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Abstracts

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ORAL & POSTER PRESENTATION

1 Auto-segmentation in LDR prostate BT: an analysis of the effective impact of image/segmentation protocol-based domain shift analysis on the performance of deep learning-based prostate segmentation from MRI architecture nn-Unet

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PURPOSE: To study the impact of domain shift on prostate MRI auto-segmentation that arises from different acquisition/segmentation protocols with a view to integrate MRI in the BT workflow.

METHODS: The nn-Unet[1] deep learning model was used for prostate auto-segmentation from T2 axial weighted MRIs acquired using 3T Siemens MRI scanners from three publicly available datasets: ProstateX, NIC ISBI 13, I2CVB[2-4] (18 subjects from each dataset). Four models were trained: three using data from a single dataset, and a fourth using mixed data from all three datasets. The Dice Similarity Coefficient (DSC) was used to compare the ground truth and model-produced segmentations in three ways: Inter-domain, in which a model was trained on a single dataset and tested on another dataset, Intra-domain, i.e. trained and tested on the same dataset, and mixed domain, i.e. trained on data from all datasets and tested on all datasets. In addition to DSC, the results from the mixed data model were visually assessed by three consultant clinical oncologists from Guy's and St Thomas' hospitals using RCR/LIKERT scales.

RESULTS: Intra-domain performances were significantly ($p<0.05$) higher than inter-domain performances and noticeable improvement was seen when mixing training data from different datasets. The results show the utility of training models using heterogenous data and that data origin should also be considered as well as scanner vendor as a source of possible domain shift. A Cohen Kappa test showed poor agreement between experts when evaluating the segmentation as "no change" needed but better agreement with "minor change" and "major change" scores.

CONCLUSION: Auto-segmentation models are sensitive to imaging acquisition and annotation protocols, as well as the well-known effect of scanner vendors. The poor agreement between the spatial overlap scores and the visual assessment scores necessitates the involvement of clinical metrics to further evaluate and tune deep learning models.

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2 Multisector dosimetric analysis of the prostate gland for the determination of optimal positions for in-vivo dosimeters in LDR prostate brachytherapy

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PURPOSE: To determine the optimal positions within the prostate for in-vivo dosimeters, developed as part of the EU H2020 Origin project, using multisector dosimetric analysis.

METHODS: Dosimetric data from post-implant CTs were obtained for 606 men treated with LDR prostate brachytherapy 2009-2020. Sectors were created by dividing the prostate into three equal thirds (base/midgland/apex), then each third into four axial sectors. Axial division was performed by two separate methods; plus-shape ("+") and cross-shape ("x"). Dose to 90% of each sector (D90%) was compared to D90% of the global prostate gland for each method.

RESULTS: Compared to the global D90% of 107.85%±11.07%, mean D90% of the anterior right base was lowest (86.77%±14.82%) and the anterior left base was second lowest (96.99%±19.38%) using the plus-shaped sector division, with the D90% < global D90% in 91.25% and 76.40% of cases respectively. Using the cross-shaped sector division, mean D90% of the anterior and left base were lowest at 86.76%±15.96% and 96.39%±15.27% respectively with D90% < global D90% in 92.41% and 77.06% of cases respectively. The posterior right midgland and posterior left midgland had the highest (142.82%±18.42%) and second highest (141.99%±19.39%) D90% respectively using the plus-shaped sector division, with the D90% > the global D90% in 96.37% and 95.87% of cases respectively. Using the cross-shaped sector division, the right and posterior midgland sectors received the highest mean dose at 142.82%±18.03% and 142.35%±19.25% respectively, with D90% > global D90% in 96.53% and 96.20% of cases respectively.

CONCLUSION: The mean D90% was lowest for the anterior right and left base sectors and highest for the posterior right and left midgland sectors with a significant percentage of the D90% of these sectors < or > global D90% respectively. Overlapping sectors of interest are appropriate locations for in-vivo dosimeters to monitor radiation dose, given their propensity for D90% differing from global D90%.

