Clinical Implementation of an Iterative Automation Framework for CyberKnife Prostate SBRT Planning

Ronnie Leung
Auckland Radiation Oncology

Introduction

CyberKnife (CK) Stereotactic Body Radiotherapy (SBRT) for prostate cancer demands high precision and adherence to strict organ-at-risk (OAR) constraints. Manual planning workflows in RayStation are often labor-intensive, involving repetitive ROI generation, complex geometric calculations for robot clearance, and trial-and-error optimization. We present the development and clinical validation of a Python-based automation script designed to standardize and accelerate this process.

Method

The automation framework is divided into four distinct sessions:

1. ROI Management: Automates structure creation from templates, performs logic-based cleanup, and executes complex algebra for derived planning structures (CTV/PTV) based on the presence of the membranous urethra.

2. Align Center Placement: Extracts fiducial coordinates to calculate the center of mass and determines the Table-to-Target Height (TTH). It calculates isocenter offsets to ensure collision-free delivery based on CT separation measurements.

3. Plan Initialization: Generates the CK plan and beam sets, applies clinical goal and class solution, and configures MLC node-set optimization parameters.

4. Intelligent Optimization: Executes an iterative optimization loop. The script evaluates clinical goal satisfaction post-optimization; if constraints for some high-priority OARs are not met, it dynamically increases optimization weights and re-runs the process.

Results

Since its clinical implementation in October 2024, the script has been utilized for 147 prostate patients (as of January 2026). The script has been improved to handle exceptions, various radiation oncologists' contouring practice, software version upgrades (RayStation 2024B) and clinical protocol changes. The automated approach ensured 100% template compliance and eliminated manual entry errors in prescriptions and beam settings.

Conclusion

The script has significantly improved planning efficiency and inter-planner consistency. By removing manual geometric calculations and automating the iterative optimization "feedback loop," this framework minimizes human error. The high level of standardization achieved suggests the potential for future reductions in manual plan-checking and quality assurance (QA) workloads.

VMAT for Breast and Regional Lymph Nodes: Implementation and Outcomes at Auckland City Hospital

Gerard Bengua
Te Puriri O Te Ora – Auckland City Hospital

Introduction

The decommissioning of the final 18 MV linear accelerator at Auckland City Hospital (ACH) in 2017 left only 6 MV and 10 MV photon beams available, limiting the ability of conventional three-field 3DCRT breast techniques to achieve adequate target coverage and dose homogeneity. This work describes the development, commissioning, and clinical implementation of a VMAT-based technique for breast and regional lymph node irradiation and reports outcomes from the first 100 treated patients.

Method

An interim tangential IMRT technique with supplementary posterior fields was employed during VMAT development. The final VMAT approach uses five to seven partial arcs to optimise PTV coverage while limiting dose to the ipsilateral lung, heart, and contralateral breast. Isocentre placement was adjusted to reduce posterior and contralateral dose spillage. Treatment planning utilised a hybrid script- and template-based workflow incorporating deep learning segmentation for automated contouring of breast/chest wall and nodal targets. Optimisation objectives were informed by retrospective analysis of clinical tangential and three-field IMRT plans, with clinical goals based on published dose constraints. Patient-specific QA was performed using Octavius and Mobius systems with 3%/2 mm gamma analysis.

Results

VMAT achieved equivalent or improved target coverage compared with IMRT across PTV_BCW, PTV_SCF, and PTV_Ax. For a prescription of 40 Gy in 15 fractions, V38 Gy exceeded 95% in supraclavicular and axillary targets, compared with approximately 45–50% for IMRT. All organ-at-risk doses met clinical goals. The majority of plans achieved gamma pass rates greater than 98%. The technique supports flexible CT simulation geometry, delivery on any departmental linac using 6 MV beams, and compatibility with CBCT and surface-guided breath-hold workflows. Median planning time was under one hour.

Conclusion

A VMAT-based breast and regional lymph node technique was successfully implemented, restoring target coverage previously achievable with higher-energy beams while improving dosimetric consistency, planning efficiency, and clinical flexibility. VMAT is now the standard technique for breast plus regional node treatments at ACH.

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MINIMISING BODY DOSE IN STEREOTACTIC RADIOSURGERY

P. Filatov, E. Toth, D. Alahakone, K. Chisholm, K. Sewell, T. Yang
Dunedin Health New Zealand

Introduction

Although stereotactic radiosurgery (SRS) is highly targeted, low-dose body scatter can contribute to secondary cancer risk, particularly in younger or benign-disease working-age patients with long life expectancy [1]. The latest NHS SRS service specification sets extracranial dose limits for patients with the highest lifetime risk [2]. This study evaluates how to implement these recommendations in clinical practice and minimise patient dose from SRS.

Method

Low-dose calculation accuracy of Monte Carlo (MC) algorithm was validated for two treatment planning systems (TPS): Monaco (Elekta) and Elements (Brainlab). A phantom representing the patient's upper body was created, and doses at 25–30 cm depth and out-of-field locations were measured using TLDs.
Clinically relevant treatment plans with varying target sizes and locations were optimised on the phantom using non-coplanar arcs and exit-dose minimisation techniques.

Results

TPS predictions were accurate within 26.5% for Monaco and 24.5% for Elements, outperforming previously reported scatter dose uncertainties [3]. Fifteen SRS plans emulated in Elements remained clinically acceptable and deliverable, with doses at 30 cm from the target kept below 10 mGy.

