTRACT

Cancer treatment for centenarians can be challenging. High-dose-rate surface mold brachytherapy is a non-invasive, radical treatment modality for surface cancer. Further, it is used for patients who cannot remain at rest or have poor posture. We performed this treatment on a 103-year-old female patient with forehead skin cancer, dementia, tremors, and kyphosis since radical surgery and external beam radiotherapy were not feasible. A custom-made surface mold with tube applicators was developed with vinyl sheet and silicone. The vinyl sheet was utilized to enable tumor visualization through the mold and to confirm the tumor position relative to the mold. The mold with tumor translucency was fixed to the tumor surface, and the radioisotope (Ir-193) was sent remotely through tube applicators for irradiation. The planning-aim doses were 48 Gy in eight fractions. The positional relationship between the mold and the tumor was confirmed similarly during irradiation by checking them through the vinyl sheet before and after irradiation. We treated the patient, although she was in constant motion during irradiation. The local tumor was well-controlled without any metastatic disease evidence. The tumor disappeared before her eventual death 11 months post-treatment. No serious adverse events were reported during the follow-up period. Our results indicate that high-dose-rate surface mold with tumor translucency brachytherapy is an effective cancer treatment for centenarians with dementia, tremors, and kyphosis.

Keywords: high-dose-rate, surface mold brachytherapy, skin cancer, centenarian

Abbreviations:
BT: brachytherapy
CTV: clinical target volume
EBRT: external beam radiotherapy
HDR: high-dose-rate
SMBT: surface-molded brachytherapy

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INTRODUCTION

The number of individuals aged 100 years in Japan has increased. Ministry of Health, Labour and Welfare of Japanese government[1] reported that the centenarian population was 90,526 in 2022 compared with 405 in 1972. Surgical therapy for surface skin cancer for centenarians is related to potential problems, including severe dementia, severe systemic diseases, and poor performance status. Therefore, surgery is an effective local treatment regimen for skin cancer,[2,3] but radiation therapy may be the treatment of choice when radical surgery is challenging. External beam radiotherapy (EBRT) is a promising form of radiation therapy but is difficult to perform if the patient is unable to maintain a stable, stationary posture on the treatment table. Brachytherapy (BT) is a viable option in such cases. BT involves using a small radioisotope inserted into or around the tumor directly. Therefore, BT can be utilized for patients who are unable to remain at rest or have poor posture.

High-dose-rate (HDR) surface-molded BT (SMBT) involves a special device with tube applicators attached to the tumor surface. Irradiation is performed by passing HDR radioisotope through the tube applicators remotely. SMBT is effective for superficial lesions.[4] Another advantage of SMBT is its non-invasiveness.

To date, few studies reported HDR-SMBT treating patients with surface skin cancer aged >100 years who cannot remain at rest or have poor posture. In particular, Yoshida et al reported a patient with skin cancer on the fingers (97 years old with dementia and difficulty in controlling body movement) treated with HDR-SMBT.[5] In this case, a dental silicone mold alone would have been sufficient for fixation since the lesion was on the hand. However, complete fixation of the mold may be difficult based on the lesion site. Using a vinyl sheet as part of the mold material would be better in such cases for tumor visualization through it and checking for any mold displacement during irradiation.

Here, we report a case that involves a 103-year-old woman who presented with a forehead skin basal cell carcinoma. She had dementia, tremors, and kyphosis and was not eligible for radical surgery and EBRT. However, she complained of irritability related to the tumor. Therefore, we treated her with HDR-SMBT, and the methods, techniques, and results of this case are presented to help with future treatment for such patients.

CASE PRESENTATION

A 103-year-old female patient with dementia, tremors, and kyphosis presented with a forehead tumor that developed 16 years earlier. She repeatedly scratched the lesion because of itching, particularly within the previous 9 years. The tumor demonstrated central ulceration, and finally, the ulcer grew deeper. A subsequent biopsy exhibited a basal cell carcinoma. The tumor diameter was 26 × 20 mm, with a maximum tumor depth of 5 mm (Fig. 1A). This case was categorized as cT2N0M0 following the Union for International Cancer Control TNM classification[6] eighth edition (2017). The tumor caused irritability, and she was treated with a topical application of sugar–povidone iodine ointment.

