SNMC, JODHPUR RAJASTHAN

Residency Road Shastri Nagar,Jodhpur - 342003

RCI (MDM), JODHPUR RAJASTHAN

Residency Road Shastri Nagar,Jodhpur - 342003

Website

31st Annual Conference of Association Medical Physicists of India (Northern Chapter)

Regional Cancer Institute, MDM, JODHPUR

NC-AMPICON 2026

Theme: Physics in modern medicine (Innovation, Integration & Impact)

20TH AND 21ST MARCH 2026

SOUVENIR

ORGANIZED BY:

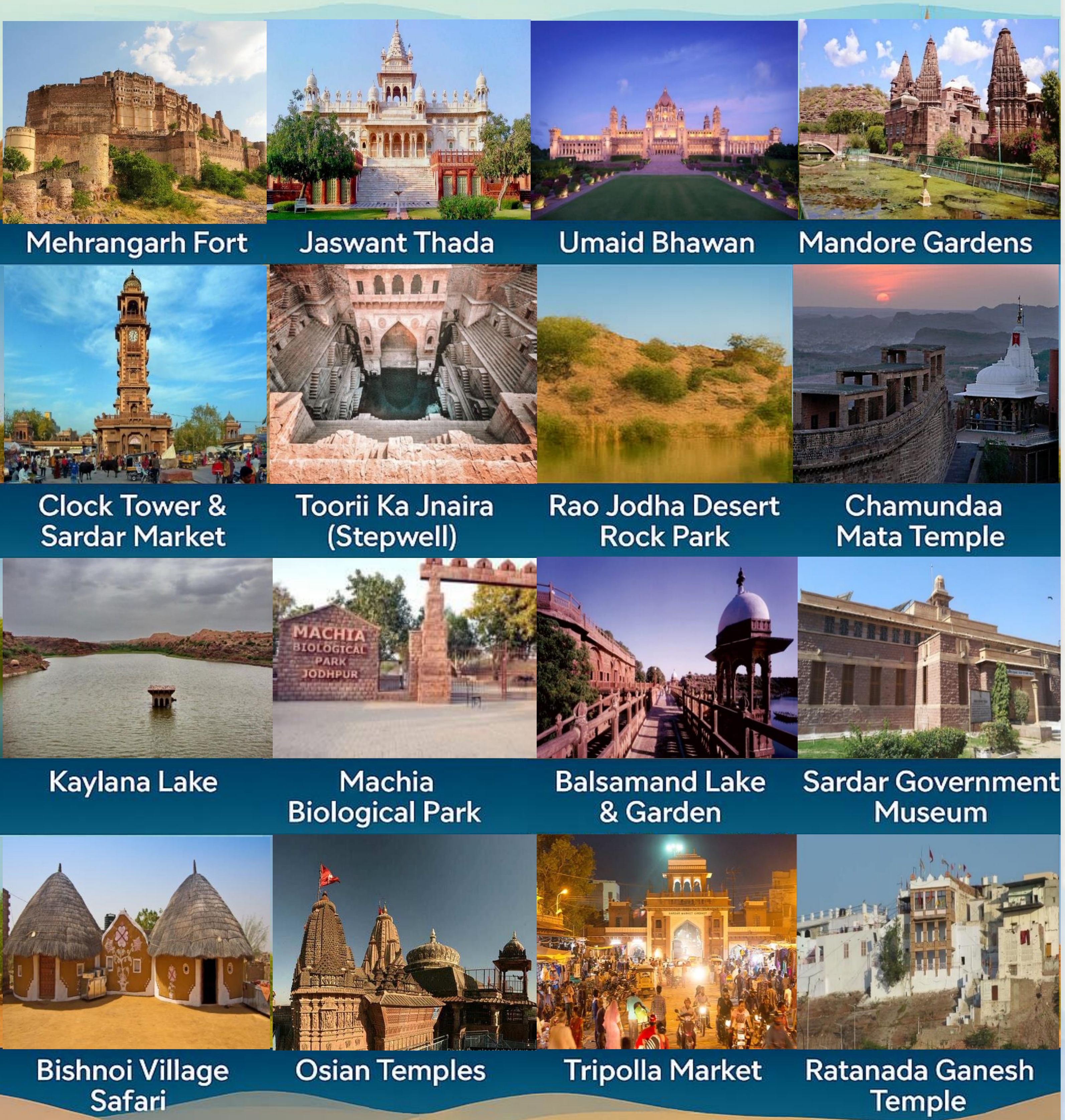
Department Of Radiological Physics MDM, JODHPUR, RAJASTHAN

VENUE: UMRAOGARH RESORT NEAR BY DALI BAI CIRCLE, JODHPUR

Theme : PHYSICS IN MODERN MEDICINE
“INNOVATION INTEGRATION & IMPACT”

Physics in Modern Medicine: Innovation, Integration & Impact reflects the vital role of physics in shaping today’s healthcare and transforming patient outcomes. From advanced imaging modalities like CT, MRI, PET-CT, and ultrasound to precision-driven radiation therapy and nuclear medicine, physics forms the foundation of accurate diagnosis and effective treatment. Innovations in medical technology, artificial intelligence, image-guided interventions, and high-precision radiotherapy continue to redefine clinical standards and expand therapeutic possibilities. The integration of physics with medicine ensures safety, quality assurance, and optimization of complex equipment and procedures, ultimately improving accuracy and minimizing risks. With its ever-growing impact, medical physics remains a key driver in advancing modern medicine toward safer, smarter, and more personalized healthcare solutions.

JODHPUR
THE BLUE CITY OF RAJASTHAN



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V.S. Shenoi
Special Guest

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Mr Sumanta Manna
Dr. Mohini Manav

Message From The Desk Of Chief Guest

गजेन्द्र सिंह शेखावत
Gajendra Singh Shekhawat

सत्यमेव जयते

संस्कृति मंत्री एवं पर्यटन मंत्री
भारत सरकार
Minister of Culture and
Minister of Tourism
Government of India

MESSAGE

"I am delighted to learn that the Department of Radiological Physics at Dr. S. N. Medical College, Jodhpur, is organizing the 31st Annual National Conference of Medical Physics (NC-AMPICON 2026) from March 20th to 21st, 2026.

In the critical domain of oncology, medical physics serves as the backbone of patient safety. By ensuring precise dose calculations and rigorous quality assurance, medical physicists translate complex science into life-saving treatment. This conference represents a vital platform for professional synergy, allowing experts to exchange insights and adopt cutting-edge methodologies.

I extend my heartiest congratulations to the Department and the organizing committee. My best wishes to all the faculty and participants for a highly productive and successful conference."

(Gajendra Singh Shekhawat)

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Message From The Desk Of Principle And Controller

Dr. B. S. Jodha
M.B.,B.S., M.S.
PRINCIPAL & CONTROLLER
Senior Professor
Department of Obst. & Gyn.

सत्यमेव जयते

Government of Rajasthan
राजस्थान सरकार
Dr. Sampurnanand Medical College & Associated Group of Hospitals, Residency Road, Jodhpur - 342003
डॉ. सम्पूर्णानन्द आयुर्विज्ञान महाविद्यालय एवं संलग्न चिकित्सालय समूह, रेजीडेन्सी रोड, जोधपुर - 342003
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Mob. : 98290-26613
E-mail : principal.drsnmc.jod@rajasthan.gov.in
Website : www.medicaleducation.rajasthan.gov.in/mcjodhpur

MESSAGE

It is indeed a matter of great pleasure that Regional Cancer Institute, Dr. S. N. Medical College Jodhpur is going to organize 31st Annual Conference of the Northern Chapter of the Association of Medical Physicists of India (NC-AMPICON-2026) on 20-21 March 2026 at Jodhpur.

The Conference is aimed to provide an opportunity to know the latest research and modern techniques in the field. An exchange of experience and suggestions for adopting of new techniques and management will definitely useful to all the participants & ultimately the benefit will go to the patients.

It will be a wonderful opportunity of meeting of old and new friends and learning from each other's experiences. I am sure, the scientific deliberations of the conference will be useful for the participants.

I congratulate orgnising committee and wish the conference, a grand success.

(Dr. B.S. Jodha)
PRINCIPAL & CONTROLLER

Shri Prabhat K Sharma,
Organizing Secretary,
NC-AMPICON 2026
Regional Cancer Institute
Dr. S.N.Medical College,Jodhpur.

Message From The Desk Of President, AMPI

Dr. Manoj K Semwal

President, AMPI

It gives me immense pleasure to know that Department of Radiological Physics, Regional Cancer Institute associated to Dr SN Medical College, Jodhpur is organizing the annual conference of Northen Chapter of AMPI i.e. NC-AMPICON20206 on 20-21 Mar 2026. The theme of the conference "**Physics in Modern Medicine: Innovation, Integration & Impact"** is meant to highlight the crucial role medical physics plays in improving the standards and brining innovations into modern medicine, specifically radiation related medicine.

The scientific programme prepared by the scientific committee is an imaginative mix of clinical medical physics, radiology, radiation oncology, nuclear medicine and on-going R&D efforts in employing AI/data sciences for innovations. Eminent experts have been invited to share their knowledge among the delegates.

I am sure the delegates, especially the younger medical physics colleagues will utilize the opportunity provided by the conference to network with experts in their respective areas of interest.

Rajasthan, especially Marwaar, has a rich cultural heritage. I am sure the delegates will experience the top-class hospitality "Padharo Mhare Desh" while exploring the culture and cuisine.

On behalf of AMPI, I congratulate Prof Devesh Gupta, Shri Prabhat Kumar Sharma and their very efficient and courteous team for organizing the NC-AMPICON 2026 with a fine balance between substance and style and wish them a grand success.

Manoj K Semwal, DipRP, PhD
President, AMPI

Message From The Desk Of Secretory, AMPI

Prof. Anuj Kumar

Secretary, AMPI

Dear Esteemed Faculty Members and Delegates,

It is with great pleasure and heartfelt enthusiasm that I welcome you to NCAMPICON 2026, to be held on 20th–21st March 2026 in the vibrant and historic city of Jodhpur, Rajasthan.

This prestigious conference is being organized under the dynamic leadership of Dr. Prabhat Sharma, Organising Secretary, and Dr. Davesh Gupta, Chairman, whose dedication and vision have been instrumental in shaping this important scientific gathering.

The theme of this year's conference, "Physics in Modern Medicine · Innovation, Integration, & Impact," highlights our collective pursuit to advance medical physics through cutting-edge innovations, interdisciplinary integration, and meaningful clinical impact. It reflects our commitment to improving patient care through scientific excellence and technological progress.

NCAMPICON 2026 promises to bring together eminent experts, researchers, and professionals from across the country, offering a rich platform for knowledge exchange, collaboration, and inspiring discussions that will shape the future of our field.

Beyond the academic excellence, Jodhpur offers a unique cultural experience. Known as the *Blue City*, it showcases the rich heritage, majestic forts, and vibrant traditions of Rajasthan. Delegates will also have the opportunity to enjoy the warm hospitality, colourful culture, and exquisite Rajasthani cuisine, making this conference both intellectually enriching and culturally memorable.

I extend my sincere appreciation to the organizing team for their tireless efforts in curating this event, and I warmly invite all participants to be a part of this exciting conference.

I look forward to welcoming you to Jodhpur for an engaging, insightful, and memorable NCAMPICON 2026.

Warm regards,
Prof. Anuj Kumar Secretary, AMPI

Message From The Desk Of President, AMPI -NC

Dr Vinod Kumar Dangwal
Chairman , NC- AMPI

It gives me immense pleasure to extend my warm greetings to all participants, speakers, and organizers of the Annual Conference of the Association of Medical Physicist of India- Northern Chapter, hosted by Department of Radiological Physics, Regional Cancer Institute, Associated to Dr S.N. Medical College, Jodhpur. Rajasthan, India during 20th and 21st March 2026. The chosen theme, **"Physics in Modern Medicine: Innovation, Integration and Impact,"** is both timely and profoundly relevant, reflecting the transformative role of medical physics in shaping the future of healthcare.

Over the past decades, the field of medical physics has witnessed remarkable advancements driven by innovation. From cutting-edge imaging technologies to precision radiotherapy techniques, physics continues to be the backbone of modern medicine, enabling early diagnosis, effective treatment, and improved patient outcomes. Today, innovation is not merely an aspiration—it is a necessity that propels us toward safer, more accurate, and personalized medical care.

Equally important is the integration of these innovations into clinical practice. Bridging the gap between research and real-world application requires collaboration among physicists, clinicians, engineers, and industry partners. Such multidisciplinary synergy ensures that technological advancements are translated into meaningful clinical benefits, enhancing efficiency, safety, and accessibility in healthcare delivery. The impact of physics in medicine is evident in every facet of patient care. Whether through advanced diagnostic imaging, targeted radiation therapy, or emerging fields such as artificial intelligence and molecular imaging, medical physicists play a pivotal role in improving the quality of life for patients. Our responsibility extends beyond technology—we are custodians of safety, accuracy, and ethical practice in medicine.

I commend the organizing committee for their dedicated efforts in bringing together such a meaningful and impactful event. I encourage all participants to actively engage, contribute, and make the most of this opportunity.

On behalf of the Chairman, Northern Chapter - Association of Medical Physicist of India, I express my sincere gratitude to Department of Radiological Physics Regional Cancer Institute, Dr S.N. Medical College, Jodhpur. Rajasthan for providing an excellent platform to exchange ideas, share knowledge, and foster collaborations. I am confident that the scientific deliberations, discussions, and interactions during this conference will inspire new perspectives and pave the way for future advancements in our field.

Wishing you all a productive and enriching conference.

With Warm Regards,

Dr Vinod Kumar Dangwal
Chairman, NC- AMPI

Message From The Desk Of Secretory, AMPI-NC

Dr B S Rana
Secretary , NC- AMPI

It gives me immense pleasure to pen this message for the souvenir of **NC -AMPI -CON 2026**. This annual conference, a cornerstone event for the medical physics community in Northern part of India, provides a vibrant platform for sharing knowledge, showcasing innovation, and strengthening professional ties.

As we gathering once again under the banner of NC- AMPI for the 31st Annual conference NC-AMPICON 2026 conducted and hosted by Department of Radiological Physics, RCI, Dr S.N. Medical College, Jodhpur form 20th -21th March 2026 with the theme "**Physics in Modern Medicine – Innovation, Integration, & Impact**". We celebrate not only our collective achievements in advancing medical physics but also the spirit of collaboration that continues to drive progress in field of Medical Physics. I I have been informed that this year's conference brings together experts, academicians, researchers, and students not only from northern part but from across the Bharat, reflecting the dynamic growth and evolving challenges to our profession.

On behalf of NC-AMPI, as its Secretary, I extend my heartfelt appreciation to the organizing committee for their dedication and hard work in making the NC-AMPICON- 2026 a grand success. I welcome all the delegates for this interactive session scheduled during one and half day that would hold talks not only in physics but also dwell into regulatory aspects impacting us. I wish to thank all delegates, speakers, and contributors for enriching the scientific sessions and discussions.

Your efforts would significantly contribute to strengthening professional collaboration and advancing the objectives of NC AMPI. The success of NC-AMPICON 2026 stands as a testament to your leadership and the hard work of your entire team.

Once again, I convey my heartfelt thanks and congratulations for organizing such a memorable and impactful conference. We look forward to continue collaboration in future endeavors too. Let this souvenir be a lasting reminder of our shared commitment to excellence, learning, and service to humanity through science.

With regards,

Dr. B. S. Rana
Secretary, NC- AMPI

Message From The Desk Of Organizing Chairman

Dr Devesh Gupta

Organizing Chairman

Welcome to NC-AMPI CON 2026. It is a matter of great joy to see the Northern Chapter come together once again — this time in Jodhpur, a city that carries its own quiet grandeur.

The theme this year "**Physics in Modern Medicine: Innovation, Integration & Impact**," reflects where our field genuinely stands. Medical Physics today is no longer confined to dosimetry and calibration; it is embedded in clinical decision-making, AI-assisted planning, and increasingly complex treatment systems. Our aim through this conference is to take stock of that journey honestly, share what is working, and think together about where we go from here.

We are hosting this event at the Regional Cancer Institute, Dr. S.N. Medical College, a young institution that has moved quickly. The facility runs a True-Beam LINAC, Vision RT, CT Simulator, BEBIG Co-60 HDR Brachytherapy, and PET CT.

My thanks to our speakers, the scientific and organizing committees, and every volunteer who has put in the work behind the scenes. These conferences run on quiet effort, and it is appreciated more than is usually said.

I hope you find the sessions useful, the conversations worthwhile, and the visit to Jodhpur memorable.

