Dansk Selskab for Medicinsk Fysik

21. DSMF Symposium

Middelfart 21. – 22. maj 2025

Velkommen til 21. DSMF symposium!

Kære deltager.
Dansk Selskab for Medicinsk Fysik byder hjertelig velkommen til dette års symposium på Milling Hotel Park.
Vi har tilrettelagt et spændende videnskabeligt program med indlæg fra såvel nationale som internationale foredragsholdere. Vi håber I finder indholdet interessant og underholdende, og at vi sammen får et par udbytterige dage på tværs af specialer.

Ud over det videnskabelige program har vi, som tidligere år såvel posterudstilling som firmaudstilling – begge dele vil der være rig mulighed for at kigge på under symposiet. Husk i den forbindelse at deltage i firmaquizzen onsdag, der er en god præmie på spil!
Onsdag afsløres det, hvem der løber med Ung Fysiker pris 2025.

Rigtig god fornøjelse!

DSMF's symposieudvalg:
Christine Voetmann
Jens Edmund
Jesper Thygesen
Peter F. Staanum
Thomas Lund Andersen
Birgitte Maria Nielsen (sekretær)



Program 2025

Onsdag d. 21. maj 2025

Session	Tid	ONKOLOGI	NUKLEARMEDICIN	RADIOLOGI
	09.30 - 10.00	**Registrering og kaffe**		
	10.00 - 10.15	**Introduktion & firmapræsentation**		
1	10.20 - 11.05	**AI in medicine: from idea to clinical implementation** *(Anne Holm, AUH)*		
2	11.15 - 12.00	**AI based tumor segmentation on MRI** *(Jesper Kallehauge, AUH)*		
	12.00 - 13.00	**Frokost**		
	13.00 - 13.40	**Ung fysiker pris 2025**		
	13.40 - 14.45	**Poster session & Firma konkurrence**		
	14.45 - 15.00	**Kaffepause**		
3	15.00 - 16.00	**Population based metabolic connectivity using [18F]FDG-PET following psilocybin** *(Mikael Palner, OUH)*		
	16.00 - 16.30	**Pause & Check-in**		
	16.30 - 18.30	**DSMF-generalforsamling 2025**		
	18.30 - 19.00	**Pause**		
	19.00 -	**Middag + bar + networking**		
Torsdag d. 22. maj 2025				
4	9.15 - 10.00	**IAEA dosimetry update: EBRT TRS no.398, rev.1** *(Claus E. Andersen, DTU)*	**CT protokoloptimering – at finde balancen mellem stråledosis og billedkvalitet** *(Anders Frodo Mikkelsen, Jesper Thygesen MT, RM)*	
	10.00 - 10.20	**Kaffepause**		
5	10.20 - 11.05	**Klinik-drevet RT: Mamma** *(Yates AUH, Hinz-berg SjUH, Kirkegaard AaUH)*	**Cyklotronbaseret produktion af alfa-emittere** *(Holger Jensen, Rigshospitalet)*	**Erfaringer med Dose Management System RSYD** *(Sofie Gregersen MT, Rsyd)*
6	11.15 - 12.00	**Klinik-drevet RT: Adaption** *(Kjeldsen SUH, Jasper SjUH, Thing SUH)*	**Klinik-nær NM** *(Micheelsen SjUH, Andersen m.fl. OUH, Staanum AUH)*	**Erfaringer fra Dose Management System fra Qaelum** *(Thilde Kofoed MT, RH)*
	12.00 - 13.00	**Frokost**		
7	13.00 - 13.45	**Quantum computing in medical physics** *(Jeanette Miriam Lorenz, FH Institute Munich)*		
8	13.55 – 14.55	**Quantum computing in medical physics** *(Jeanette Miriam Lorenz, FH Institute Munich)*		
	14.55 -15.00	**Kaffe og kage** **Tak for denne gang!**		

ABSTRACTS – PROGRAM

Session 1

AI in medicine: from idea to clinical implementation
Anne Holm, Aarhus Universitetshospital

Præcis segmentering af risikoorganer (OAR) er en forudsætning for effektiv og sikker stråleterapi (RT). Traditionelt er dette en tidskrævende proces præget af interobservatør-variation. Kunstig intelligens (AI) kan standardisere segmenteringen, øge overensstemmelsen mellem klinikere, reducere tidsforbruget og dermed bidrage til en mere effektiv ressourceudnyttelse i sundhedsvæsenet.

På Kræftafdeling, Aarhus Universitetshospital, har vi aktuelt implementeret AI-segmentering af OAR, for thorax, hoved-hals, hjerne og bækkenknogler. Vi arbejder desuden på at udvide systemet til også at omfatte øvre abdomen og bløddelsstrukturer i bækkenet.

Vores anvendelse af AI-segmentering er identificeret som Medical Device Software (MDSW) og derfor underlagt EU's Medical Device Regulation (MDR). Vi har valgt at implementere vores AI-segmentering under Artikel 5.5 (in-house developed). Implementeringen har krævet opbygning af omfattende dokumentation og procedurer for ledelse, risikostyring, validering, verificering og løbende monitorering.

I præsentationen vil jeg dele erfaringer fra vores implementeringsproces og den kliniske anvendelse.

Session 2

AI based tumor segmentation on MRI
Jesper Folsted Kallehauge, DCP, Aarhus Universitetshospital

AI-based tumor segmentation on MRI is a rapidly evolving field with growing relevance for radiotherapy planning. This presentation provides a critical overview of recent literature on deep learning approaches for automated tumor delineation, with a focus on methodological trends, reported performance, and clinical applicability. Key challenges such as data heterogeneity, model generalization, and validation strategies will be discussed. The talk aims to contextualize current developments for medical physicists and highlight considerations for future clinical integration.

Session 3

Population based metabolic connectivity using [18F] FDG-PET following psilocybin
Mikael Palner, Research unit of Clinical Physiology and Nuclear Medicine, OUH

Pharmacotherapy with classical psychedelics shows promising benefits in trials in various neuropsychiatric disorders. While acute psychedelic effects last a few hours, positive therapeutic effects can persist long after a single drug administration. LSD, psilocybin, and the phenylethylamine 2C-B exert their psychedelic effects via agonism at serotonin 2A (5-HT2A) receptors but differ pharmacologically in other respects. Therefore, we used serial positron emission tomography (PET) with the glucose analogue FDG to test the hypothesis that LSD, psilocybin, and 2C-B induce distinct patterns of changes in metabolic activity and connectivity within biologically informed rat brain networks and confirmed their occupancies in vivo with a PET ligand for 5-HT2A receptors.

Distinct differences in both metabolic activity and connectivity within two biologically informed brain networks we notable doing the acute action of the three drugs, psilocybin, LSD and 2C-B. While LSD and 2C-B was more similar in their action with wide-spread cortical hypometabolism. All three drugs induced distinct long-term changes in both networks, psilocybin increased metabolic activity in the insula, while 2C-B induced changes in the nucleus accumbens and ventral tegmental area together with changes in connectivity between the amygdala and hypothalamus. Our findings of acute and persistent changes in metabolic activity and connectivity within these networks provide new insights into understanding the shared and drug selective mechanisms underlying the therapeutic effects of psychedelic substances in neuropsychiatric disorders.

Session 4

ONKOLOGI

IAEA dosimetry update: EBRT TRS no.398, rev.1

Claus E. Andersen, DTU

The IAEA TRS-398 code of practice underpins reference dosimetry with ionization chambers in external beam radiotherapy. Following this code, it is possible to achieve traceable absorbed dose to water measurements in clinical beams with an acceptable uncertainty. The code includes cobalt-60 gamma, kV x-rays, MV x-rays, MeV electrons, protons, and heavy ions. The code was first published in 2000, and a revised version (called TRS-398 rev. 1) came out in 2024. This presentation will discuss the changes in the revised code with an emphasis on MV x-ray dosimetry, and with some details concerning the data in the code that came from measurements at DTU including primary standards measurements by VSL from the Netherlands. The presentation will also shortly discuss the future of cobalt-60 calibrations, that may be phased out internationally due to increases in cost, availability and safety requirements.

NUKLEARMEDICIN OG RADIOLOGI

CT protokoloptimering – at finde balancen mellem stråledosis og billedkvalitet

Jesper Thygesen, Indkøb og Medicoteknik, Region Midtjylland, Anders Frodo Mikkelsen, NUK-PET, AUH

Der foretages flere og flere CT-skanninger, og flere patienter får også opfølgende skanninger enten som overvågning eller monitorering af effekten af behandling. Vi har pligt til hver gang at vurdere fordele og ulemper for patienten ved at få foretaget undersøgelsen.