Finance-source: The ORIGIN project is an initiative of the Photonics Public Private Partnership (www.photonics21.org), and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 871324. Authors are also supported by the Research and Development Division of the Public Health Agency of NI (COM/5610/20).

3 The Impact of Environmental Sustainability Issues on Brachytherapy Practice

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PURPOSE: It is well known that we face a climate and environmental crisis, and many organisations such as WHO and the UN are warning that sustainability and healthcare issues are connected. It does not therefore seem appropriate to practise without a wider consideration of how what we do impacts on the sustainability problem.

METHODS: The NHS recognises this and has launched the "Greener NHS" initiative; however, many staff are either unaware of this, or have not fully considered its implications for how we work. This poster summarises the NHS response to the environmental crisis.

RESULTS: Surveys of NHS staff at two centres have shown that sustainability is a major concern for over 90% of staff (one survey returning 91% of staff regarding sustainability as "extremely" or "very" important, and no respondents rating sustainability as "not at all important"), but one about which they have limited knowledge and do not feel empowered to act on (only 10% of staff were "extremely" or "very" aware of the "Greener NHS" initiative and net zero ambitions, and 82% did not find it easy to make changes to improve sustainability at work).

CONCLUSION: Experience to date suggests that there is a need to stimulate the discussion within hospital departments in order to ensure that appropriate priority is given to sustainability issues. Staff need to be aware of the "Greener NHS" initiative, and the opportunities to improve sustainability within NHS departments. This poster hopes to inform and stimulate discussion on how we should respond as a brachytherapy community.

4 A retrospective study looking at Rectal and Urethral dose delivered following Low Dose Rate Prostate Brachytherapy with and without a pre-rectal hydrogel (SpaceOAR)

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PURPOSE: Retrospective analysis of dose data to assess the change in rectal and urethral dose following Low Dose Rate (LDR) Prostate brachytherapy using biodegradable pre-rectal hydrogel (SpaceOAR) at Kent Oncology Centre between October 2020 and December 2021 to ensure that there was no increase in urethral dose and demonstrate a reduction in rectal dose following insertion.

METHODS: Patients at high risk of late rectal toxicity were had SpaceOAR inserted following LDR Brachytherapy implant. Records were retrospectively reviewed on a prospectively maintained database. Rectal and urethral doses were analysed from the final implant plant and the post implant CT. Bladder and bowel toxicity were graded at 3 months and 12 months after treatment using CTCAE criteria and patients were sent a PROMs questionnaire.

RESULTS: 90 patients underwent LDR brachytherapy implant. 45 patients were deemed to be at higher risk of late bowel toxicity and had a SpaceOAR inserted following their implant. The mean Rectal V100 (< 2.0cc objective) and Urethral D30 at the end of implant (before SpaceOAR) was similar between the two groups; Rectal V100 1.18cc (0.25 – 2.0) no SpaceOAR vs 1.11cc (0.0 -2.25) with Space OAR, Urethral D30 176.56Gy (160.77 - 192.32) no SpaceOAR vs 178.17Gy (165.30-189.82). Data from patient Day 0 post implant CT demonstrates a reduction in the Rectal D2.0cc with the insertion of SpaceOAR; 97Gy (41.8 – 174.4) no SpaceOAR 65.8Gy (28.2 – 108.9) with SpaceOAR. There was no significant difference in the post implant CT Urethral D30 160.30 Gy vs 157.5Gy.

CONCLUSION: This retrospective planning study confirms that a Pre-rectal hydrogel inserted following LDR Prostate Brachytherapy reduces the dose delivered to the rectum without increasing the urethral dose. No significant rectal symptoms were reported by patients in either group. We feel that a pre-rectal hydrogel should be considered in patients with high risk of bowel toxicity.

5 MRI-based planning in prostate low dose rate (LDR) brachytherapy – a retrospective volumetric and dosimetric comparison with the traditional 2-step transrectal ultrasound (TRUS) based technique

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PURPOSE: For low risk (LR) and favourable intermediate risk (fav-IR) prostate cancer, LDR brachytherapy is an accepted standard of care with excellent outcomes[1]. The 2-step Seattle approach[2] has, in some centres, been replaced by 1-step procedures. These reduce patient visits and can allow for adaptive radiotherapy. In a single Australian institution, we used patients' diagnostic MRI scans to generate a brachytherapy plan with a view to dispensing with the pre-implant TRUS.

