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Intraoperative single fraction high-dose-rate brachytherapy for head and neck cancers

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ABSTRACT

PURPOSE: To report on the use of single fraction high-dose-rate brachytherapy in delivering localized intraoperative radiation therapy to sites in the head and neck region inaccessible to intraoperative electron beam radiotherapy (IOERT).

METHODS AND MATERIALS: After maximal surgical resection, 7.5–20 Gy intraoperative high-dose-rate brachytherapy (IOHDR) was delivered to 65 patients using custom-made surface applicators.

RESULTS: The 1-, 3-, and 5-year local control rates for the entire group were 77%, 69%, and 59%, respectively. The 1-, 3-, and 5-year overall survival rates were 83%, 63%, and 42%, respectively, with a median overall survival of 50 months. There were no major intraoperative or postoperative complications.

CONCLUSIONS: IOHDR can be used to treat selected locally advanced head and neck tumors arising at sites inaccessible to IOERT or at institutions not using IOERT. A prospective multi-institutional study with a larger number of patients treated with IOHDR is needed to firmly establish the efficacy of IOHDR in this population group.

Keywords: Head and neck neoplasms; Skull base; High-dose rate; Brachytherapy; Intraoperative radiotherapy

Introduction

Head and neck cancers constitute about 5% of all newly diagnosed cases in the United States. Despite aggressive surgical and radiotherapeutic treatment, locally advanced tumors recur in 30–50% of patients (1, 2). Chemotherapy has produced encouraging results in nasopharyngeal, laryngeal, and pyriform sinus tumors (3–5).

In an attempt to improve local control, a few centers have advocated the use of intraoperative electron beam radiotherapy (IOERT) as part of the overall management of selected primary and recurrent head and neck tumors (6–18). Some of the potential advantages include shielding and/or retraction of critical structures from the radiation beam and ability to visualize the tumor bed thereby minimizing treatment volume and avoiding geographic miss. Incorporating IOERT in primary management has led to local control rates on the order of 40–70% with acceptable complication rates (6, 7). However, IOERT has distinct limitations. It is not possible to use the IOERT applicator at certain sites in the base of the skull or in the periorbital and paranasal sinuses because of their narrow anatomy. Although not mandatory, it is preferable to perform IOERT with a dedicated intraoperative linear accelerator, which is available in only a few centers.

Conventional brachytherapy, though possible, is difficult to deliver at the base of the skull and paranasal sinuses due to limited access. Further, it is not possible to shield critical tissues. Hence, in an effort to treat these relatively inaccessible sites optimally, an intraoperative high-dose rate (IOHDR) brachytherapy program was initiated at The Ohio State University in 1992. This report presents our

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entire experience with IOHDR in a variety of head and neck tumors to illustrate the scope of IOHDR in the head and neck area.

Methods and materials

The IOHDR procedure is performed as previously described (20, 21). In brief, the surgery is performed in a dedicated shielded surgery suite. After optimal resection of the primary site, the tumor bed is evaluated. The tumor bed may be grossly positive, grossly resected with microscopically positive or microscopically negative margins as determined by the surgeon, radiation oncologist, and the pathologist. Gold marker seeds are placed at the resection margins whenever possible to delineate the extent of the tumor to facilitate subsequent external beam radiation treatment (EBRT) planning. Gold marker seeds are preferred over surgical hemoclips that are used at some institutions because they are more radio-opaque and moreover cannot be confused with the hemoclips placed for hemostasis. At The Ohio State University, IOHDR is used only if IOERT cannot be performed, because the latter is faster, easier, and less personnel intensive.