Vi gennemgår Total Risk Index og ser på de mange forskellige faktorer, som spiller ind i optimeringen af undersøgelsen så patientens gevinst overstiger ulempen.

De forskellige strålerisikofaktorer gennemgås, samt hvilke muligheder man har for at evaluere billedkvalitet og dermed sikrer den diagnostiske værdi af undersøgelsen.

Vi præsenterer de værktøjer, fantomer og software, som vi bruger til at vurdere skanningsparametrenes indvirken på om undersøgelsen indeholder nok information til at svare på de kliniske spørgsmål i henvisningen.

Session 5

ONKOLOGI

Klinik-drevet RT: Mamma
Esben Svitser Yates AUH, Thomas Hinz-Berg SjUH, Trine Kirkegaard AaUH

Preliminary studies of VMAT vs. RAD dose planning for high-risk breast cancer.

Esben Svitzer Yates[1], Harald Spejlborg[1], Anne Ivalu Sander Holm[1], Lars Nyvang1, Jolanta Hansen[1]
[1:] Department of Medical Physics, Aarhus University Hospital, Aarhus, Denmark

Introduction: Internal mammary node (IMN) radiotherapy (RT) improves survival in node-positive breast cancer patients [1]. Irradiating the internal mammary nodes increases the delivered dose to the heart and lungs, prompting the use of advanced dose planning techniques like Volumetric Modulated Arc Therapy (VMAT) or RapidArc Dynamic (RAD).

Most treatment planning systems are unable to optimize for dose robustness outside the patient's body. To address this, VMAT plans were developed, incorporating an artificial tissue rim during optimization to ensure a relevant skin flash; this rim is removed during final plan evaluation. This dual-phase process optimization and evaluation on separate CT scans can be cumbersome and time-consuming.

In this study, we evaluated the performance of Siemens Varian's new optimization and delivery method, RAD with VMAT. With RAD, the artificial tissue rim is integrated during the optimization phase, thereby streamlining the process and eliminating the need for the time-consuming iterative steps, reducing the optimization procedure to a single phase.

Materials and Methods: VMAT and RAD plans were calculated for 10 left-sided high-risk patients. The VMAT plans were set up using three arcs, with angles ranging from 179° to 310°. The RAD plans employed two arcs with the same angular spacing, accompanied by four static fields. The medial and lateral static fields were set up with angles between [315°;330°] and [130°;150°], respectively.

Results: For both VMAT and RAD dose plans, the target coverage was acceptable. Generally, RAD plans had a better coverage of CTVp_breast/CTVp_chestwall than VMAT plans and the Dmean to the OAR was equivalent or lower.

For the heart, the contralateral breast and the contralateral lung the Dmean was 16.6%, 22.1%, and 12.7% lower, respectively, compared to the VMAT plans.

The Dmean calculated for ipsilateral lung was 3.3% higher. This slight increase in dose is correlated to an increase in target coverage and is consistent with the RAD plans having a more tangentially opposing dose profile.

The RAD plans demonstrated better coverage of the CTVp_breast/CTVp_chestwall compared to the VMAT plans, as illustrated in Figure 1.

Conclusion: RAD is a relatively new program and the full potential of the new optimizer is yet to be seen. However, even at this stage, we can already observe significant dose reduction for OARs. This study will be expanded with an investigation of the robustness of both the VMAT and the RAD plans.

Reference list

1. Nielsen, A.W.M., L.B.J. Thorsen, D. Özcan, L.W. Matthiessen, E. Maae, M.L.H. Milo, et al. Internal mammary node irradiation in 4541 node-positive breast cancer patients treated with newer systemic therapies and 3D-based radiotherapy (DBCG IMN2): a prospective, nationwide, population-based cohort study. Lancet Reg Health Eur, 2025. 49: p. 101160 DOI: 10.1016/j.lanepe.2024.101160.

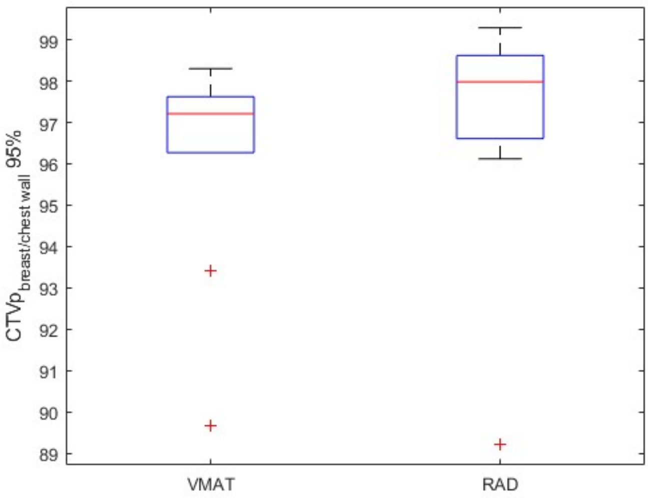

Figure 1. V95% for $CTVp_{breast/chestwall}$ in VMAT and RAD plans.

Hybrid og avancerede teknikker til dosisplanlægning af mammae

Thomas Hinz-Berg Johansen
Onkologisk afdeling, Sjællands Universitetshospital, Næstved, Danmark

Strålebehandling til patienter med brystkræft er meget alsidig med mange muligheder for forskellige teknikker, tilpasset den individuelle patients anatomi. Ved udelukkende at holde sig til konventionelle behandlingsmetoder med 3D konform stråleterapi (3DCRT), vil man ofte komme ud for meget komplekse løsninger, ofte med brug af neutronkontaminerende energier, for patienter med stort brystvolumen, kort afstand mellem target og hjerte, samt generel ”udfordrende” anatomi i forhold til dosisplanlægning.

For at opnå en individualiseret behandling, må der derfor gøres brug af alle planlægningsteknikker til rådighed. Med et klinisk flowchart som kan give et samlet overblik over forskellige problemstillinger ved dosisplanlægning af mammae, vil man være i stand til at vælge de mest passende behandlingsteknikker.

Ved hybrid-planlægning, hvor brugen af 3DCRT og VMAT blandes, vil man kunne øge antallet af frihedsgrader med tilføjelsen af korte VMAT-buer, samtidig med at man bevarer den velkendte robusthed ved 3DCRT felter. Korte VMAT-buer kaldes også ”butterflyteknik”.
I tilfælde hvor dosis til risikoorganer overstiger DBCG-retningslinjer ved brug af 3DCRT, vil man i stedet kunne gøre brug af ren VMAT-teknik. Dette kan enten være i form af korte butterflybuer eller længere VMAT-buer, for at imødekomme de ønskede krav.

Med en fordeling af dosisbidrag på 90% fra 3DCRT-felter og 10% fra butterfly buer, kan man opnå en øget konformitet og homogenitet i forhold til konventionelle teknikker, ved helbrystbestråling med stort brystvolumen (>700 cc). Dosis til risikoorganer øges ikke betydeligt. Dette kan gøres uden at gøre brug af nogen form for skinflash. Robusthed i forhold til hævelse og geometrisk flyt forbliver høj.
Skal lymfeknudestationer også bestråles og 3DCRT ikke er acceptabelt, anbefales brugen af butterflyteknik ved mastektomier og en blanding af lange buer med butterflybuer ved lumpektomi Optimering med lav NTO på ca. 300-400 vil øge de tangentielle bidrag for at mindske kontralaterale dosisbidrag.

Individuelt tilpasset brug af VMAT-buer, enten i form af en kombination med 3DCRT eller for sig selv, mindsker samlet behandlingstid, simplificerer og forkorter dosisplanlægningstid som løsningsmulighed for avancerede patienttilfælde, hvor konventionelle teknikker ikke er tilstrækkelige.

Reducing preposition variations and monitor intrafraction movement with surface-guided radiation therapy for breast cancer patients

Trine O Kirkegaard[1], Ingelise Jensen[1], Thomas O Kristensen[1], Marie Louise Holm Milo[2,3], Martin S Nielsen[1,3]

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[2]Department of Oncology, Clinical Cancer Research Center, Aalborg University Hospital, Aalborg, Denmark. [3]Department of Clinical Medicine, Aalborg University, Aalborg, Denmark.

