Medical Dosimetry, Vol. 32, No. 4, pp. 246-253, 2007

0958-3947/07/$–see front matter

ELSEVIER

doi:10.1016/j.meddos.2007.02.002

# RADIATION THERAPY OF LARGE INTACT BREASTS USING A BEAM SPOILER OR PHOTONS WITH MIXED ENERGIES

EUGENE P. LIEF, PH.D., MARGIE A. HUNT, M.S., LINDA X. HONG, PH.D., and HOWARD I. AMOLS, PH.D.

Department of Radiation Oncology, Mount Sinai School of Medicine, New York, NY; Department of Medical Physics, Memorial Sloan-Kettering Cancer Center, New York, NY; and Department of Radiation Oncology, Montefiore Medical Center, Bronx, NY

(*Received* 17 *October* 2006; *accepted* 8 *February* 2007)

**Abstract—Radiation treatment of large intact breasts with separations of more than 24 cm is typically performed using x-rays with energies of 10 MV and higher, to eliminate high-dose regions in tissue. The disadvantage of the higher energy beams is the reduced dose to superficial tissue in the buildup region. We evaluated 2 methods of avoiding this underdosage: (1) a beam spoiler: 1.7-cm-thick Lucite plate positioned in the blocking tray 35 cm from the isocenter, with 15-MV x-rays; and (2) combining 6- and 15-MV x-rays through the same portal. For the beam with the spoiler, we measured the dose distribution for normal and oblique incidence using a film and ion chamber in polystyrene, as well as a scanning diode in a water tank. In the mixed-energy approach, we calculated the dose distributions in the buildup region for different proportions of 6- and 15-MV beams. The dose enhancement due to the beam spoiler exhibited significant dependence upon the source-to-skin distance (SSD), field size, and the angle of incidence. In the center of a 20 × 20-cm$^2$ field at 90-cm SSD, the beam spoiler raises the dose at 5-mm depth from 77% to 87% of the prescription, while maintaining the skin dose below 57%. Comparison of calculated dose with measurements suggested a practical way of treatment planning with the spoiler—usage of 2-mm "beam" bolus—a special option offered by in-house treatment planning system. A second method of increasing buildup doses is to mix 6- and 15-MV beams. For example, in the case of a parallel-opposed irradiation of a 27-cm-thick phantom, dose to $D_{max}$ for each energy, with respect to midplane, is 114% for pure 6-, 107% for 15-MV beam with the spoiler, and 108% for a 3:1 mixture of 15- and 6-MV beams. Both methods are practical for radiation therapy of large intact breasts.** 

*Key Words:* **Radiation therapy, Breast cancer, Beam spoiler, Buildup, Skin dose.**

## INTRODUCTION

For radiation therapy of breast carcinoma, it is standard practice to use tangential 6-MV x-ray beams. However, for patients with breast separation of 24 cm and larger, this technique can result in some regions receiving a dose of 115% of the prescription or higher. A more homogeneous dose distribution throughout the breast can be achieved with higher energy photons, *e.g.*, 15 MV; however, this delivers unacceptably lower doses in the buildup region (Figs. 1a and 1b). To overcome this disadvantage, many institutions[1–7] use beam spoilers with high-energy photon beams, to raise the dose in the buildup region while maintaining the homogeneous dose distribution throughout the rest of the treatment volume.

In some previous works,[8,9] Monte Carlo calculations were performed to assess dose in the buildup region due to the beam spoiler. Experimental verification of the results should be based on meticulous measurements of the dose in the buildup.[10–12] In some aspects, electron contamination from the beam spoiler is similar to that of a wedge, especially for large treatment fields.[13,14] Nevertheless, these devices are different, and in some instances (like head scatter), the wedges can absorb as much or more than they contribute.

This study takes a quantitative approach to the beam spoiler usage, exploring the dose distribution for various source-to-skin distances (SSDs), field sizes, and angles of incidence. First, we performed dose measurements in the buildup region of normal and oblique 15-MV beams with the spoiler, using water tank, ion chamber, and radiographic film. One purpose of these measurements was to find out how much the beam spoiler improves the dose distribution in the buildup region, depending on the field size and SSD. Another purpose was to collect data for construction of beam data tables of the "spoiled" beam in the treatment planning system and to test different methods of dose calculation in the buildup region. The ultimate purpose was to enable the treatment planning system to account for the presence of the spoiler in the beam. Several different approaches were tested for modeling the beam spoiler with the Memorial Sloan-Kettering Cancer Center (MSKCC) in-house treatment planning system.[15]

As an alternative for improving the dose inhomogeneity both in superficial regions and at depth, we studied usage of beams with mixed energies. The idea of

Reprint requests to: Eugene P. Lief, Ph.D., Assistant Professor, Department of Radiation Oncology, Christ Hospital, 176 Palisade Ave., Jersey City, NJ 07306. E-mail: ELief@cristhospital.org