Conclusion

Elements and Monaco MC algorithms can assess body dose from SRS within known uncertainties. Clinically viable SRS plans for C-arm linacs can be optimised to substantially reduce body dose without compromising treatment quality. Given documented scatter-induced cancer risks, especially in younger patients, such dose-minimisation strategies are clinically important and warrant wider adoption.

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PyRadiomics in RayStation – From Voxels to Value

Andy Anderson, Joe Perry
Te Puriri O Te Ora – Auckland City Hospital

Introduction

Radiomics is a rapidly evolving field of research concerned with the extraction of quantitative metrics—the so-called radiomic features—within medical images. Radiomic features capture tissue and lesion characteristics such as heterogeneity and shape and may, alone or in combination with demographic, histologic, genomic, or proteomic data, be used for clinical problem solving.[1] PyRadiomics[2] is a Python library for deriving radiomic features from images. RayStation provides a python Application Programming Interface (API) for automation and interrogation.

Method

In RayStation 2024B, a scripting environment was generated and PyRadiomics was installed. A script was written to convert the imageset accessible to the RayStation API into an object that PyRadiomics could interrogate.

Results

The script, when run, processes the imageset the user indicates, and creates a mask using a user-defined ROI. These are passed to PyRadiomics for feature extraction.

Conclusion

This is a powerful tool for performing radiomic feature extraction on any patient in the database, though further testing is needed on images other than CTs in Head First Supine orientation.

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Generalisation of AI Trained on Simulated Data for Digital Holographic Interferometry

Aiden Soal
University of Canterbury

Introduction

Bridging the gap between artificial intelligence (AI) models trained on simulated data and their performance on real-world data remains a central challenge [1]. Accurate and robust generalisation typically requires large datasets, yet acquiring sufficient experimental training data is often impractical. As a result, high-quality simulated data are frequently used either as a substitute for, or a complement to, experimental measurements. Whether models trained in this way can generalise beyond their simulated training domain, particularly under systematic deviations from the training distribution, remains an open question. Digital holographic interferometry (DHI) [2], when combined with AI models trained on simulated data, provides a promising framework for investigating robustness, domain shift, and real-world deployability.

Method

Simulated datasets were generated using the Python package *Diffractio* to model optical interference under noisy conditions, including phase wrapping effects, offering a lightweight alternative to commercial optical simulation software. A range of object geometries and phase distributions was introduced to construct a representative training dataset. A Pix2Pix conditional generative adversarial network (cGAN) was trained to map interferograms to corresponding phase reconstructions. Model performance was evaluated by systematically increasing the deviation between the training data and novel inputs, thereby assessing the network's capacity for generalisation under domain shift.

Results

The trained model generalised well to moderate deviations from the training distribution and was able to reconstruct previously unseen object shapes with reasonable accuracy. However, as additional components were incorporated into the reconstruction pipeline and overall system complexity increased, performance degraded and generalisation became increasingly limited.

Conclusion

AI models trained on simulated holographic data can successfully generalise to unseen structures and moderate domain shifts. However, increasing reconstruction complexity significantly reduces robustness, highlighting a sensitivity to domain mismatch. These results emphasize the need for more realistic simulation frameworks and improved generalisation strategies to support reliable deployment of AI-assisted DHI systems in real-world settings.

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Contrast Agents in CT

Steven Muir
Te Whatu Ora Canterbury

Introduction

The administration of contrast agents has a big impact on the quality of a CT image but is often not part of a Medical Physicist's knowledge base. This presentation describes details of how contrast agents are used in CT.

Method

Interviews with MIT's responsible for using contrast agents and a review of The CT Handbook: Optimizing Protocols for Today's Feature-Rich Scanners [1], resulted in a greater understanding of how contrast agents are used in CT.

Results

Contrast agents may be administered in three ways, with fixed timing, with a monitored region of interest, or by using a test bolus to establish timing before the main contrast is given. Quantity and speed of injection, speed of the CT scan, concentration of iodine, and kVp selection all have an impact on the visibility of the iodine. Dual iodine/saline injections and biphasic injections can also be used for specific scans. Cost and safety of contrast agents is also discussed, particularly in the light of new scanners requiring less contrast agent to get a similar enhancement.

Conclusion

Understanding more about how contrast agents are administered is useful for medical physicists when seeking to optimise CT protocols.

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Beam Energy issues in CT – promise vs reality

Steven Muir
Te Whatu Ora Canterbury

Introduction

Beam energy in CT has a big impact on image quality. This presentation describes how beam energy, dual energy and photon counting systems are used in CT, particularly exploring the reality of what is practiced at Christchurch Hospital compared to what is promised by the vendors.

Method

Interviewed MIT's responsible for performing scans, reviewed The CT Handbook: Optimizing Protocols for Today's Feature-Rich Scanners [1], and reviewed M. Cellina's paper on "the role of dual-energy computed tomography (DECT) in emergency radiology: a visual guide to advanced diagnostics"[2].

Results

Interesting differences occur between what is described in the literature and what is practiced at Christchurch Hospital. Virtual Monoenergetic Images (VMI) are very commonly used to improve image quality for a variety of conditions. The GE Revolution and Siemens Naeotom scanners use these extensively, however the Siemens Force and Drive scanners are limited by the field of view on the B-tube and so do not create VMI images for many conditions.