Introduction*:* The primary aim of this study was to investigate the feasibility of surface-guided radiation therapy (SGRT) using Exactrac Dynamic (ETD) for prepositioning of breast cancer patients treated in free breathing compared to conventional skin-marker setup. A secondary aim was to assess intrafraction movement using surface data captured during treatment.
Materials and methods: Twenty-one breast cancer patients were included. They were treated with whole- or partial-breast irradiation in free breathing using 3D conformal planning technique. In a

crossover study design, each patient was setup with both the skin-marker- and SGRT procedure but for different fractions in random order. The setup offset was evaluated using 3D couch shifts from subsequent image guidance, acquired as orthogonal MV-kV for whole-breast and kV-kV for partial-breast and boost plans.
Intrafraction movement, excluding periodic respiration, was evaluated using the log-files from ETD, where surface data was recorded per monitor unit delivered. For each main field a mean surface displacement from baseline was found, and the difference between the two main fields for each fraction represented the intrafraction movement.
Results: No significant difference was found in mean population setup offset between SGRT and skin-marker setup. SGRT demonstrated reduced random population errors in vertical (VRT) and longitudinal (LNG) direction and reduced systematic population errors in lateral (LAT) direction (table 1). A systematic vertical offset was observed for both SGRT and skin-marker setup.
Analysis of the intrafraction movement showed no mean population shift in LNG and LAT, but a small, significant shift of -0.3 mm in VRT. Random and systematic population errors where below 1 mm in all directions.
Conclusions: Surface guided setup using ETD showed no significant difference in mean population setup offset compared to conventional skin-marker setup. SGRT was, however, superior to skin-marker setup as the systematic- and random errors were reduced indicating improved consistency. Subsequent IGRT is still advisable for final patient positioning.
We demonstrated that ETD SGRT were able to track the individual patient movement and found a small mean population shift in VRT.

	VRT (mm)			LNG (mm)			LAT (mm)		
	M (95%ci)	∑	σ	M (95%ci)	∑	σ	M (95%ci)	∑	σ
Skin-marker (n = 127 fx)	-2.6 (-4.1, -1.1)	3.4	3.5	-0.8 (-2.0, 0.3)	2.6	3.6	-0.2 (-1.4, 0.9)	2.5	2.6
SGRT (n = 201 fx)	-2.5 (-3.6, -1.5)	2.3	2.5	-0.6 (-1.5, 0.3)	2.0	2.4	-0.9 (-1.6, -0.2)	1.6	2.1
p-value	0.94*	0.09**	0.03*	0.76*	0.28**	0.01*	0.22*	0.04**	0.06*

*Table 1: IGRT match after prepositioning showing the setup offset using the skin-marker- vs SGRT procedure in VRT, LNG and LAT direction in terms of mean population offset (M) with 95% confidence interval (95%ci), systematic population error (Σ) and random population error (σ). *Paired t-test. ** F-test. All tests are with 5% significance level.*

NUKLEARMEDICIN

Cyklotronbaseret produktion af alfa-emittere

Holger Jensen, PET and Cyklotron unit, Rigshospitalet

RADIOLOGI

Erfaringer med Dose Management System RSYD

Sofie Gregersen, Medicoteknik, RSYD

Session 6

ONKOLOGI

Klinik-drevet RT: Adaption

Mads Møgelmose Kjeldsen, SUH, Bettina Skjold Jasper, SjUH, Rune Thing, SUH

Reduktion af PTV-marginer for Patienter med Prostatakræft Gennem Online Adaptiv Stråleterapi på Ethos

Betina Skjold Jasper

Med Ethos indføres muligheden for CBCT-baseret online adaptiv strålebehandling. Ved online adaptiv strålebehandling indtegnes og planlægges på dagens anatomi, hvorfor interfraktionel anatomisk forandring og bevægelse er elimineret. Det betyder, at de adaptive PTV-margener, modsat konventionelle IGRT-margener, ikke skal tage højde for disse interfraktionelle forandringer. Der er således baggrund for at PTV-margener kan reduceres når patienter behandles online adaptivt.

En reduktion i PTV-margener vil utvetydigt betyde en reduktion af dosis til normalvæv. Ultimativt kan en reduktion i PTV-margener føre til færre bivirkninger og dermed en bedre behandling.

Dette studie fokuserer på patienter med prostatakræft, der modtager adaptiv strålebehandling mod prostata, sædblærerne samt pelvine lymfeknuder. Disse patienter behandles med i alt 78 Gy mod prostata og sædblærer (CTV-T) og 56 Gy mod pelvine lymfeknuder (CTV-E) fordelt på 39 fraktioner med 5 ugentlige fraktioner.

PTV-margener omkring CTV-T (PTV-T) og CTV-E (PTV-E) undersøges separat og evalueres retrospektivt én fraktion ugentligt. Nuværende PTV-T indtegnes som en margen til CTV-T på 5 mm lateralt samt anteriort og posteriort og 7 mm cranialt og caudalt. Nuværende PTV-E er en isotrop margen på 7 mm fra CTV-E. Ud over sædvanlige PTV-T og PTV-E indtegnes yderligere 5 test-strukturer: CTV-T udvides isotropt med henholdsvis 3 mm og 4 mm, og CTV-E udvides isotropt med 3 mm, 4 mm og 5 mm. Intrafraktionel bevægelse vurderes baseret på forskellen mellem planlægnings-CBCT og verifikations-CBCT. Verifikations-CBCT tages umiddelbart efter adaption og umiddelbart før behandling. Fysiker vurderer ved offline gennemgang af verifikations-CBCT den mindste PTV-margen der dækker CTV-T hhv. CTV-E.

Baseret på 97 fraktioner fordelt på 13 patienter, var en PTV-T margen på 3 mm dækkedende for intrafraktionel bevægelse for 86% af fraktionerne. En PTV-T margen på 4 mm dækkede intrafraktionel bevægelse for hele 98% af fraktionerne. For det elektive target, var en PTV-E margen på 4 mm dækkende ved 92% af fraktionerne. En PTV-E margen på 3 mm var tilstrækkeligt ved 68% af fraktionerne.

Konklusionen er, at der er evidens for at indskrænke PTV-margener for både prostata og sædblære samt for elektive lymfer for patienter behandlet online adaptivt. Både PTV-T og PTV-E kan på sikker vis reduceres til 4 mm. En yderligere margenreduktion omkring prostata kan komme på tale, hvis PTV-T deles op i PTV til prostata og PTV til sædblærer.

Characterization of a solid water material for true end-to-end testing

Authors: Rune Slot Thing[a,b], Bjarke Mortensen[a,b], Martin Berg[a,b] and Liubov Nesterenko[a]

[a] *Vejle Hospital, University Hospital of Southern Denmark, Dept. of Oncology, Vejle, Denmark*
[b] *Radiotherapy Research Team, Department of Oncology, Vejle Hospital, University Hospital of Southern Denmark, Denmark*

Purpose

Phantom-based end-to-end (E2E) tests are typically designed with phantoms requiring density overrides in the treatment planning system (TPS) to allow for accurate dose calculations. The main reason for this is the lack of phantom materials that are water or tissue equivalent at both kV and MV photon energies. In this work, we characterize a known water equivalent plastic material designed for quality assurance in the kV energy range, for high energy photon beams in accordance with the IAEA TRS-483 protocol. A simple E2E test method is developed using a cylindrical phantom made from the same plastic material.

Materials and methods

A set of 30x30 cm^2 slabs made from CT HE Solid Water was manufactured by Sun Nuclear (Sun Nuclear Corporation - A Mirion Medical Company, Melbourne, Florida, USA), in thicknesses varying from 1 to 50 mm. In one 20 mm slab, a cavity for the Sun Nuclear SNC125c ion chamber was drilled, allowing dose measurements to be performed.
To determine the water equivalence of this material, we measured Percentage Depth Dose curves (PDDs), output factors (field sizes 3x3-20x20 cm^2), Tissue Phantom Ratios ($TPR_{20/10}$), and absolute dose measurements at 10 cm depth. Based on the absolute dose measurements, we also determined the phantom dose conversion factor, $k^{w,plastic}_{Q,msr}$, from IAEA TRS-483. An E2E test using a cylindrical phantom made from CT HE Solid Water with inserts of other materials was prototyped, using a 5x5 cm^2 field. Measurements were performed on Elekta linacs (Elekta AB, Stockholm, Sweden) using beam energies of 6 MV, 10 MV FFF, and 10 MV.

Results

Measurements of PDD curves using the slabbed phantom made from CT HE Solid Water showed high equivalence with water (< 1% difference) at depths of 10 cm or more. At more shallow depths, the dose measured in the solid water phantom was up to 2% less than the reference dose measured in water, possibly owing to differences in electron transport properties of the slabbed solid water phantom compared to true water. Measurement of output factors and $TPR_{20/10}$ agreed with reference measurements in water within 0.7% and 0.5%, respectively. $k^{w,plastic}_{Q,msr}$ was determined to 1.004-1.007 for all beam energies, with a combined measurement uncertainty of 0.005.
The E2E test showed agreement within 2% between TPS-calculated and measured dose, using no material overrides in the TPS.