The radiation oncologist judged that EBRT was not feasible because of her dementia, tremor, and kyphosis disabling her to maintain her position at rest on the treatment bed. Therefore, HDR-SMBT was selected as monotherapy. The brachytherapists developed a custom-made mold utilizing a vinyl sheet and dental silicone (Coltoflax, Yoshida Dental Trade Distribution Co, ltd, Tokyo, Japan). The standard textbook described the use of this material for applicator securing.[7] Furthermore, this material has been our standard applicator-holding material during

Fig. 1 Pictures illustrating the forehead of the 103-year-old female patient

Fig. 1A: An ulcerated forehead tumor categorized as cT2N0M0 following the Union for International Cancer Control Classification[6] eighth edition (2017).

Fig. 1B: The tumor became almost flattened 16 days after high-dose-rate surface mold with tumor translucency brachytherapy.

Fig. 1C: The tumor disappeared and slight desquamation was observed nine months after high-dose-rate surface mold with tumor translucency brachytherapy.

BT for several years.[5,8,9] Generally, molds are solely made of silicone. However, the patient in this case demonstrated a lot of movement, and the mold moved, potentially preventing accurate irradiation. Therefore, a vinyl sheet was used for the mold material as an ingenious so that the tumor could be seen through it after fixing the mold to check the exact tumor and mold positioning. Additionally, dental silicone was placed around the vinyl sheet to stabilize the vinyl sheet and tumor. We utilized vinyl sheets with a 1-mm thickness. We hollowed out the vinyl sheet following the tumor shape and overlapped each sheet until the tumor mass was filled into the vinyl sheet (Fig. 2A, B). However, the mold that was prepared from the vinyl sheets did not completely fit the patient's forehead because the skin surface was curved (Fig. 2B). Therefore, we utilized dental silicone to fill the gap between the marginal area of the vinyl sheets and the skin surface (Fig. 2C). This helped the vinyl sheets with transparency to be fixed to the tumor and we could confirm the position of the tumor relative to the mold through the vinyl sheets. Afterward, four flexible-tube applicators were inserted into the mold, and the surface mold with tumor translucency was finished (Fig. 2D, E).

MicroSelectron-HDR was used as the treatment planning machine and Oncentra (Nucletron, ELEKTA AB, Stockholm, Sweden) as the planning software. We took computed tomography for treatment planning. The gross tumor volume (GTV) was equal to the clinical target volume (CTV) to prevent irradiating a wide area. Our planning-aim dose fraction schedule was 48 Gy in eight fractions for 4 weeks (Fig. 3). The D100 of the CTV (minimum dose of the CTV) was 46.4 Gy in eight fractions after dose calculation. The D90 of the CTV (the dose that covered 90% of the CTV) was 52 Gy in eight fractions.

She was in constant motion during irradiation because of her tremor. Therefore, the positional relationship between the mold and the tumor was checked through the vinyl sheets of mold before and after irradiation. Fortunately, no major mold displacement was found before or after each treatment session. Hence, irradiation was completed without incident. She missed one hospital appointment because of vomiting, but this was not associated with HDR-SMBT. She

