Severe late toxicity involving the lungs, kidneys and thyroid was relatively low. The risk of second cancers was acceptable. Our study indicates that this approach is both safe and effective.

84 A 3D OPTICAL SCANNER FOR IMAGE ACQUISITION IN 3D PRINTING- OPTIMIZING IMAGE ACCURACY THROUGH THE DEVELOPMENT OF AN IN-HOUSE DESIGNED GANTRY

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Purpose: The use of 3D printing for medical use is well established and has been utilized in clinical practices ranging from surgical planning to individualized medical implants. Three-dimensional printing has been implemented at our institution to create customized treatment accessories such as shielding and immobilization. In order to use 3D printing, the topography of the patient must first be acquired. We have previously achieved this using resource intensive methods such as a plaster mould or a CT scan. Recently, 3D scanners have been developed which are low cost (~$500), and can quickly acquire both the topographical and texture information of a patient. These scanners use methods such as structured light in order to construct accurate 3D models in minutes. We have characterized a structured light 3D scanner (3D Systems Sense), and have designed and built a scanning gantry in order to assess the clinical viability of this technology.

Methods and Materials: The gantry consists of a circular hoop formed from square aluminum tubing, with a diameter of 126.5 cm. The optical scanner is mounted to an arm that can be moved isocentrically along the circumference of the hoop. The scanner-to-surface distance is adjustable to accommodate differently sized regions of the body. The gantry can tilt with respect to the patient table, allowing for acquisition of topography from virtually any direction. The gantry was built in-house with a total cost of about $500.

An anthropomorphic head phantom was used to quantify the accuracy of the gantry-mounted 3D scanner. Meshes acquired using the 3D scanner were compared to a mesh generated from a high resolution CT scan, which was taken to be the gold standard. Optimal scan settings were identified and final assessment of the accuracy of the scanner was quantified using the Hausdorff distance between the two meshes.

Results: The in-house gantry enabled quick and easy acquisition of patient topographical information with a low cost 3D scanner. Acquisition was much easier than using the scanner free-hand. The mean Hausdorff distance was typically found to be less than 0.5 mm, with maximum errors in the range of 1-2 mm. This was deemed to be clinically acceptable and the scanner has been used to design treatment accessories for several skin cancer patients.

Conclusions: Through a collaborative and innovative approach, an optical scanner gantry has been developed which can quickly, easily and accurately acquire topographical information. This information can then be used to design customized treatment accessories for many different treatment sites and modalities, including bolus and immobilization for both photon and electron treatments and shielding for orthovoltage treatments. The gantry is very lightweight and easy to store.

85 CAN VMAT IMPROVE CONFORMALITY WHILE MAINTAINING KIDNEY DOSE FOR SEMINOMA PATIENTS

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Purpose: To evaluate the use of VMAT planning techniques for para-aortic and ipsilateral pelvic irradiation in seminoma patients, driven by standard kidney contours and automatically generated concentric rings about the PTV.

Material and Methods: Ten seminoma patients with small volume retroperitoneal nodes (< 5 cm) were randomly selected. CTV1 included the gross tumour plus a 5 mm margin, and CTV2 was contoured based on an expansion of blood vessels. PTV was defined by addition of 5 mm margin around the corresponding CTV, with PTV1 extending from 2 cm below the top of kidney to the top of femoral head, and modified to exclude both kidneys. The prescription dose (in 20 fractions) was 25 and 35 Gy for PTV1 and PTV2 respectively. Abdominal and pelvic organs at risk (OAR) were contoured. For each patient, a conformal (AP-PA, 18 MV) and VMAT (two 360-degree coplanar arcs, six MV, 15-degree collimator twist) plans were created. Dose constraints for the VMAT optimization were D2% for abdominal and liver (D50% < 350 cGy, max EUD < 350 cGy), 2Gy/10Gy, and D50% = 18 Gy cGy, D2% = < 500 cGy) for other structures. VMAT reduced the volume of normal tissue receiving 5% of the prescribed dose by 11% to 2%, compared to the conformal AP-PA plans (p = 0.005). Kidney D2% was reduced by 6Gy with VMAT (p = 0.03), while the kidney D50% was 1.3 Gy higher (p = 0.01). There was no significant difference in D2% for either heart or pancreas. VMAT reduced spinal cord dose: D2% (28.2 Gy +/- 2.2 versus 32.2 Gy +/- 4.4, p = 0.02) and D50% (12.6 Gy +/- 8.7 versus 19.8 Gy +/- 7.4, p = 0.01), and reduced the D2% for bone marrow (p = 0.01), large bowel (p = 0.05) and stomach (p = 0.05) but not for bladder or liver. Conversely, the conformal APPA resulted in lower D50% to bone marrow (p = 0.01), large bowel (p = 0.05), stomach (p = 0.01), bladder (p = 0.05) and liver (p = 0.05).