Dual energy is generally not used for metal artifact reduction despite vendor claims that it improves artifact visualisation. Direct electron density software also does not utilise dual energy acquisition.

Other conditions such as imaging of pancreas, appendicitis, gastrointestinal bleeding, bowel ischaemia, kidney stones, pyelonephritis, urinary bleeding, bone marrow oedema, neurological haemorrhage, vertebral collapse, ligament lesions and gout can utilise dual energy information, but in many cases this is not implemented at Christchurch Hospital.

Conclusion

Significant differences exist between scanning practice at Christchurch Hospital and what is described in literature. The various reasons for this are because:

1. The feature is not reliable enough to be used clinically (e.g. VNC).
2. Siemens Force and Drive scanners are limited by field of view and speed for many dual energy applications.
3. Radiology staff have not learnt how to implement the new technology.

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Naeotom Alpha spectral CT: introduction to technology and applications

Nicholas Cook
Canterbury District Health Board

Introduction

Christchurch Hospital recently installed the Siemens Naeotom Alpha Peak, one of the first full-body, photon-counting, spectral CT scanners in New Zealand. Photon Counting Detectors (PCD) mark a significant change in CT technology and applications over Energy Integrating Detectors (EID). Improving EID spatial resolution is dose-limited and spectral applications are compromised by poor energy resolution from overlapping X-ray spectra. PCD technology with smaller detector pitch and a monolithic detector layer allows improved spatial resolution (Fig. 1). With PCD, electronic noise is rejected by energy threshold, and energy resolution is reduced from 10's of keV to a few keV. Since all these advantages are available in a single scan, users no longer have to choose between high spatial resolution or spectral material decomposition.

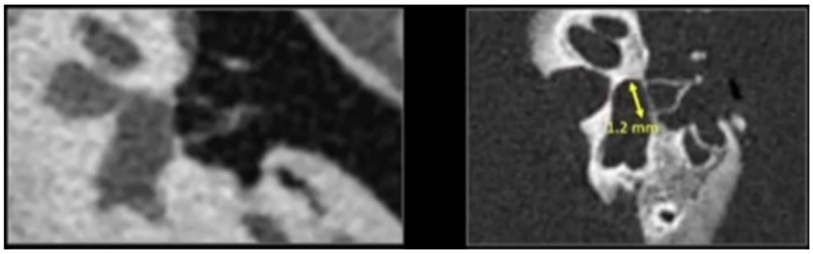

Figure 1. 0.4mm (Force UHR) and 0.2mm (Naeotom UHR) slices showing improved stapes visualisation [1].

Photon-counting CT is a new and developing technology with evolving understanding and protocols. All major manufacturers plan to release photon-counting CT, Siemens predicts all their CTs will be photon counting by 2030. Significant applications include high spatial resolution CTA with removal of plaque calcification to show true lumen, giving more accurate stenosis evaluation. Lesion characterisation may also be improved and could replace MRI for some contra-indicated patients [2].

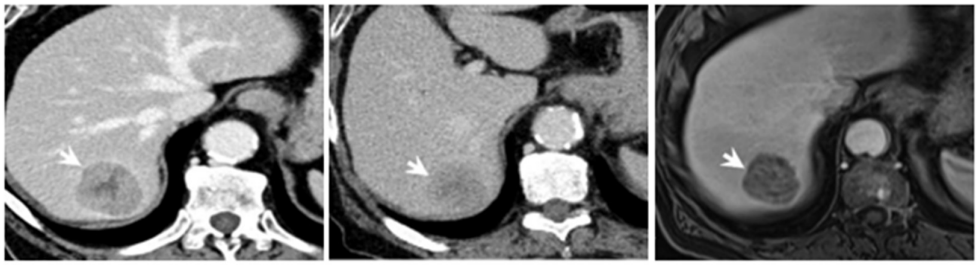

Figure 2. Delayed phase enhancement of hepatic lesion in PCD-CT, EID-CT and MRI, adapted from [2].

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RTRSIG: Establishment of a College-wide TEAP training collaboration

Alicia Moggré, Emma Dyce
Christchurch Hospital

Introduction

Completion of ACPSEM's Training Education and Assessment Program (TEAP) allows prospective Radiation Oncology Medical Physicists (ROMPs) to achieve professional certification within Australia and New Zealand [1]. ROMP TEAP consists of competency-based clinical education across ten Key Areas encompassing 80 learning outcomes. Structured programmatic assessment mandates oral, written, practical and entrustment-based assessments by local supervisors/trainers to assess registrar theoretical understanding and practical skills, benchmarked against external summative assessments. Training materials and local assessment tools are not generally centrally provided and have typically been developed locally or in regional collaborations making TEAP very resource intensive for individual clinical departments. A College-wide collaboration to share training and assessment resources was proposed.

Method

Previous informal collaborations encountered difficulties relating to intellectual property and perceived "fairness" of resource sharing, so initial steps involved consulting key stakeholders across all states/NZ including trainers/preceptors in both public and private sectors, and ACPSEM TEAP Coordinators/Education office. Initial individual meetings outlining the proposal then allowed confidence for each group to commit their support to the initiative knowing all other groups were also willing to contribute fairly. A Terms of Reference [2] based around ACPSEM Guidelines on Special Interest Groups [3] requirements was drafted and circulated for review, and subsequently approved by the ACPSEM Board.

