printed boluses. Gafchromic EBT3 film (International Specialty Products, Wayne, NJ) placed between phantom slabs provided dose profile measurements. An Epson Expression Scanner 10000 XL (Epson, Long Beach, CA) was used to determine the optical density of the films and film analysis were performed using Film QA Pro software (Ashland Inc., Bridgewater, NJ).

Results: The mean value of Hounsfield unit (HU) of the 3D printed boluses was provided analyzing their Computed Tomography (CT) scans. Negative HU were due to the air gap inside the infill pattern. The mean HU increased with the percentage infill, resulting in higher bolus density (Tab. 1). This reduced the distance from the surface of the phantom where the maximum dose occurs (dmax) as shown in Fig.1. Build-up peaks shifted towards the phantom surface when any bolus was used. ABS and PLA boluses with an infill percentage of 40% had comparable performance to the commercial bolus.

	%infill	HU	density [g/cm³]	d_{max} [mm]
no Bolus	--	--	--	16.9
commercial Bolus	--	0	1.0	7.4
ABS	10	-694.0	0.28	10.6
	20	-593.8	0.39	9.4
	40	-393.5	0.60	5.6
	60	-166.5	0.87	0
PLA	10	-629.7	0.35	14.5
	20	-492.5	0.49	11.6
	40	-245.2	0.78	9.2
	60	-51.2	0.97	0
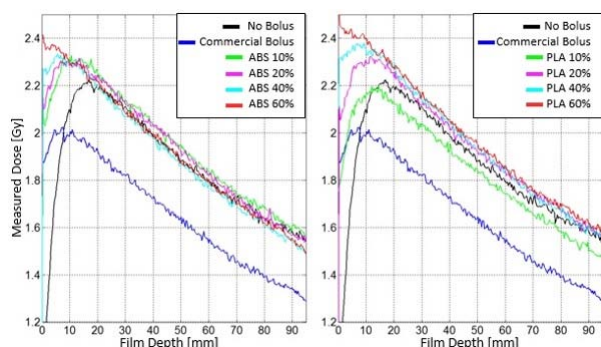
Conclusion: The dosimetric analysis of the 3D printed flat boluses showed that they can decrease the skin-sparing as a commercially available bolus. The performed analysis accurately describes the physical behavior of these plastic materials, in order to represent them in treatment planning system for precise treatment delivery. Moreover, patient-specific boluses could be outlined from patient CT images and 3D printed, thus shaping the actual anatomy of the patient. This procedure may represent a viable alternative to commercially available conventional boluses, potentially improving the fitting between bolus and skin surfaces.

EP-1948
Multicentre comparison for small field dosimetry using the new silicon diode RAZOR

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Purpose or Objective: Multicentre comparisons of dosimetrical parameters are important to ensure the same quality of the treatment in radiotherapy centres, and allow to identify systematic errors. In this study, small fields dosimetric parameters were collected in a national context using a common acquisition procedure and a specific dosimeter. The aim of this study was to provide indicative values for each Linac model for small field dosimetry measurements. This can be useful for centres with reduced experience in small fields dosimetry.

Material and Methods: Thirty-four centres with different LINACs joined this project: 2 Siemens, 7 Elekta Agility, 6 Elekta Beam Modulator, 12 Varian CLINAC and 7 Varian TrueBeam. All measurements were performed using the new IBA unshielded silicon diode RAZOR and the Stealth flat ionization chamber fixed on the gantry as reference. The RAZOR was positioned at 10cm depth in water phantom and SSD=90cm. In and Cross-line beam profiles ranging from 0.6-5cm (nominal field size). The actual in-plane (I) and cross-plane (C) FWHM were considered to calculate the effective field size, defined as (A*B)^0.5. Ouput factors (OF) were calculated and normalized to the 3x3 cm2. OF were calculated for both nominal (OF_N) and effective (OF_E) field sizes. The penumbra width was defined as the distance between the 80% and 20% isodose levels. Two identical diodes were adopted to speed up the data collection.

Results: OF_N were in agreement over the different models up to 1x1 cm2 field size. Higher agreement was obtained with OF_E, for the smallest fields different trends were obtained depending on vendors and models, see Fig.1. Penumbra measurements were in agreement each other for each field size and accelerator model.

Output Factor SSD=90cm d=10cm
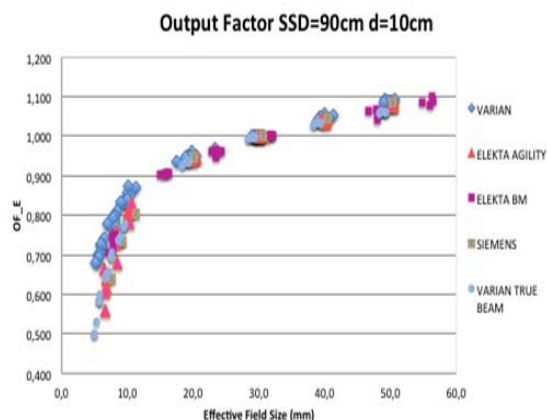
Conclusion: This study shows an high consistency of small field dosimetry in the involved radiotherapy departments using this new generation silicon diode; consequently, the values reported may actually be used by other centers as indicative values, especially in the case of small fields when suitable detector are not commonly available. Moreover, these results confirm that the new RAZOR silicon diode can be used to assess dosimetric accuracy in small-field delivery. In general, the adopted methodology removes much of the ambiguity in reporting and interpreting small field dosimetric quantities and facilitates a clear dosimetric comparison across a population of linacs.