Conclusion

The CT HE Solid Water material was found to be water equivalent to within 1% for beam energies between 6 and 10 MV. E2E testing is feasible with an accuracy of about +/- 2%, thus adding a sanity

check of the entire data flow of a Radiotherapy department, but not rendering more specific testing of sub-systems obsolete.

NUKLEARMEDICIN

Klinik-nær NM

Mille Micheelsen, SjUH , Christian Walther Andersen, Christian Glarbo Pedersen, Svend Hvidsten, OUH, Peter Frøhlich Staanum, AUH.

Reduktion af CT dosis på diagnostisk og lavdosis PET/CT

Mille Micheelsen, Klinisk Fysiologisk Nuklearmedicinsk Afdeling, Sjællands Universitetshospital

Skift fra [^{99m}Tc]-Tetrofosmin til [^{15}O]H_2O Myocardieperfusion og [^{123}I]-FPCIT til [^{18}F]Pe2I DaT

Christian Walther Andersen, Christian Glarbo Pedersen, Svend Hvidsten, Nuklearmedicinsk Afdeling, OUH

I efteråret 2024 udsendte direktionen på OUH besked til alle afdelinger om, at der skulle findes besparelser i budgetterne for 2025. I den forbindelse valgte afdelingen at skifte to undersøgelser ud: Myocardieperfusion bliver nu lavet som [^{15}O]H_2O-PET/CT (tidligere [^{99m}Tc]-Tetrofosmin-SPECT/CT), og DaT-billeder bliver nu lavet som [^{18}F]Pe2I-PET/CT (tidligere [^{123}I]-FPCIT-SPECT/CT). Disse to undersøgelser blev valgt ud fra en vurdering af den formodede besparelse og at den nye undersøgelse formentlig ville blive mindst lige så god. Vi vil præsentere og sammenligne billeder og analyse fra både de tidligere og nuværende undersøgelser.

Diagnostisk CT skanning af c.prostata patienter udført i forbindelse med knogleskintigrafi på ny SPECT/CT skanner

Peter Frøhlich Staanum, Nuklearmedicin og PET, AUH.

Baggrund: I den nyeste generation af SPECT/CT skannere er CT kvaliteten væsentligt forbedret i forhold til tidligere modeller. Dette muliggør i højere grad end tidligere kontrast-forstærkede CT skanninger af diagnostisk kvalitet.

Her berettes om implementering af diagnostisk CT skanning af c. prostata patienter til opfølgning for bløddelsmetastaser. Skanningen udføres i forbindelse med knogleskintigrafi til opfølgning for knoglemetaser, hvilket gør forløbet enklere for både patienter og personale.

Materiale og metoder: Diagnostisk CT udføres på en Siemens Pro.specta X7 SPECT/CT skanner. CT kontrast administreres vha. en Bayer Centargo kontrastpumpe. Skanningen udføres som en 2-faset CT skanning med en arteriel fase over thorax og abdomen til under leveren, samt en venøs fase over abdomen og bækken (fra over leveren). Protokollen blev sat op i samarbejde med afdelingen Røntgen&Skanning og tilrettet efter løbende evaluering af skanninger.

Resultater: Protokollen er tilpasset, så skanningerne er tilfredsstillende i sammenligning med de tilsvarende skanninger udført på Røntgen&Skanning. Diagnostisk CT skanning af c. prostata patienter inden for AUHs henvisningsområde udføres nu rutinemæssigt.

Konklusion: Diagnostisk CT skanning af c. prostata patienter udføres rutinemæssigt på en Siemens Pro.specta X7 SPECT/CT skanner i forbindelse med knogleskintigrafi undersøgelse til gavn for såvel patienter som personale.

RADIOLOGI

Erfaringer fra Dose Management System fra Qaelum
Thilde Kofoed, Region Hovedstaden

Session 7 & 8

Quantum computing in medical physics
Jeanette Miriam Lorenz, FH Institute Munich

Development of quantum hardware and software is progressing rapidly. With the availability of first generally-accessible quantum computers, their potential use for applications can increasingly be explored. One prospective field of application is data science in the medical sector including medical physics, where quantum-enhanced AI could lead to the ability to analyze more complex patterns in the data than classical AI methods. An example is medical imaging, where frequently only limited training data is available – making the use of classical AI methods challenging. However, presently available quantum computers are still limited in the number of qubits, the connectivity and are affected by noise.

Due to this, it is currently impossible to obtain a clear quantum advantage like in Grover's or Shor's algorithm already today. But can we still profit from the currently available Noisy-Intermediate Scale quantum (NISQ) computers now or in the near future? What are the steps to take to obtain a practical quantum advantage in academic and industrial applications? What are the potential application fields, e.g, in the medical sector?

My talk will first give an introduction to quantum computing, focusing in particular on near-term quantum computing: what is a ‚practical' quantum advantage? Then we look towards example applications in medical physics and tune in to the question which kind of advantages quantum computers may offer.


Unstoppable
The NAEOTOM Alpha Class

ABSTRACTS

Posters

National and local diagnostic reference level intervals – concepts and examples

Autors: Asbjørn Seegert[1] ,Sofie Gregersen[1]
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Introduction
In this poster national and local diagnostic reference level intervals "DRLi's" for CT examinations are investigated. Similarities and difference of concepts are explained and examples of usages are shown.

Materials & Methods
DRLi is an interval of dose levels created for specific examination types, helping in evaluating whether a dose is acceptable, too high or too low.

National DRLi's for the standard patient are based on scanner median doses from all scanners in a country. National DRLi's in Denmark was published in 2018.

A national DRLi is used in the optimization process. If the dose median from present examinations from a scanner is above the interval, reduction of dose should be considered and if below the interval image quality should be evaluated.

Local DRLi's for different weight classes are based on individual patient doses from examinations performed in a local department. Two methods to express DRLi are suggested.

Local DRLi represents actual local dose levels for different weight classes. If a planned patient dose is compared with the DRLi, the radiographer has the possibility to correct the examination, if the dose is too high or too low. Retrospectively evaluation is also possible.

Results
The poster shows examples of using national DRLi's to optimize dose and image quality and examples of how local DRLi's can be created and visualized to use in daily practice.

Summary
National DRLi's are used in the optimizations of examination protocols.
Local DRLi's are used to evaluate planned patient doses.
Examples of usages are shown.

Real-time dosimetry for estimating eye lens doses of cardiologists

Sofie Gregersen & Steffen H. Hansen, Medicoteknik, Region Syddanmark

Introduction

Cardiologists work in close proximity to the patient during fluoroscopy procedures, exposing them to considerable amounts of scatterred radiation. This study evaluates whether the eye lenses of cardiologists are at risk of exceeding the Danish dose limits of 20 and 15 mSv/year for category A and B radiation workers, respectively.

Materials & Methods

To estimate doses to the eye lens, cardiologists from Odense University Hospital, were equipped with personal Raysafe i3 live dosimeters. The dosimeters were worn on the outside of the thyroid gland protection during all procedures for a period of 1-2 weeks.

Results

As seen in table 1 the workloads and radiation exposures of the cardiologists varied a lot. The largest dose measurement was a total exposure of 180 µSv from 30 CAG/PCI procedures performed in one week. Assuming constant workload this would result in a total dose of 8 mSv/year. Since the dose is measured at shoulder height and the cardiologist is wearing lead glasses, it is safe to assume that the dose to the eye lens is about 50% of the measured dose [1], e.g. 4 mSv/year. This is well below the dose limit of 15 mSv/year for category B.

Summary

It is demonstrated how live dose measurements make it possible to estimate eye lens doses. It is conservatively estimated that the cardiologist with the highest exposure have an annual dose to the eye lens of 4 mSv, which is well below the maximal 15 mSv/year for category B radiation workers.

Acknowledgements

The authors wish to thank the involved cardiologists at Odense University Hospital, Denmark.

Appendix

Table 1: Measured and estimated dose data for seven cardiologists in the study.

Cardiologist	#procedures	#weeks	Measured dose (µSv)	Estimated annual dose (mSv)	Lead glasses	Estimated annual dose to eye lens (mSv)
1	30	1	180	8	Yes	4
2	37	2,5	190	3,5	Yes	1,8
3	24	2	180	4	Yes	2
4	10	2	40	1	Yes	0,5
5	5	0,5	10	1	No	1
6	10	0,5	13	1	Yes	0,5
7	NA	2,5	4	<0,1	Yes	<0,1

References

[1] J. S. Magee *et al.*, “Derivation and application of dose reduction factors for protective eyewear worn in interventional radiology and cardiology,” *J. Radiol. Prot.*, vol. 34, no. 4, pp. 811–823, Dec. 2014, doi: 10.1088/0952-4746/34/4/811

Daily online adaptive IMRT of Vulvar carcinoma: A multicenter study

Bak, M. E. et al.