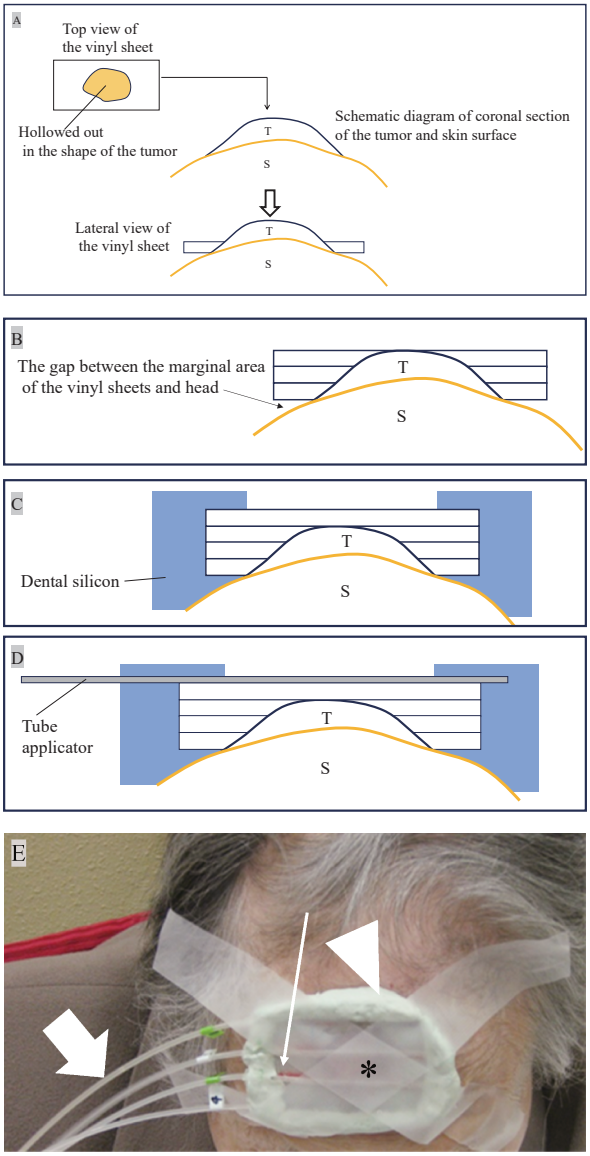

Fig. 2 Creation of a custom-made surface mold

Fig. 2A: The vinyl sheet, of which the inside was hollowed out in the shape of the tumor, was placed over the tumor.

Fig. 2B: The vinyl sheets were overlapped until the tumor was filled into the vinyl sheets.

Fig. 2C: Dental silicon was utilized to fill the gap between the marginal area of the vinyl sheets and the skin surface.

Fig. 2D: The tube applicator was passed through dental silicon and glued to the vinyl sheets. Tube applicators served as induction paths for high-dose-rate radioisotopes (Ir-192).

Fig. 2E: Picture of the patient attached to a custom-made surface mold with tumor translucency with four tube applicators. Tube applicators (thick arrow) passed through dental silicon (arrowhead) and glued to the vinyl sheet (thin arrow). Tumor (*) was visible through the vinyl sheets, and its position in relation to the mold could be assessed.

T: tumor

S: skin surface

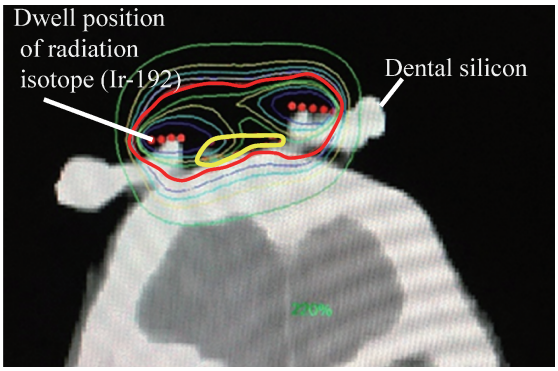

Fig. 3 Dose distribution curve on coronal view of planning computed tomography
We achieved good coverage of the clinical target volume (yellow line) by the planning-aim dose (6 Gy in fraction; red line).

soon recovered and continued the treatment until completing all eight sessions. It required 33 days for the treatment from start to finish.

The tumor had nearly flattened 16 days post-treatment (Fig. 1B) and decreased in size to 20 × 13 mm at 51 days post-treatment. It decreased in size to 14 × 7 mm at 93 days post-treatment. The tumor had disappeared, and the ulcer was completely epithelialized at 135 days post-treatment. Sugar–povidone iodine ointment was discontinued 6 months post-HDR-SMBT. Only slight desquamation remained in the area 9 months post-HDR-SMBT (Fig. 1C). Unfortunately, she died of an unrelated disease 11 months post-HDR-SMBT. A complete response was achieved until she died and no serious adverse events occurred.

DISCUSSION

Treating these very old patients radically and palliatively is often difficult. However, Ministry of Health, Labour and Welfare of Japanese government[10] reported that the life expectancy of a 103-year-old woman will be 1.9 years in 2021. Our patient complained of local tumor irritability, which negatively influenced her quality of life. Therefore, we considered curative and palliative treatments.