EP-1949
Developing a Radiotherapy Quality Assurance programme as part of the HIPPO trial (NCT02147028)
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Purpose or Objective: Outlining of target and OAR volumes is integral to the radiotherapy process but inherently subject to variability. The hippocampus is a small structure not commonly contoured by clinicians requiring considered anatomical interpretation in its delineation. HIPPO is a randomised phase II trial of Hippocampal Sparing (HS) versus Conventional Whole Brain Radiotherapy after surgical resection or radiosurgery in favourable prognosis patients with 1-4 brain metastases. We set out to inform the development of a dedicated HIPPO RTQA programme through evaluation of hippocampal contouring.

Material and Methods: Two clinical oncologists from different UK radiotherapy centres and a radiologist from each centre independently outlined the hippocampus on 2 different 1 mm slice thickness planning CT datasets after registration with the T1 weighted gadolinium enhanced MRI (3D volumetric MRI, axial acquisition, 1 mm slice thickness, no slice gap, 1 x 1 x 1 mm voxels) on their planning system. The datasets were re-registered by one of the centres. The four hippocampal contours for each case were anonymised and reviewed collectively and a gold standard contour defined. We compared each contour with its respective gold standard using the DICE coefficient and volume difference.

Results:

Table 1

Outliner	Case 1 DICE similarity coefficient	Case 1 Volume difference (cm³) between outline and gold standard.	Case 2 DICE similarity coefficient	Case 2 Volume difference (cm³) between outline and gold standard.)
1	0.84	0.05 (-1%)	0.79	1.9 (+26%)
2	0.83	0.5 (+8%)	0.86	1.01 (+15%)
3	0.87	0.15 (+3%)	0.75	0.41 (+7%)
4	0.81	0.5 (+8%)	0.81	0.75 (-13%)

Conclusion: Reasonable concordance of the outlines in comparison to the gold standard was achieved in both cases. In case 1, all 4 outlines achieved a DICE coefficient greater than 0.80 and a hippocampal volume less than 0.5cm3 different to the gold standard. However, in case 2, despite DICE coefficients greater than 0.79 suggesting good spatial relationship between the clinicians' and the gold standard contour, greater variability was evident with a larger range in volume outlined. During collective review, some systematic differences were noted between the two participating centres' outlines, despite a high level of agreement on hippocampal boundaries during the review, highlighting CT-MRI co-registration as a potential source of variability between different centres and planning software. As a result of these findings, the pre-trial outlining benchmark case requires all centres to independently co-register the CT and MRI images and export the registration object as part of data submission. In order to comprehensively quality assure hippocampal outlining as part of the HIPPO RTQA programme, an on-trial component of the first two HS patient contours being reviewed prospectively before treatment is also undertaken. The implementation and quality assurance of less familiar outlining practice in the development of radiotherapy techniques requires careful consideration. This process has informed the development of a dedicated RTQA programme for the HIPPO trial highlighting the importance of aligning QA with clinical practice. HIPPO is funded by Cancer Research UK and The Brain Tumour Charity

EP-1950
Monte Carlo dose calculation of Viewray hybrid MRI-Co60 radiotherapy system: a repeatability study
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Purpose or Objective: The ViewRay MRI-Co60 hybrid system (MRIdian® [1,2]) is a novel technology that provides soft tissue imaging during radiotherapy thus allowing real adaptive radiotherapy possibilities and image guidance. The combination of Co60 with 0.35 Tesla MRI allows for MR-guided intensity modulated radiation therapy (IMRT) step and shoot delivery with multiple beams (3 Co60 heads 120° apart). MRIdian dose calculation takes advantage of a full Monte Carlo-based algorithm. The aim of this work was to evaluate the repeatability of the dose calculation of MRIdian plans for rectal cancer treatments.

Material and Methods: Ten patients affected by locally advanced rectal cancer (cT3-cT4; cN0, cN+) were manually segmented on Eclipse TPS v11. MRIdian step and shoot IMRT plans (7 groups of 3 fields each) were calculated 5 times for each patient. The prescribed dose for PTV2 was 45 Gy and 55 Gy for PTV1 through simultaneous integrated boost. The PTV1 V95, the conformity index CI [3] and the Wu's homogeneity index HI were computed for each patient. The coefficient of variation (CV), defined as the ratio of the standard deviation to the mean, was calculated for each set to express the precision and repeatability of the Monte Carlo dose calculation. The estimated beam-on time was also recorded for each plan.