A DOSIMETRIC SUMMARY OF COMMON BOLUS MATERIALS

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ABSTRACT

Commercially available tissue equivalent bolus materials (SuperFlab, TX151 solidifying powder and Elasto-Gel) were evaluated for clinical build-up. Measurements were obtained for photon energies of 6MV, 10MV,and 18MV. Use, reproducibility of placement, and clinical life expectancy were evaluated, including changes in physical characteristics such as shrinkage and moisture content. Tests indicate that these three bolus materials closely mimic equivalent thicknesses of tissue if properly maintained. If proper handling of the material is not observed, irreversible adverse physical changes occur.

Solidifying powder rapidly dries out if not sealed, degrading tissue characteristics and flexibility. Elasto-Gel remains malleable throughout treatment and does not readily lose its moisture, however its physical and radiological characteristics show large changes if exposed to excessive moisture. Since Superflab is distributed sealed, the problem of changes due to moisture content was not observed. Clinically, all perform well as bolus, but for day-to-day use, the adhesive quality of the Elasto-Gel decreases setup time, conforms better and the placement is more reproducible.

Key Words: Bolus, Tissue Equivalence, Super Flab, Elasto-Gel

INTRODUCTION

Any material may be used as bolus if it has the following attributes: the ability to conform to the patient contour, it is relatively simple to place, and is simple to cut and shape. The purpose for incorporating bolus into a treatment plan is to deliver a higher percentage of the dose to skin than an open beam can deliver. The dosimetric data for several bolus materials was evaluated at three different photon energies, 6, 10, 18MV. The parameters of importance are 1. transmission data and 2. dose in the build up region, both of which may be needed to calculate treatment time / monitor units.

METHODS AND MATERIALS

In this study three different commercially available materials were evaluated. The three materials and their thicknesses were Superflab (5mm), Elasto-Gel (3mm & 5mm), and TX151 solidifying powder (7mm). Superflab is readily available through many commercial venders. Elasto-Gel is relatively new for use as a bolus and was originally designed as a wound dressing, available only through Southwest Technologies, Inc. The solidifying powder was purchased from Radiation Products Design, Inc.

In the build up region the doses change rapidly, and are extremely sensitive to the thickness and composition of the bolus material. Build up measurements were performed using the Marcus parallel plate chamber. A Velkly type correction[1] was applied to the individual sets of data. Open field percent depth dose was measured with RMI solid water concurrently to provide a standard by which to normalize the data. The detector centered in a 10cm x 10cm field at 100cm SSD. When bolus was added it was placed on top of the chamber, without disrupting the alignment. To obtain depth dose data, known thicknesses of solid water were placed between the bolus and the chamber maintaining 100cm from the source to solid water distance. Data was acquired from the surface to a nominal Dmax depth for 6, 10, and 18MV photons. To determine the actual bolus depth dose all values were normalized to the open field Dmax. A correction was applied to account for the energy sensitivity of the chamber. The correction factor is specific to our chamber. However, it was experimentally determined using Velkly methodology. Transmission data was acquired using a 10cm x 10cm open field as reference with the PTW farmer type chamber at nominal Dmax and the bolus material in question placed on top of the accessory tray.

RESULTS

Each of the materials tested had dosimetric properties similar to that of water. Buildup region doses and open field solid water relative doses are shown in Tables 1-3 and Figure 1-3. In all cases dose is greater than 100%, due to the finite sampling of data and the use of a nominal Dmax for normalization. The transmission data needed for monitor unit calculations can be seen in Table 4.

In order to evaluate the clinical utility of the individual materials, several relevant factors have to be considered. The factors which are of interest are conformability, reproducibility and ease of application. Conformability refers to the ability of the bolus to stay in contact with the patient over a wide variety of surface slopes. The Elasto-Gel conformed better then the other materials. Both Superflab and the solidifying powder have to be sealed, thus limiting the angle of curvature allowed. When this angle is surpassed, air gaps occur between the patient and the bolus. In all materials, the thinner the bolus the better the conformability, thus a more uniform dose is achieved under the material.