Conclusions: It is possible to generate organ-sparing VMAT plans with only the kidneys and automatically generated concentric PTV rings included in the optimization process. Use of VMAT for para-aortic/pelvic irradiation improves the conformity of the isodoses to the PTV and reduces the maximum dose to the surrounding OAR, but at the cost of an increase in the low dose region.

86 USING OPTICAL SCANNER AND 3D PRINTER TECHNOLOGY TO CREATE LEAD SHIELDING FOR RADIOTHERAPY OF FACIAL SKIN CANCER WITH LOW ENERGY PHOTONS: AN EXCITING INNOVATION

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Purpose: Treatment of non-melanoma skin cancers of the face using ortho-voltage radiotherapy may require lead shielding to protect vulnerable organs at risk (OAR). As the human face has many complex and intricate contours, creating a lead shield can be difficult. The process can include creating a plaster mould of a patient’s face to create the shield. It can be difficult or impossible for a patient who is claustrophobic or medically unable to lie flat to have a shield made by this technique. Other methods have their own shortcomings. We aimed to address some of these issues using an optical scanner and 3D printer technology.

Methods and Materials: The clinicians identified three patients with skin cancer involving the nose who required treatment with low energy photons and would benefit from lead shielding. Marking was made on these patients to define the field. Optical images of these patients were acquired using a consumer-grade optical scanner (3D Systems, Sense). A 3D model of each patient was processed with mesh editing software (Autodesk, MeshMixer v2.9) before being exported as an STL file to software controlling the printer (Repetier-Host). A positive model of each face was printed using polyactic acid on a consumer-Grade 3D printer...
(MakerGear, M2). The infill settings were chosen so that the resulting models would be very rigid and durable. Using a hammer, a 3 mm thick, layer of lead was bent to fit the contours of the model. A hole was then cut out to define the field, and the lead was clear coated.

**Results:** The lead shields created were remarkably accurate and fit the contours of the patients. The hole cut to define the field exposed only a minimally sized site to be irradiated. The rest of the face, including vulnerable OAR, were protected. The length of time during which the patient’s presence was required was minimal, as was the time spent by staff to create the mask.

**Conclusions:** Using this technology to create lead shielding for radiotherapy of skin cancer of the face is an innovative and exciting approach. This could save valuable clinic time and add patient convenience. Some traditional methods require an extra appointment to create a facial mould. The optical scan can be obtained on the day of the visit with no subsequent visit required until first treatment. If there are issues generating the lead shield the patient doesn’t need to come in for another visit; the saved 3D optical image can be used to generate another lead shield. The cost of manufacture is also low; centres, such as those in the developing world that may not have the infrastructure to treat skin cancer with electrons could use this method to safely deliver ortho-voltage treatments. A significant number of patients suffer from claustrophobia, and this could be addressed by using this technology.

### 87 CAN WE REDUCE NORMAL TISSUE RADIATION EXPOSURE? - A CRANIOSPINAL IRRADIATION TECHNIQUE WITHOUT JUNCTION MATCHING USING VARIAN ECLIPSE PLATFORM

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**Purpose:** Medulloblastoma most frequently occurs in the pediatric age group and craniospinal irradiation (CSI) is a standard component of management. CSI is technically challenging due to the possibility of multiple junctions, each with shifts, required to treat the craniocaudal axis; more so if the patient requires anesthesia. Several techniques are described in the literature addressing how to avoid junctions however the use of those techniques for all comers is an issue. The aim of this work is to develop a simple image guided IMRT technique for CSI on the Varian Eclipse platform, deliverable on Varian linacs, with intrafraction modulation junctions while reducing dose to normal structures.