With warm regards,

Dr. Devesh Gupta
Organizing Chairperson, NC-AMPI CON 2026
Ex Senior Professor & HOD, Radiological Physics
Regional Cancer Institute, Dr. S.N. Medical College, Jodhpur

Message From The Desk Of Organizing Secretory

Sh. Prabhat K Sharma

Organizing Secretary

It gives me great honor to warmly welcome all delegates, speakers, and students to the Annual Conference of the Association of Medical Physicists of India (AMPI) – Northern Chapter, being hosted by the Department of Radiological Physics, Regional Cancer Institute, associated to Dr. S.N. Medical College, Jodhpur, on 20th and 21st March 2026.

It is truly a joy to see you all this time in Jodhpur, the beautiful Blue City of Rajasthan. Known for its royal heritage, warm hospitality, and vibrant culture, Jodhpur offers a unique charm through its iconic Mehrangarh Fort, traditional handicrafts, and the unforgettable taste of local Rajasthani cuisine. I hope your visit here becomes both academically meaningful and personally memorable.

The theme of this conference, "**Physics in Modern Medicine: Innovation, Integration & Impact**," is timely and highly relevant. Medical physics has grown rapidly over the years, contributing significantly to modern healthcare. From advanced diagnostic imaging to highly precise radiotherapy, physics continues to strengthen the foundation of patient care. Innovation today is not just progress—it is a necessity that helps us deliver safer, more accurate, and more personalized treatments.

Equally important is how we integrate these innovations into real clinical practice. This requires strong collaboration among medical physicists, clinicians and researchers. Such teamwork ensures that new technologies are not only developed, but also applied responsibly for the benefit of patients.

We are proud to host this conference at the Regional Cancer Institute, Jodhpur, which is rapidly developing into a strong center for cancer care. The institute is equipped with advanced facilities including TrueBeam LINAC, Vision RT, CT Simulator, BEBIG Co-60 HDR Brachytherapy, and PET-CT, enabling high-quality diagnosis and treatment.

I encourage all participants to actively engage in the sessions and discussions. I am confident this conference will strengthen professional bonds, inspire new ideas, and contribute to the future growth of medical physics.

With warm regards,

Sh. Prabhat K Sharma
Organizing Secretary,
NC-AMPI CON 2026
Asst. Professor & HOD, Radiological Physics

SCIENTIFIC SCHEDULE

31ST Annual Conference of Association Medical Physicists of India (Northern Chapter)

NC-AMPICON 2026

SCIENTIFIC SCHEDULE

Session I

DAY 1- 20th March 2026 (FRIDAY)		
7:30 AM– 8:30 AM	**REGISTRATION**	
SESSION 1 **8:30 AM – 11:00 AM**	**CHAIRPERSONS: Dr. V K Dangwal, Dr. R K Bisht, Dr. B S Rana, Dr. Manindra B Mishra**	
8:30 AM – 8:45 AM (I-1)	Radiobiological Considerations In SRS/SABRT, UHDRT, SFRT, Particle Therapy & Road Ahead	Dr. Manoj Semwal
8:45 AM – 9:00 AM (I-2)	Size Specific Dose Estimation In CT: CTDI Volume New Approach	Dr. Pratik Kumar
9:00 AM – 9:15 AM (I-3)	Paradigm Shift In Regulation After Introduction Of SHANTI Act On Atomic Energy	Dr. P K Dash Sharma
9:15 AM – 9:30 AM (I-4)	Commissioning Of PBS Proton Therapy Machine: Practical Insights And Challenges	Dr Umesh Gayake
9:30PM- 9:40 PM (O-1)	Radiation Exposure During Pregnancy: Evidence-Based Fetal Risk Assessment And Clinical Management In Diagnostic And Therapeutic Practice.	Dr. Athiyaman M
9:45 AM - 10:45 AM	**Dr. N.C. Singhal Oration**	
10:45 AM - 11:00 AM	**TEA**	

Session II

SESSION 2 11:00 AM - 12:00 PM	CHAIRPERSONS: Dr. R K Munjal, Dr. Balasubramanian N, Dr. Chithra Krishnamoorthy, Dr. Satinder Kaur	
11:00 AM–11:15 PM (I-5)	Optimizing vDIBH Implementation: Challenges & Machine Learning–Based Feasibility Prediction.	Dr. Teerthraj Verma
11:15 PM – 11:30 PM (I-6)	Reliable AI Models For Medical Imaging Applications	Dr. Deepak Mishra (IIT Jodhpur)
11:30 PM- 11:45 PM (I-7)	Recent Trends In Ionizing Radiation Detection	Dr. Pradeep Narayan (DRDO)
11:45 PM- 12:00 PM (T-1)	Advances In AlignRT Enhancing SGRT Precision, Safety and Workflow	Mr. Robin Baweja VisionRT

Session III

SESSION 3 12:10 PM- 2:30 PM	CHAIRPERSONS: Dr. Anoop Srivastava, Dr. Jyoti Bisht, Dr. Ananth K, Dr. Nidhi Marjara	
12:10 PM -12:25 PM (T-2)	RapidArc Dynamic Insights	Mr. Himank Kalra Siemens Healthineers
12:25 PM- 12:40 PM (I-8)	AAPM TG-186 For Brachytherapy	Dr. Reena Sharma
12:40 PM- 12:55 PM (I-9)	Physicist And Physician Collaboration For Optimized Brachytherapy	Dr. Bharti Devnani
PANEL DISCUSSION 1:00 PM – 2:00 PM	3D Printing In Radiotherapy: Bridging Innovation And Clinical Practice MODERATOR: Dr O P Gujar CHAIRPERSON: Dr Kuldeep Jeetha, Dr Murli Ram, Dr Pawan Jangid, Dr Natarajan	
	PANELIST: Dr. Deepak Arora, Dr. L M Aggarwal, Dr. N P Patel, Dr. Mary Joan, Dr. Akansha Sankhla, Dr Jitendra Nigam, Dr Pratik Daga	
2:00 PM – 2:30 PM	**LUNCH**	

Session IV

SESSION 4 2:30 PM- 3:40 PM	CHAIRPERSONS: Dr Athiyaman M, Dr Ravi Kant, Dr Sushma Mondal, Dr Rajni Verma	
2:30 PM – 2:45 PM (I-10)	Standardization Of Dose Reporting In Cervical Cancer Brachytherapy: From ICRU Point A To ICRU 89 Volume Based Parameters	Dr. Arvind Shukla
2:45 PM – 3:00 PM (I-11)	Cardiac Sparing Techniques In Left Sided Breast Cancer	Dr. Tripti Saxena
3:00PM- 3:10 PM (O-2)	Evaluation Of Image Registration Accuracy and Its Impact on Dose Accumulation for FF And FFF Beams In Adaptive Radiotherapy of Bladder Cancer	Dr. Silambarasan N S
3:10PM- 3:20 PM (O-3)	Hybrid gEUD -Assisted Optimization Versus DVH-Only Planning Across Bilateral Breast IMRT And Head-And-Neck VMAT	Dr. Sandeep Singh
3:20 AM – 3:30 AM (O-4)	Structured Reporting of Orthopantomogram (OPG) Radiographs: An AI-Ready Framework	Dr. Mohini Manav
3:30 PM – 3.45 PM	**TEA**	

Session V

SESSION 5 3.45 PM – 4:55 PM	CHAIRPERSONS: Dr. Kirti Chaturvedi, Dr Manoj Suman, Dr. Vinod Pandey, Dr Sonal Varshney	
3:45 PM – 4:00 PM (I-12)	Diffusion MRI: Its Physics and Expanding Role In Two Decades	Dr. Ajai Srivastava
4:00 PM- 4:15 PM (I-13)	AI In Medical Physics: Transforming Treatment Accuracy and Patient Outcomes	Dr. Anuj Tyagi
4:15 PM – 4:30 PM (I-14)	Medical Exposure In Diagnostic-Radiology & Need for Radiation Dosimetry In Diagnostic Radiology	Dr. B. S. Rana
4:30 PM – 4:45 PM (I-15)	Advance Radio-Diagnostic Machines and Technology	Dr. R K Bisht
4:45 PM- 4:55 PM (O-5)	Organ Proximity Effects on Spatial Dose Fall-Off Metrics In Head and Neck Radiotherapy	Dr. Subhendu Ghosh

Session VI

SESSION 6 5:00 PM – 6:00 PM	INAUGURATION
6:00 PM	GENERAL BODY MEETING (GBM)
7:30 PM – 10:30 PM	GALA DINNER

Session VII

DAY 2: 21st March 2026 (SATURDAY)		
SESSION 7 **8:30 AM- 10:00 AM**	**BEST PAPER PRESENTATION** **CHAIRPERSONS: Dr L M Aggarwal, Dr Arvind Shukla, Dr Mary Joan, Dr. Pawan Singh**	
8:30 AM – 8:40 AM (BP-1)	Compressive Study and Validation of An Enhanced Leaf Model (ELM) In Eclipse Treatment Planning System	Rahul Langdi
8:40 AM – 8:50 AM (BP-2)	Comprehensive Dosimetric and Mechanical Evaluation of Hyperarc/VMAT Delivery for Small and Large Target Volumes	Dheeraj Kumar
8:50 AM – 9:00 AM (BP-3)	Development Of A 3D-Printed Phantom Plate–Based OSLD System for Two-Dimensional Dose Verification In Gamma Knife Perfexion	Deepika Soni
9:00 AM – 9:10 AM (BP-4)	Axis-Specific Robustness and Clinically Relevant Displacement Thresholds In Single- And Multi-Channel Vaginal Cylinder HDR Brachytherapy	Ayusha
9:10 AM – 9:20 AM (BP-5)	Comparative Analysis Of MPC, EPID And Quick Beam Checker For Daily QA In Varian Truebeam LINAC	Lokesh Kumar Sharma
9:20 AM- 9:30AM (BP-6)	Evaluation Of Collimator Transmission for FF And FFF Photon Beams of A Modern Linear Accelerator Using TLDS and an IC	Ms. Satyamma. B. Maddi
9:30 AM- 9:40 AM (BP-7)	Influence of Optical Annealing Intensity on the Sensitivity Calibration of Al2O3:C OSLDs	Dandpani Epili
9:40 AM – 9:50 AM (BP-8)	Translating 3d Printing into Practice: Early Clinical Use of A Custom Brachytherapy Applicator	Senthilkumar
9:50 AM – 10:00 AM (BP-9)	Dosimetric Verification of Source Strength of Co-60 HDR Brachytherapy Using A TLD With Krieger Phantom	Rohan K Panda

Session VIII

SESSION 8 **10:30 AM- 12:00 AM**	**CHAIRPERSONS: Dr. L. Nithya, Dr. Manoj Kulshreshtha, Dr Salil Raja, Dr. Gaurav Jain**	
10:30 AM- 10:45 AM (I-16)	Radiobiology Beyond 4'Rs For Radiotherapy	Dr. Arun Chougule
10:45 AM- 11:00 AM (I-17)	The Future of Medical Physics Education: From Time-Based To Competency Based	Dr. V. Subramani
11:00 AM- 11:15 AM (I-18)	VMAT-Based Total Body Irradiation (TBI) And Total Marrow & Lymphoid Irradiation (TMLI): Physics, Planning, And Clinical Implementation	Dr. C.P. Bhatt
11:15 AM -11:30 AM (T-3)	Enhancing Planning Efficiency: Scripting & Automation	Dr Swati Shama ELEKTA
11:30 AM -11:40 AM (T-4)	The Major Impacts Of Different Technologies On Patient Specific Quality Controls	Mr. Karan Bhateja PTW
11:40 AM- 12:00 PM	TEA	

Session IX

SESSION 9 **PANEL DISCUSSION:** **12:00 PM- 1:00 PM**	**Artificial Intelligence- Shaping The Future Of Modern Medicine.** MODERATOR: **Dr V.P Pandey** CHAIRPERSONS: **Dr. Hemlatha A, Dr. Lalit Mohan Singh, Dr. Rakhi Barman, Dr Neeraj Kumar** Panelists: Dr Chithra Krishmoorthy, Dr Radhakrishnan B Nair, Dr Rajshekhar Mahalingam, Dr Atul Tyagi, Dr Vinod Pandey, Dr Avinav Bharti, Dr Gaurav Jain
1:00 PM- 1:30 PM	**VALEDICTORY FUNCTION**
1:30 PM – 2:30 PM	**LUNCH**

ABSTRACTS OF INVITED SPEAKERS AND DELEGATES

Radiobiological Considerations in SRS/SABRT, UHDRT, SFRT, Particle Therapy

M K Semwal
DipRP, PhD Army Hospital (Research and Referral), Delhi
Cantonment Adjunct Faculty (Physics), IIT Ropar, India

Radiation biology forms the scientific basis of therapeutic applications of ionising radiation. The advancements in radiation delivery technologies & radiation biology have often gone hand in hand but at times advancement or evolution of the former has spurred the evolution in the latter or vice versa. From low dose rate to conventional fractionated radiotherapy to present day ablative radiation deliveries, flash radiotherapy and microbeam therapy capabilities have all been triggers for further exploration in radiation biology. At times, radiobiology as a science followed the observed biological effects of radiation.

Modern radiation delivery technologies such as intensity modulated radiotherapy (IMRT), image guided radiotherapy (IGRT), stereotactic radiosurgery (SRS), stereotactic body ablative radiotherapy (SABRT) have resulted in deviation from the long accepted conventional fractionation schedules of radiotherapy. Hypo-fractionations with dose per fraction reaching upto 20Gy per fraction in SABRT and even upto 100 Gy in SRS are becoming norms for what is called as ablative radiotherapy. The holy-grail of 4Rs can't properly explain the biological effects in hypo-fractionated or single fraction SRS/SBRT.

In a radiation oncology facility, traditionally, a clinical medical physicist or a radiation oncologist provides the necessary radiobiological inputs in terms of applying gap corrections or for changing one form of fractionation to another with similar biological equivalence. Of late treatment planning systems (TPS) have started incorporating radiobiological aspects in optimising the treatment plans. Many experts are of the view that these formulations may not be adequate, especially, when it comes to the present-day hypo-fractionation schedules in SRS/SRT/SBRT. Some other researchers are investigating on the use of LET (linear energy transfer) distributions as a surrogate for RBE (radiobiological effectiveness) in the planning of treatments. Their hypothesis is that by minimizing LET and the associated RBE in organs-at-risk (OAR), the incidence of adverse treatment effects can be reduced. They also found that mean LET in OARs (organs at risk) was inversely proportional to mean dose. Yet another challenge for radiobiology is in the cases of altogether new radiation delivery technologies namely ultra-high dose rate (UHDRT) delivered in few milliseconds, micro-beam delivery (MRT)/Spatially fractionated RT (SFRT), and better understanding of particle therapy and hypofractionation RT biology.

Clearly, the road ahead is beyond the LQ model and its modifications to provide satisfactory and comprehensive biological basis for these relatively newer modalities of radiotherapy. Exploring computer simulations and AI for micro-dosimetry, LET estimation and ultimately for cellular and tissue level biological effects seem to be the way forward in this journey. Some of the work reported in literature will be discussed.

Paradigm Shift in Regulation of Radiation Facilities after Introduction of SHANTI Act parameters

Dr. P. K. Dash Sharma Former Head, Radiation Applications Safety Division Atomic Energy Regulatory Board (AERB), India

The use of ionizing radiation in medicine has expanded rapidly in recent decades, necessitating a robust and adaptive regulatory framework to ensure safety of patients, workers, and the public. The introduction of the SHANTI Act represents a landmark development in India's radiation safety governance, providing a comprehensive legal and regulatory foundation.

The enactment of the SHANTI Act marks a significant transformation in the regulatory framework for radiation safety in India, particularly impacting facilities engaged in medical applications of ionizing radiation. It presents an overview of the evolving regulatory regime, highlighting the shift towards a structured, risk-informed, and graded approach under the strengthened oversight of the Atomic Energy Regulatory Board (AERB), which is a statutory body under the SHANTI Act.

The revised framework introduces enhanced authorization processes, improved compliance mechanisms, and clearer delineation of responsibilities among stakeholders. In the context of medical radiation facilities—including diagnostic radiology, radiotherapy, and nuclear medicine—the regulatory system now emphasizes lifecycle-based control, from design and installation to operation and decommissioning. The graded approach ensures proportional regulatory requirements based on risk, thereby optimizing both safety and operational efficiency.

Harmonization of AERB safety codes and guides with statutory provisions under the SHANTI Act has enabled consistent implementation of radiation protection principles such as justification, optimization (ALARA), and dose limitation. Strengthened provisions for quality assurance, personnel monitoring, and radiation safety have further reinforced regulatory effectiveness in healthcare settings.