METHODS: A retrospective planning study was undertaken. 10 patients undergoing prostate LDR brachytherapy for LR or fav-IR prostate cancer were selected at random. Each had available pre-biopsy multiparametric MRI scans of prostate; the T2-series was imported into treatment planning software (TPS). Four independent radiation oncologists contoured CTV and OARs on each patient's MRI scan. The contours of each clinician were combined to form an "average" MRI contour set for each patient on which the medical physics expert generated an LDR plan per institutional protocol (prescription = 145 Gy). Each patient then had 2-step LDR implant using I-125 seeds by Seattle method[2]. MRI plans were compared to final TRUS plans as implanted, across volumetric and dosimetric variables. Paired 2-sided T-tests were used to identify significant difference in means.

RESULTS: Volumetric results - there were no significant differences in gland volume or maximum linear dimensions between MRI and TRUS contours. *Dosimetric results* - the MRI plans used significantly fewer seeds per plan: mean-MRI = 92.4 seeds, mean-TRUS = 96.7 seeds (p=0.014). MRI plans had significantly higher V100_rectum dose: mean-MRI = 0.33cc, mean-TRUS = 0.14cc (p=0.008); for both MRI and TRUS, these V100_rectum figures are still well inside GEC-ESTRO (=2cc)[1] and institutional (=1cc) tolerances. There was no significant difference in the domains: number of needles, V100_prostate, V150_prostate, D90_prostate, V150_urethra.

CONCLUSION: MRI-based planning may obviate the need for TRUS volume study, with no clinically significant dosimetric difference.

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POSTER PRESENTATION

6 Independent DVH QA test of a Brachytherapy Treatment Planning System

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PURPOSE: To develop a test to independently verify Dose Volume Histogram (DVH) calculations on a Low-Dose-Rate Brachytherapy Treatment Planning System.

METHODS: An in-house program was developed with Matlab to calculate dose points following the TG43 algorithm with 2D anisotropy and radial functions. A 5cm cube was created with 1x1x1mm3 voxels. 2 I125 (AgX100) sources of 100U air kerma strength were placed on opposite corners. Doses were calculated from each source to the centre of every voxel. The dose was considered uniform within each voxel. Contributions from both seeds were added and a differential dose-volume-histogram (DVH) was calculated based on voxel doses. Dummy images were acquired on Variseed TPS with a BK FlexFocus scanner and BK transrectal probe. A 5cm cube was 'contoured' with the aid of the Digital Ultrasound template visible on each 1mm slice. 2 Seeds were placed on opposite corners and the resulting DVH of this structure was exported as a text file. The calculated and planned DVHs were compared and a parameter was defined to quantify the agreement between both curves. Dose and volume differences were calculated for each point and thresholds were set to evaluate differences higher than 2%.

RESULTS: There was excellent agreement between both DVHs. All points passed with differences less than 1%.

CONCLUSION: The test can be part of a routine QA program or for post-upgrades checks. The code can be modified to include more seeds or simple structures. Future work will include the verification of clinical margins that are used in prostate brachytherapy.

7 Paperless process of a Low Dose Rate Brachytherapy Department

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PURPOSE: The Radiotherapy Department of the Belfast Trust moved to a paperless system in 2021. The Brachytherapy Team designed a workflow with Aria OIS (Varian) and Variseed Treatment Planning System (Varian) for a pre-plan technique of permanent brachytherapy implants.

METHODS: During 2020 and 2021, regular meetings were held between the Paperless implementation team and Varian Clinical Solutions specialist to evaluate the old process and documents. Then, the Clinical Team decided the best strategy to replace the workflow with user groups, care paths, tasks, encounters, prescription templates, dynamic documents and questionnaires. Lag times were set for every task to display when actions were expected to be due. A new version of the Employers Procedures was issued to reflect both workflows and the signature requirements to approve treatments electronically. The Radiotherapy Quality System was also updated. Prior to the implementation, training sessions for "Superusers" via Microsoft Teams were held for awareness and changes of the new workflow. This information was then disseminated through the team. First patients were treated through both paper-based and paperless systems until the Team was confident to move to a full paperless path.