Reproducibility can be broken down into two areas of interest. First, the actual manufacturing of the material, and second the ability to position the bolus reproducibly in daily treatments. The constancy of the Elasto-Gel and the Superflab surpassed that of the solidifying powder. Both materials are commercially made and presumably have a quality control program in place, monitoring the material composition and thickness. TX151 powder is mixed in the department and can vary greatly. The amount of water added has the greatest effect on the density, but other variables are also important. To get a uniform bolus, the mixing and setup time should be consistent. The setup time is controlled by the temperature of the water. If the water is hot, the powder will settle during the cooling. If the water is too cold the material will setup before it is thoroughly mixed. This leaves areas of high and low density throughout the material, leading to a non-uniform dose below. The reproducibility of setup and ease of setup are related. Both the solidifying powder and the Superflab have to be taped in place. This adds to setup time and can cause compression to the bolus. The Elasto-Gel has an adhesive property which will hold it in place, thus patient setups are faster and more accurate.

The clinical life expectancy is defined as the length of time in which one piece of bolus can be used for patient treatments. The only material that actually degrades with time is the TX151 powder. Over time, the material loses its moisture content and becomes less flexible, increasing its overall density thus changing its dosimetric quality. The other two materials do not break down over time. The life expectancy is also determined by possible contamination. The Elasto-Gel was originally manufactured as a burn dressing that wicks moisture to it. With this characteristic it is not recommended that the same piece of material be shared between patients, but that each person will have a custom bolus. Depending on the condition of the skin surface the bolus may have to be changed over the course of the patient's treatments. The Superflab may be cleaned between patients, therefore allowing one sheet of bolus to be used for many cases. The material will keep the dosimetric quality as long as the external covering is not compromised.

CONCLUSIONS

A dosimetric evaluation of three commercially available bolus materials was performed. The study evolved three different energies and for several thicknesses of material. The materials evaluated were Superflab, Elasto-Gel, and TX151 solidifying powder. All three materials work well as bolus and are essentially water equivalent. Advantages and disadvantages were observed in the clinical implementation of using the different materials. Advantages are commercially made, adhesive, variable thickness. Disadvantages are short shelf life, variable density, and not reusable. Each material has it's own unique combination of properties which may make it superior for specific situations.

REFERENCE

1. D. E. Mellenberg, Jr., "Determination of buildup region over-response corrections for a Markus type chamber," Med. Phys. 17, 1041-1044 (1990)