It also addresses key implementation challenges, including the need for capacity building in medical institutions, increased awareness among stakeholders, and adaptation to revised regulatory requirements. The role of digital platforms in streamlining authorization and regulatory oversight is also highlighted.

Overall, the SHANTI Act-driven reforms represent a forward-looking regulatory paradigm that enhances safety, transparency, and accountability, while supporting the safe expansion of radiation technologies in medicine.

Commissioning of Pencil Beam Scanning Proton Therapy: Practical Insights and Challenges

Umesh Bharat Gayake

General Manager, Optimus Oncology Private Limited, India

The commissioning of Pencil Beam Scanning (PBS) proton therapy systems is a critical step to ensure accurate, safe, and clinically reliable dose delivery. PBS offers superior dose conformity through dynamic spot delivery and energy modulation, with typical energy ranges from 70 MeV to 226 MeV corresponding to treatment depths of approximately 4 to 32 cm in water. Key beam parameters such as integrated depth dose (IDD), spot size, absolute dose calibration, and virtual source position are essential inputs for treatment planning system (TPS) modelling.

A major component of commissioning involves the development and validation of a Monte Carlo (MC) dose calculation engine, which provides high-precision dose prediction in heterogeneous media. Beam modelling includes tuning of energy spectra, spot profiles, and scattering parameters to accurately reproduce measured pristine Bragg peaks and lateral dose distributions. The energy spread is particularly optimized to match distal fall-off characteristics, ensuring consistency between measured and simulated data . Validation is performed through comparisons of MC calculations with measured data across multiple energies and geometries, including patient-specific quality assurance scenarios.

Regulatory requirements play a vital role in commissioning, encompassing dosimetric verification, mechanical and safety checks, and compliance with international protocols such as TRS-398. Independent audits and documentation of system performance are recommended prior to clinical implementation.

Overall, PBS commissioning integrates precise beam data acquisition, robust MC modelling, and rigorous validation procedures, ensuring high accuracy in dose delivery and adherence to regulatory standards for safe clinical deployment.

Reliable AI Models For Medical Imaging Applications

Dr. Deepak Mishra
Associate Professor Computer Science & Engineering IIT
Jodhpur

Medical Imaging plays a vital role in enhancing patient care today; however, it presents unique challenges, including image interpretation, the limited availability of expert radiologists, varying imaging protocols, and observer-dependent image quality in modalities like ultrasound imaging. There's a silver lining, though! Recent advancements in AI and deep learning hold incredible potential to streamline medical imaging tasks and enhance radiology workflow. Addressing the reliability challenge of AI models is key that requires the development of robust, calibrated, trustworthy, and privacy-preserving solutions. During the talk, I will share my group's contributions in this field, particularly our innovative work on learning transfer-ready representations, data-free distillation, and semi-automatic echocardiography

Recent Trends in Ionizing Radiation Detection parameters

Dr. Pradeep Narayan
Defence Laboratory, DRDO, Jodhpur

Ionizing radiations are emitted from both natural and man-made sources, that play a major role in various applications such as; health care, consumer product, industry and research etc. Being a source of energy, it has deleterious effects to human health in addition to its various beneficial applications. Radiation being invisible, odourless and soundless, detection plays important role in its control and optimal utilization. The detection of this radiation has evolved over the past several decades from simple observations to precise measurements in space, time, and energy.

The alpha particle was first detected by Crookes in 1903 using zinc sulphide screen through scintillation process. First single radiation event was made visible in cloud chamber, in 1911 by C. T. R. Wilson. Besides photographic, ionization, and scintillation, other effects of radiation were noticed very early. Further effects of radiation were the colouring of glasses or minerals as well as the bleaching of colours and a slightly elevated temperature. In the 1940s, electronic photo-multiplier tubes were introduced and matched with scintillators to convert the weak light flashes into usable electric pulses that could be counted electronically. Photographic dosimetry was made quantitative in 1942 and film badges for routine personnel monitoring designed. Organic scintillators introduced in 1947. In 1948 the thallium-activated sodium iodide crystal was discovered which became commercially available in 1950, and was widely used thereafter.

Hess in 1910 provided the first evidence for cosmic rays by using an ionization chamber during a balloon flight. In 1928 Geiger and Muller introduced a new type of gas-filled counter that responded to individual radiation-induced events by giving a high-electrical output signal. The counter was further developed in the 1930s and, because of its simplicity, ease of operation, and cheapness, rapidly found wide use. In the late 1940s a third type of gas-filled detector, the proportional counter, was introduced which amplified the charge originating in the gas.

Subsequently, it was realized that solids being about 1000 times denser than a gas, there would be a great advantage in using solids for development of small size detectors. Radiation detectors which measure the ionization produced in solid dielectrics, and which are the solid-state analogue of gaseous chambers, emerged in late 1950s and early 1960s. At present, silicon-based detectors predominate in charge particle spectrometry, while germanium is more widely used in ion-drifted detectors for gamma-ray measurements. The studies which led to the development of the thermo-luminescent dosimeter (TLD) started in 1948 by L.F. Heckelsberg. In 1966, small pieces of LiF first came into large-scale use as personnel dosimeters. These TLD chips have gradually replaced the photographic film badges in personnel dosimetry.

Metal Halide Perovskites have emerged as promising material in radiation detection due to their unique features, including large bulk resistance, strong stopping power, and high mobility-lifetime product. With the advent of composite and nano materials, new avenue opened up for development of highly sensitive and all-in-one type detectors catering the needs of alpha, beta, x-ray, gamma, neutron and heavy ion detection simultaneously by single instrument. Extensive research is underway at Defence Laboratory, Jodhpur for the development of highly sensitive and all-in-one type of ionizing radiation detectors for various applications of mankind and will be discussed during the talk.

Standardization of dose reporting in Cervical Cancer Brachytherapy: From ICRU Point A to ICRU 89 Volume based

Dr. Arvind Shukla Professor
Radiological Physics RNT Medical College & Associated Hospitals, Udaipur

High-dose-rate (HDR) brachytherapy plays a pivotal role in the definitive management of cervical cancer. Traditionally, dose prescription and reporting were based on point-based systems such as Point A, as recommended in ICRU Report 38. While this approach provided a standardized framework, it was inherently limited in representing patient-specific anatomy and true dose distribution.

The introduction of ICRU Report 89, in conjunction with GEC-ESTRO recommendations, has led to a paradigm shift from point-based to volumetric, image-guided brachytherapy. This approach utilizes CT/MRI-based planning for accurate delineation of GTV, HR-CTV, and IR-CTV, along with organs at risk (OARs) such as bladder, rectum, sigmoid, and bowel.

From a physics reporting perspective, ICRU 89 emphasizes dose–volume parameters. Target coverage is assessed using HR-CTV D90 and D98, with D90 being the most robust parameter for prescription and evaluation. For OARs, D2cc is the most reliable predictor of toxicity, while D0.1cc highlights dose hotspots. ICRU 89 also establishes the relationship between traditional and volumetric reporting. Point A remains important for reference and comparison but does not reflect individual anatomy. In contrast, HR-CTV D90 provides a patient-specific representation of target dose. ICRU rectum point doses tend to overestimate rectal D2cc by ~20%, whereas ICRU bladder point doses underestimate bladder D2cc by ~20%, with variability among patients. Hence, an integrated approach combining point-based and volumetric parameters is recommended. TRAK represents the integral physical dose but lacks radiobiological relevance. EQD2 is essential for combining EBRT and brachytherapy doses and is recommended by ICRU 89 using α/β = 10 Gy for tumor and 3 Gy for OARs.

Accurate applicator placement, reconstruction, and image guidance are essential for precise dose delivery. The transition to image-guided adaptive brachytherapy enables patient-specific optimization and improved outcomes.

In conclusion, ICRU 89 provides a comprehensive physics-based framework for dose prescription and reporting, improving treatment accuracy, tumor control, and toxicity outcomes.

Cardiac Sparing Techniques in Left-Sided Breast Cancer

Dr. Tripti Saxena
MD, MBA (HAHM), Director Radiation Oncology
Max Super Speciality Hospital Patparganj

Radiotherapy remains a cornerstone in the management of breast cancer; however, treatment of left-sided breast cancers poses a unique challenge due to the proximity of the heart and coronary arteries to the radiation fields. Increasing evidence has highlighted the association between radiation exposure to the heart and long-term cardiac morbidity. Modern breast radiotherapy, therefore focuses on strategies that minimise cardiac dose while maintaining optimal tumour control.

Effective cardiac sparing is achieved through a combination of three key approaches. The first involves intelligent target and volume modification, including precise contouring of breast and nodal volumes and careful selection of internal mammary node irradiation. The second pillar is motion management, particularly the use of deep inspiration breath hold (DIBH), which increases the distance between the heart and chest wall during treatment. The third component is advanced planning techniques, such as field-in-field planning, IMRT, and hybrid approaches, which allow improved dose conformity and reduction of cardiac hotspots.

Together, these strategies represent a paradigm shift in breast radiotherapy, demonstrating that optimal heart sparing is achieved not by technology alone, but through the thoughtful integration of target design, motion control, and advanced treatment planning.

Diffusion Weighted MR Imaging: Physics and its expanding role in the last two decade

Dr. Ajay Srivastava
Associate Professor SNMC Agra

Diffusion-weighted MRI (DWI) is a non-invasive MR imaging technique that probes tissue microstructure by measuring water-molecule displacements known as Brownian movement . Since its discovery in the late 1980s by Li Bihan et al(1) , this imaging method that does not require any tracer injection, has experienced exponential growth, becoming a pillar of modern clinical imaging." "DWI enables the investigation of tissue microstructure. DWI signal attenuation reflects both molecular diffusion and other incoherent motions (e.g., microcirculation). The apparent diffusion coefficient (ADC) models diffusion in tissue but differs from free-water diffusion because of barriers such as membranes and macromolecules. Intravoxel incoherent motion (IVIM) separates true diffusion from faster pseudodiffusion (microcirculation) by modelling multiple signal components. For anisotropic tissues (notably brain white matter), diffusion tensor imaging (DTI) uses a tensor formalism to characterize directional diffusion and in fiber orientation.Historically central to neuroradiology (acute ischemia, connectivity), DWI/DTI now extend widely across organs. Recently this technique highlights multiparametric combinations (T1/T2 mapping, MR elastography, BOLD), radiomics, and IVIM-DTI for microcirculation. Key challenges are scanner/sequence harmonization, protocol optimization (fat suppression, b-values), and scan time constraints. The field is moving toward consensus technical recommendations to support multicentre clinical translation. Diffusion weighted MRI (DWI) plays a significant role in MR LINAC technology by providing functional imaging data that complements anatomical imaging. Diffusion-weighted imaging (DWI) plays a significant role in MR-LINAC technology by providing functional imaging data that complements anatomical imaging. DWI contributes to MR-LINAC:

1. Improved Tumor Delineation: DWI enhances the ability to differentiate between tumor tissue and surrounding healthy tissues, which is crucial for precise radiation targeting. This is particularly important for tumors in areas with complex anatomy, such as the brain, pancreas, and liver.
2. Real-Time Adaptation: DWI can detect changes in tumor cellularity during treatment, allowing for adaptive radiation therapy. This means the radiation plan can be adjusted in real-time based on the tumor's response, optimizing treatment effectiveness.
3. Predicting Treatment Response: DWI provides information about the tumor's microenvironment, such as cell density and water diffusion. Changes in apparent diffusion coefficient (ADC) values during treatment can indicate tumor response, helping clinicians decide on dose escalation or alternative strategies.
4. Reducing Treatment Volumes: By providing detailed functional imaging, DWI can help reduce planning target volume (PTV) margins, minimizing radiation exposure to surrounding healthy tissues and reducing side effects.
5. Guiding Dose Escalation: DWI can identify poorly responding tumor areas, enabling targeted dose escalation to improve local control and treatment outcomes.

Medical Exposure In Diagnostic-Radiology & Need for Radiation Dosimetry In Diagnostic Radiology

Dr B S Rana
Medical Physicist Deptt. of Radiodiagnosis,
PGIMER, Chandigarh

Medical exposure from diagnostic radiology represents a significant and continuously increasing component of population radiation dose worldwide. According to reports from the United Nations Scientific Committee on the Effects of Atomic Radiation, medical imaging contributes substantially to collective effective dose, with notable variations across modalities, countries, and healthcare levels.

The presentation gives an overview of global trends in diagnostic radiation exposure, associated uncertainties, and modality-wise contributions. While conventional radiography and dental imaging account for the majority of procedures, computed tomography (CT) and interventional radiology (IR) contribute disproportionately higher doses, together accounting for nearly 70% of the collective dose despite a smaller fraction of total examinations.

Key challenges in radiation dosimetry include complex X-ray beam characteristics, variability in clinical practices, and limitations in direct dose measurement. Standardized methodologies, as recommended in International Atomic Energy Agency TRS-457, play a crucial role in ensuring accuracy, traceability, and comparability of dose measurements across different systems and institutions.

The presentation highlights dosimetric approaches in radiography, fluoroscopy, and CT, emphasizing parameters such as air kerma, kerma-area product (KAP), and CT dose indices (CTDI). It also underlines the importance of diagnostic reference levels (DRLs) and size-specific dose estimates (SSDE) for dose optimization in clinical practice.

Overall, the presentation underscores the need for continuous monitoring, standardization, and optimization of radiation dose to ensure patient safety while maintaining diagnostic efficacy.

Dr Bhupendra Singh Rana

Advanced radio-diagnostic machines in medicine and technology& Road Ahead

R K Bisht
Medical Physics Unit, Dr BRA-IRCH, AIIMS,
New Delhi, India

Diagnostic machines installed in the radiology department utilise electromagnetic radiation and radiofrequency waves to produce detailed images of the internal structures of the human body. These images help clinicians in the diagnosis and early detection of diseases. The quality of images is instrumental in the most appropriate treatment planning of the ailment. Advanced radio-diagnostic machines in medicine revolutionised the treatment by enabling precise detection of diseases. The hybrid imaging is one of the most advanced modalities in radio-diagnostic departments. The hybrid imaging technique combines two or more diagnostic techniques, such as anatomical CT - MRI and functional or metabolic PET - SPECT, into a single integrated scan to improve diagnostic precision, particularly in oncology, neurology, and cardiology. Compact and portable handheld cameras are now available to take radiographs of all parts of the human body with appreciable accuracy, which makes diagnostics more accessible in rural areas and emergency situations. The image processing time is less than 3 seconds on these machines, whereas the shorter irradiation time results in less image blur. New imaging techniques such as advanced digital radiography, photon counting CT, contrast-enhanced radiographs / CT, multi-slice CT scanners, low to ultra-low dose CT protocols and recent interventional radiology techniques have obvious evidence of improved patient safety and therapeutic gain. Image-guided procedures following robotic-assisted interventions using recent protocol, allow minimally invasive interventions with high precision. Cone Beam Computed Tomography (CBCT), which uses cone shaped X-ray beam, rotating around the patient to produce high-resolution 3D images of the facial bones and teeth in a few seconds is recently introduced for dentistry. The machine offers lower radiation doses (5-15 times less) than conventional techniques, which makes it ideal for dental and ENT procedures. Advanced computer processing in creating multi-sectional images offers precise evaluation of tumours and vascular diseases. Ultrasound computed tomography (USCT) is a recent and non-ionising imaging modality that uses high-frequency sound waves to create high-resolution 3D, cross-sectional images of soft tissue, like breast and other organs, to identify soft tissue anomalies. Recent innovations, integrate artificial intelligence, 3D reconstruction and ultra-low-dose radiation techniques, enhance diagnostic accuracy while minimising the radiation risk to the patient and operator. Future machines will focus on molecular – level imaging, which certainly improve the clinical outcomes by facilitating the detection of disease before structural changes. These advanced radio-diagnostic machines are shaping diagnostic radiology towards great accuracy and personalised patient care.

AAPM Task Group Report 186: Model Based Dose Calculation Methods in brachytherapy- Current status and

Dr. Reena Sharma Medical Physicist cum RSO,
PGIMER Chandigarh

AAPM report TG-186 provides updated guidelines for brachytherapy dose calculations, addressing the limitations of the traditional TG-43 formalism by introducing Model-Based Dose Calculation Algorithms (MBDCAs) for brachytherapy (BT). The main focus in this report is to better account for material heterogeneities and scatter conditions, especially for low-energy isotopes. The TG report also ensure practice uniformity by improving the dose calculation accuracy in BT.