Results

The ROMP TEAP Resources Special Interest Group (RTRSIG) was formally established with a Leadership Executive in place by September 2025 consisting of a Chair, TEAP Coordinator representative, eight Key Area Leads and three early career representatives; supported by Practice Groups for each Key Area (averaging 10 members each). Procedures for review/approval of resource, upload to ACPSEM's learning management system and resource database for periodic review were developed, with 39 submitted resources currently under review.

Conclusion

A successful College-wide collaboration to share training resources is underway, leading to increased efficiency and alignment of expectations for all ROMP TEAP registrars.

References

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Motion Tracking in Complex Media: The Matrix Approach

Abigail Moull, Laura Cobus
University of Canterbury

Introduction

Wave-based imaging faces challenges in resolution due to background scatterers. Speckle is a noisy, grainy texture in the resulting image that arises when waves are scattered by small random objects in a heterogeneous medium. Images are often dominated by speckle, causing the incoming and outgoing waves, and hence the resulting image, to be distorted [1]. As a result, motion tracking in complex media is a fundamental challenge for wave-based imaging systems as increased scattering rapidly deteriorates image quality. Traditional imaging approaches, such as confocal or speckle tracking methods, assume single scattering or stable speckle patterns. While effective in static or weakly scattering environments, these techniques break down in complex media where speckle decorrelates rapidly.

Method

We present an alternative framework for motion tracking in complex media based on the matrix approach to imaging. This method uses concepts from information theory and random matrix theory to extract novel information from experimental data that is inaccessible in conventional imaging. In our work, we measure the reflection matrix which captures the full spatiotemporal response between all transmit-receive pairs in an array, retaining information typically lost in conventional imaging. From the reflection matrix, we construct the Wigner-Smith time-delay operator, Q [2,3].

Results

Motion and structural changes within the medium are identified by examining the time evolution of the eigenspaces of Q. Variations in these eigenspaces reflect localised perturbations of the wavefield, allowing motion tracking without dependence on speckle correlations or speckle stability.

Conclusion

The proposed approach is demonstrated in the context of ultrasound imaging, where it enables robust motion tracking in complex scattering media. However, this framework is applicable to any system interrogated by a dense array of sensors, including optical imaging, seismology, and sonar.

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HyperSight CBCT imaging for pelvic cases: A feasibility study

Nevin Koshy Azhaketh, Ruth Smith
Te Puriri O Te Ora – Auckland City Hospital

Introduction

Anatomic changes in patients may require adaptive planning over the treatment course. Patients with significant anatomical changes from their plan will have a repeat CT (re-CT) to determine whether a replan is required.

Cone beam computed tomography (CBCT)-acquired images could be used to assess if a replan is required. Traditional CBCT imaging has several issues that prevent it from being used for direct adaptive planning-such as lower image quality due to increased photon scatter, limited field of view (FOV), and inconsistency in Hounsfield Units (HU).

Varian HyperSight (HS) uses a combination of novel detector chemistry and software improvements to provide improved image quality, a large FOV, and consistent HU. A feasibility study was conducted to see whether HyperSight could be used as an alternative to re-CT for pelvic patients to assess whether a replan is required

Method

A CT-physical density (PD) curve was generated for a Varian TrueBeam enabled with HyperSight. The CT-PD curve was generated using a Gammex Advanced Electron Density (AED) body phantom.

The TPS dose calculation accuracy of the HS CT-PD curve was compared against the clinical CT CT-PD curve. This was done in a set of rigid phantoms following AAPM MPPG 5.b. Test 6.2 [3]. Ionisation chamber measurements were made in-phantom and compared to dose calculated on CT scans of the phantoms to validate the HS CT-PD curve.

Six pelvic patients who had been imaged with HyperSight and had a re-CT were assessed for the study. The re-CT plan was compared to each patients closest HS CBCT. The re-CT and HS images were rigidly registered and the plans were copied across to the HS dataset and recalculated. Dose Volume Histogram (DVH) results were compared between HS-dataset and re-CT dataset. The re-CT and HS planned dose distributions were also compared with gamma analysis at a range of gamma criteria.

Results

The HS CT-PD curve was validated using MPPG 5.b. test 6.2. Dose calculation difference were within ±0.5% for all phantoms and all energies. The TPS-calculated and measured dose differences were <1.0%.

DVH differences for targets varied up to ≈ 5.0% whilst average DVH differences were ≈ 2.0%. DVH differences for OARs varied up to 20% whilst average DVH differences were within 3.0-5.0%. However, this is limited by the anatomical movement and presence of gas in pelvic patients which is not fully overcome by rigid registration alone. However, previous work in phantom has shown that DVH differences can be limited to 2% [1,2]

Gamma analysis pass rates were greater than 96% for all plans for gamma criteria 3%/2mm, 2%/2mm, and 3%/1mm.

Conclusion

HS can be used to generate images that may be suitable for pelvic treatment planning. Dose calculation accuracy is within ≈ 2-3% when using rigid registration alone.