Sterile IOHDR applicators of various sizes and shapes with parallel in-built holes 1 cm apart are available in the operating room (Fig. 1). For flat or gently sloping surfaces, a silicone applicator with limited flexibility is used, whereas, for irregular or curved surfaces a foam applicator is more appropriate. Hollow plastic catheters are inserted into the holes of the selected applicator 1 cm apart and held in place using buttons and friction collars. The number of catheters varies depending on the target width and ranges from one to eight. The applicator with the embedded catheters is placed on the target volume and secured with sutures or gauze packing. In rare cases the catheters are sutured directly onto the tumor bed. In some instances, the overlying bone (usually the maxilla) may have to be resected to facilitate applicator positioning. The bone is subsequently regrafted after the IOHDR procedure. Critical structures adjoining the treatment volume are displaced with the aid of a retractor or gauze. Pliable and sterile lead sheets of various sizes are available, if needed, to shield the uninvolved critical normal tissues that cannot be displaced. A radiograph is obtained with dummy sources placed in the catheters for verification/documentation and quality assurance. Whereas these radiographs are not used for brachytherapy treatment planning, they are useful in planning the postoperative EBRT field.

While the clinician is preparing the IOHDR applicator, the brachytherapy technologist transports the remote high-dose rate afterloading machine to the operating room and the physicist prepares the final treatment plan. The availability of preplanned dosimetry simplifies the treatment planning procedure and avoids delay. Treatment plans using parallel catheters 1 cm apart are available for the various applicators. As detailed in our previous report (19) equal dwell weights are used to permit dose intensification at the center of the target volume, which can be presumed to have the highest risk for residual tumor. In addition, quality assurance is simplified with fewer chances for error. This is very important in the intraoperative setting. The use of an optimized plan (with the dose optimized at a plane 1 cm from the catheter plane) will provide satisfactory dose homogeneity at 1 cm from the dwell positions. However, with an optimized plan, the dose distribution at the applicator surface (which is the presumed site of microscopic disease) has the undesirable effect of being higher at the periphery where there is low risk of disease, as opposed to the center that has the maximum risk for tumor but receives a lower dose (19). Under these circumstances, we prefer the treatment plan using equal dwell weights, which results in dose intensification at the tumor site but with lower doses to normal tissue sites (19). Occasionally, an applicator needs to be cut to custom fit the tumor bed. In these cases, the available treatment plan is modified. The final treatment plan is transferred over the network to the treatment console. The ends of the catheter are connected to the HDR machine after the required quality assurance checks. The dose delivered ranges from 7.5 to 20 Gy and is prescribed at 0.5 cm depth from the applicator surface (1 cm from the catheter plane) at the center of the implant. The treatment duration generally varies from 5 to 30 min depending on the treatment volume and source activity. During the entire treatment, the patient and the machine are monitored using video cameras and remote anesthesia monitors.

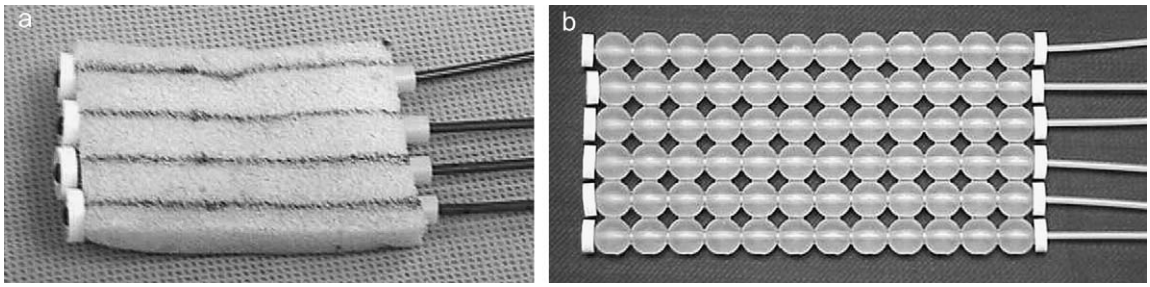

Fig. 1. Intraoperative HDR applicators made of foam (a) are used to treat irregular and sharply curved surfaces, whereas silicone-based applicators (b) are used to treat flat or gently sloping tumor beds.