The inclusion of heterogeneity correction algorithm is new to BT calculations. Although, BT dose calculation accuracy is highly dependent on scatter conditions and photoelectric effect cross-sections relative to water. In specific situations, like low and intermediate energies and certain tissue, the difference between the water-based BT dose calculation formalism (TG-43) and MBDCAs can lead to differences in calculated doses exceeding a factor of 10. MBDCAs raised three major issues that are not addressed in TG 43 recommendations: (1) MBDCA calculated doses are sensitive to the dose specification medium, resulting in energy-dependent differences between dose calculated to water in a homogeneous water geometry (TG-43), dose calculated to the local medium in the heterogeneous medium, and the intermediate scenario of dose calculated to a small volume of water in the heterogeneous medium. (2) MBDCA doses are sensitive to voxel-by-voxel interaction cross sections. Neither conventional single-energy CT nor ICRU/ICRP tissue com-position compilations provide useful guidance for the task of assigning interaction cross sections to each voxel. (3) Since each patient-source-applicator combination is unique, having reference data for each possible combination to benchmark MBDCAs is an impractical strategy. Hence, a new commissioning process is required. Two levels of commissioning are recommended: reproducing TG-43 dose parameters and testing the advanced capabilities of MBDCAs. For validation of heterogeneity and scatter conditions, MBDCAs should mimic the 3D dose distributions from reference virtual geometries. Potential changes in BT dose prescriptions and MBDCA limitations are also discussed. In using MBDCAs, it is recommended that the radiation transport should be performed in the heterogeneous medium and, at minimum, the dose to the local medium be reported along with the TG-43 calculated doses. Assignments of voxel-by-voxel cross sections represent a particular challenge. Electron density information is readily extracted from CT imaging, but cannot be used to distinguish between different materials having the same density. Therefore, a recommendation is also made to use a number of standardized materials to maintain uniformity across institutions. Sensitivity analysis shows that this recommendation offers increased accuracy over TG-43. MBDCA commissioning will share commonalities with current TG-43-based systems, but in addition there will be algorithm-specific tasks. TG-186 encourages a transition to more accurate, patient-specific dosimetry while maintaining, at minimum, parallel reporting with TG-43.

Radiobiology beyond the classical 4 R's for Radiotherapy

Prof. Arun Chougule
PhD, FIUPESM, FAMS, FIOMP Dean and Chief Academic Officer
Swasthya Kalyan Group, Jaipur

Cancer incident is increasing so also the management and radiotherapy has evolved as the main modality of treatment. Further the biological foundations of radiotherapy have evolved through more than a century of experimental observation, clinical insight, and technological innovation. Early radiobiological understanding was shaped by the Bergonié–Tribondeau law (1906), which proposed that cellular radiosensitivity is directly related to proliferative capacity, mitotic activity, and degree of differentiation. This principle provided the first biological explanation for differential tumour and normal tissue responses to ionizing radiation and established radiation as a rational modality for cancer treatment.

Subsequent clinical experimentation by Regaud and Coutard in the early twentieth century demonstrated that fractionated irradiation could achieve durable tumour control while sparing late responding normal tissues. Their work introduced the concept that biological response is influenced not only by total dose but also by dose per fraction and overall treatment time, laying the groundwork for modern fractionation schedules. These observations preceded mechanistic understanding but accurately reflected underlying processes of cellular repair, repopulation, and tissue recovery.

The classical four R's of radiobiology - Repair, Reassortment, Repopulation, and Reoxygenation have provided the conceptual foundation for fractionated radiotherapy for several decades. While these principles successfully explain many aspects of tumour and normal tissue responses to ionizing radiation, they are increasingly insufficient to capture the biological complexity revealed by modern radiation techniques, molecular oncology, and systems biology. With the advent of high precision radiotherapy, hypofractionation, stereotactic body radiotherapy (SBRT), particle therapy, and biologically guided treatment strategies, a broader radiobiological framework is required.

This talk explores radiobiology beyond the 4 R's, emphasizing emerging biological processes that critically influence radiation response. Concepts of intratumoral heterogeneity, cancer stem cell dynamics, and microenvironmental regulation, particularly the roles of hypoxia gradients, immune cell infiltration, and stromal signalling will be discussed. The limitations of clonogenic survival as the sole endpoint has led to the conceptual expansion of radiobiology to include the 5th, 6th, and 7th R, reflecting a more comprehensive understanding of radiation response.

The 5th R: Radiosensitivity emerged from clinical observations of marked interpatient and intratumoral variability in radiation response, even among histologically similar tumours. Advances in genomics and molecular profiling have demonstrated that intrinsic radiosensitivity is governed by DNA damage response capacity, cell-cycle regulation, epigenetic states, and metabolic pathways. Recognition of radiosensitivity underscores the importance of biological heterogeneity and provides the basis for biomarker driven dose individualization and biologically guided tailor-made radiotherapy.

The 6th R: Reactivation of the Immune Response has its genesis in the growing evidence that radiation is not merely a local cytotoxic modality but also a potent immune modulator. Radiation-induced immunogenic cell death, antigen release, cytokine signalling, and modulation of the tumour microenvironment can stimulate systemic antitumour immunity, occasionally resulting in abscopal effects. This paradigm shift has profound clinical implications, particularly in the era of immunotherapy, where radiotherapy is increasingly used as an immune adjuvant to enhance treatment response.

The 7th R: Remodelling of the Tumour Microenvironment reflects the recognition that radiation response is critically shaped by dynamic interactions between tumour cells, stromal components, vasculature, hypoxia, and immune infiltrates. Radiation induced vascular normalization, fibroblast activation, extracellular matrix remodelling, and changes in hypoxic niches influence both tumour control and normal tissue toxicity. This 7th R emphasizes that radiation effects extend beyond tumour clonogen to the entire biological ecosystem of the tumour.

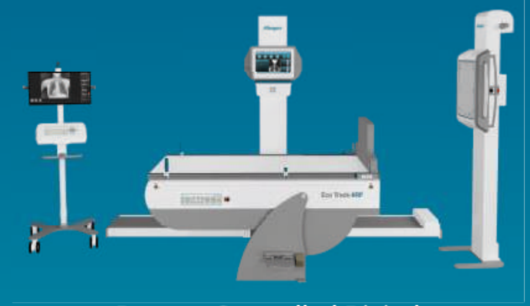
Together, the 5th, 6th, and 7th R's expand radiobiology from a cell centric to a systems level discipline, integrating molecular, immunological, and microenvironmental determinants of response. Understanding these principles is essential for the rational design of Hypofractionated regimens, adaptive strategies, and combination therapies. Moving beyond the classical 4 R's enables the transition toward biology integrated, personalized precision radiotherapy, with the potential to improve therapeutic ratio and ultimate clinical outcomes.

Recent insights into DNA damage response signalling, epigenetic regulation, and metabolic reprogramming highlight how radiation interacts with cellular pathways beyond simple DNA double strand break repair. The concept of radiosensitivity as a dynamic and context dependent phenotype is introduced, influenced by genomic instability, cell plasticity, and treatment induced selection pressures.

The talk further addresses how these expanded radiobiological principles can influence personalized radiotherapy, including biomarker guided dose prescription, genomically guided, adaptive treatment strategies, and rational combinations with immunotherapy and targeted agents. Moving beyond the 4 R's enables a shift from purely physics driven optimization toward biology integrated precision radiotherapy.

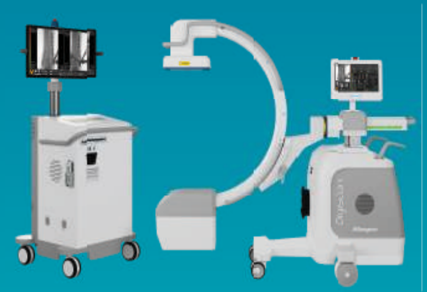
In conclusion, radiotherapy is not merely the delivery of dose, it is the manipulation of biology across space and time. Embracing radiobiology beyond the classical 4 R's is essential for understanding treatment response in the modern era and for translating biological knowledge into clinically meaningful gains in tumour control while minimizing normal tissue toxicity.

Fixed Digital Radiography System (Ceiling Suspended)

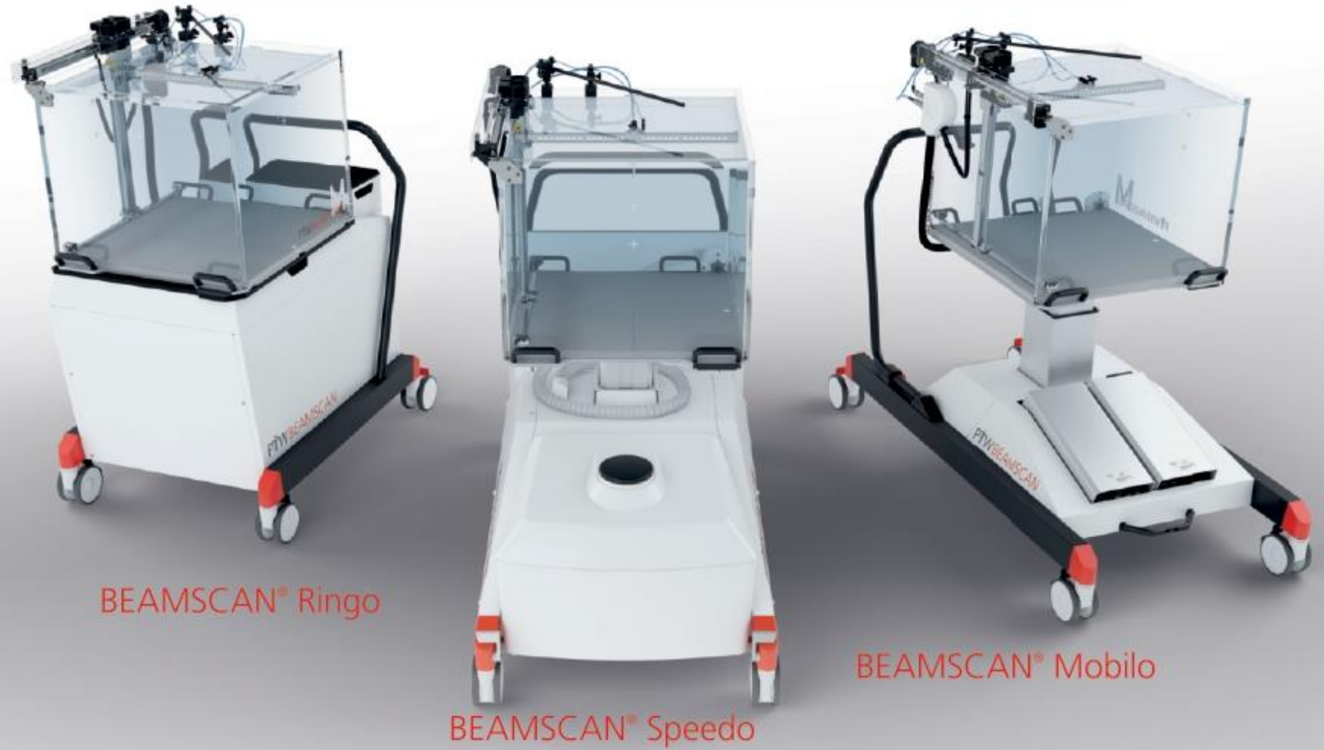


Remote Controlled Digital Radiography and Fluoroscopy System

Full-Field Digital Mammography System with 3D Tomosynthesis



C-Arm with Flat Panel Detector Embedded with DSA



Oral Presentation

AMPI-NC CON 2026

Radiation Exposure During Pregnancy: Evidence-Based Fetal Risk Assessment and Clinical Management in Diagnostic and Therapeutic Practice

Athiyaman M[1], Chandrasekhar[2], Kathambari[3], Shankar Lal Jakhar[4], Kamlesh Kumar Harsh[5], Neeti Sharma[6].
[1-3] Department of Radiological Physics,
[3-6]Department of Radiation Oncology,
[7-9] Sardar Patel Medical College, Bikaner, Rajasthan

Introduction
Radiation exposure during pregnancy presents a complex clinical and ethical challenge requiring careful balance between maternal benefit and fetal safety. Fetal radiation effects are categorized as deterministic (threshold-based) and stochastic (non-threshold). Deterministic effects include embryonic death, congenital malformations, central nervous system abnormalities, and growth retardation, whereas stochastic effects primarily involve childhood malignancy and potential hereditary risk. Radio sensitivity varies with gestational age, with highest vulnerability during organogenesis and early CNS development. Structured risk assessment and dose optimization are therefore essential.

Materials and Methods
This work integrates radiobiological principles, published fetal dose data from diagnostic procedures, and therapeutic radiotherapy experience. Fetal doses from conventional radiography, fluoroscopy, computed tomography (CT), and external beam radiotherapy were analysed. Determinants of fetal dose—including gestational age, distance from field edge, beam energy, shielding, field size, and treatment duration—were evaluated. Dose-reduction strategies included beam collimation, minimizing exposures, limiting fluoroscopy time, optimizing technical parameters, and preferential use of ultrasound or MRI. Clinical management pathways for pelvic and non-pelvic malignancies during pregnancy were reviewed in accordance with international safety guidance.

Results
Fetal dose varies significantly depending on modality and anatomical region. Conventional radiographs of the chest, skull, and thoracic spine deliver negligible doses (<0.01 mGy). Abdominal and pelvic radiographs typically result in mean fetal doses of 1–2 mGy, with maximum values up to 10 mGy. Fluoroscopic studies such as barium enema may deliver mean doses of 6–7 mGy (maximum ~24 mGy). CT examinations demonstrate greater variability: CT chest contributes <1 mGy; CT abdomen approximately 8 mGy; and CT pelvis averages 25 mGy, with reported maximum values approaching 70–80 mGy.

Deterministic effects are unlikely below 50–100 mGy. During the pre-implantation period (0–14 days), the “all-or-none” phenomenon predominates. The 8–15 week period represents peak sensitivity for CNS injury, with intellectual impairment reported at doses exceeding 100–200 mGy. Stochastic risk increases proportionally with dose; excess childhood cancer risk is estimated at approximately 0.006% per mGy. Thus, a 10 mGy exposure would increase absolute childhood cancer risk by approximately 0.06% above baseline.

In radiotherapy, fetal dose decreases exponentially with distance from the treatment field. Brain tumor irradiation typically results in fetal doses around 30 mGy. Mantle field irradiation without shielding may reach 400–500 mGy, while additional shielding can reduce fetal dose by 40–50%. Pelvic radiotherapy during pregnancy almost invariably results in severe fetal consequences and is therefore contraindicated.

Discussion

Radiation management during pregnancy should be guided by scientific evidence rather than fear. A single clinically justified abdominal radiograph (1–3 mGy) remains far below deterministic thresholds and carries minimal absolute stochastic risk. In contrast, abdominal or pelvic radiotherapy is not undertaken during pregnancy due to the high likelihood of fetal injury. For non-pelvic malignancies, meticulous treatment planning, shielding, and fetal dose estimation are implemented. These practices reflect the structured and ethically guided approach adopted by radiation oncologists, diagnostic radiologists, medical physicists, and obstetricians, ensuring optimized maternal care while minimizing fetal risk.

Conclusion

Diagnostic radiation procedures, when optimized, are generally safe and remain well below deterministic thresholds. Radiotherapy—particularly involving pelvic fields—poses substantial fetal hazard and requires strict contraindication or alternative strategies. Evidence-based multidisciplinary management ensures appropriate maternal treatment while safeguarding fetal well-being.

Evaluation of Image Registration Accuracy and its Impact on Dose Accumulation for FF and FFF Beams in Adaptive Radiotherapy of Bladder Cancer

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Objective: Recent advances in technology have greatly improved the accuracy of radiotherapy, which is a key part of cancer treatment. Adaptive Radiotherapy (ART) provides enhanced clinical results for specific cancer sites, including urinary bladder and prostate. Since ART requires multiple CT simulations to account for anatomical changes between the initial treatment and the subsequent boost, accurate Image Registration (IR) is essential for precise cumulative dose calculation. This study compares the accuracy of four registration methods in the Eclipse Treatment Planning System (TPS)—Auto, Manual, Point Matching, and Deformable—using Target Registration Error (TRE) and Dice Similarity Coefficient (DSC), while evaluating the impact on dose summation for Flattening Filter (FF) and Flattening Filter-Free (FFF) beams.

Materials and Methods**:** The data of ten bladder cancer patients were used in the present study. CT simulations were conducted at baseline and following Phase I of treatment were taken for analysis. The image sets were aligned using the four aforementioned registration methods. DSC was recorded for individual organs, and TRE was calculated to quantify registration error. IMRT plans were generated in Eclipse (v17.0) for a Varian TrueBeam Linac. Phase I used 6 MV beams; Phase II utilized both 6 MV and 6 MV-FFF beams. Following registration, plan summations were created, and Dose-Volume Histograms (DVH) were compared across all four methods for the target and Organs at Risk (OAR).