FIGURE 1

6MV BUILD-UP CURVES FOR VARIOUS BOLUS MATERIALS

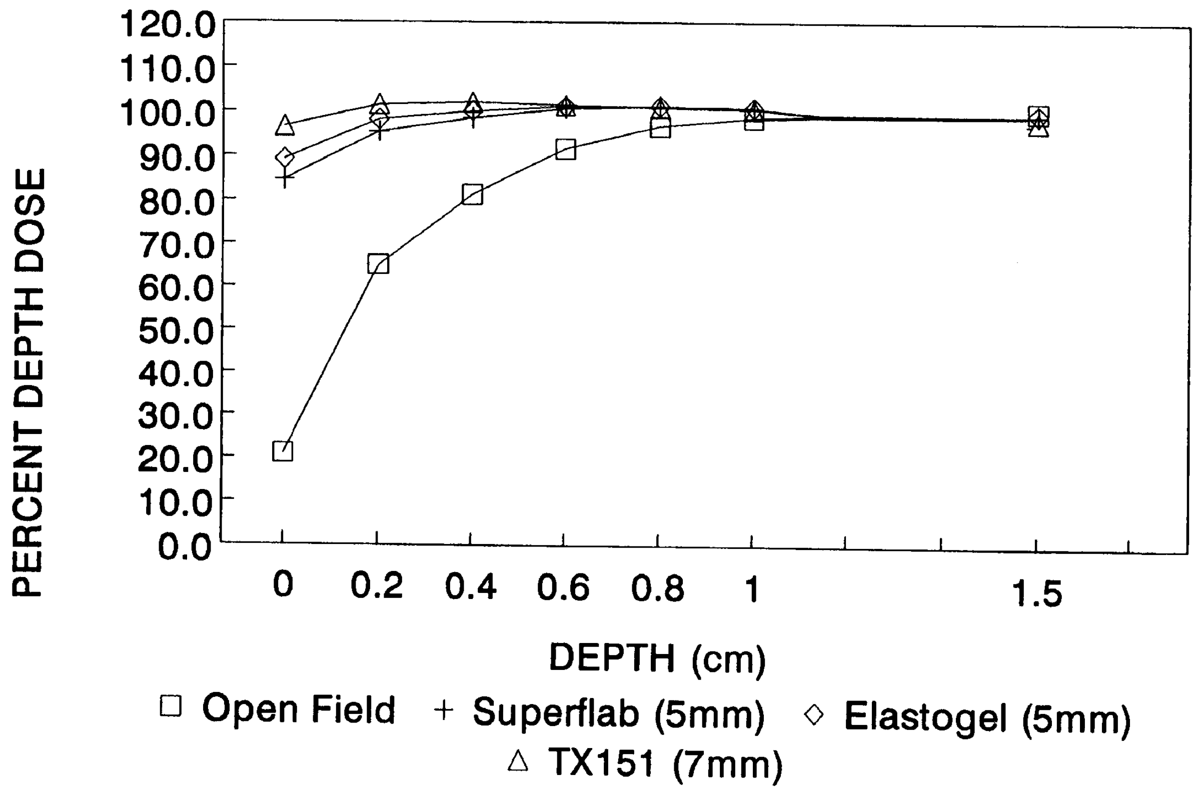


FIGURE 2