Vulvar carcinoma is a rare malignancy that accounts for 0.3% of all cancers globally. Vulvar cancer spreads for the most part through direct extension to adjacent structures and lymphatic system. Treatment of vulvar cancer carries a significant risk of late effects and complications. The rarity of vulvar carcinoma results in treatment strategies mainly coming from retrospective studies. Surgery is the primarily preferred treatment in resectable disease. Adjuvant RT is used to reduce the risk of recurrences in vulvar cancer patients with high-risk features.

Postoperative radiotherapy for vulvar carcinoma is challenging due to a high burden of radiation sequelae, relatively high risk of locoregional disease recurrence and technically challenging targets combined with a high frequency of postoperative lymphocele causing daily anatomical variations. Adaptive radiation therapy can be used to account for both systematic and random complex anatomical changes (see example in Figure 1) as well as time trends, potentially reducing the required safety margin .

Based on a preliminary study, showing that target dose coverage was significantly improved with online adaptive RT compared to IGRT and that this gain was robust during the time on the couch, we aim to start a trial to further develop and optimize the use of Ethos for vulvar carcinoma. We propose a prospective multicenter study aimed at documenting procedures and outcomes after online adaptive RT to postoperative vulva cancer patients. A database for side effects, PRO and disease control (based on CTCAE 5.0, EORTC QLQ-C30 and QLQ-VU34 scores) will be established. Technical treatment details, such as frequency of adaptation, adaption time, and applied margins will be recorded. Rigshospitalet aims to accrue approximately 15 patients per year into this trial. Arhus University Hospital are expected to participate in this protocol later in 2025 with a similar patient accrual rate.

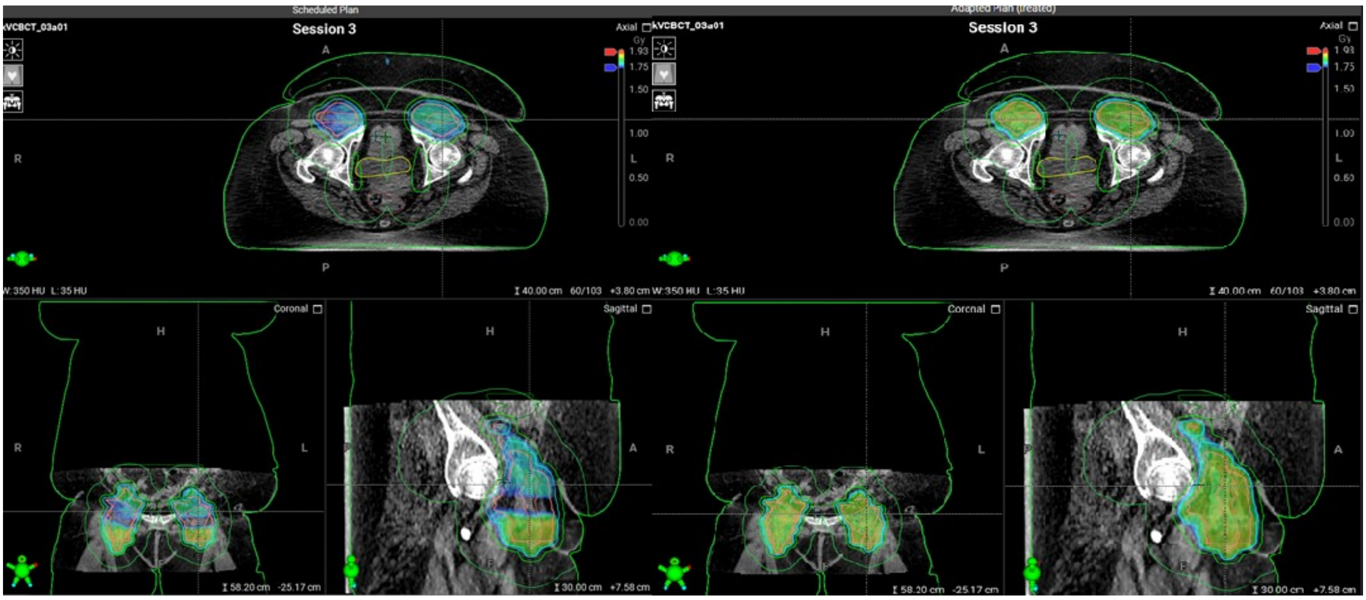

Figure 1 - Example of patient with big anatomical change (abdomen hangs lower than on planning CT) causing scheduled plan to not cover target. By having the adaptive plan as an option, dose to target could be achieved.

CT-QARS: Software for quality assurance of CT image quality in accordance with Danish guidelines

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Introduction
In 2023, physicists from Region of Southern Denmark developed a free QA-tool for analyzing CT images in accordance with the guidelines for CT quality control (QC) by the Danish Radiation Safety Authority (SIS) [1]. This abstract describes functionalities, focusing on Catphan-analyses, in the Matlab-based QA-tool *CT-QARS* (CT Quality Assurance, Region of Southern Denmark) [2].

Materials & Methods
The SIS-guidelines require the following analyses:

- Images from water phantom: Image noise, CT-numbers, and uniformity.
- Images from Catphan 600/700 [3]: Linearity, pixel size, slice thickness, modulation transfer function (MTF), and slice sensitivity profile (SSP).

Well-proven Matlab-routines for water analyses were developed and used for QC prior to this project. Inspired by the Catphan-manual new Matlab-routines were written and tested on images from different systems: 4 GE, 3 Siemens, 1 Canon, and 1 Toshiba scanners. All images passed SIS-criteria based on analyses in CT AutoQA Lite/Plus from QA Benchmark.

Results
Linearity measures all had R^2>0.999 and pixel sizes perfectly agreeing with nominal values. Slice thicknesses deviated from nominal values within tolerances in 44 cases. A 45th case exceeded, but was already at boundary of tolerance from previous analysis. Compared to previous analyses the mean deviation (range) for MTF50 and MTF10 was 4% (1%-10 %) while 4% (1%-8 %) for SSP.

Summary
CT-QARS is capable of analyzing images from water and Catphan phantoms. Comparisons to previous data illustrate that CT-QARS is a relevant tool for QC of CT image quality in accordance with SIS-guidelines.

Acknowledgements
CT-QARS was motivated by a national collaboration with other physicists:
Jonas Hermansen (Zealand), Jesper Thygesen (Aarhus), Asger Petersen (Aalborg), and Anders Mikkelsen (Aarhus)

[1] *Modtage- og statuskontrol af CT-skannere*. SIS, 2017. Available: https://www.sundhedsstyrelsen.dk/da/udgivelser/2017/Modtage--og-statuskontrol-af-CT-skannere-Protokol. [Accessed: Feb. 26, 2024]
[2] "CT-QARS hompage." Available: https://medicoteknik-rsd.dk/fysikerfunktion/ct-qars. [Accessed: J un. 03, 2024]
[3] "Catphan Phantoms — The Phantom Laboratory." Available: https://www.phantomlab.com/catphan-phantoms. [Accessed: Feb. 28, 2024]

Antal strålebehandlinger i Danmark nationalt og lokalt i et historisk perspektiv

Forfattere: Bjarke Mortensen[i], Annette Ross Jakobsen[ii], Ditte Sloth Møller[iii], Ole Nørrevang[iv], Henrik Robenhagen Jensen[v], Eva Samsøe Hinsby[vi], David Sjöström[vii], Ivan Richter Vogelius[viii], Martin Berg[i]Sygehus Lillebælt, [ii]Aalborg Universitetshospital, [iii]Aarhus Universitetshospital, [iv]Dansk Center for Partikelterapi, [v]Odense Universitetshospital, [vi]Sjællands Universitetshospital, [vii]Herlev Hospital, [viii]Rigshospitalet

Formål:
Kendskab til udviklingen i antal udførte strålebehandlinger nationalt på stråleterapiområdet er essentielt for lokalt i egen afdelinger at kunne agere i forhold til landsdækkende trends, men også nationalt strategisk i forhold til eksempelvis nationale kræftplaner, national indførsel af screeningsprogrammer eller væsentlig ændringer i behandlingsbehovet ved overgang til eksempelvis hypofraktioneringsregimer.