Results: Across the four registration methods, the DSC for the bone marrow, bowel, and femoral heads ranged from 0.81 to 0.93, while the rectum ranged from 0.60 to 0.63. Point matching exhibited a cumulative error standard deviation of ±0.81 mm, compared to ±1.32 mm – ±1.78 mm for the other methods. Despite these variations in registration metrics, the DVH statistics for the summation of FF-FF and FF-FFF plans showed no significant variation across the four registration techniques.

Conclusion: While image registration is a fundamental component of adaptive planning, the observed variations in DSC and TRE did not significantly impact the final dose statistics in Eclipse. This results reveals that volume variation was accounted during dose mapping. This statement is well supported by DSC variation observed in the rectum. For more accurate dose estimation in ART, further exploration of non-rigid (deformable) dose summation is recommended to improve the confidence of dose reporting.

Hybrid gEUD-Assisted Optimization Versus DVH-Only Planning Across Bilateral Breast IMRT and Head-and-Neck VMAT

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Purpose: To compare DVH-only inverse planning versus hybrid DVH plus generalized equivalent uniform dose (gEUD) optimization across two clinically demanding sites: bilateral breast IMRT and head-and-neck (H&N) VMAT.

Methods: Bilateral breast cohort (n=10): DVH plans (DV) were compared with DVH refined using gEUD objectives (DV-gEUD). Endpoints included PTV V95%, conformity index (CI), homogeneity index (HI), heart mean dose and V30Gy, total lung mean dose and V20Gy, and planning time. H&N cohort (n=5, re-irradiation VMAT): DVH plans were compared with plans adding a spinal cord Max EUD objective (gEUD90% and gEUD80%), evaluating spinal cord Dmax, target coverage, HI, and contralateral parotid mean dose.

Results: Bilateral breast: target quality was maintained (V95% 99.06±0.44% DV vs 98.92±0.50% DV-gEUD; CI 1.29±0.10 vs 1.32±0.11; HI 1.10±0.03 vs 1.11±0.03). OAR sparing improved: heart mean dose 19.3±6.7 Gy to 16.5±5.7 Gy and heart V30Gy 14.8±13.7% to 10.0±10.3%; lung mean dose 17.5±3.5 Gy to 15.0±3.8 Gy and lung V20Gy 28.7±7.9% to 23.6±7.6%. Planning time decreased from 58.74±15.40 to 39.32±9.11 minutes. H&N: spinal cord Dmax decreased from 412.2±86.2 cGy (DV) to 341.7±106.7 cGy (gEUD90%) and 328.5±108.8 cGy (gEUD80%); HI increased from 1.1099±0.0160 to 1.1256±0.0210; contralateral parotid mean dose decreased from 491.0±337.0 to 335.4±221.2 cGy.

Conclusion: Hybrid DVH plus gEUD optimization improved clinically relevant OAR sparing across two sites while preserving target coverage, supporting gEUD objectives as a workflow-compatible enhancement to conventional DVH planning.

Title: Structured Reporting of Orthopantomogram (OPG) Radiographs: An AI-Ready Framework

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Aims/Objectives

Orthopantomogram (OPG) radiography is widely used for evaluation of dental anatomical structures. However, variability in interpretation and reporting can lead to inconsistencies and limits the availability of standardized datasets for artificial intelligence (AI) applications. Structured reporting systems can improve reporting quality, ensure completeness of findings, and enable the creation of well-annotated datasets for future AI development. The aim of this work was to develop a structured digital reporting system for OPG radiographs that standardizes the documentation of dental and maxillofacial findings while supporting the creation of AI-ready datasets.

The specific objectives were

- To design a structured reporting template covering major dental, periodontal, and maxillofacial findings observable on OPG images.
- To develop a user-friendly application that allows dentists to upload OPG images in formats such as JPEG, PNG, and PDF.
- To automatically generate a formatted PDF diagnostic report based on clinician-entered findings.
- To store structured annotations in a format suitable for future AI model development.

Materials and Methods

A structured OPG reporting template was developed in consultation with dental professionals to ensure clinical relevance and completeness. The template includes sections for patient information, dentition status, tooth-wise pathology, periodontal findings, jaw bone assessment, maxillary sinus evaluation, temporomandibular joint (TMJ) findings, and other abnormalities such as fractures or calcifications. Each parameter is recorded using predefined selectable options to ensure reporting consistency and reduce ambiguity.

A desktop-based reporting application was developed to operate in an offline clinical environment. The system allows dentists to load OPG images in multiple formats including JPEG, PNG, and PDF. Clinicians complete the structured form by selecting relevant findings such as dental caries stage, periapical pathology, bone loss pattern, impacted teeth, or cystic lesions.

The software was developed using Python for backend processing, while the graphical user interface was implemented using the PyQt/Qt framework. Based on clinician inputs, the system automatically generates a formatted PDF report and stores it locally using automated file naming based on patient ID and examination date for organized data management.

Results

The developed application enables structured reporting of OPG images while maintaining a workflow similar to routine dental practice. The standardized reporting template ensures consistent documentation of diagnostic findings and improves completeness of reports. Automated PDF generation also reduces reporting time and minimizes variability in report formatting.

Discussion

The structured input format generates labeled datasets that are suitable for machine learning applications such as classification and detection of dental pathologies. By converting routine clinical reporting into structured annotations, the system creates valuable datasets that can support future AI model development in dental imaging.

Conclusion

The proposed reporting system improves clinical reporting efficiency while simultaneously facilitating the creation of high-quality annotated datasets for AI research. Future work will focus on collecting larger annotated OPG datasets and using them to train AI models for automated detection of dental abnormalities such as caries, periodontal disease, and periapical lesions.

Organ Proximity Effects on Spatial Dose Fall-off Metrics in Head and Neck Radiotherapy

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Objectives

To investigate the influence of anatomical proximity between target volumes and organs at risk (OARs) on the behavior and interpretive value of the Dose Fall-off Index (DFI) in head and neck radiotherapy.

Material and Methods

A retrospective dosimetric analysis was performed on 160 head and neck radiotherapy treatment plans. The analysis included the parotid glands, larynx, oral cavity, and pharyngeal constrictor muscles. The Dose Fall-off Index (DFI) was calculated for each OAR, defined as the ratio of total organ volume to the sub-volume receiving at least 50% of the prescription dose. DFI distributions were compared across different organs without stratification by treatment technique.

Results

Far-field organs such as the parotid glands demonstrated a wide range of DFI values, indicating variability in achievable spatial dose fall-off. In contrast, near-field organs located partially or entirely within intermediate-dose regions showed DFI values clustered close to unity, reflecting limited geometric separation from high-dose target volumes.

Discussion

The results indicate that organ-centric gradient metrics such as DFI are strongly influenced by anatomical context. While DFI provides meaningful spatial information for organs with sufficient separation from the target, its discriminatory capacity is inherently limited for organs situated close to or overlapping with high-dose regions.

Conclusion

The clinical interpretability of gradient-based metrics like DFI depends on organ proximity to the target volume. Awareness of these anatomical constraints is essential for appropriate integration of spatial dose fall-off metrics into routine radiotherapy plan evaluation.

BEST PAPER PRESENTATION

Compressive Study and Validation of an Enhanced Leaf Model (ELM) in Eclipse Treatment Planning System.

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Purpose:
This study aims to compare and evaluate the effect of Enhanced Leaf Model (ELM) model in Eclipse (Varian Medical Systems, Palo Alto) version 18.0.1 versus the traditional DLG model in the older versions in Dose calculation. The Enhanced Leaf Model (ELM) implemented in modern versions of the Eclipse Treatment Planning System (TPS) has been developed to improve the representation of MLC leaf transmission, tongue-and-groove effects, rounded leaf ends, and inter-leaf leakage. This study presents a comparative evaluation of ELM against the conventional dosimetric leaf gap (DLG) based model to assess its impact on dose calculation accuracy and clinical plan quality.

Methods and Materials:
This study was conducted using the Eclipse Treatment Planning System (Varian Medical Systems, Palo Alto, CA). The measurements were performed on a Varian TrueBeam linear accelerator to evaluate the ELM. Multileaf collimator (MLC) characteristics were assessed using sweeping gap fields and closed leaf fields and picket fence test. 12 Volumetric Modulated Arc Therapy (VMAT) plans were generated on 6 targets of spherical and cylindrical shape (3 Sphere of diameter 2cm, 3cm and 5cm, Cylinder of diameter 2cm, 2.5cm and 5cm with length of 5 cm). Plans were generated in the treatment planning system (TPS) using both the conventional MLC model (Acuros15.5.11) and the Enhanced Leaf Model (Acuros18.0.1). Calculated dose distributions from both models were compared with measurements in EPID using gamma index analysis with stringent criteria of 1%/1 mm, 2%/2mm and 3%/3mm to quantify dosimetric agreement.
Results:
The Eclipse version (Acuros18.0.1) incorporating ELM demonstrated improved agreement with measured dose distributions compared to the conventional MLC model version (Acuros15.5.11). Gamma passing rates increased consistently, particularly for highly modulated VMAT plans and in regions influenced by MLC leaf ends. Sweeping gap and closed leaf field and Picket Fence test measurements showed reduced discrepancies in MLC transmission and leaf tip modeling with ELM. A detailed quantitative analysis to further validate the observed dosimetric improvements is currently ongoing.
Conclusion:

The Enhanced Leaf Model provides superior dosimetric accuracy compared to the conventional MLC model on a Varian TrueBeam linear accelerator. Improved agreement in both planar and point-dose measurements, along with higher gamma pass rates at 1%/1 mm, highlights the clinical benefit of ELM for accurate MLC modeling. These findings support the clinical implementation of ELM in modern treatment planning systems to enhance dose calculation reliability for advanced radiotherapy techniques.
Keyword:
Enhanced Leaf Model (ELM), Dosimetric Leaf Gap (DLG), Picket Fence test, Sweeping Gap Test.

Comprehensive Dosimetric and Mechanical Evaluation of HyperArc/VMAT Delivery for Small and Large Target Volumes

Dheeraj Dhingani

Purpose: This study evaluates the dosimetric and mechanical accuracy of stereotactic HyperArc/VMAT delivery using gamma analysis, absolute dose measurements with PinPoint and diamond detectors, and trajectory logbased mechanical performance metrics. The influence of target (tumor) size on dosimetric accuracy is investigated.

Methods: Quality assurance (QA) measurements were performed for photon beam energies of 6 MV, 6 FFF, 10 MV, 10 FFF, and 15 MV, with spherical target diameters ranging from 5 mm to 40 mm. Absolute dose measurements were acquired using PinPoint ionization chambers and diamond detectors and compared with treatment planning system (TPS) calculated doses. Gamma analysis was conducted using 3%/3 mm and 2%/2 mm criteria. Trajectory log files were analyzed to quantify multileaf collimator (MLC) positional errors, gantry and collimator deviations, monitor unit (MU) delivery errors, and dose rate variations.

Results: Gamma pass rates exceeded 99% for target sizes ≥10 mm for 3%/3 mm criteria, while a systematic reduction was observed for 5 mm targets, with 2%/2 mm gamma values as low as 70–90%. Dose differences between measured and TPS values were within ±4% for target sizes ≥20 mm but increased up to 38% for 5 mm targets. Trajectory log analysis demonstrated excellent mechanical accuracy, with average MLC RMS errors below 0.02 mm and gantry and collimator errors below 0.05°. Log-based gamma analysis showed 100% passing rates, confirming accurate delivery.

Results: Gamma pass rates exceeded 99% for target sizes ≥10 mm for 3%/3 mm criteria, while a systematic reduction was observed for 5 mm targets, with 2%/2 mm gamma values as low as 70–90%. Dose differences between measured and TPS values were within ±4% for target sizes ≥20 mm but increased up to 38% for 5 mm targets. Trajectory log analysis demonstrated excellent mechanical accuracy, with average MLC RMS errors below 0.02 mm and gantry and collimator errors below 0.05°. Log-based gamma analysis showed 100% passing rates, confirming accurate delivery.

Introduction Stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT) require submillimeter geometric and dosimetric accuracy due to the delivery of high doses in a limited number of fractions. HyperArc and VMAT are advanced delivery techniques designed to achieve highly conformal dose distributions while sparing surrounding healthy tissue. Despite technological advancements, small-field dosimetry remains challenging due to detector volume averaging, lateral electronic disequilibrium, and treatment planning system (TPS) beam modeling uncertainties.

Mechanical uncertainties such as MLC positioning errors, gantry rotation deviations, and dose rate fluctuations may also contribute to discrepancies between planned and delivered dose. Therefore, comprehensive QA combining dosimetric and mechanical evaluation is essential.

This study aims to systematically evaluate HyperArc/VMAT delivery using gamma analysis, absolute dose measurements, and trajectory log analysis, with a focus on the dependence of QA metrics on target size.

2. Materials and Methods

2.1 Treatment Planning and Target Sizes

Spherical targets with diameters of 5, 10, 20, 30, and 40 mm were contoured in a stereotactic phantom. Treatment plans were generated using a commercial TPS for multiple photon beam energies including 6 MV, 6 FFF, 10 MV, 10 FFF, and 15 MV. HyperArc/VMAT plans were optimized to deliver prescription doses to the target while minimizing dose to surrounding structures.

2.2 Dosimetric Measurements

Absolute dose measurements were performed using a PinPoint ionization chamber and a diamond detector placed at the center of each target volume. Measured doses were compared with TPS-calculated doses. Percentage dose error was calculated using:

% Error = (D_measured − D_TPS) / D_TPS × 100

2.3 Gamma Analysis

Two-dimensional gamma analysis was performed using 3%/3 mm and 2%/2 mm criteria with a 10% dose threshold. Gamma passing rates were evaluated for each target size and beam energy to assess dosimetric agreement between measured and planned dose distributions.

2.4 Trajectory Log Analysis

Trajectory log files generated during treatment delivery were analyzed to extract MLC leaf position errors, gantry and collimator angle deviations, MU delivery errors, and dose rate variations. Log-based reconstructed dose distributions were also evaluated using gamma analysis.

3. Results

3.1 Gamma Analysis Results

Gamma passing rates were greater than 99% for target sizes ≥10 mm using 3%/3 mm criteria. For 2%/2 mm criteria, passing rates decreased for 5 mm targets, with values as low as 70–90%. These results indicate increased uncertainty in very small field

3.2 Absolute Dose Measurement Results

Dose differences between measured and TPS-calculated values were within ±4% for target sizes ≥20 mm. For 10 mm targets, dose errors ranged from 3–11%. For 5 mm targets, dose errors increased significantly, reaching up to 38%, particularly for flattening filter-free beams. These findings demonstrate the limitations of conventional detectors and TPS modeling in small-field dosimetry.

3.3 Mechanical Performance from Trajectory Logs

Trajectory log analysis revealed average MLC RMS errors below 0.02 mm and maximum errors below 0.03 mm. Gantry and collimator mean errors were below 0.05°. MU delivery errors were below 0.05 MU, and dose rate variations were within expected clinical limits. Log-based gamma analysis demonstrated a 100% passing rate, confirming highly accurate mechanical delivery.

4. Discussion

The observed reduction in gamma pass rates and increase in dose error for small targets are attributed to detector volume averaging, output factor uncertainties, and TPS beam modeling limitations. Mechanical delivery errors were minimal, indicating that dosimetric discrepancies are primarily due to small-field physics rather than linac performance. These findings are consistent with previous reports highlighting the challenges of stereotactic small-field dosimetry.

For clinical stereotactic treatments, dedicated small-field detectors such as diodes and microDiamond detectors, along with Monte Carlo-based dose calculation algorithms, are recommended to improve dosimetric accuracy.

5. Conclusion

This study demonstrates that HyperArc/VMAT delivery provides excellent mechanical and dosimetric accuracy for clinically relevant target sizes. However, significant uncertainties exist for sub-centimeter targets, emphasizing the need for advanced dosimetric techniques and stringent QA protocols in stereotactic radiotherapy.

Development of a 3D-Printed Phantom Plate–Based OSLD System for Two-Dimensional Dose Verification in Gamma Knife Perfexion

Author: Deepika soni1 , Dr. Reena Sharma2

Key Words: LGK, OSLD, PMMA & PS QA, CAD Introduction Leksell Gamma Knife (LGK) Perfexion is a dedicated stereotactic radiosurgery system that delivers high single-fraction doses using multiple converging Co-60 beams, resulting in steep dose gradients and sub- millimetre spatial accuracy. Due to these characteristics, independent verification of planar dose distribution remains challenging. At present, there is no device available worldwide for performing patient specific quality assurance in LGK. The objective of this study was to design and implement in-house 3D printed Poly (methyl methacrylate) (PMMA) phantom plates for already available original spherical phantom (O_phantom). And to perform a two-dimensional (2D) dose measurement using optically stimulated luminescence dosimeters (OSLDs) for patient specific dosimetric verification for LGK treatments.