**Methods and Materials:** Using Varian treatment planning software and linacs the proposed technique sets one table height and one lateral position for all plans as well as allows for imaging of each of the two or three isoentres to verify patient set up. Further, the spinal axis is treated using three IMRT fields which allows for decreased dose homogeneity while limiting the amount of patient volume being treated to a low dose, while the brain is treated using IMRT with a POP arrangement.

**Results:** Using the proposed technique we re-planned patients previously treated prone with extended source to skin distance (SSD), with field matching on skin. All planning parameters were compared. The proposed technique reduced plan maximum dose on the order of 10% while also reducing the mean dose to the optic structures and heart. The maximum dose to the kidneys was comparable between techniques while the mean dose to the lung was slightly higher with the new technique while the maximum dose to the lungs was lower with the new technique. Using the new technique, two further patients were scanned and planned in supine position. The total PTV length for these patients was 74 and 56 cm respectively. Delivery of general anesthesia and monitoring was easy.

**Conclusions:** The proposed technique is a simple to deliver, image guided IMRT technique using Varian equipment with intrafraction modulated junctions. This technique allows for easy set up verification and less dose to normal structures.

### 88 THE USE OF RESPIRATORY GATING FOR DELIVERY OF STEREOTACTIC ABLATIVE RADIOTherapy (SABR): IS THERE AN IMPACT ON ONCOLOGIC OUTCOMES?

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**Purpose:** Respiratory gating (RG) has been postulated as a method of reducing the irradiation of normal lung during SABR. RG refers to tumour treatment only during a specific phase or amplitude of the breathing cycle, in distinction to non-gated (NG) free-breathing delivery. The inability to visualize the tumour during RG with most systems has led to the hypothesis that geometric misses could occur, leading to a lower rate of local control (LC). The goal of this study was to assess oncological outcomes in patients receiving RG versus NG treatments.

**Methods and Materials:** Outcomes for patients treated with SABR in 2010-15 for either primary non-small cell lung cancer (NSCLC) or metastatic disease were reviewed. Patients received a risk-adapted approach, using 3, 5, or 8 fractions (all with BED > 85 Gy(10) depending on tumour size and location. Tumour motion was assessed using 4D-CT. RG was generally used when tumour motion was > 7 mm, with RG treatment delivered during end-expiration. Outcomes for RG and NG groups were estimated using Kaplan-Meier analyses, with propensity matching (in a 1:1 ratio with a caliper width of 0.20) to control for baseline differences.

**Results:** One hundred and nine patients were treated for primary NSCLC and 39 for oligometastatic cancers. Median follow up was 17 months. Median age was 75 (range 42-94), most were male (56%), median FEV1 was 71% predicted (range 23-127% predicted), and median age-adjusted Charlson score was 7 (range 3-13). Most patients (85%) had one lesion treated. In the whole cohort, there were eight local failures (three-year local control rate 88%), and nine regional failures (three-year regional failure rate 85%). Tumour location was the strongest predictor of use of RG (59% for lower lobe tumours versus 15% for others). Patients who received RG were also more likely to be older, with more target lesions, a higher Charlson score, and larger targets (all p<0.05); these differences were no longer significant after matching. Comparing RG versus NG outcomes in matched patients (n = 52 in each group), there were no differences in LC (p = 0.23) associated with delivery technique.

**Conclusions:** The use of RG does not appear to adversely affect local control rates. Further research is needed to determine if dosimetric benefits of RG lead to clinically improved outcomes.

### 89 TOTAL BODY IRRADIATION WITH VMAT - A FOCUS ON SCROTAL SHIELDING

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**Purpose:** Total body irradiation (TBI) is given as part of a conditioning regime for stem cell transplant. Methods of delivery are often labour intensive, not comfortable for the patient, and provide limited capabilities for shielding critical structures without compromising treatment goals of irradiating the whole body, including skin, to a uniform ± 10% of the prescription dose. For example, our previous technique involved full patient bolus packing at extended SSD using lateral treatment fields. The patient’s arms were used to provide attenuation for lungs, and there was no ability to shield the gonads without compromising the dose to the pelvic bones.

**Methods and Materials:** At the Tom Baker Cancer Centre (TBCC), we have implemented a new total body irradiation method that delivers a uniform dose using volumetric modulated arc therapy (VMAT) through gantry speed and MLC motion optimization. The MLC motion is limited to shielding for the lungs and reducing hot spots, and consequently, plans are not highly modulated. This allows us to streamline the treatment planning and quality