RESULTS: The whole patient care path was created on Aria OIS with patient appointments and tasks. The Encounters Workspace was used to display actions, documents and questionnaires that replaced the old paper forms. Some of the tasks that were adapted are: referral, patient phone calls, planning process, seed calibration, tasks on implant day, CT appointment, CT dosimetry, post-treatment checks and follow-up at the end of the care path.

CONCLUSION: The paperless system optimized the workflow and minimized manual transcription errors. It was also an opportunity to review the process.

8 An Interactive Database for LDR brachytherapy Workflow Management and Audit

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PURPOSE: To develop a database to centralise all activities related to the LDR brachytherapy workflow; serving to streamline the process of recording clinical data; simplify ordering and tracking of brachytherapy LDR sources; automate routine steps in the process and provide a tool for future audits.

METHODS: The database is organised in Excel. Data input is controlled through user forms programmed in visual basic. Measures to prevent foreseeable errors in data entry are implemented. Database comprises of two sections: (1) Source logistics and (2) Clinical data. Source logistics includes sources order, receipt, seeds tracking and seeds disposal. Real-time calculation of the source activities enables accurate assessment of the current source stock status, planning of source orders and source disposal. Clinical information is subcategorised to pre-implant, implant and post-implant activities. Data is protected and access to data is limited to authorised users. Automation through calendar reminders and emails are utilised.

RESULTS: Implementing the database has enhanced efficiency of a paperless clinical workflow and improved control of source logistics and its audit. The patients' data is in a convenient format, easily accessible for clinical audit. A data summary page is available on any selected patient. All time-regulated activities are automated: a calendar reminder is sent automatically on the dates when the seed delivery is expected, when post-implant CT is planned and on the upcoming seeds disposal date. An automatic email is generated with the post-implant dosimetry results ensuring the clinicians receive this information in a consistent format. Source data is available to ensure that the Trust meets the environment agency regulations.

CONCLUSION: Paperless and centralised, the database is used as a logbook to record all events and activities related to LDR brachytherapy workflow, improving efficiency. The database provides a tool to simplify clinical audits and radioactive source audits.

9 Implementation of an Independent Dose Calculation Software for Prostate Brachytherapy Plan Checks

Wilson J, Gibson J
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PURPOSE: To evaluate and implement SunCHECK patient DoseCHECK – the SunNuclear platform already used within the department for EBRT dose verification – for independent 3D dose calculation of prostate brachytherapy plans from Oncentra Prostate TPS. In addition to the advantage of being the same platform used by the wider department, DoseCHECK also offers a more robust dose verification than the previous software used, which calculates point doses alone.

METHODS: SunCHECK was added as a DICOM peer on Oncentra Prostate and the export method determined. A total of 15 current and historic prostate plans were exported and analysed by DoseCHECK using the default brachytherapy template in the first instance, which was then adapted to establish relevant assessment criteria.

RESULTS: Due to the extremely high doses seen in brachytherapy close to the source, it was determined that local gamma analysis was more appropriate than global, and that a low threshold was required to prevent too many points being excluded from the calculation. Local gamma criteria 2%/1mm, 0.01% threshold were set and 13/15 plans achieved the 95% pass rate. Dosimetric information based on the individual target and OAR structures was used to aid plan assessment in the cases of failing overall gamma, and all plans met the criteria for clinical acceptance as a result of this. Point dose difference (tolerance 1%) and source strength agreement (tolerance 0.5%) were also assessed and passed in all cases.

CONCLUSION: DoseCHECK was found to be suitable for providing an independent dose calculation for prostate brachytherapy plans produced using Oncentra Prostate. The analysis options available were investigated and assessment parameters along with pass/fail criteria were selected for clinical use. This software has now been implemented into our clinical workflow.