Materials and Methods:

This study was performed on LGK Perfexion, Custom phantom plates were designed using computer-aided (CAD) software and fabricated with 3D printing technology. Precisely defined grooves were incorporated in three different PMMA plates to allow reproducible placement of OSLDs in a predefined planar geometry. For OSLDs measurements, the PMMA plates were assembled inside a Original Spherical Phantom (mPhantom), enabling simulation of intracranial treatment conditions. Before that, the PMMA plates were checked for uniformity and attenuating properties. The Ct scan of the mPhantom was taken, HU values of both O_phantom and PMMA plate was noted. For PMMA attenuating properties, the charge measurements were recorded for both plates.

Results:

The 3D-printed PMMA plate system was checked for uniformity and the observed range of Hounsfield unit (HU) is shown in table 1. The impact of attenuation is negligible and is within 1.5%. This system is enabled accurate, stable, and reproducible positioning of OSLDs within the spherical phantom. Successful acquisition of 2D planar dose distributions was achieved correspondence with the planned high-dose regions and steep dose fall-off, demonstrating the system's capability to capture the complex dose distributions characteristic of Gamma Knife Perfexion.

MATERIAL		HU RANGE
PHANTOM PLATE		-27 to -50
PMMA PLATE	Groove	-950 to -1000
	Solid	-90 to -300

Discussion:

Accurate dosimetric verification is critical in Gamma Knife radiosurgery due to the high doses per fraction, sharp dose gradients, and stringent spatial accuracy requirements. The cross verification of planned doses is rarely used in LGK treatments. The modified phantom utilises OSLDs to measure the delivered doses in small sensitive volume along with scattered outside target doses. This proposed 3D-printed PMMA plate–OSLD system provides a flexible, customizable, and cost-effective approach for planar dose verification for patient specific quality assurance in Gamma Knife treatments. 2D system offers limitations as it does not adequately capture the complexities of 3D dose delivery. So, we are in a process to develop a 3D verification.

Conclusion:

This study demonstrates that a 3D-printed PMMA plate–based OSLD system can be effectively used for two-dimensional dose verification in Gamma Knife Perfexion. The proposed method is simple, adaptable, and clinically practical, and has potential application in patient-specific quality assurance and commissioning verification for stereotactic radiosurgery

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Axis-Specific Robustness and Clinically Relevant Displacement Thresholds in Single- and Multi-Channel Vaginal Cylinder HDR Brachytherapy

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Aims /Objectives

Applicator displacement during vaginal cylinder HDR brachytherapy can potentially compromise target coverage and organ-at-risk sparing due to steep dose gradients around the source. However, axis-specific sensitivity and clinically tolerable displacement limits are not well established. This study evaluates the dosimetric robustness of single-channel (SCVA) and multi-channel vaginal applicator (MCVA) plans under controlled translational displacements and identifies displacement magnitudes associated with clinically meaningful dose variation.

Material and Methods

CT datasets of 25 patients were retrospectively analysed. Applicator reconstruction was performed using the applicator library in the Oncentra Brachy treatment planning system (Version 4.7). For all patients, the target volume was uniformly contoured as the upper one-third of the vagina (typical length 3–4 cm), with dose prescribed at 5 mm depth from the applicator surface. For each patient, baseline plans (0 mm displacement) were generated for both applicator types (30 or 35 mm cylinders) using identical prescription and optimization parameters. Virtual translational displacements (±1–3 mm) were independently applied along lateral (X), cranio–caudal (Y), and anteroposterior (Z) axes while maintaining fixed dwell positions and times. Percentage dose variation relative to baseline was calculated for High-Risk CTV (HRCTV) D90/D98 and bladder and rectum D2cc. Clinically significant deviation was predefined as ≥3% and ≥5% change from baseline.
Data are reported as median percentage change, and paired comparisons between SCVA and MCVA were performed using the Wilcoxon signed-rank test, with $p < 0.05$ considered statistically significant.

Results

Axis-Specific Robustness: Dose variation demonstrated clear axis dependence. HRCTV D90 was most sensitive to Z-axis displacement, with median reductions of -6.07 % (SCVA) and -9.05 % (MCVA) at +2 mm and up to −11.08% and −14.73%, respectively, at +3 mm. Clinically relevant target dose degradation (≥3%) occurred from ±1 mm along the Z-axis, compared to ≥2 mm along X and ≥3 mm along Y.
Bladder and rectum D2cc also showed greater sensitivity along the Z-axis, with dose variation exceeding 5% at ±1–2 mm and reaching >20% at 3 mm displacement. Comparative Robustness (SCVA vs MCVA): Statistically significant differences between SCVA and MCVA were observed for HRCTV D90 primarily in the Y and Z directions ($p < 0.05$). However, the absolute median percentage dose differences were <3% in most scenarios. Rectum D2cc demonstrated statistical significance. However, the magnitude of inter-technique difference remained below the predefined clinical threshold, while Bladder D2cc showed no significant differences. Clinically relevant divergence (>3%) was confined to HRCTV D90 at ≥2 mm displacement in the Y and Z axes

Conclusion

Vaginal cylinder HDR brachytherapy is highly sensitive to anteroposterior displacement, with clinically meaningful deviations occurring at shifts as small as 1–2 mm. Both applicator designs demonstrated comparable geometric robustness, as inter-technique median dose differences were largely <3%, with clinically relevant divergence primarily observed for HRCTV D90 at ≥2 mm displacement. OAR dose variations between techniques remained clinically negligible. These findings highlight the importance of meticulous applicator positioning, adequate immobilization, and image-guided verification to ensure accurate and reproducible dose delivery.

Comparative Analysis of MPC, EPID and Quick Beam Checker for Daily QA in Varian Truebeam LINAC

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Aim:

To compare the performance of Machine Performance Check (MPC), EPID-based QA, and Quick Beam Checker (QBC) for daily quality assurance of Varian TrueBeam LINAC focusing on output constancy, beam symmetry and flatness.

Materials and Methods:

Daily QA measurements performed over six month period were considered and analysed for 6 MV Flattened (FF) and 6 MV Flattening Filter Free (FFF) photon beams. In routine the MPC was performed using the automated vendor (Varian) provided QA workflow. For EPID-based QA, we utilized portal images acquired with a 10 × 10 cm^2 open field at Isocentre. For QBC measurements, the device was positioned at Isocenter using lasers for 20 × 20 cm^2 open field. Recorded data of daily QA i.e, output constancy, symmetry & flatness was evaluated with percentage deviation & standard deviation (SD) with respect to baseline values.

Results:

For the 6 MV FF beam, calculated mean output deviation (±SD) for MPC, EPID & QBC was 0.45% (±0.63%), −1.41% (±0.52%) & 0.72% (±0.61%) respectively. Flatness deviation for EPID & QBC was −0.23% (±0.19%) & −0.19% (±0.03%) and Symmetry deviation for EPID & QBC was −0.48%(±0.31%) & −0.027% (±0.072%).
For the 6 MV FFF beam, calculated mean output deviation (±SD) for MPC, EPID & QBC was 0.19% (±0.47%), −0.50% (±0.74%) & 0.09% (±0.53%) respectively. Symmetry deviation for EPID & QBC was −0.08% (±0.46%) & −0.52% (±0.23%).

Discussion and Conclusion:

Daily QA comparison on the Varian TrueBeam demonstrated that MPC, EPID, and Quick Beam Checker provide consistent monitoring of output constancy. However, EPID exhibited greater variability in flatness and symmetry, particularly for FFF beams (Due to steep dose gradient & increased sensitivity towards positioning). Quick Beam Checker showed superior reproducibility for flatness and symmetry (low SD), suggesting higher mechanical stability. MPC output agreed well with QBC, supporting beam stability. The variation in flatness and symmetry can be attributed to measurement points, the QBC measures with 5 detectors (5mm) whereas the EPID has array of detectors with measurement pixel size of 0.4 mm. EPID gives a visual information for the quick general interpretation as well as one can overlays previous images for instant comparison and evaluation. Recently developed an AI tool for evaluation of flatness, symmetry and output consistency trend line using EPID data. Overall, all systems remained within clinical tolerance, confirming beam performance stability and a combined approach enhanced confidence in machine performance.

Keywords: Output Constancy, Flatness, Symmetry, Flattening Filter, MPC, EPID, QBC, Daily QA

Evaluation Of Collimator Transmission for FF And FFF Photon Beams of A Modern Linear Accelerator Using TLDS and an IC

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Aim

To evaluate collimator transmission for flattened (FF) and flattening filter free (FFF) photon beams of a modern medical linear accelerator using an ionization chamber and thermoluminescent dosimeters (TLDs), and to verify compliance with IEC 60601-2-11 and AERB acceptance criteria.

Introduction

Transmission radiation measurements are essential components of acceptance testing and quality assurance of medical linear accelerators. Radiation outside the primary field arises from head leakage, collimator transmission, and internal scatter. Although peripheral doses are small relative to the prescribed tumour dose, they contribute to whole-body integral dose and may increase the probability of stochastic effects, including radiation-induced secondary malignancies. This is particularly significant in paediatric and long-term surviving patients. IEC 60601-2-11 specifies limits for treatment head leakage and beam-limiting device transmission. According to AERB recommendations, secondary collimator leakage at normal treatment distance (NTD) shall not exceed 2% (maximum) and 0.75% (average), while patient-plane leakage shall be limited to 0.2% (maximum) and 0.1% (average). Compliance verification is therefore critical for radiological safety.

Materials and Methods

Measurements were conducted on a Varian True Beam SVC linear accelerator using a Farmer-type ionization chamber. $CaSO_4$:Dy (0.05 mol%) Teflon-embedded TLD discs (0.8 mm thickness, 13.3 mm diameter) with 5 mm virtual water build-up were used for validation. Detectors were positioned at maximum and representative leakage locations.

Average leakage was assessed at 12 predefined points: four along the principal axes at 1/3R and eight along axes and diagonals at 2/3R, where R (28.3 cm) corresponds to the radius of the circle enclosing the maximum 20 × 20 cm^2 field. All measurements were referenced to NTD and compared between detector systems.

Results

For 6 MV beams, average individual jaw transmission in FF mode was 0.48% (X) and 0.41% (Y), with combined transmission of 0.010%. The 6 MV FFF beam showed reduced averages of 0.19% (X) and 0.21% (Y), and combined transmission of 0.007%.

For 10 MV beams, FF mode demonstrated averages of 0.55% (X) and 0.61% (Y), with combined transmission of 0.012%. The 10 MV FFF beam exhibited lower averages of 0.24% (X) and 0.26%, and combined transmission of 0.006%.

For 15 MV FF beams, average individual jaw transmission was 1.16%, with maximum values below 2%. Combined transmission remained low at 0.012%. All measurements complied with IEC and AERB limits, and good agreement was observed between ionization chamber and TLD results.

Discussion

Transmission increased with photon energy, consistent with higher beam penetration at 15 MV. FFF beams demonstrated slightly lower transmission compared to FF beams, likely due to reduced head scatter following removal of the flattening filter. The consistently low combined jaw transmission values confirm effective attenuation by the secondary collimator system. Agreement between ionization chamber and TLD measurements supports the suitability of both detectors for leakage assessment. Although measured leakage levels were well within regulatory limits, routine verification remains important to minimize unintended exposure and long-term stochastic risk.

Conclusion

Collimator transmission and leakage radiation for FF and FFF photon beams were within IEC 60601-2-11 and AERB limits. Results provide baseline data for acceptance testing and routine QA, ensuring radiation safety and regulatory compliance.

Influence of Optical Annealing Intensity on the Sensitivity Calibration of Al2O3:C OSLDs

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Aim: This study evaluated the impact of optical annealing at 20, 000 and 100, 000 Lux on the sensitivity—defined as Luminescence Counts per unit dose (counts/cGy)–of Al2O3:C nanoDot OSLDs (Optically Stimulated Luminescence Dosimeter).

Materials and Methodology: Two sets (5 OSLDs each) of OSLDs (LANDAUER's nanoDot OSL) with manufacturer-quoted sensitivities of 0.91 and 0.92 were used in the experiments. The experimental protocol involved three distinct stages: initial measurement, second reading after one annealing cycle, and third reading after subsequent annealing. A fixed dose was delivered using a fixed number of Monitor Units using TrueBeam Linear accelerator version 3.0 (Varian Medical Systems, Palo Alto, CA, USA with 6MV Xray beams for each measurement. The corresponding luminescence signals were recorded in the high-count range (~210,000 counts). Sensitivity (S) was calculated as follows:

$$S = \frac{\text{Luminescence (Counts)}}{\text{Dose (cGy)}}$$

Results: For the 20,000 Lux group, the sensitivity evolved from an initial 496.72 counts/cGy to 498.07 counts/cGy after annealing, representing a slight increase of +0.27%. For the 100,000 Lux group, the sensitivity transitioned from 491.41 counts/cGy to 492.05 counts/cGy after annealing, demonstrating higher stability with a minimal shift of +0.13%. An initial "priming" jump in response was observed between the first and second measurements, after which the sensitivity factors stabilized.

Discussion: The measured sensitivity of approximately 492–498 counts/cGy confirms the high-gain nature of the OSLDs. The slight upward drift in sensitivity at 20,000 Lux suggests that lower-intensity light is less effective at clearing deep

electron traps, which then contributes to a higher signal in subsequent readings. The 100,000 Lux protocol provided a more stable and reproducible Counts/cGy ratio across the test cycles.

Conclusion: Both annealing intensities are clinically acceptable for resetting the OSLDs. However, 100,000 Lux annealing is recommended for precision radiotherapy dosimetry, as it minimizes sensitivity drift, ensuring a more consistent calibration factor for patient dose verification. Furthermore, the mandatory practice of priming new OSLD batches is essential to minimize residual signal interference and ensure a consistent calibration factor for accurate patient dose verification

Translating 3d Printing Into Practice: Early Clinical Use Of A Custom Brachytherapy Applicator

Dr.S. Senthilkumar Madurai Medical College & Govt. Rajaji Hospital, Madurai.

Background and Aim :

High-dose-rate (HDR) brachytherapy requires precise source positioning and artifactfree imaging to ensure optimal tumor coverage while minimizing radiation exposure to adjacent normal tissues. Conventional applicators are often costly, offer limited customization, and incorporate metallic components that may generate imaging artifacts, potentially compromising target delineation and treatment planning accuracy. Additive manufacturing provides a practical pathway toward patient-specific, cost-effective solutions. This study reports the development, technical validation, and early clinical implementation of a metalfree, locking 3D-printed applicator for HDR brachytherapy.

Materials and Methods

An in-house applicator was conceptualized using open-source computer-aided design (CAD) software and fabricated via fused deposition modeling (FDM). A medical-grade, tissueequivalent polymer (Senflap) was selected based on its biocompatibility, mechanical strength, and compatibility with standard sterilization protocols. A fully polymer-based locking mechanism was engineered to securely retain afterloading catheters without the use of metallic reinforcement. The design underwent iterative refinement based on structured multidisciplinary feedback from radiation oncologists and medical physicists to optimize ergonomics and clinical functionality. Mechanical reliability was evaluated through stress testing, catheter pull-out resistance assessment, and durability analysis following repeated sterilization cycles. Dosimetric validation was performed using Gafchromic film within a water-equivalent phantom to verify source positional accuracy. Computed tomography (CT) imaging was conducted to assess artifact presence and structural visualization. Early clinical feasibility was documented during HDR procedures, focusing on device handling, workflow integration, and adaptability to patient anatomy.

Results

The finalized applicator demonstrated robust structural stability and reliable catheter fixation, maintaining performance after multiple sterilization cycles. Catheter displacement during dosimetric evaluation remained within ±1 mm, confirming accurate source positioning. CT imaging revealed complete elimination of metallic streak artifacts, enhancing target visualization and contouring for image-guided brachytherapy (IGBT). Manufacturing costs were significantly reduced, estimated at less than 10% of comparable commercial applicators. Early clinical use indicated favorable handling characteristics, anatomical adaptability, and improved procedural workflow without device-related complications.

Conclusion The successful integration of 3D printing technology into routine HDR brachytherapy practice demonstrates the feasibility of a customizable, metal-free applicator with dependable mechanical and dosimetric performance. This innovation represents a scalable and economically viable alternative to conventional commercial systems and holds substantial potential to expand access to high-quality brachytherapy, particularly in resource-constrained healthcare settings.