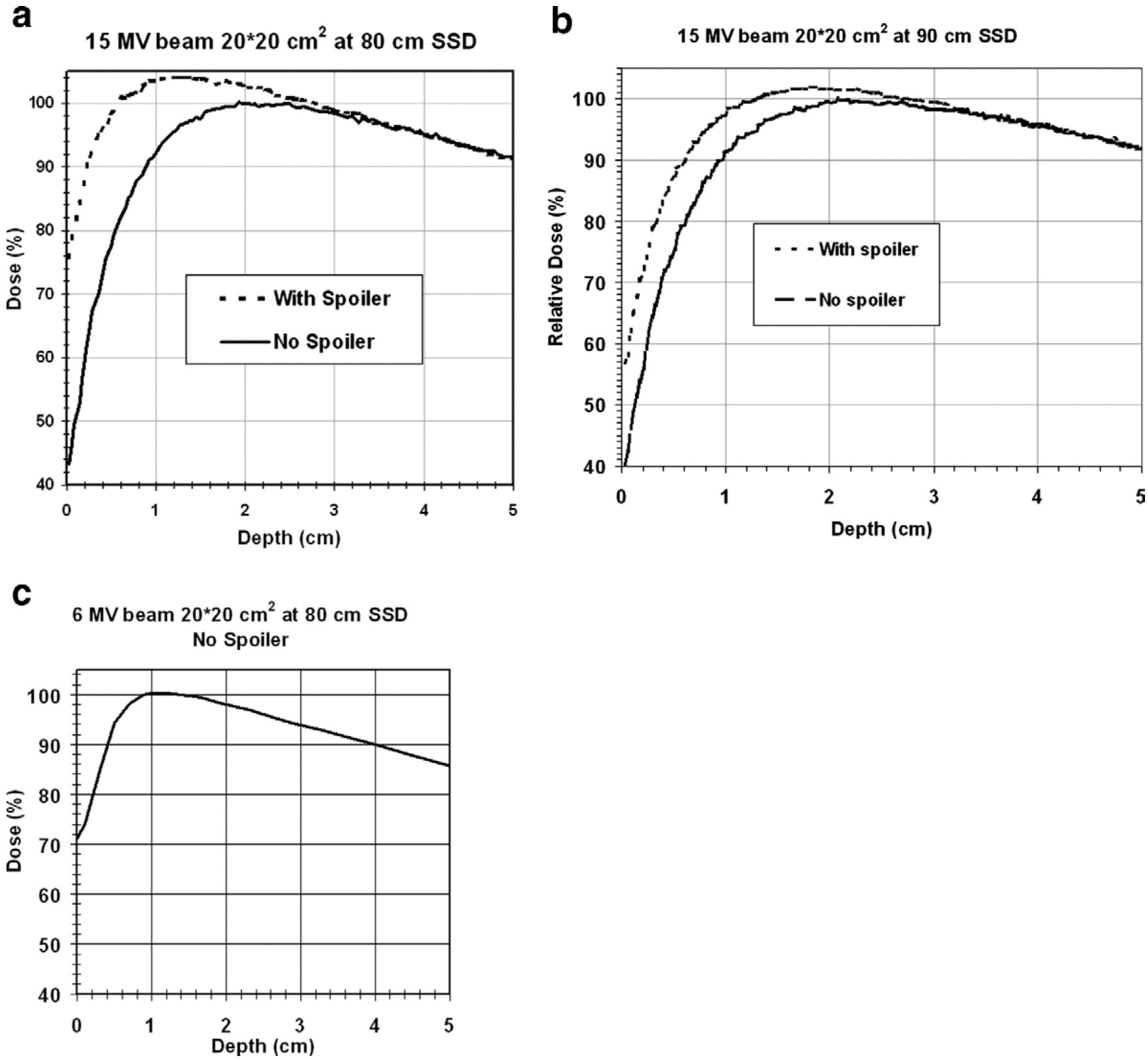


Fig. 1. Depth-dose curves in the buildup region for 6- and 15-MV beams 20 × 20 $cm^2$ at SSD of 80 and 90 cm with and without the beam spoiler. The measurements were performed for the normal incidence using a scanning diode in a water tank. (a) A 15-MV beam with the spoiler at 80-cm SSD (dashed curve) delivers a higher dose in the buildup than (b) a similar beam at 90-cm SSD (dashed curve); 15-MV beam without the spoiler (solid curve); and (c) 6-MV beam at 80-SSD (solid curve). Curves for "unspoiled" 6- and 15-MV beams are normalized to a 100% at their respective points of $D_{max}$, while the curves for 15-MV beams with the spoiler are normalized to coincide with the "unspoiled" beams at 5-cm depth, by correction for spoiler transmission factor = $(0.941)^{-1}$. Depth-dose curves for 15-MV beams with and without the spoiler measured at the same SSD coincide at all depths after 5 cm.

mixing different modalities for post-mastectomy chest wall irradiation was explored in a study[16] where the treatment was performed with electrons mixed with photons to achieve the desired dose distribution. In this study, we considered mixing high and low energies of photon beams for intact breast irradiation. We analyzed the dose distribution in the buildup region created by parallel-opposed photon beams with mixed energies of 6 and 15 MV incident on a rectangular phantom with large separation. By varying the proportions of the 2 energies in the mixture, one can change the magnitude of the hot spots as well as the dose distribution in the buildup region and possibly match the dose distribution created by the high-energy beam with the spoiler.

## METHODS AND MATERIALS

The principle of the beam spoiler operation is creation of secondary electrons with energies lower than maximum photon energy, similar to production of such electrons by a photon wedge.[13] These electrons deposit their dose at shallow depths in tissue, both within the photon field and outside it. Because of the nature of the scattering process, one could expect the additional dose deposited by electrons to have significant dependency upon the SSD, field size, and the angle of incidence. These preliminary considerations suggest the main directions for this study: additional dose in the buildup region, both in the field and outside it, as a function of SSD, field size, and the angle of incidence.