Metode:
I forbindelse med vurdering af behovet for strålefraktioner i Danmark har der været indsamlet behandlingsdata fra de danske stråleterapicentre. I 2004 estimerede Acceleratorudvalget under Dansk Selskab for Klinisk Onkologi behovet for strålebehandlinger i Danmark i 2007 på basis af indsamlede data fra 2003. Tilsvarende udarbejdede Sundhedsstyrelsens Task Force vedr. Strålebehandling i 2008 en rapport vedr. det forventede behov i 2012 på baggrund af data fra 2007. Et af hovedformålene i Kræftplan II (2005) var at sikre en tilstrækkelig kapacitet, således alle kræftcentrene kunne behandle patienterne inden for en maksimal ventetid på 4 uger.
Cheffysikergruppen i Danmark har siden i eget regi årlig videreført og vedligeholdt indsamling af behandlingsdata. Ovenstående data er suppleret med data for perioden 1996-2002 indsamlet af Sundhedsstyrelsen i forbindelse med evaluering af Kræftplan I's gennemførsel (2004).

Resultat:
Der foreligger data for det samlede antal udførte strålebehandlinger i Danmark fra 1997 til 2024, mens komplette lokale behandlingsdata er tilgængelige for alle centre fra 2006.
Opfølgningsarbejdet på Kræftplan II forudsagde en øgning i behandlingsniveauet fra estimeret 214.916 (realiseret 210.101) i 2007 til et behandlingsniveau på 281.821 (realiseret 269.030) strålefraktioner i 2012. Øgningen over den femårige periode var forudsagt til 31,1% (5,5% årlig øgning), mens der blev realiseret en kapacitetsøgning på 28,0% (5,1% årlig øgning). Allerede i 2009 formåede de danske stråleterapicentre dog at udføre 270.088 strålefraktioner, hvorefter der fra 2009 til 2014 blev udført mellem 263.424 og 276.151 (middel 268.252).
Det i Danmark hidtil største antal strålefraktioner 276.151 blev leveret i 2013, men med øget brug af hypofraktioneringsregimer og dette især indenfor strålebehandling af patienter med mammacancer fra 2014, har antallet af årligt udførte strålefraktioner været aftagende med omkring 0,8% årligt, dog med en stagnerende/svagt stigende tendens de seneste 4 år.

Konklusion/diskussion:
I forbindelse med de nationale tiltag og bevillinger som de første to Kræftplaner i starten af 00'erne tilførte området, formåede de danske stråleterapicentre omtrent at fordoble antallet af udførte strålefraktioner i perioden fra 2000 til 2009.
Nationale tendenser afspejles ikke nødvendigvis på de enkelte lokale stråleterapicentre, idet fx hjemtagning af patienter efter regionsdannelsen eller fra udlandet tilsyneladende maskerer udviklingen på nationalt niveau.
Med en udvikling mod øget brug af hypofraktionering, genbehandlinger, samt både offline og online adaptive dosisplanlægningsstrategier ligger den fremtidige kapacitetsmæssige udfordring i lagt højere grad på planlægningssiden. Her kommer AI for både indtegning og (re)planlægninger til at spille en væsentlig rolle.

The Influence of Background Activity on Recovery Coefficients in Flash3D and xSPECT Reconstructions: A SPECT Phantom Study

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Background

Quantification is essential for the accurate determination of uptake values, phantom studies and dosimetry in radionuclide therapy. However, the partial volume effect (PVE), object size, shape, and varying background activity compromise the estimation of recovery coefficients (RCs), and thus, the accurate quantification of activity concentration. This SPECT phantom study investigates how background-to-sphere activity ratios (BSRs) influence RCs in Flash3D and xSPECT reconstruction methods and whether the expected linear dependency from the RCs on the BSR holds.

Methods

A NEMA IEC PET body phantom with six spheres (10, 13, 17, 22, 28, and 37 mm in diameter with a volume between 0.5 and 26.5 ml) was used. The spheres were filled with a Tc-99m solution with a concentration of 0.2 MBq/ml. Six acquisitions were performed with varying sphere-to-background ratios (SBRs): ∞:1, 14.7:1, 7.3:1, 4.5:1, 2.0:1, and 0.96:1, corresponding to BSR-values of approximately 0, 0.07, 0.14, 0.22, 0.5 and 1.

Scanning was performed using a Siemens Symbia Intevo Bold SPECT/CT-scanner with Low Energy High Resolution (LEHR) collimators on both heads. Scans consisted of 120 projections in a 256×256 matrix. Reconstruction was done using Flash3D (15i12s) and xSPECT algorithms (72 iterations, 1 subset), followed by 10 mm Gaussian post-filtering. Both attenuation (CT-based) and scatter (energy window based) correction was performed. RCs and calibration factors (CFs) were computed from the reconstructed images. CFs were calculated using the conventional method on 60 regions of interest (ROIs), as described in 'NEMA NU 2-2018

Volumes of interest (VOIs) for the spheres were defined by selecting the voxel with the maximum value as the center, and the radius was adjusted to match the true volume as closely as possible. The mean voxel values within these VOIs were used for RC calculation. Identical VOIs were applied in the background to obtain the corresponding background activity concentrations.

Results

The following figures show the dependency of RC on sphere size (diameter) and BSR across the six phantom scans.

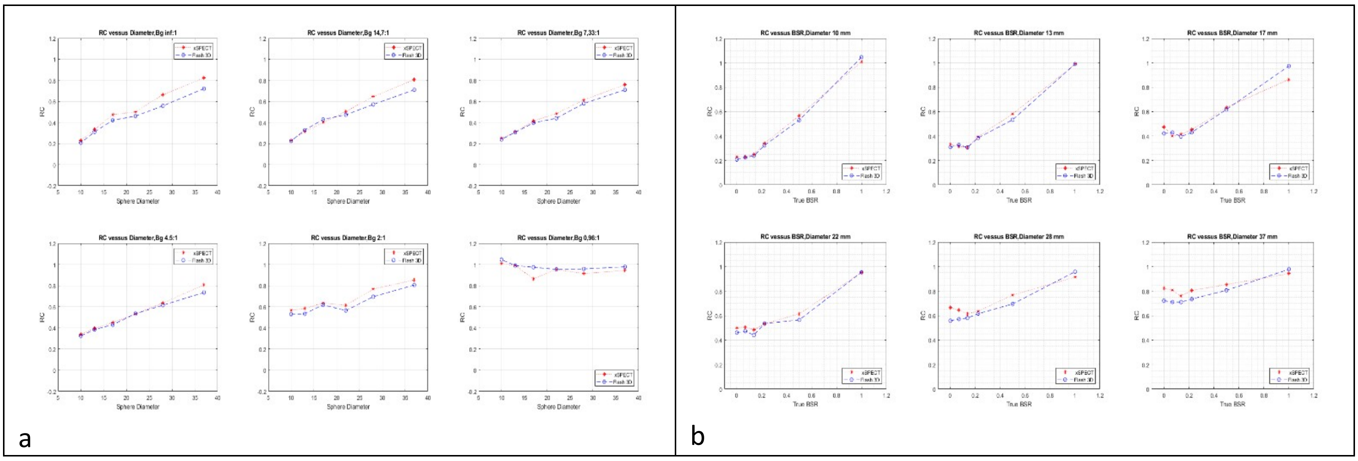

Figure 2 *Figure 1 (a) RC as a function of sphere diameter for six scans with increasing background-to-sphere activity ratios between 0 and 1. (b) RC as a function of background-to-sphere activity ratio for each individual sphere.*

The dependency of RC on object size, especially in smaller spheres, is evident in Figure 1a and aligns with published literature. Figure 1b shows the influence of BSR on RC, with a more or less linear tendency, but not for small spheres in low background.

Conclusion

Figure 1 shows that xSPECT generally yields marginally higher recovery coefficients (RCs) than Flash3D across all sphere sizes and background conditions. The difference is most pronounced for larger spheres and lower background-to-sphere activity ratios (BSRs), where xSPECT demonstrates more effective compensation for signal loss. Overall, the performance difference between the two methods remains limited but consistent. A more or less linear tendency of RC as a function of BSR is found, but it does not seem to hold for the three smallest spheres in low background (BSR<0.15).