Dosimetric Verification of Source Strength of Co-60 HDR Brachytherapy Using a TLD with Krieger Phantom

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Objective: Independent verification of source strength is a key quality assurance requirement in high-dose-rate (HDR) brachytherapy. The reference air kerma rate (RAKR) directly influences dose calculations based on the TG-43 formalism and must be validated at the user level according to international recommendations. This study aimed to evaluate the HDR ^{60}Co source strength using $CaSO_4$: Dy thermoluminescent dosimeters (TLDs) placed in a customized Krieger phantom and to compare the results with measurements obtained using a calibrated ionization chamber.

Material and Methods: Measurements were performed using a ^{60}Co HDR source installed in a SagiNova after loader (Eckert & Ziegler BEBIG GmbH, Germany) with an activity of 56.27 GBq. A cylindrical PMMA Krieger phantom (20 cm diameter and 12 cm height) containing four measurement positions located 8 cm radially from the source at angular positions of 0°, 90°, 180°, and 270° was used. Two independent methods were employed to determine the RAKR. In the first approach, a thimble ionization chamber was placed sequentially at each measurement position within the phantom. Corrected readings were obtained by applying standard correction factors including temperature-pressure, recombination, polarization, and calibration factors according to established dosimetry protocols. In the second approach, $CaSO_4$: Dy TLD chips were positioned using a specially designed insert plug that ensured reproducible source-detector geometry. Measurements were performed at the same radial distance and angular positions. Each measurement was repeated three times to improve reproducibility. TLD readings were corrected for linearity, fading, angular response, and beam quality factors. The TLD calibration coefficient was obtained by irradiating reference dosimeters with a ^{60}Co external beam delivering 1 Gy at 80 cm SSD and 5 cm depth.

Results and Discussion: The $CaSO_4$: Dy TLD chips installed in the Krieger phantom provided reliable and clinically acceptable estimates of HDR ^{60}Co source strength. The phantom geometry allowed four measurements to be performed at equal radial distances under identical geometrical conditions, ensuring consistency in scatter conditions. The measured RAKR values obtained using both methods were in close agreement with the manufacturer-specified calibration values. The deviation from the manufacturer's value was less than 5% for both techniques. The mean percentage differences were 3.33% for the TLD measurements and 3.81% for the ionization chamber measurements. The results demonstrate that $CaSO_4$: Dy TLDs can provide accurate measurements of HDR ^{60}Co source strength when used with a Krieger phantom. The customized insert design ensured precise positioning of the TLDs and maintained consistent geometry during measurements. The observed deviations were within the tolerance limits recommended by international dosimetry guidelines and were also consistent with previously reported studies.

Conclusion: The design provided a stable source–detector geometry, minimized positional uncertainties, and eliminated the need for in air calibration. The demonstrated accuracy and reproducibility support its broader applicability, particularly for institutions performing independent source verification and remote TLD audit programs The combination of CaSO4: Dy TLD chips with the dedicated phantom insert provides an effective, efficient tool for routine verification and TLD-based audit applications. Therefore, this technique can serve as an economical and clinically acceptable alternative for routine source strength verification and quality assurance in HDR brachytherapy.

BEST POSTER PRESENTATION

DAY 1: 20th March 2026 (FRIDAY)		
Afternoon Session	**Best Poster Presentation** **Chairpersons: Dr. L M Aggarwal, Dr. Sonal Varshney, Dr. Sumanta Manna, Dr. Hemlatha A, Dr Shasank Shukla**	
(P-1)	A Dosimetric and Complexity Comparison of IMRT versus VMAT in Left-Sided Breast or Chest Wall Radiotherapy	Gunjan Sharma
(P-2)	AI-based Predictive Quality Assurance Model for Longitudinal Output Monitoring of a Fixed Digital Radiography System	Siddharth Dhondiyal
(P-3)	Radiobiological Analysis of Tumor Control Probability and Normal Tissue Complication Probability in IMRT and VMAT for Head and Neck Cancer	Pratibha Singh
(P-4)	Dosimetric Comparison of Field-in-Field 3DCRT, Pure VMAT and Hybrid VMAT in Left-sided Breast cancer Radiotherapy	Priyanshu Kumawat
(P-5)	Geometric and Dosimetric Enhancement of Hippocampus-Avoidance Whole Brain Radiotherapy Using an Incremental Multi-Arc VMAT Technique on Halcyon.	Abhay kumar singh
(P-6)	Assessing the Performance of the microDiamond and Semiflex 3D Detectors for Small Field Dosimetry in 1.5 T Magnetic Field on the Elekta Unity MR-Linac	Sanjana Choudhary
(P-7)	TRS 398 Rev.1 (2024): Key protocol changes and clinical implications	Chanchal
(P-8)	A Comparative Evaluation of Generalized Equivalent Uniform Dose-Based Objectives and Dose-Volume-Based Objectives on Organs at Risks for Head and Neck Cancer	Rakhi Barman
(P-9)	Pre-Treatment Prediction of Brain OAR Dose Constraint Feasibility in Cerebral Arteriovenous Malformations (AVMs) Using Logistic Regression.	Pooja Dhaundiyal
(P-10)	Dosimetric Impact of Coplanar versus Non-Coplanar VMAT on Hippocampal Sparing in Whole Brain Radiotherapy	Dipesh
(P-11)	Stereotactic Radiosurgery with CyberKnife S7: Advancing Precision without Incisions	Anil Singh Dabola
(P-12)	Effective and precise planning with brachytherapy applicators using library-based and manual catheter reconstruction methods: a preliminary study	Arghyajit Paul
(P-13)	Analysis of Breakdown Issues of the Bhabhatron-II TAW Over Three Years and Preventive Actions Implemented.	Dr. Pawan Kumar Singh

DAY 2: 21st March 2026 (SATURDAY)		
Morning Session	**Best Poster Presentation** **Chairpersons: Dr. L Nithya, Dr. Anil Rajani, Dr. Pawan Jangid, Dr. Jeev Raj Bhati, Dr. Lalit Mohan Singh**	
(P-14)	Evaluation of Effective Radiation Dose from CT Examinations with Respect to Reference Dose Levels (from U.S. standards)	Bagishma BS
(P-15)	First Clinical Experience in Total Skin Electron Irradiation: Power of Knowledge Sharing	Sathiyaraj Palanivel
(P-16)	Preliminary Evaluation of Setup Errors using Offline Review- A Positional Observation Study of Pelvic Cases	Ms. Ilhana Mariyam
(P-17)	Comprehensive evaluation of static and dynamic MLC performance and delivery synchronization for RapidArc VMAT	KISHAN
(P-18)	Beyond Conventional Planning: Assessing the Role of Hybrid Techniques in Left-Sided Breast Radiotherapy	KATHAMBARI V
(P-19)	A Comparative In Vivo Study of Contralateral Breast Dose During 3D-CRT, IMRT, and VMAT Using Thermo-luminescent Dosimetry	Nandhakumar G
(P-20)	Dosimetric Evaluation of TLD-100 Chips and Rods for Flattened and Flattening-Filter-Free Photon Beams	Nainsy Singhal
(P-21)	Estimation of institutional PTV margin for radio therapy of pelvic cancer using electronic portal imaging device	Rajendra Tripathi
(P-22)	Determining End-of-Life of Radiation Generating Equipment Using Bathtub Curve–Based Reliability Analysis: An Institutional Study	Mohini Gupta
(P-23)	Comparison of Dosimetric Leaf Gap measured Using Various Detectors for IMRT and VMAT Applications	Sushil K Shukla
(P-24)	Automated Quantitative Evaluation of CT Image Quality Parameters Using Catphan 504 Phantom: A Comparative Analysis of Pylinac and radiochromic.com Software	Kavyasri S
(P-25)	Automated Classification of Metaphase Images for Dicentric Chromosome Analysis Using Deep Learning	Dharuman V

A Dosimetric and Complexity Comparison of IMRT versus VMAT in Left-Sided Breast or Chest Wall Radiotherapy

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Objective: To perform a dosimetric and complexity comparison between Intensity Modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) in left-sided postmastectomy radiotherapy (PMRT).

Materials and Methods: Fifteen patients with left-sided breast carcinoma undergoing PMRT were retrospectively planned with both IMRT and VMAT techniques using 6 MV photons in Eclipse TPS (v16.1). A prescription dose of 42.5 Gy in 16 fractions was delivered to the PTV. IMRT plans employed seven coplanar fields, while VMAT plans used two partial arcs. Dose–volume histogram parameters were analyzed for PTV coverage, conformity, monitor units (MU), and doses to organs at risk (OARs) including ipsilateral lung, contralateral lung, heart, contralateral breast, and spinal cord.

Results: PTV coverage (V95%) was comparable between VMAT (94.94%) and IMRT (94.95%). VMAT demonstrated significantly lower ipsilateral lung doses, with reduced V5 (77.12% vs 91.75%), V10 (47.75% vs 60.85%), V20 (24.37% vs 28.86%), and mean lung dose (12.92 Gy vs 16.56 Gy). Mean heart dose was lower with VMAT (6.69 Gy) compared to IMRT (8.50 Gy), along with reduced heart V20 (4.80% vs 8.28%). However, VMAT showed slightly higher low-dose exposure to the contralateral lung and contralateral breast. Spinal cord maximum doses were comparable between techniques. VMAT also required substantially fewer monitor units than IMRT.

Conclusion: VMAT provides superior ipsilateral lung and cardiac sparing without compromising target coverage, although IMRT offers marginally better contralateral organ sparing. Individualized technique selection may optimize therapeutic ratio in left-sided PMRT.

AI-based Predictive Quality Assurance Model for Longitudinal Output Monitoring of a Fixed Digital Radiography System

Siddharth Dhondiyal[1] , Raj Kishor Bisht[1] , Sneha Theres OJ[1] , Deepika S[1] , Sahil R[1] , Thamarai Selvi P[1] , Ram Karan Verma[1] , Sushma Rani Mandal[1] , Avinav Bharti[1] , Pratik Kumar[1]

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Aim: The quality assurance (QA) program in diagnostic radiology validates the performance of radiological equipment; however, it does not predict the machine's behaviour during the validity period. The study aims to develop an AI-based predictive model to detect longitudinal drift in the machine output, identify abnormal behaviour to adapt predictive maintenance over routine QA. Material and Methods: The radiation output of two fixed digital radiography machines was monitored for a period of two years at intervals of 49 days each. The data was collected for the exposure parameter settings of (a) 60 kVp -100 mAs and (b) 100 kVp - 50 mAs. Linear regression modelling was applied to evaluate output drift after the data were computationally cleaned from a dataset to fix the inconsistency. The slope of the regression line was used to quantify the drift rate. The coefficient of determination (R^2) was calculated to assess trend strength. The system was trained using the data obtained during one year, and the trend of machine output was predicted using the regression equation. In addition to the output drift, the residual analysis was also performed for an early detection of anomalies, if present. The output consistency was evaluated against ±10% tolerance. The deviations > ±2 from the predicted values were labelled as abnormal. Results: For 60kVp -100mAs, a weak positive drift trend was observed with a low R^2 value, however, for the exposure parameters 100 kVp - 50 mAs, it was a moderate positive drift trend with a higher R^2 value. A weaker positive drift indicates minor longitudinal variation, and the higher positive drift trend is suggestive of major structured variation post QA programme. It was also observed that the output predicted for both exposure sets was within ±10% tolerance, comparing the proposed and measured values. No persistent instability was observed in anomaly detection on computing deviations. The study demonstrates that basic machine learning techniques or linear regression can successfully transform routine QA data into a predictive monitoring tool. Drift modelling indeed allows early detection of gradual output change, which helps in estimating the machine performance.

Conclusion
An AI-based proposed longitudinal QA model effectively quantified drift and predicted trend of machine output. Result of the study demonstrates the feasibility of integrating predictive analytics into routine diagnostic radiology QA programs to improve equipment reliability and support preventive maintenance strategies.

Radiobiological Analysis of Tumour Control Probability and Normal Tissue Complication Probability in IMRT and VMAT for Head and Neck Cancer

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Aim
To compare the radiobiological and dosimetric outcomes of Intensity-Modulated Radiation Therapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) in head and neck cancer radiotherapy by estimating Tumour Control Probability (TCP) and Normal Tissue Complication Probability (NTCP), with analysis of which technique may offer a more favourable therapeutic ratio.

Materials and Methods
This retrospective study includes treatment plans from head and neck cancer patients previously treated with either IMRT or VMAT. Dosimetric parameters such as planning target volume (PTV) coverage and doses to key organs at risk (OARs) including parotid glands, spinal cord, and brainstem were extracted from dose–volume histograms (DVHs). Radiobiological modelling was performed to estimate TCP and NTCP for target volumes and OARs. Comparative analysis between IMRT and VMAT plans was conducted with appropriate statistical methods.

Results
Preliminary radiobiological analysis of treatment plans indicates emerging trends in Tumour Control Probability (TCP) and Normal Tissue Complication Probability (NTCP) between IMRT and VMAT plans. Based on early model calculations, VMAT demonstrates equivalent or slightly higher TCP estimates compared to IMRT, consistent with findings from radiobiological comparisons in similar planning studies that report slightly higher TCP for VMAT due to improved dose conformity and target coverage characteristics. However, the analysis of the full patient cohort is still underway.

Conclusion
Early findings support the hypothesis that VMAT may provide comparable or modestly enhanced radiobiological outcomes compared with IMRT in head and neck radiotherapy by maintaining tumour dose coverage while reducing normal tissue dose exposure. Final conclusions regarding TCP and NTCP differences will be established after completion of ongoing retrospective data processing. This study aims to enrich existing dosimetric comparisons with radiobiological insights relevant to clinical technique selection.

Dosimetric Comparison of Field-in-Field 3DCRT, Pure VMAT and Hybrid VMAT in Left-sided Breast cancer Radiotherapy

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Objectives:
To Compare the dosimetric parameters of Field-in-Field 3DCRT, Pure VMAT and Hybrid VMAT in Left-sided Breast cancer Radiotherapy and to determine the optimal beam weight ratio in Hybrid planning

Material and Methods:
This retrospective study includes 25 left sided breast cancer patients treated on TRUEBEAM Linear Accelerator (Varian Medical Systems, Palo Alto, CA). All the patients underwent CT simulation on a breast board. In the studied cohort, the average Chest Wall Separation was 28 cm, the Central Lung Distance was 3.8 cm, and the Maximum Heart Distance was 3.2 cm.

For each patient, three separate treatment plans i.e. FiF-3DCRT (using AAA Algorithm), pure VMAT, and Hybrid VMAT (using AcurosXB algorithm with dose grid size 2.5mm) were generated for dosimetric comparison using the Eclipse Treatment Planning System (Version 16.01.10, Varian Medical System). Hybrid VMAT plans were generated using three fixed beam weight ratios of FiF-3DCRT to VMAT (9:6, 10:5 and 11:4), corresponding to relative dose contributions of 60%:40%, 67%:33%, and 73%:27%, respectively. All plans were optimized to deliver a prescribed dose of 40Gy in 15 fractions (2.67Gy per fraction) to the planning target volume (PTV), while ensuring adequate target coverage and minimizing dose to Organ-At-Risk (OARs).

Statistical analysis was performed using one-way Analysis of Variance (ANOVA) to evaluate dosimetric differences among the three techniques. Post-hoc comparisons were conducted using Tukey's Honestly Significant Difference (HSD) test with the IBM SPSS statistical software package.

All the plans were analysed for PTV coverage as well as OARs constraints. The parameters selected for analysis are: $D_{95\%}$, $D_{98\%}$, $D_{50\%}$, $D_{2\%}$, $V_{107\%}$, $V_{105\%}$, Homogeneity Index (HI), Conformity Index (CI) for the PTV & total treatment time i.e. MU.

Similarly, parameters used for following OARs are: Heart (D_{mean}, V_{17Gy}, V_{35Gy}), Ipsilateral lung (V_{17Gy}, V_{20Gy}, D_{mean}), Contralateral Lung (V_{5Gy}, D_{mean}), Contralateral Breast (D_{mean}).

Results:
Compared to FiF-3DCRT, VMAT demonstrated improved target conformity and enhanced sparing ($p<0.05$). However, VMAT was associated with an increased low-dose bath to contralateral OARs ($p<0.05$). To address this limitation, three hybrid beam weight ratios (9:6,10:5 and 11:5) were evaluated. All hybrid configurations achieved adequate target coverage (D95% > 95% and D98% > 92%) with CI values approaching ranging from (0.94–0.96), and HI of 0.13–0.14 showing no statistically significant differences among the hybrid ratios ($p > 0.05$). Additionally, all hybrid plans demonstrated significantly reduced low-dose spillage compared to VMAT ($p < 0.05$).