10MV BUILD-UP CURVES FOR VARIOUS BOLUS MATERIALS

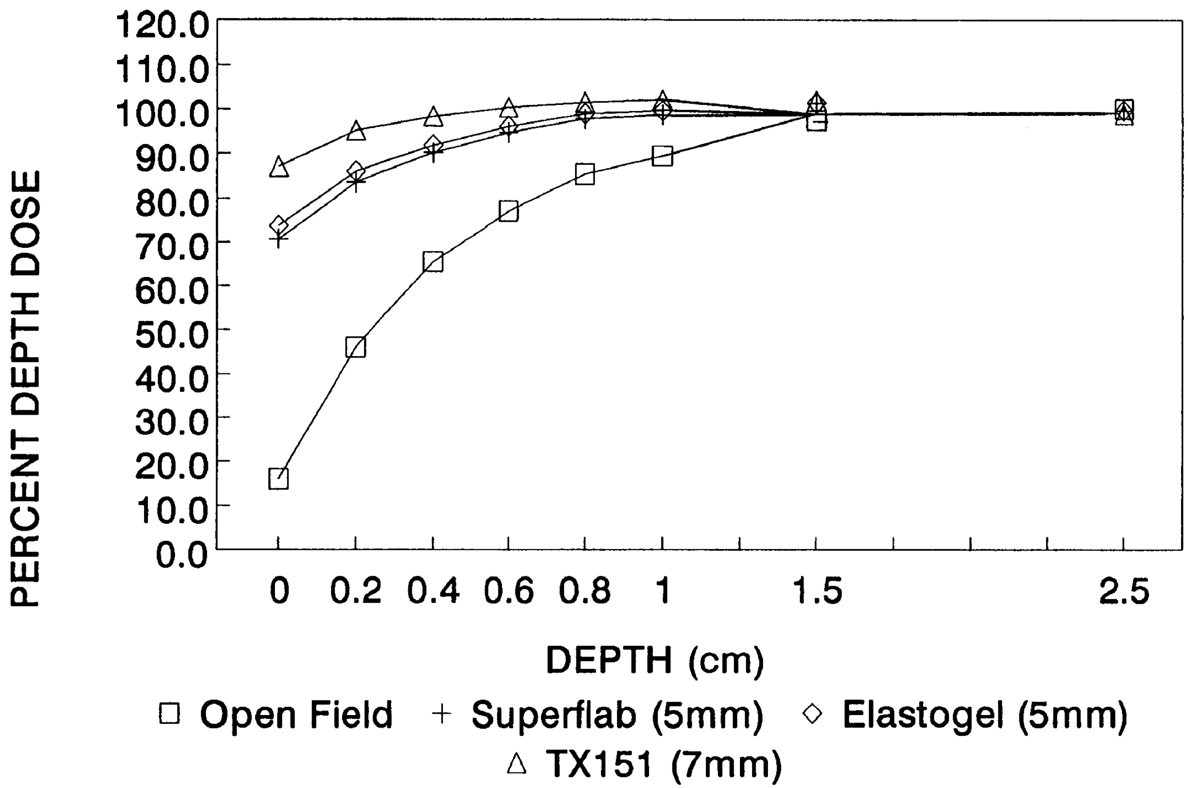
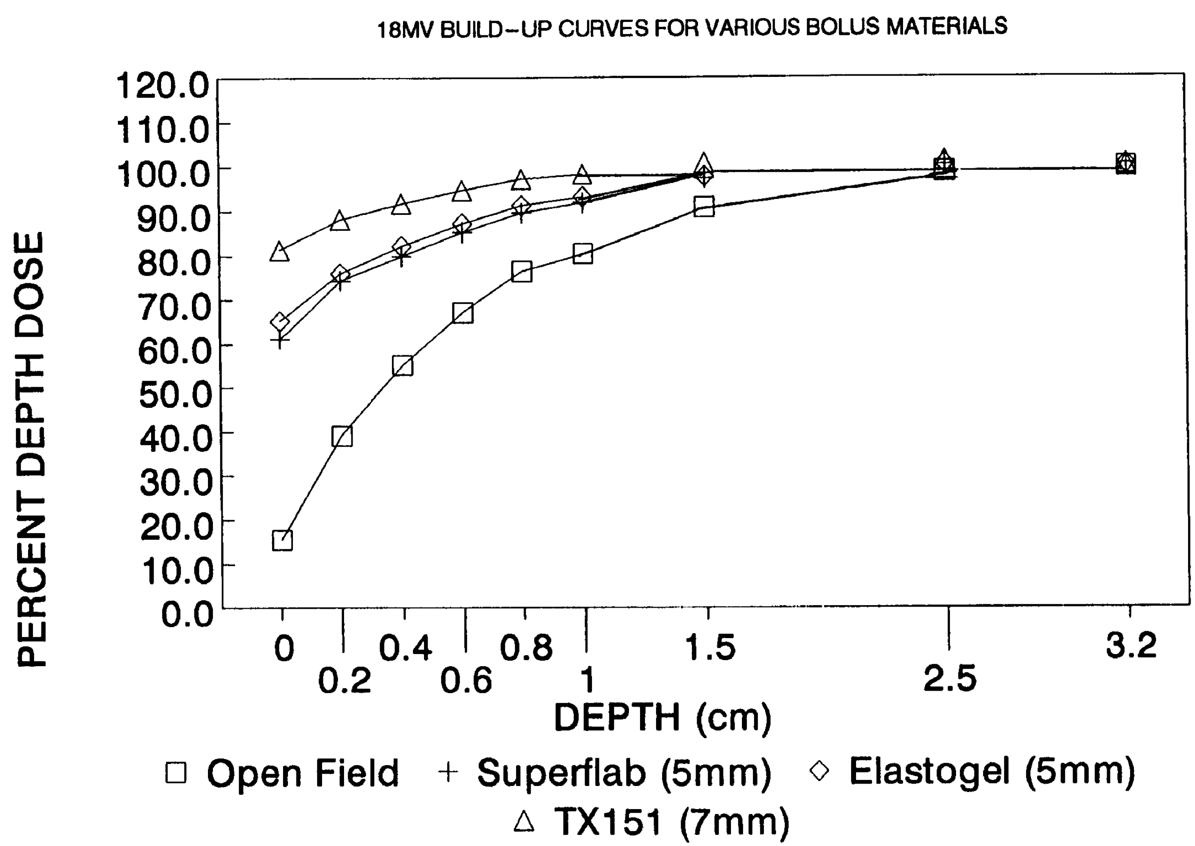