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The challenges of implementing a single enhanced leaf model across three TrueBeam linear accelerators

Ben Scarlet, Omer Ali, Moamen Aly
Health New Zealand - Waikato

Introduction

With Aria/Eclipse version 18, a new MLC leaf model was introduced by Varian [1]. The Enhanced Leaf Model (ELM) claims to more accurately model the physical design of the MLC on Varian linacs and should improve dose calculation accuracy. In a multi linac department, having a single beam model provides clear workflow advantages. This work describes the implementation of the ELM on three TrueBeam linacs at the Waikato Regional Cancer Centre (WRCC) utilising a single beam model.

Method

ELM configuration data was measured using the Varian procedure [1].The data were averaged and the ELM was configured for AAA and Acuros XB algorithms for all photon energies (6X, 6FFF, 10X, 10FFF and 15X). Validation followed the work of van Esch et al. [2], utilising static wallpaper and narrow MLC gap fluence plans measured using portal dosimetry and film. Further validation utilised previous clinical plan delivery via portal dosimetry and using ArcCheck and SRS MapCheck devices [3].

Results

Input data showed two TrueBeams had very similar characteristics while the third had increased MLC transmission. Algorithms were reconfigured with the average data from the two matching TrueBeams. Fluence plan validation showed improved leaf modelling at leaf tips compared with previous versions, but based on our observation, the tongue and groove effect is still not accurately modelled. Furthermore for small target SABR and SRT plans, agreement between measured and calculated doses varied depending on which linac plans were delivered on. 6FFF and 10FFF transmission had to be manually adjusted in beam configuration to improve agreement with MapCheck verifications across all linacs.

Table 1: ELM configuration results for each photon energy for both Acuros XB and AAA. Values in parenthesis for FFF beams were the pre-adjustment results

Energy	6X	6FFF	10X	10FFF	15X
Transmission (%)	1.43	1.00 [1.22]	1.64	1.20 [1.47]	1.60
Leaf Gap (mm)	-0.47	-0.53	-0.39	-0.41	-0.37

Conclusion

ELM was successfully configured and validated across the TrueBeams at the WRCC. Validation results showed improved MLC modelling as expected, however modifications to the model needed to be made to maintain appropriate agreement between planned and measured dose distributions across all linacs.

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Monte Carlo Percentage Depth Dose Curve generation for the Xstrahl X150

Andrew Williams, Simon Berke
Wellington Blood and Cancer Centre

Introduction

Measuring Percentage Depth Dose (PDD) curves for superficial kV beams is notoriously difficult [1]. As part of the commissioning of a new Xstrahl X150 superficial radiotherapy unit we generated the PDD for the full range of applicator sizes and beam energies to be used clinically using the EGSnrc [2] Monte Carlo (MC) software and these were verified against ion chamber measurements and BJR 25 [3].

Method

Our MC model was quite simple and did not fully modelled the x-ray tube and applicator assembly unlike previous MC models of superficial units [4]. Instead, we used SpekCalc 1.1 [5] to generate the beam spectrum at the exit of the unit's ionisation chamber for each of the 80, 120 and 150 kV beams using the Xstrahl specified filtration. We also added 3.6 mm of water and 0.1 mm of graphite to simulate the ion chamber. The radiation transport was then modelled from this point through the air into a water phantom using the EGSnrc DOSRZnrc code with the geometry as shown in Figure 1. Calculations, performed on a 24 core Xeon workstation, took between 10 and 90 minutes, depending on energy and applicator, to reach a reported statistical uncertainty of 0.1%.

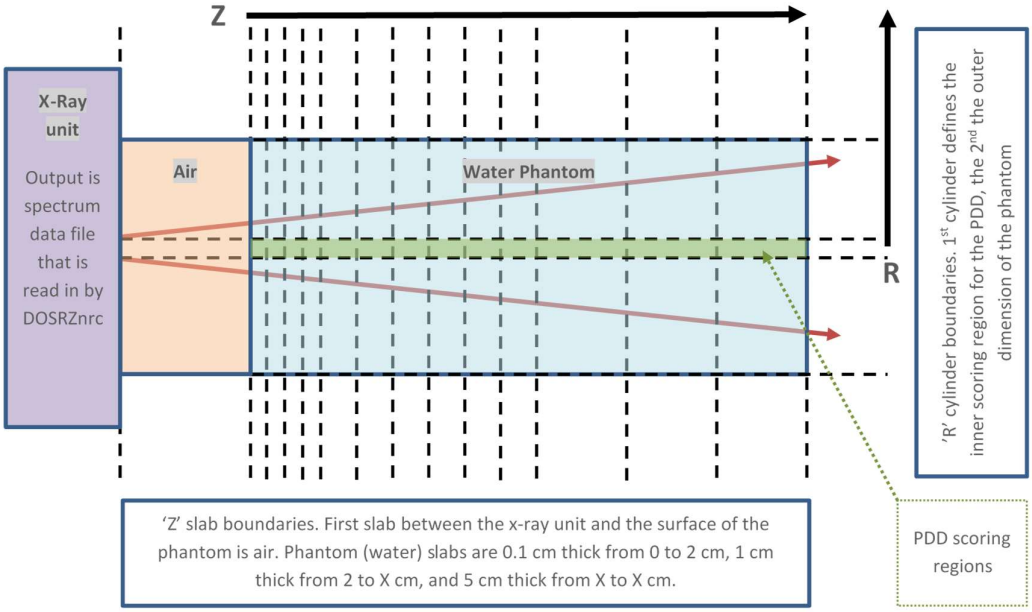

Figure 1 RZ cylindrical geometry used by DOSRZnrc to generate the PDD

MC calculated PDD were compared to those measured using an Advanced Markus chamber in Solid Water HE [6] and BJR 25 tabulated data.