Validation of a commercial scintillator detector system for IMRT treatment plan verification on an MR-linac

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[2]University of Southern Denmark, Department of Clinical Research, Odense, Denmark
[3]Elekta Instrument AB, Stockholm, Sweden
[4]Technical University of Denmark, Department of Health Technology, Roskilde, Denmark

Purpose:
Real-time phantom or in-vivo dosimetry is a valuable tool for radiotherapy plan verification during advanced treatments in MR (magnetic resonance) linacs, such as during the commissioning of MR-driven gating. Scintillators may be ideal detectors for such measurements since this detector type does not disturb the MR image quality needed for the gating[1]. However, scintillator dosimetry is critically dependent on the ability of the system to separate light from the scintillating element and Cerenkov light produced in the optical fibre cable. We, therefore, designed a test that would evaluate the ability of a commercial scintillator system to work under conditions relevant to gating where the dosimeter needs to provide accurate results both while being in the primary beam and while being in the penumbra or entirely out of the field.

Materials and Methods:
A scintillator dosimetry system (Medscint, Quebec, Canada) with 1.4 mm diameter fibres was used [2]. A TM30013 Farmer-type ionization chamber (PTWdosimetry, Freiburg, Germany) was adopted for comparison. The two different detectors were, in turn, inserted into a cylindrical water phantom (∅4 cm) [3]. 7 MV FFF irradiations were delivered by a Unity MR-linac (Elekta, Stockholm, Sweden) at 5×5, 10×10 and 20×20 cm^2 field sizes. The gantry angle was varied from -180° to 180° in steps of 30°. A beam of 100 MU was delivered at each gantry angle. The detector position varied longitudinally from -12.5 cm to 12.5 cm in steps of 2.5 cm around the isocentre. While maintaining the scintillator at a fixed position, the fibre was arranged in three ways: straight out of the phantom (i.e. with minimal fibre in the beam) or with one or two loops of additional fibre around the phantom positioned on the couch.

Results:
Figure 1 shows the effect of placing additional fibre in the beam. The sensitivity to extra fibre was found minimal (~1%) with the scintillator in the primary beam, whereas the impact with the scintillator outside the primary beam was >75% at negative positions and >10% at positive positions. Figure 2 demonstrates that the Farmer measurements are symmetric in the out-field regions in contrast to the scintillator.

Conclusions:
The scintillator detector was found to have a negligible sensitivity to additional fibre for measurements in the primary beam, whereas a strong influence of the fibre cable was found during the measurements in low-dose area of the beam. Therefore, caution must be taken when the scintillator is outside the primary beam.

References:

[1] Klavsen MF, Ankjærgaard C, Behrens CP, Vogelius IR, Boye K, Hansen RH, et al. Time-resolved plastic scintillator dosimetry in MR linear accelerators without image distortion. Radiat Meas 2022;154. https://doi.org/10.1016/j.radmeas.2022.106759.

[2] Uijtewaal P, Côté B, Foppen T, de Vries W, Woodings S, Borman P, et al. Performance of the HYPERSCINT scintillation dosimetry research platform for the 1.5 T MR-linac. Phys Med Biol 2023;68. https://doi.org/10.1088/1361-6560/acb30c.

[3] Riis HL, Christiansen RL, Tilly N, Tilly D. Dosimetric validation of the couch and coil model for high-field MR-linac treatment planning. Z Med Phys 2023. https://doi.org/https://doi.org/10.1016/j.zemedi.2023.02.002.

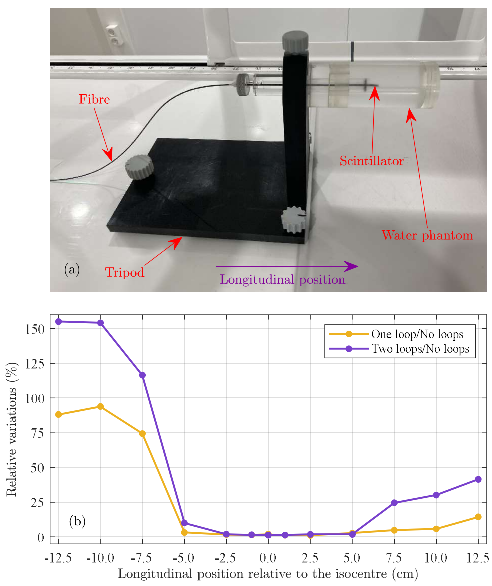

Figure 1. Effect of the amount of fibre in the beam. (a) The phantom positioned on the couch with no loops of fibre in the beam; (b) The relative variation of the absorbed dose at the field size 10×10 cm^2 with different amounts of fibre in the beam.

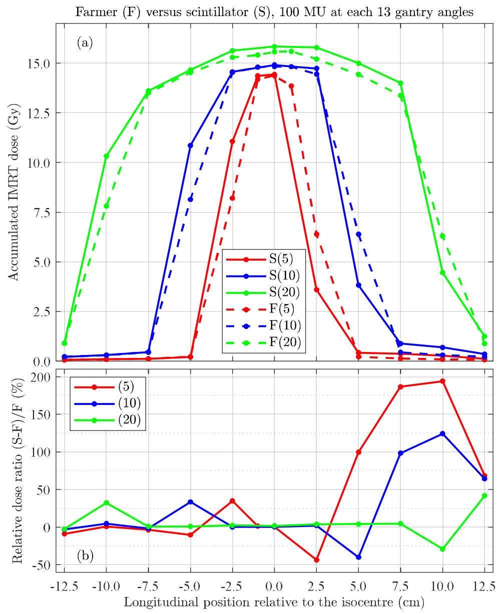

Figure 2. Absorbed dose measured using a scintillator (S) detector and a Farmer (F) chamber. The numbers in brackets refer to the square field sizes in centimetres (cm). (a) Absolute dose; (b) Relative dose.

Evaluating Modulation Factors for Adaptive Treatments on Ethos

Mette MB Nielsen and Eva Samsøe
Department of Oncology, Zealand University Hospital, Næstved, Denmark

Introduction

Modulation factor (MF), defined as MU/Gy, can be used as a measure for plan complexity, where a higher modulation factor indicates a more complex plan with longer treatment delivery and an overall increase in radiation dose. This study retrospectively reviewed the MF of dose plans created in the Ethos treatment planning system (TPS) from 74 patients treated with online adaptive radiotherapy using the Varian Ethos Therapy system.

Methods

In the Ethos TPS, an initial reference plan is generated. This plan serves as the basis for daily plan optimization during adaptive treatments on the machine. Each day, a new patient model is created based on daily patient anatomy. The reference plan is recalculated (scheduled plan) and reoptimized (adaptive plan) based on this model and finally, the reference plan based on patient anatomy, or the adapted plan is selected for delivery.
74 patients with cancers in the pelvic region (prostate w/ or w/o lymph nodes (LN), Bladder w/ or w/o LN and gastrointestinal (GI)) were investigated with respect to MF. Adaptive sessions were evaluated weekly for each patient, but always with a minimum of three evaluation fractions per patient. A total of 384 adaptive treatments were reviewed.

Results

All 74 patients were treated with intensity-modulated radiation therapy (IMRT) technique, using either 7, 9 or 12 fields. Of the 384 investigated adaptive sessions, the adaptive plan was selected in 377 cases (98%). The MF was dependent on no. of treatment fields and treatment type and plans with more than one dose level resulted in higher MFs compared to plans with a single dose level.

Treatment site	# adaptive treatments	Avg. MF for ref. plans ± avg. diff. on adapt. plans (MU/Gy)		
		7 fields	9 fields	12 fields
Prostate	71	571,9 ± 60,3	681,1 ± 72,3	722,1 ± 85,7
Prostate w/ LN	116	-	969,8 ± 44,3	1095,2 ± 51,0
Bladder	19	475,9 ± 64,8	562,1 ± 58,3	859,7 ± 97,4
Bladder w/ LN	83	-	848,8 ± 103,1	1088,4 ± 102,3
GI (1.8 Gy/fr.)	67	702,3 ± 33,4	793,0 ± 43,2	1005,7 ± 60,9
GI (5 Gy/fr.)	21	-	647,4 ± 37,0	787,7 ± 34,9

Table: Average MF for 7, 9 and 12 IMRT fields and the average difference in MF for adaptive plans per treatment site.

With the average MF being in the range 476 to 1095 MU/Gy for these plans, the MF for Ethos IMRT is significantly higher than volumetric modulated arc therapy on TrueBeam, where the MF usually is below 400 MU/Gy.

Conclusion

MFs were dependent on field geometry and dose complexity. The average difference of the MF on adaptive plans compared to reference were also found to be dependent on treatment site and field geometry.