FIGURE 3



18MV BUILD-UP CURVES FOR VARIOUS BOLUS MATERIALS
PERCENT DEPTH DOSE
120.0
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
0.2
0.4
0.6
0.8
1
1.5
2.5
3.2
DEPTH (cm)
Open Field
Superflab (5mm)
Elastogel (5mm)
TX151 (7mm)

TABLE 1

VARIAN 2100C 6MV

DEPTH (cm)	OPEN FIELD	5 m m SUPERFLAB	3 m m ELASTOGEL	5 m m ELASTOGEL	7mm TX151	10mm ELASTOGEL
0.0	20.9	84.6	76.0	89.2	96.6	94.0
0.2	65.0	95.4	90.8	98.1	101.5	100.4
0.4	81.3	98.5	96.3	100.1	102.0	101.5
0.6	91.6	100.7	99.5	101.1	101.4	101.6
0.8	96.7	101.1	100.6	101.2	100.9	101.3
1.0	98.6	100.6	100.9	100.9	100.5	100.8
1.5	100.0	99.2	99.5	99.5	97.8	98.9

TABLE 2

VARIAN 2100C 10MV

DEPTH (cm)	OPEN FIELD	5 m m SUPERFLAB	3 m m ELASTOGEL	5 m m ELASTOGEL	7mm TX151	10mm ELASTOGEL
0.0	15.9	70.7	61.6	73.8	87.1	87.1
0.2	46.0	83.5	75.7	85.9	95.1	95.1
0.4	65.5	90.1	85.1	91.8	98.3	98.3
0.6	77.1	94.6	90.9	96.0	100.3	100.3
0.8	85.3	97.7	94.9	98.9	101.5	101.5
1.0	89.4	98.7	96.7	99.6	102.0	102.0
1.5	97.4	101.3	100.1	101.4	101.9	101.9
2.5	100.0	99.6	99.8	99.7	98.9	98.9

TABLE 3

VARIAN 2100C 18MV

DEPTH (cm)	OPEN FIELD	5 m m SUPERFLAB	3 m m ELASTOGEL	5 m m ELASTOGEL	7mm TX151	10mm ELASTOGEL
0.0	15.5	61.2	52.4	65.3	81.3	81.3
0.2	39.0	74.3	64.9	75.9	88.1	88.1
0.4	55.1	79.8	74.5	82.1	91.7	91.7
0.6	67.2	85.3	81.7	87.2	94.7	94.7
0.8	76.4	89.6	87.3	91.2	97.2	97.2
1.0	80.4	91.9	89.8	93.2	98.3	98.3
1.5	90.8	97.3	96.1	97.8	100.8	100.8
2.5	98.9	100.3	100.6	100.6	101.4	101.4
3.2	100.0	100.6	100.4	100.5	100.5	100.5

TABLE 4

TRANSMISSION DATA

6V

SUPERFLAB (5mm) =0.970
ELASTOGEL (3mm) =0.977
ELASTOGEL (5mm) =0.966
TX151 (7mm) =0.960

10MV

SUPERFLAB (5mm) =0.980
ELASTOGEL (3mm) =0.985
ELASTOGEL (5mm) =0.977
TX151 (7mm) =0.964

18MV

SUPERFLAB (5mm) =0.982
ELASTOGEL (3mm) =0.987
ELASTOGEL (5mm) =0.979
TX151 (7mm) =0.973