Results

As shown in Figure 2 for 80 kV, the measured PDD agrees much better with the MC calculations (max difference 4% global dose for 150 kV, 15 cm diameter applicator) than the BJR 25 data (max difference 7% global dose for 120 kV, 2 cm diameter applicator).

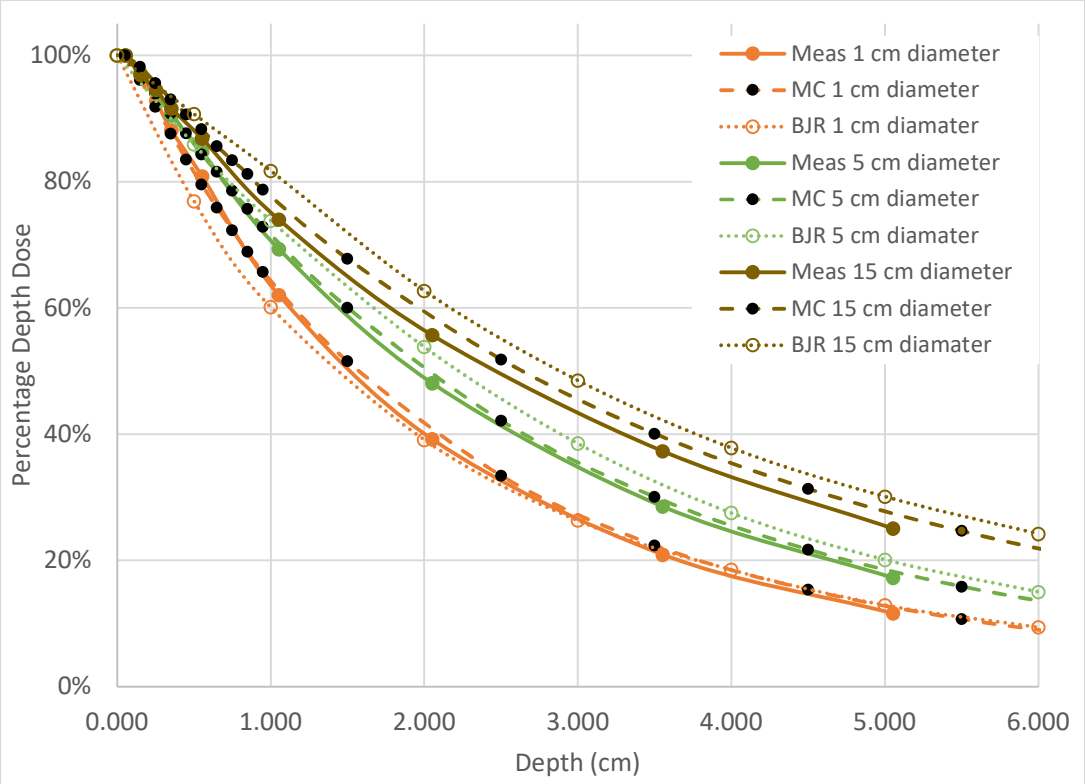

Figure 2 80 kV PDD. The solid lines are measured data in Solid Water HE with solid dots showing the measurement points. The dashed lines are MC calcs with the black dots showing the calcultion points. The dotted lines are BJR 17 data with hollow circles showing the tabulated data points. Measured data is with ±3% of MC calcs and ±6% of BJR 25.

Conclusion

PDD with superior accuracy than the BJR 25 tabulated data can be calculated using simple MC techniques without the need to fully model the x-ray tube. These PDD are now being used in our centre as our clinical reference data.

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SGRT commissioning and clinical implementation experience

Arun Patel
Wellington Blood and Cancer Centre

Introduction

Surface Guided Radiotherapy (SGRT) uses optical surface imaging to aid patient setup and monitor for intrafraction motion during treatment. This presentation details the commissioning and go-live process, as well as potential future developments, of an AlignRT (VisionRT) SGRT solution on three Varian TrueBeam linacs.

Method

AlignRT installation and acceptance took five days, followed by two weeks of physics commissioning following ESTRO-ACROP guidance [1]. Go-live occurred immediately after commissioning, with AlignRT being used for all treatment sites.

Results

Commissioning results met the suggested ESTRO-ACROP tolerances, achieving a translational and rotational tracking accuracy of 1mm and 1° respectively. Tests were performed using a modified MultiMet-WL (Sun Nuclear), torso, and immobilised head phantom, while a QUASAR respiratory (IBA Dosimetry) phantom was used to test gating performance.

Figure 3 – The modified MultiMet-WL (left), torso (centre), immobilised head (right) phantoms used for commissioning tests.

Feedback following release was positive; radiation therapists reported improved setup troubleshooting and fewer imaging repeats, and have fully withdrawn tattooing patients at CT. Physicists were able to integrate AlignRT QC into existing procedures with a minimal change to current workflow.

Issues occurred due to phantom incompatibility with AlignRT cameras, requiring modification shown in Figure 1 (left), as well as hardware problems with Bluetooth and in-room monitor connectivity.

Future developments include using AlignRT for routine linac QC setup, significantly reducing reliance on lasers.

