Clinical applications of gel dosimeters

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Abstract. This short communication raises some issues regarding the use of gel dosimeters in a clinical setting. Further, the need for improvements to attract future interest is discussed. The gel dosimetry method is unique owing to its 3D properties. This is not fully utilised in the present publications. New methods to evaluate and compare dose distributions are needed to further develop the dosimeter gel systems. Undoubtedly there is a continuous need for 3D dosimetry as radiation therapy applications become more and more complex.

1. Introduction
The potential for a dose image read-out of a radio-sensitive gel volume and thereby the possibility to undertake true 3D dosimetry in clinical applications has attracted a great interest. As stated more than 15-years ago, gel dosimetry is a totally non-invasive and non-destructive method, since the dosimeter gel phantom itself forms the detector-a feature not shared with any dosimetric system [1].

This short communication raises some issues regarding the use of gel dosimeters in a clinical setting. Further, the need for improvements to attract future interest is discussed. For a complete review please refer to previous DOSGEL proceedings.

2. Development of the gel dosimeter method for clinical applications
The development of gel dosimetry must be twofold, basic investigations and feasibility studies to find the suitable applications where gel dosimetry puts extra value into the quality assurance procedure (Figure 1, from reference [2]).

Today several new applications that would benefit from 3D dosimetry can be added to right in Figure 1. One example is dynamic arc therapy, which could include variations in gantry angles, MLC movement, MLC speed, and dose rate. Further, various gated treatments that involve the problem of a moving target and deliberately interrupted beams introduce delicate problems for conventional detector methods.
Figure 1. In order for gel dosimetry to become a standard tool for 3D verification in radiotherapy a number of areas should be investigated (left). There are a number of clinical applications for which such a system could be highly suitable (right).

It is difficult and often unfair to compare the uncertainty of a volumetric dosimetry method with traditional detectors. However, there is a lack of benchmarking studies to help the users understand what can be achieved when using gel dosimetry. As with all detectors there are inherent limitations and uncertainties. Despite this, a gel measurement could be of great value even with a relatively poor standard uncertainty. This can be accepted as the combined attractive features of the method, as the potential for high-resolution dosimetry with an excellent geometric integrity and volumetric dose determinations, add new measured information regarding the evaluated clinical applications.

To put the development into perspective two studies from our group will serve as examples. One of the first quantitative studies where gel data was compared with treatment planning data in a clinical application (Gamma Knife) was presented in 1992 [3] (Figure 2).

Figure 2. MR image (left) and relative dose profiles (right) through the isocenter in the Gamma Knife application from 1992 (o calculated, ▲ measured).
From this study the size of the target and the geometric positioning in 2D could be determined. However, one can note the large scatter in the data points. More recent stereotactic data include volumetric evaluations as comparisons of calculated and measure dose volume histograms, gamma distributions, isodose volumes and traditional dose profiles in three dimensions [4] (Figure 3).

**Figure 3.** Absorbed dose profiles through the isocenter for a stereotactic application from 2008 (— calculated, • measured). The X axis shows the lateral, Y the anterior-posterior and Z the cranial-caudal direction. The gray vertical lines in each plot mark the extension of the planning target volume (PTV). Zero is the isocenter position on each plot.

In addition to the obvious improvement of the data uncertainty, the introduction of an independent method to normalize the gel data allows for an absolute absorbed dose comparison (in Gy). Gel dosimetry cannot be expected to alone solve all dosimetry problems and this is particularly true if the uncertainty level should be preserved. The combination of several dosimetry methods is needed to accomplish a safe and effective process when for example commissioning new treatment techniques.

**3. Future aspects**

Undoubtedly there is a continuous need for 3D dosimetry as radiation therapy applications become more and more complex. The publication rate and the citation frequency (gel dosimetry/Web of Science (ISI)) indicate that the research area has been at a relatively high and constant level during the last recent years (Figure 4).

**Figure 4.** Citation frequency of publications matching the search criteria “gel dosimetry”(Web of Science (ISI), September 2008).
To continue to attract the interest of clinical active medical physicists and researchers there are some important issues to be aware of when using gel dosimetry in clinical applications:

- Use the gel systems in relevant situations where the 3D properties are of importance.
- Combine with traditional detector systems.
- Published “good practice” strategies should be followed.
- Be aware of, or when possible avoid, the limitations of the specific gel system used (dose rate, fractionation, LET etc).

Some of the important future aspects to be addressed by the gel dosimetry community include:

- Development of new 3D dose/volume comparison methods.
- Development of new improved, non-toxic gel compositions.
- Reporting of relevant uncertainty estimations (c.f. [5] and references therein).
- The use of anthropomorphic phantoms.

References
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