Clinical Study of VMAT vs. 3DCRT for Breast Cancer with Lymph Node Involvement: Better Coverage, Faster Treatment, and No Increased Contra-Lateral Organ Dose

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Introduction

Lymph node coverage, particularly of the internal mammary nodes (IMN), is crucial in breast cancer radiotherapy, supported by clinical evidence. Volumetric Modulated Arc Therapy (VMAT) has shown advantages over 3D Conformal Radiotherapy (3DCRT) in planning studies for breast cancer treatments involving lymph nodes, including IMN. However, several studies have indicated that VMAT can result in an increased low-dose exposure to both contralateral and ipsilateral organs. Despite these findings, there is limited clinical data directly comparing VMAT and 3DCRT. This study aims to evaluate clinical data, including target coverage, treatment time, and doses to organs at risk (OARs) for patients treated with either technique.

Materials and Methods

In a clinical study, VMAT was introduced for locoregional breast cancer radiotherapy, including IMN, at our institution in June 2023, following a pilot study. The study included 203 patients: 106 received 3DCRT (June 2022-May 2023) and 97 received VMAT (June 2023-May 2024). Of these, 174 were treated with gating (92 in the 3DCRT group and 82 in the VMAT group). Target volume and OAR contouring followed ESTRO guidelines. Treatment planning used Pinnacle with auto-planning, a 10mm skin-flash, and Elekta linacs for delivery. Daily IGRT with CBCT was performed for all patients, and in the VMAT group, plans were recalculated if external contour variations exceeded 8 mm to check the robustness of the VMAT plan. Treatment times, recorded in MOSAIQ, were measured from beam-on to beam-off. All patients received 40 Gy in 15 fractions, with 2 and 1 in the 3DCRT group receiving a final boost and a simultaneous boost respectively, and 4 patients in the VMAT group receiving a simultaneous integrated boost. The 3DCRT utilized a tangential field-in-field technique, while VMAT used a two-arc "butterfly" technique.

Results

Treatment times were significantly shorter for VMAT: median 4.0 minutes (IQR 3.6–4.6 min) compared to 6.6 minutes (IQR 5.9–9.0 min) for 3DCRT ($p < 0.001$). Coverage of CTVp_breast/CTVp_chest was similar between the two techniques, but VMAT provided better coverage of lymph node regions. Doses to OARs were comparable between both groups.

Conclusions

To our knowledge, this is the first large clinical study directly comparing VMAT and 3DCRT for breast cancer patients. The significant reduction in treatment time with VMAT, especially in patients requiring longer treatments, improves patient comfort and treatment precision. Importantly, this study demonstrates that VMAT can be performed without the increased low-dose exposure to the contra-lateral OAR commonly associated with the technique.

Optimisation and harmonization of image quality and radiation dose in chest X-ray protocols using quantitative image quality evaluation phantom

Introduction

In a radiology department with five digital radiography systems each system has their own protocol settings for chest X-rays. These different settings include exposure parameters and geometric settings, both of which are critical factors affecting radiation dose and image quality. Radiologists in the department have expressed dissatisfaction with the variation in image quality between radiography systems. The aim of this study was to optimise image quality and radiation exposure during chest X-ray examinations while standardising protocols across different radiography systems.

Materials & Methods

Five Siemens digital X-ray systems were used for harmonising chest protocols and for evaluating radiation dose and image quality. Image quality was assessed using a CDRAD 2.0 image quality assessment phantom and 20 cm PMMA plates to simulate chest of patient. The CDRAD image analyser v 2.1.9 calculated the contrast-detail resolution of CDRAD X-ray images of the systems and generated image quality parameters: the inverse image quality figure (IQFinv) and the contrast-detail curves has been used . The Monte Carlo simulation software PCXMC v. 2.0.1 was used to calculate the effective dose.

Results

Image quality and radiation dose were evaluated for the harmonised and non-harmonised chest protocol for all systems (Table 1). Although the effective doses of the harmonised protocols were slightly higher for some systems compared to default protocols, the optimised protocols consistently provided better image quality compared to default chest protocols for all systems.

Summary

The image quality and the radiation dose for the patient were optimised for the chest protocol of the systems. Clinical exposure parameters and geometric settings of the five systems were harmonised.

Table 1: Effective dose and image quality of both non-harmonised and harmonised chest protocols for all imaging systems.

Systems	Projections	Effective dose [mSv]	IQFinv	Protocols
Sys 1	PA	0.04	2.39	Non-harmonised
	LAT	0.03	2.28	
Sys 2	PA	0.04	2.13	
	LAT	0.02	1.64	
Sys 3	PA	0.04	2.20	
	LAT	0.02	1.69	
Sys 4	PA	0.03	1.84	
	LAT	0.02	1.77	
Sys 5	PA	0.04	2.12	
	LAT	0.03	2.09	
Sys 1	PA	0.03	2.17	Harmonised
	LAT	0.02	2.76	
Sys 2	PA	0.05	2.47	
	LAT	0.04	2.45	
Sys3	PA	0.04	2.61	
	LAT	0.04	1.85	
Sys 4	PA	0.04	2.97	
	LAT	0.03	2.48	
Sys 5	PA	0.07	2.32	
	LAT	0.05	2.56	

Keywords: Chest X-ray, Image quality and dose optimisation and protocol harmonisation

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Robust planning of VMAT for breast cancer including loco-regional lymph nodes.

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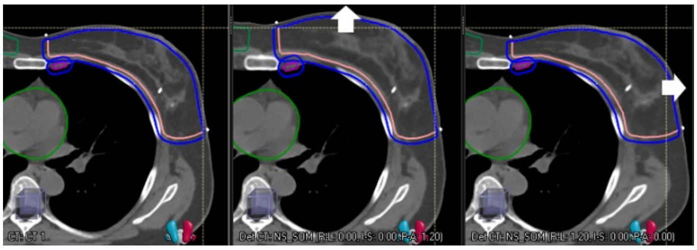
Introduction

In breast radiotherapy, irradiation of the internal mammary nodes (IMN) is increases overall survival. VMAT has the potential to improve the dose coverage compared to traditional conformal techniques. However, for VMAT the dose distribution to organs at risk (OAR) is different and robustness of the dose distribution to anatomical variations as observed during treatment on daily CBCT can be challenging. This study evaluates VMAT in comparison to tangential 3D-CRT for left-sided breast cancer including loco-regional lymph nodes. We evaluate the dose distributions and robustness to common anatomical variations.

Methods

Consecutive patients receiving loco-regional, tangential RT for left-sided, locally advanced breast cancer following lumpectomy are enrolled. Post treatment, a VMAT treatment plan is made in RayStation (RaySearch Lab. AB, Sweden) using dual, 6MV, 230 degree partial arcs. During VMAT planning, anatomical changes in the anterior and lateral direction are taken into account using simultaneous optimization on the planning CT and two deformed planning CTs (see figure 1). Dose is set to 50 Gy in 25 fractions. Both 3D-CRT and VMAT plans are evaluated on the planning CT as well as the deformed planning CTs.

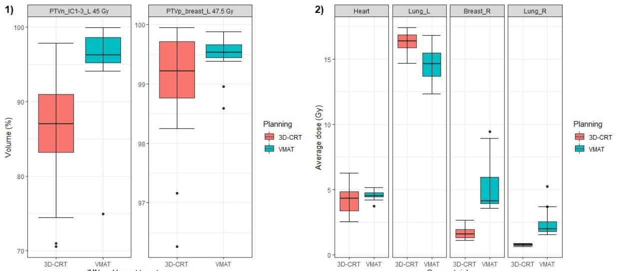
Figure 1. *Planning CTs with anatomic changes according to the white arrows. 1) As scanned 2) Anterior expansion 3) Lateral expansion.*



Results

In figure 2, the target coverage and average dose to OAR is compared. The VMAT plans have a slightly higher PTVp_breast V47.5Gy compared to the 3D-CRT plans. However, there is also an increase in V52.5Gy. For the internal mammary chain V45Gy is increased by 9%-points. The dose to OAR is distributed differently. While the median mean heart dose remains roughly unchanged, the relative volumes receiving 20 and 40 Gy are reduced. The contralateral lung and breast receive higher average dose; contributed by more of the organ receiving lower dose levels 5-15Gy. Considering the target coverage, the 3D-CRT plans are generally robust to the simulated anatomical changes. The VMAT plans are also robust, maintains higher dose coverage, and in no cases inferior.

Figure 2. *Boxplots comparing the planning techniques. 1) Relative target coverage for IMN and breast. 2) Average doses to OAR.*



Conclusion

Two radiotherapy techniques for treatments of breast and loco-regional lymph nodes are compared. Both techniques can deliver a proficient target coverage in a robust manner. The VMAT technique results in 9%-points better coverage of the IMN. However, this is at the cost of a lower dose levels spreading through the patient and longer planning times.

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