Conclusion

The AlignRT commissioning process was a success, with the system released for clinical use within the expected timeframe. Staff found it aided patient setup across all treatment sites, and are no longer tattooing patients at CT. AlignRT is expected to be further integrated to aid linac QC setup in the future.

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Proton Minibeam Radiation Therapy: Monte Carlo Modelling and Evaluating Equivalent Uniform Dose for Pre-Clinical Applications

Evie Yeo[1], Steve Marsh[2], Juergen Meyer[3]
[1]Dunedin Hospital,[2]University of Canterbury, [3]Univeresity of Washington, Seattle

Introduction

Proton minibeam radiation therapy is an emerging technique that uses spatially fractionated minibeams to irradiate a tumour with a non-uniform pattern. Spatially fractionated radiation therapy (SFRT) presents challenges in dosimetry due to limited understanding of cellular responses when irradiated with highly spatially modulated beams. To evaluate clinical effectiveness of SFRT, the radiobiological metric equivalent uniform dose (EUD) is used. This work modelled a preclinical proton beamline with a minibeam collimation system and evaluated the impact of tissue heterogeneity on EUD by comparing SFRT dose distributions in a heterogeneous model phantom versus a homogenous water phantom.

Method

In this work, a TOPAS Monte Carlo beamline model of the University of Washington Precision Proton Radiotherapy Platform (PPRP) was developed, incorporating a portable minibeam collimation system. We compared SFRT in a homogenous water phantom and a heterogenous mouse model to assess the impact of tissue heterogeneity and geometry on EUD. Additionally, SFRT was compared uniform irradiation as shown in Figure 1, to compare EUD with uniformly irradiated dose.

Results

EUD was highly sensitive to variations in tissue density for the proton beam. Simulations showed that dose distributions derived from uniform phantoms cannot be easily extrapolated to non-uniform phantoms with heterogeneous density. Additionally, SFRT produces an enhanced Bragg peak (BP) EUD while delivering the same surface biological effect as uniform irradiation. For lower biological surface doses of 1 Gy, the EUD at the BP was 1.16 times larger than uniform irradiation dose, with this effect increasing substantially at higher doses. At 8 Gy, the BP EUD was 5.3 times larger.

Conclusion

This novel approach to visualise EUD provides a practical framework for visualising EUD and highlights the impact of heterogeneous tissue densities in proton SFRT, as well as an enhanced Bragg peak dose.

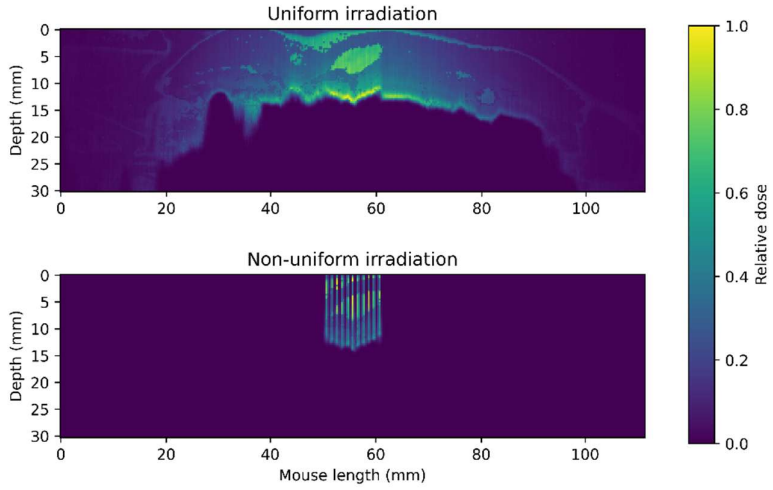

Figure 1: Sagittal view of dose distributions within a mouse phantom, irradiated uniformly (top) and non-uniformly with SFRT (bottom).

Validation of Gafchromic™ EBT4 Film for Applicator Factor and Profile Measurements for 80 kV and 100 kV Beams at Wellington Blood and Cancer Centre

Chrizia Cayanan, Gray Lu, Shelley Bulling, Rebecca Day
Wellington Blood and Cancer Centre

Introduction

Superficial X-ray (SXR) beams in the 50 – 150 kVp range are widely used for treating shallow lesions at or near the skin surface [1] due to their characteristic surface dose maximum [2]. Dosimetry at kV energies is challenging due to steep dose gradients, strong energy dependence of detector response, and variations introduced by applicator field size and design [2, 3].

Radiochromic film offers several advantages for kV dosimetry, including high spatial resolution, and two-dimensional dose measurement capability. This project investigates the feasibility of using Gafchromic™ EBT4 film (Ashland™ Inc.) for SXR dosimetry at Wellington Blood and Cancer Centre (WBCC), focusing on applicator factor (AF) and profile measurements. This work was performed in preparation for commissioning a new Xstrahl 150 unit.

Methods

EBT4 measurements were performed using an Xstrahl 100 unit for 80 kV (1.92 mm Al HVL) and 100 kV (4.83 mm Al HVL) beams with circular applicators. Calibration and measurement films were irradiated at the surface and at 1 cm depth in a plastic water phantom (CIRS Plastic Water® LR). Film dosimetry was performed using multichannel dosimetry with FilmQA Pro™ (Ashland™ Inc.). Measured AFs were compared against WBCC reference values and Australasian Clinical Dosimetry Service (ACDS) audit results. Film profiles were compared with microDiamond (PTW 60019) measurements using dose differences and gamma analysis.