Surgical resection is the preferred treatment for locally limited skin cancer. Local control after Mohs micrographic surgery is approximately 95%.[2,3] Radiotherapy is a good alternative treatment for patients who are ineligible for surgery, and EBRT is an effective non-invasive outpatient-based treatment method. Zaorsky et al analyzed 21 publications, including 9,729 patients, in a meta-analysis. Of these patients, 9,255 received EBRT, with a median 1-year and 5-year local control rates of 98% and 86%, respectively.[11] However, EBRT is difficult to administer to centenarians. Almost all patients have dementia, and such patients have difficulties remaining on the treatment bed of a linear accelerator.

BT may be indicated for these patients. Two types of BT are useful for skin cancer lesions. The first is interstitial BT (ISBT), wherein the low-dose-rate (LDR) radioisotope, or tube applicators through which HDR radioisotope is sent remotely, is implanted into the tumor lesion. This modality is effective for deep-seated lesions.[4] The second is SMBT the special device, also known as mold, with the LDR radioisotope, or tube applicators through which HDR radioisotope is sent remotely, is attached to the tumor surface.

LDR BT provides a superior biological advantage compared with HDR-BT. However, the patient must remain alone in a radiation-shielded room until completing the treatment. This indicates that adequate care is difficult. Additionally, the direct manual handling of the radioisotope inevitably exposes medical staff. In contrast, HDR-BT exhibited none of the aforementioned drawbacks because the irradiation is performed by remotely moving the HDR radioisotope through tube applicators inserted into or around the tumor. Patients are only required to briefly enter the shielded treatment room during the actual irradiation. Therefore, the patient was admitted to a general hospital room. This is especially important for the very elderly who require adequate nursing care. Furthermore, CTV dose distribution was optimized by adjusting the position and dwell time of the radioisotope as it moved through the applicator.[12] The Groupe Européen de Curiethérapie and the European Society for Radiotherapy and Oncology Advisory Committee for Radiation Oncology Practice recommended a recent American Brachytherapy Society (ABS) report, providing a detailed summary of 19 published protocols for ISBT and SMBT. The median age of the patients belonged in the "older" category, and local controls ranged from 90% to 100%.[13] The ABS reported that SMBT should be indicated for superficial lesions with depths of ≤5 mm and ISBT should be indicated for deep lesions with depths of >5 mm.[4] Therefore, we selected HDR-SMBT as the best modality for our patient.

The mold was easily developed by brachytherapists. Additionally, we devised the use of the mold with tumor translucency so that the positional relationship between the mold and the tumor could be reliably ascertained because the patient has significant body movements caused by tremors. Brovchuk et al performed HDR-BT for 751 patients with non-melanoma skin cancer (ISBT:SMBT:a combination of both modalities = 518:225:8). They revealed a complete response in 96% of the cases with a local relapse in only 0.4%.[14]

Another problem is determining the optimal radiation dose fraction schedule. Smaller doses with higher fraction sizes were desirable because higher fraction doses may be a risk factor for late complication rates. However, the patient would be required to come to the hospital more frequently with this protocol. Admission exhibited a risk associated with her psychological disorder, including delirium. During the outpatient-based treatment, her family could accompany her, although they were also old. Thus, they could not attend daily. Additionally, the patient had difficulty to visit regularly. We decided to treat her once or twice a week with fraction doses of 6 Gy because we were afraid that the patient or her family could not complete the treatment course.

Next, decisions regarding the total number of treatment fractions were a challenge. A total of 48 Gy in eight fractions may be high for patients aged >100 years. However, we were concerned that mold displacement would reduce the actual irradiated dose to the tumor because the patient could not remain still. Furthermore, we considered that this schedule would be tolerable because we involved no CTV margin with the GTV.

Fortunately, HDR-SMBT was completed, although one cancellation was observed during the treatment course. The local control result was excellent without any metastasis occurrence. The tumor disappeared before the patient's eventual death, and local irritating symptoms nearly disappeared.

CONCLUSION

Based on our results, HDR surface mold with tumor translucency BT appears to be useful for centenarians who could not remain at rest or have poor posture, although total irradiation doses and fraction size remain issues that should be resolved in future studies.

ETHICAL STATEMENT

All procedures completed were under the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Declaration of Helsinki 1964, as revised in 2013. This article included no identifying information.

