Head and neck field matching verification using three dimensional PAGAT polymer gel dosimetry

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1. Introduction
Independent jaw collimation on modern linear accelerators allows matching of non-diverging field edges (laterals and anterior) when using head and neck treatment techniques. It is a common practice to split a head and neck cancer radiotherapy treatment volume into two separate abutting mono-isocenter fields because the treatment volume lies above and below the line of the shoulders. In a standard three field technique parallel-opposed lateral fields are used to treat the primary tumour site, upper and mid-cervical nodes and a single anterior field is used to treat the lower neck and superior mediastinal lymph nodes. If these fields are non-diverging fields, there is a possibility of creating an under dose or over dose region at the junction of the abutting fields. Film dosimetry is the currently accepted tool for verification of non-diverging field matching [1]. The purpose of this study was to evaluate the suitability of the PAGAT polymer gel dosimeter as a tool for verification of the dosimetric match of non-diverging field junctions of a mono-isocenter setup.

2. Materials and Methods
The PAGAT polymer gel was manufactured [2] and poured into a cylindrical phantom of diameter 9 cm and 20 cm length. A control phantom for each separate field arrangement was also used. The polymer gel phantom was placed inside a water tank so that the center of the phantom was at the isocenter of the linear accelerator of a known depth. In all exposures dose to the center of the non-diverging field at measurement depth was 5 Gy [2]. A 6MV beam from a Varian Clinac 2100C/D was used for irradiation throughout the experiment. First, a single non-diverging field penumbra region along the central axis was investigated. The beam profiles across the penumbra region were determined using the PAGAT gel, IC-10 ionization chamber, film, and diode. This methodology was repeated for two adjoining mono-directional non-diverging fields and head and neck orthogonal fields.
The profile across the junction of the non-diverging head and neck orthogonal fields was simulated using an ADAC Pinnacle treatment planning system. The head and neck orthogonal non-diverging field arrangement for gel phantom is shown in figure 1a. The exposed gels were imaged using Vision 1.5T MRI scanner (Siemens, Germany) using a circularly polarized head coil. All images were acquired in coronal plane with the selected slice being transaxial through the phantom. T2 weighted imaging was performed using a multiple spin-echo pulse sequence with 64 equally spaced spin-echoes with a TE of 20 ms, TR of 5000 ms, slice thickness of 10 mm, matrix size of 256 x 256, FOV 220 mm in both the frequency and phase encoding directions with one acquisition [3]. The base images were transferred to a personal computer. T2 and R2 maps were computed using modified radiotherapy gel dosimetry image processing software [4] (figure 1b) coded in MATLAB (The Math Works, Inc, USA). R2 (1/T2) profiles across the asymmetric fields at the isocenter were derived (figure 2).

3. Results and Discussion

Measured D80 - D20 widths for single asymmetric non-diverging field profiles are presented in Table 1. D80 - D20 widths for film, diode, and gel profiles coincided within 0.90 mm except for that of the diode. The maximum difference is associated with the lateral electron disequilibrium due to volume effects [5,6]. Penumbra widths of the polymer gel and film fall within that of diode and IC-10 chamber. The FWHM across the non-diverging mono-directional asymmetric field junction show a minimum relative dose of diode in the under-dose region of 11.5 %, 10.4 %, and 12.1 % less than that of the gel, film, and IC-10 chamber respectively. The diode has the highest spatial resolution and exhibits little volume effects as seen with the IC-10. The FWHM profile was observed to be 6.10 mm and 5.70 mm higher than that of gel and film respectively. The FWHM across the non-diverging orthogonal head and neck field junction are also given in Table 1. The FWHM of the PAGAT polymer gel and film were found to be within 0.5 mm. The maximum difference between gel and Pinnacle treatment planning system simulated profiles was 7 %. Differences are associated with several factors such as CT voxel limitation (1 mm³), the size of the detector used for measurement of modeled profiles in the Pinnacle treatment planning system.
4. Conclusions
Film can be replaced by PAGAT polymer gel dosimeters for verification of field matching for non-diverging fields, and has an advantage of non-directional dependence of the sensitivity. The diode has superior dose resolution but is not useful in head and neck orthogonal field measurement.

### Table 1. Measured D_{80} - D_{20} widths for single asymmetric non-diverging field profiles.

| Dosimeter            | Single Field D_{20} - D_{80} ±ΔD_{20} - D_{80} (mm) | Adjoining Fields FWHM ± ΔFWHM (mm) | Head and Neck Fields FWHM ± ΔFWHM (mm) |
|----------------------|------------------------------------------------------|------------------------------------|----------------------------------------|
| IC-10 Ionisation Chamber | 8.15±1.14                                           | 8.5±0.4                            |                                        |
| Gel                  | 5.38±1.00                                            | 2.4±0.1                            | 2.4±0.5                                |
| Film                 | 6.01±1.14                                            | 2.8±0.1                            | 2.8±0.2                                |
| Diode                | 5.15±1.14                                            | 3.0±0.1                            |                                        |

5. References
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