Results

For applicators larger than 3 cm, measured AFs agreed with WBCC and ACDS values within ± 1.3%. For smaller applicators, deviations up to 6.2% were observed. Acceptable agreement was found between EBT4 and microDiamond profiles, with differences primarily in the penumbra and out-of-field region. Gamma pass rates exceeded 90% for most applicators under the 2%/2mm criteria.

Conclusion

EBT4 film is suitable for SXR dosimetry at these beam energies. We recommended it for profile measurements and secondary verification of AFs during commissioning, acknowledging the increased uncertainty for small applicators.

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Retreatment Workflow at Auckland Radiation Oncology and Evaluation of Future upgrades to Raysearch RayStation's Retreatment Solution

Deirdre Hutton
Auckland Radiation Oncology

Introduction

Deformable registration in RayStation (Hybrid Intensity and Structure Based) was first commissioned at Auckland Radiation Oncology in 2014. We have since had a lot of experience with retreatments and have over the years adapted our workflow.

Results

The changes over time in that workflow and challenges with retreatments will be presented.
We have had the opportunity to look at new developments in the RayStation Retreatment workflow which will be introduced in version 2026.

These developments will be assessed and presented in the context of improvements to the Auckland Radiation Oncology workflow and suggestions made for future development.

Ruthenium Eye Plaque Radiation Therapy: investigation into radiation safety risk to determine appropriate patient restrictions

Trulani van der Heyde, Christine Thompson
Te Puriri O Te Ora – Auckland City Hospital

Introduction

Ruthenium LDR ocular brachytherapy employs Ru-106 eye plaques [1], which decay via beta particle emission with a half-life of 373.6 days, to deliver an apex dose to eye tumours of 100Gy. The dose rate from a beta particle emitter decreases rapidly with distance from the source, but still poses risk, especially for staff and visitors in contact with the patient. The concept of ALARA is applied and this work investigates suitable patient, staff, and visitor restrictions, to ensure safety of employees and the public.

Method

A beta scintillation meter was used to perform a range of survey measurements for an eye plaque of a current patient. The observed relationship between proximity and dose rate was established, and it guided appropriate patient restrictions. A conservative approach was taken and upper bounds for all influencing factors on the dose rate that may be received within the treatment room were used. Including eye plaque size, ruthenium source age and activity, time in-situ, and visitor proximity.

Results

For a visitor distance of at least 1 metre from the eye plaque, the maximal visitation time per day should be limited to 17 hours, after which the dose constraint of 10% of the 1mSv annual public dose limit [2] could be reached. This is well over the daily permitted visitation hours of the hospital of 11.5 hours and therefore no further restrictions were required.

Conclusion

Radiation safety restrictions for patients must match the relevant risks. Isolation creates undue stress and impacts mental wellbeing of patients. Based on this study, the restrictions for eye plaque patients were relaxed, to allow increased visitation and a substantially more comfortable and tolerable treatment experience. In accordance with ALARA, exposure of young children was still limited, as included in the updated signage for these patient restrictions as follows:

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Untold tales of New Zealand's X-Ray pioneers

Steven Muir
Te Whatu Ora Canterbury

Introduction

Stories of New Zealand's X-Ray pioneers are hard to find and very sparse on details. Most histories credit Dr William Hosking from Masterton as the first to use X-Rays in New Zealand in 1896 [1,2,3]. The exact date when Hosking began taking X-Rays was unknown. Dunedin historians Begg and Jamieson [4,5] credit Kempthorne Prosser & Co as being the first to take X-Rays in New Zealand on 26th August 1896. The oldest surviving X-Ray image was thought to be taken by Henry de Lautour in 1899 [4].

Method

National Library's Papers Past website contains a searchable database of every paper published in New Zealand. Searching for keywords such as "X-Ray" and "Rontgen" uncovered many stories that have never been mentioned in existing history books and has shown that many of the existing historical records are incorrect.

Results

Key findings are:

- Hosking did not take X-Rays until March 1897 and was 12th in New Zealand to take X-Rays.
- Augustus Hamilton was the first to take an X-Ray image in Dunedin in May 1896.
- Walter and Robert Thompson were the second people to take X-Ray images in Christchurch in June 1896 as an advertising stunt for their music shop.
- The oldest surviving X-Ray in New Zealand is an image of a frog taken by Dr William Evans at Christ's College School in September 1896, stored at Canterbury Museum. The X-Ray tube the image was taken with still survives at Christ's College, as well as the original frog at Canterbury Museum. The historical significance of this information was not previously recognised.
- George Percy Hausmann (escape artist and magician) took the next-oldest surviving X-Ray images of Lady Glasgow & Alice Boyles hands on 2nd October 1896. These images were previously unknown in New Zealand, but were discovered in the State Library of South Australia.
- Kempthorne, Prosser & Co took the first medical image in New Zealand 26 August 1896
- Out of the first fifteen Xray pioneers in New Zealand, nine have never been mentioned in books of X-Ray history before.

Conclusion

The increasingly available digitization of historical records means that many significant facts and artifacts about X-Ray pioneers in New Zealand have been discovered.

Percy (Professor) Hausmann, a little-known early X-Ray pioneer of New Zealand

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