3D measurement of absolute radiation dose in grid therapy

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1. Introduction

Spatially fractionated radiotherapy through a grid is a concept which has a long history [1,2] and was routinely used in orthovoltage radiation therapy in the middle of last century to minimize damage to the skin and subcutaneous tissue [3–5]. With the advent of megavoltage radiotherapy and its skin sparing effects the use of grids in radiotherapy declined in the 1970s. However there has recently been a revival of the technique for use in palliative treatments with a single fraction of 10 to 20 Gy [6–10].

In this work the absolute 3D dose distribution in a grid irradiation is measured for photons using a combination of film and gel dosimetry.
repetition time (TR) of 2000 ms. Parameters included slice thickness of 5 mm, field of view $256 \times 256$ mm$^2$ and image size of $256 \times 256$ pixels resulting in voxels of $1 \times 1 \times 5$ mm$^3$.

![Image](image1.png)

**Figure 1.** The grid (left) and the grid mounted on an Elekta SL25 linear accelerator (right).

### 3. Results

The irradiated gel phantom is shown in figure 2a, and figure 2b shows the 25 % and 75 % isodose contours taken from the MRI images. Contours resulting from film measurements of the depth-dose along the central axis and cross-beam profile at $d_{\text{max}}$ are shown in figures 2c and 2d respectively. Results indicate that the main source of dose in the ‘shaded’ areas of the grid is the divergence of the primary beam and its multiple penumbrae.

Figure 3a shows percentage depth-dose data along the central axis, which corresponds to an open hole in the grid. Figure 3b shows the proportional increase of open field central-axis percentage-depth data when compared to that of a grid field. The results indicate that the minimum dose under the shielded portions of the grid is between 20 and 30% of the peak grid dose at a given depth. As the spacing between the divergent holes increases with depth, the greater contribution of scattered radiation compensates for the penumbral overlapping near the surface (at $d_{\text{max}}$).
**Figure 2.** Photograph of the irradiated gel phantom (a), 25 % and 75 % isodose surfaces from the gel dosimeter (b), isodose plot through the central axis from film (c) and cross beam profile at dmax from film (d).

**Figure 3.** Central axis depth-dose data for open field and grid field (a). Results of open field percentage depth-data divided by grid field percentage-depth data (b).
4. Conclusion

Grid therapy is considered to offer significant therapeutic advantages over conventional radiotherapy, particularly for palliative treatments [9,11]. This work has shown that when planning for a treatment through a grid, careful consideration must be taken of the very different dosimetry characteristics of the irradiated volumes compared to open field treatments.

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References

[1] Kohler H 1909 Zur Roentiefentherapie mit massendosen MMW 56 2314–6
[2] Liberson F 1933 The value of a multi-perforated screen in deep x-ray therapy Radiology 20 186–95
[3] Jolles B 1949 The study of connective tissue reaction to radiation: The sieve or chess method Br. J. Cancer 3 27–31.
[4] Mark H 1950 A new approach to the roentgen therapy of cancer with the use of a GRID J. Mt Sinai Hosp. 17 46–8
[5] Mark H 1950 Clinical experience with irradiation through a GRID Radiology 58 338–42
[6] Mohiuddin M, Curtis D L, Grizos W T and Komarnicky L 1990 Palliative treatment of advanced cancer using multiple nonconfluent pencil beam radiation Cancer 66 114–8
[7] Reiff J E, Huq M S, Mohiuddin M and Suntharalingam N 1995 Dosimetric properties of megavoltage grid therapy Int. J. Radiat. Oncol. Biol. Phys. 33 937–42
[8] Mohiuddin M, Fujita M, Regine W F, Megooni A S, Ibbott G S and Ahmed M M 1999 High-dose spatially-fractionated radiation (grid): A new paradigm in the management of advanced cancers Int. J. Radiat. Oncol. Biol. Phys. 45 721–7
[9] Lin K, Huang C, Lin J and Chu T 2002 Surface dose with grids in electron beam radiation therapy Appl. Radiat. Isotopes 56 477–84
[10] Zwicker R D, Meigooni A and Mohiuddin M 2004 Therapeutic advantage of grid irradiation for large single fractions Int. J. Radiat. Oncol. Biol. Phys. 58 1309–15
[11] Fong P M, Keil D C, Does M D and Gore J C 2001 Polymer gels for magnetic resonance imaging of radiation dose distributions at normal room atmosphere Phys. Med. Biol. 46 3105–13