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.

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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.

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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. CTV2 included the gross tumour plus a 5 mm margin, and CTV1 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: Rt and Lt Kidney (D50% <350 cGy, max EUD < 350 cGy); RingPTV+2 cm (max dose = PTVmin), Normal tissue 4 cm beyond PTV (max dose < 1000 cGy, D50% < 150 cGy, D20% < 500 cGy). No other structures were included in the optimization. The maximum (D2%), mean (D50%) and minimum dose (D98%) for PTVs and OAR were obtained and compared between plans.

Results: There was no difference in the coverage of PTV2, while VMAT provided better PTV1 coverage: mean D98% was 24.2 Gy +/- 0.16 versus 23.9 Gy +/- 0.25 (p = 0.05). Use of VMAT reduced the volume of normal tissue receiving 95% of the prescribed dose from 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% or D50% 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 conformality 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.

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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 polylactic acid on a consumer-Grade 3D printer