CONFLICTS OF INTEREST STATEMENT

One of the authors (Ken Yoshida) assumes an advisory role at Chiyoda Technol dealing with remote afterloader (microSelectron-HDR) in Japan. The other authors have no conflicts of interest associated with this manuscript.

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REFERENCES

1 Ministry of Health, Labour and Welfare. *Annual change in the number of persons aged 100 years or older by sex*. Published in Japanese. Ministry of Health, Labour and Welfare; September 2022. Accessed September 6, 2024. https://www.mhlw.go.jp/content/12304250/000990671.pdf

2 van Lee CB, Roorda BM, Wakkee M, et al. Recurrence rates of cutaneous squamous cell carcinoma of the head and neck after Mohs micrographic surgery vs. standard excision: a retrospective cohort study. *Br J Dermatol*. 2019;181(2):338–343. doi:10.1111/bjd.17188

3 Leibovitch I, Huilgol SC, Selva D, Hill D, Richards S, Paver R. Cutaneous squamous cell carcinoma treated with Mohs micrographic surgery in Australia I. Experience over 10 years. *J Am Acad Dermatol.* 2005;53(2):253–260. doi:10.1016/j.jaad.2005.02.059

4 Ouhib Z, Kasper M, Calatayud JP, et al. Aspects of dosimetry and clinical practice of skin brachytherapy: the american brachytherapy society working group report. *Brachytherapy*. 2015;14(6):840–858. doi:10.1016/j.brachy.2015.06.005

5 Yoshida K, Akita K, Yoshida A, et al. Single-fraction palliative high-dose-rate brachytherapy for symptom management in a 97-year-old patient with dementia. *J Palliat Med*. 2024;27(8):1102–1106. doi:10.1089/jpm.2023.0450

6 Brierley JD, Gospodarowicz MK, Wittekind C, eds. *TNM classification of malignant tumors*. 8th ed. Willey-Blackwell; 2017.

7 Martin AG, Lacroix F, Niedernayr T, et al. Genitourinary brachytherapy. In: Devlin P, Cormack R, Holloway C, et al eds. *Brachytherapy: Applications and Techniques*. 2nd ed. Demos Medical Publishing; 2016:Chapter 4.

8 Yoshida K, Yamazaki H, Takenaka T, et al. A dose-volume analysis of magnetic resonance imaging-aided high-dose-rate image-based interstitial brachytherapy for uterine cervical cancer. *Int J Radiat Oncol Biol Phys*. 2010;77(3):765–772. doi:10.1016/j.ijrobp.2009.05.027

9 Mikami M, Yoshida K, Takenaka T, et al. Daily computed tomography measurement of needle applicator displacement during high-dose-rate interstitial brachytherapy for previously untreated uterine cervical cancer.

Brachytherapy. 2011;10(4):318–324. doi:10.1016/j.brachy.2010.11.006
10 Ministry of Health, Labour and Welfare. *Simplified life table*. Published in Japanese. Ministry of Health, Labour and Welfare; 2021. Accessed September 6, 2024. https://www.mhlw.go.jp/toukei/saikin/hw/life/life21/dl/life21-07.pdf
11 Zaorsky NG, Lee CT, Zhang E, Keith SW, Galloway TJ. Hypofractionated radiation therapy for basal and squamous cell skin cancer: a meta-analysis. *Radiother Oncol*. 2017;125(1):13–20. doi:10.1016/j.radonc.2017.08.011
12 Yamazaki H, Inoue T, Yoshida K, et al. Brachytherapy for early oral tongue cancer: low dose rate to high dose rate. *J Radiat Res*. 2003;44(1):37–40. doi:10.1269/jrr.44.37
13 Guinot JL, Rembielak A, Perez-Calatayud J, et al. GEC-ESTRO ACROP recommendations in skin brachytherapy. *Radiother Oncol.* 2018;126(3):377–385. doi:10.1016/j.radonc.2018.01.013
14 Brovchuk S, Park SJ, Shepil Z, Romanenko S, Vaskevych O. High-dose-rate skin brachytherapy with interstitial, surface, or a combination of interstitial and surface mold technique. *J Contemp Brachytherapy.* 2022;14(2):107–114. doi:10.5114/jcb.2022.114661