Overall, the 9:6 hybrid ratio provided optimal cardiac sparing without compromising target coverage, whereas the 11:4 ratio minimized the low-dose bath to contralateral structures. The 10:5 ratio demonstrated a balanced intermediate dosimetric profile.

.**Conclusion:**

VMAT provided superior cardiac and ipsilateral lung sparing with improved target coverage, but at the cost of increased low-dose exposure to contralateral organs. The Hybrid technique demonstrated a balanced dosimetric profile, reducing heart dose significantly compared to 3DCRT while limiting low-dose bath compared to VMAT.

The Hybrid VMAT plan with a 9:6 beam weight ratio achieved optimum cardiac sparing with comparable target coverage and reduced low-dose exposure, demonstrating a clinically balanced alternative to FiF-3DCRT and pure VMAT.

Geometric and Dosimetric Enhancement of Hippocampus-Avoidance Whole Brain Radiotherapy Using an Incremental Multi-Arc VMAT Technique on Halcyon.

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Aim:Hippocampus-avoidance whole brain radiotherapy (HA-WBRT) aims to reduce radiation-induced neurocognitive impairment by reducing the dosage to hippocampus neural stem-cell regions while preserving adequate whole-brain target coverage. The Halcyon platform features a dual-layer multileaf collimator (MLC) with an effective leaf width of 1 cm and resolution of 0.5cm at isocentre, which may limit fine spatial modulation around small avoidance structures. The goal of this study is to ascertain whether incremental multi-arc VMAT geometry may get over this hardware restriction without sacrificing target coverage or delivery efficiency.

Materials and Methods:35 consecutive cranial CT datasets were retrospectively replanned to a prescribed dose of 30 Gy in 10 fractions.All contoured of targets and organs at risk (OARs), including bilateral hippocampus and hippocampus avoidance regions were contoured in accordance with RTOG 0933 criteria by radiation oncologist. Three-field, four-field, five-field, and six-field VMAT plans were generated. In order to improve efficient fluence modulation, semi-arcs (90°–270°) used orthogonal collimation (90°/270°), whereas full arcs (181°–179°, CW/CCW) used complimentary collimator angles (15°/345°). Maximum doses to the brainstem, optic chiasm, spinal cord, and lenses were recorded. Target coverage and plan quality were evaluated using cumulative DVH-derived metrics, including PTV $D_{2\%}$, $D_{50\%}$, $D_{95\%}$, $D_{98\%}$, conformity index (CI), gradient index (GI), hippocampus D_{mean}, D_{max} & D_{min} .One-way ANOVA was used to compare the total monitor units (MU).

Results:The integral PTV dose was kept within ±1% of 30 Gy (30.4–30.7 Gy), and prescription integrity was maintained across all geometries. Regions with high doses stayed constant ($D_{2\%}$: 107.5–109.0%). With arc augmentation, near-minimum target coverage improved; $D_{98\%}$ rose from 89.4% in the 3-field plan to 92.6% in the 6-field design, while HI improved from 0.18 to 0.15. The 6-field plan showed better within-target homogeneity and $D_{95\%}$ coverage (96.2%), whereas the 5-field arrangement produced the sharpest peripheral GI = 1.36 and the highest CI = 0.85. Bilateral hippocampal Dmean stayed between 13–14 Gy, while the hippocampus minimum dose varied from 9.88–11.22 Gy, with slight decreases seen in multi-arc geometries. Every increased OAR dosage stayed within the recognized tolerance ranges. With arc complexity, mean MU rose dramatically from 720 ± 85 to 889 ± 95; ANOVA $p < 0.001$.

Discussion:Incremental multi-arc augmentation improved near-minimum PTV coverage and intratarget dose uniformity, partially compensating for the spatial resolution constraints imposed by the 1-cm MLC. However, these dosimetric gains were associated with significantly increased modulation complexity, reflected by higher MU and potential prolongation of treatment delivery.

Conclusion:Incremental multi-arc VMAT geometry enhances PTV homogeneity and modestly improves hippocampal sparing on the Halcyon platform. The 6-field configuration achieved superior uniformity, while the 5-field plan demonstrated an optimal balance between conformity and efficiency. Optimized arc strategies may mitigate hardware-related modulation limitations while preserving clinical feasibility.

Keywords: HA-WBRT, IM-VMAT, DL-MLC, PTV Coverage, and OAR Sparing.

Assessing the Performance of the microDiamond and Semiflex 3D Detectors for Small Field Dosimetry in 1.5 T Magnetic Field on the Elekta Unity MR-Linac

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Aim: The study aims to assess the performance of PTW microDiamond and Semiflex 3D detector for small field dosimetry in 1.5T magnetic field on the Elekta Unity MR-Linac.

Material and methods: Dosimetric characteristics—including warm-up stability, linearity, percentage depth dose (PDD), beam profiles, and output factors—were evaluated for the PTW microDiamond and Semiflex 3D ionization chamber using an Elekta Unity MR-Linac (7 MV FFF and SSD 143.5cm).

Measurements were performed in a PTW BeamScan MR water phantom and the microDiamond was oriented "face-on" (perpendicular to the magnetic field, parallel to the beam), while the Semiflex 3D was positioned "edge-on" (parallel to the magnetic field, perpendicular to the beam). Dose linearity (5–2000 MU) was assessed for field sizes from 1×1 to 10×10 cm2. PDDs, profiles, and output factors were recorded at 10 cm depth (133.5 cm SSD) for the same field size range, with the microDiamond performance compared against the Semiflex 3D.

Results: Both detectors demonstrated warm-up stability within 0.3% for repeated 500 MU deliveries. Linearity measurements showed maximum variations of 1.8% for the microDiamond and 1.0% for the Semiflex 3D, both occurring at 1×1 cm^2 for 5 MU. Percentage Depth Doses (PDDs) showed good agreement across all field sizes (1×1 to 10×10 cm2), with mean d_{max} values of 1.28±0.1 cm (microDiamond) and 1.27±0.1 cm (Semiflex 3D).

The microDiamond recorded narrower penumbras, while the Semiflex 3D overestimated penumbra width by an average of 1.8±0.6 mm (inline). Both detectors captured central axis deviation and crossline asymmetry, consistent with the expected influence of the static magnetic field on electron trajectories.

The Semiflex 3D was observed to underestimate the output factors in small fields, whereas the microDiamond-measured output factors demonstrated slight overresponse in the smaller fields when compared with the Monte-Carlo calculated factors provided by Elekta (maximum variation up to 0.5%).

Discussion: Contrary to conventional linacs, the typical reduction of d_{max} in small fields was absent; instead, d_{max} systematically increased with field size. This suggests the MR-Linac cryostat significantly attenuates head scatter and reduces secondary electron contamination.

The microDiamond detector yielded a narrower penumbra in lateral profiles compared to the Semiflex 3D, a direct consequence of its 0.004 mm^3 sensitive volume minimizing the volume averaging effect.

Both detectors recorded a perceptible shift of the dose maximum from the central axis in crossline profiles, induced by the Lorentz force acting on secondary electrons. This effect exhibited enhanced magnitude as field sizes decreased.

The Semiflex 3D underestimates Output factors due to volume averaging across the sharp small-field gradients. Conversely, the microDiamond exhibits a minor overresponse (≤0.5% variation) due to the density perturbation effect.

Conclusion: This study confirms that while both detectors are stable for MR-Linac dosimetry, the microDiamond is superior for small-field characterization due to its minimal volume averaging and superior penumbral resolution. The superior performance and minimal deviation of the microDiamond validate its necessity for accurate small-field dosimetry on the Elekta Unity. Extending this work to include non-standard geometries and high-gradient regions will facilitate characterization of the detector response during complex, intensity-modulated deliveries.

TRS 398 Rev.1 (2024): Key protocol changes and clinical implications

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Objective

The IAEA Technical Reports Series no. 398 (TRS 398), published in 2000, established the international gold standard for reference dosimetry in absorbed dose to water for external beam radiotherapy across all modalities. After two decades of clinical implementation, culminated the necessity of a revised edition in 2024. This revision incorporates advancements in ionization chamber technology, updated fundamental dosimetric data from ICRU Report 90 (2016), improved stopping power data, and new protocols for emerging radiotherapy modalities including flattening-filter-free (FFF) beams, proton therapy, and light ion therapy. This study aims to review the key differences between both.

Methodology

A comparative study was done using official IAEA documentation and expert summaries. Changes in photon, electron, FFF (flattening filter free), and proton beam protocols were reviewed. Focus areas such as beam quality specifiers, correction factors, reference conditions and detector compatibility were included.

Results

The key differences as found were:

The water mean excitation energy value increased from 75 eV to 78 eV and it directly affects stopping power ratios for both photons and charged particles, resulting in subtle but systematic changes to Kq values and absorbed dose calculations.

For photon beams: Addition of new ionization chambers, obsolete ones were removed. Kq factors were updated incorporating ICRU-90 stopping powers. Beam quality metric i.e. TPR 20/10 were refined with field-size adjustments for FFF beams.

Introduction of volume averaging correction factor for FFF beams, addressing the distinct spatial dose distribution characteristics absent in conventional flattened beams.

For electron beams: Clear cross-calibration guidance and updated Kq values for thimble and plane parallel chambers. Scope limited to R50 ≤ 10 g/cm^2 i.e. max 25 MeV as prior to 50 MeV. Use of plastic phantoms were prohibited.

For proton beams: Greater emphasis on pencil beam scanning (PBS). ICRU 90 based Kq values were recalculated and found within 2% of original. Adjusted reference depths in plateau and new guidance on polarity/recombination effects.

Discussion

These revisions aims to enhance precision while simplifying protocols for emerging technologies. Clinics have to recalibrate FFF and high energy electron beams, potentially reducing uncertainties. No major shifts in absorbed dose to water formalism.

Conclusion

Adopting TRS 398 rev.1 ensures compliance with current standards, minimizing errors in QA and patient dosimetry. Training and transition strategies for Medical Physicists to implement the revised report has to be put in place.

A Comparative Evaluation of Generalized Equivalent Uniform Dose-Based Objectives and Dose-Volume -Based Objectives on Organs at Risks for Head and Neck Cancer

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Aims/Objectives: Radiotherapy in cancer treatment uses high energy radiation to kill cancer cells. The goal of radiation therapy is to kill tumour cells, that is, to maximise tumour control probability (TCP), and to minimize normal tissue complication probability (NTCP). Modern day radiotherapy treatment techniques use computerised treatment plans to obtain a clinically acceptable plan with maximum TCP and minimum NTCP, using inverse treatment planning optimization. Most commercially available treatment planning systems (TPS) has dose-volume (DV) based and generalized equivalent uniform dose (gEUD) based optimization techniques to handle the complexity of inverse planning in Intensity Modulated Radiotherapy (IMRT) and Volumetric Modulated Arc Therapy (VMAT) treatment plans. In particular, gEUD provides a single metric for reporting non-uniform dose distribution, using it as a single organ specific parameter to account for the biological response according to the delivered dose distribution in that organ. The purpose of this study is to evaluate the potential advantage of gEUD-based optimization in VMAT planning by comparing various dosimetric parameters against traditional DV-based optimization plans, aiming to assess improvements in dose distribution.

Materials and Methods:

A cohort of 10 head and neck cancer patients were selected retrospectively using standard dose fractionation protocol of 70Gy and 56Gy in 35# to the primary tumour volume and the nodal volume respectively. All the plans were carried out using 6MV-photon beam commissioned for Varian TrueBeam V3.0. 10 physically-based (DV-based) VMAT (pVMAT) plans and 10 biologically-based (gEUD-based) VMAT (bVMAT) plans were acquired for each of the cases in Eclipse TPS V18.0.1 using AAA algorithm. The biological objective cost functions in bVMAT plans were used for organs at risk (OARs), while physical dose objectives were used for the target volumes.

The dosimetric parameters evaluated for the targets were Homogeneity Index (HI) and Conformity Index (CI), while maximum dose (Dmax) and mean dose (Dmean) were evaluated for OARs - spinal cord and parotid glands, respectively.

Results: There was no significant difference in the target coverage between the pVMAT and bVMAT plans. However, a significant statistical difference was observed in the maximum dose for spinal cord between the two plans ($p = 2.69933E-05$). Furthermore, the mean dose to the parotid glands differed significantly between the two plans ($p = 0.0091$).

Discussion: In all the 10 cases it was possible to achieve better dose constraints for spinal cord and parotid glands using gEUD based-optimization. gEUD allows for the evaluation of OARs

by summarizing a 2D dose-volume histogram into a single metric that accounts for the specific biological response characteristics of each structure.

Conclusion: Biological based optimization offers substantial advantage over the traditional DV- based optimization in case of OARs. gEUD is a competing alternative that needs to be considered and that it may prove useful as a result of investigations

Pre-Treatment Prediction of Brain OAR Dose Constraint Feasibility in Cerebral Arteriovenous Malformations (AVMs) Using Logistic Regression.

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Title: Pre-Treatment Prediction of Brain OAR Dose Constraint Feasibility in Cerebral Arteriovenous Malformations (AVMs) Using Logistic Regression.

Objective: This study aims to develop and validate a machine learning-based logistic regression model for predicting the achievability of clinician-prescribed brain V_{12Gy}(cc) constraints in cerebral AVM SRS planning based on AVM volume and evaluate its reliability using statistical metrics.

Materials and Methods: A retrospective cohort of 100 patients with cerebral AVM treated using stereotactic radiosurgery was analysed. Treatment plans were generated at a 60% prescription isodose line covering 95% of the target volume using the VOLO optimizer in the Precision Treatment Planning System (Accuray). AVM volume (cc) was used as the input feature. A binary outcome variable was created for each plan by comparing the clinically obtained V_{12Gy}(cc) constraint with the physician-prescribed patient-specific V_{12Gy}(cc) constraint ("Yes or No"). V_{12Gy}(cc) was selected as the primary normal brain dose metric due to its established association with radiation-induced toxicity following single-fraction stereotactic radiosurgery. A logistic regression model was developed using Scikit-learn. The dataset was divided into training (80%) and testing (20%) subsets, with feature standardization applied using training data only. Model performance was evaluated using a confusion matrix and classification metrics including sensitivity, specificity, precision, F1 score, and accuracy. External validation was performed using an independent dataset to assess pre-treatment predictive reliability.

Results and Discussion: On the test dataset, the model demonstrated excellent sensitivity, ensuring reliable identification of achievable cases, with comparatively lower specificity. External validation was performed on an independent dataset, where the model achieved an accuracy of 80%, sensitivity of 0.83, precision of 0.83, and specificity of 0.75, correctly identifying the majority of clinically achievable cases. These findings indicate good

generalizability of the model and consistent performance in identifying clinically achievable dose constraints. The high sensitivity suggests the model is particularly effective in minimizing false-negative predictions, which is critical in pre-treatment decision-making. The observed performance supports the feasibility of using AVM volume as a predictive feature for assessing dose constraint achievability prior to planning.

Conclusion: The Logistic regression model demonstrated strong potential for pre-treatment prediction of dose constraint achievability in cerebral AVM stereotactic radiosurgery planning, maintaining ≥80% accuracy and high sensitivity on external validation. Early estimation of constraint feasibility enables planners to determine, prior to the optimization, whether the prescribed dose objectives are likely to be achievable, thereby enabling faster planning and reduced replanning or prescription modifications. The 60% prescription isodose line offered an optimal balance between target coverage and normal brain sparing, consistent with established radio surgical practice. Despite limitations including a modest dataset size and reliance on a single input feature, the model highlights the feasibility of integrating a machine learning–based predictive tool into routine planning workflows to enhance efficiency, improve planning consistency, and support patient-specific planning strategies.

Dosimetric Impact of Coplanar versus Non-Coplanar VMAT on Hippocampal Sparing in Whole Brain Radiotherapy

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Aims/Objectives: Hippocampal avoidance whole brain radiotherapy (HA-WBRT) aims to reduce radiation-induced neurocognitive decline, guided by RTOG 0933 dose constraints. Beam geometry influences dose distribution around small avoidance structures like the hippocampi. This study compares dosimetric differences between coplanar and non-coplanar VMAT techniques in HA-WBRT, focusing on hippocampal sparing, target coverage, conformity, homogeneity, and delivery efficiency.

Materials and Methods: Ten previously treated WBRT datasets were retrospectively replanned for HA-WBRT with a prescription dose of 30 Gy in 10 fractions. Plans were generated on a Varian TrueBeam linear accelerator with a 2.5 mm high definition multileaf collimator (MLC). Two strategies were developed for each patient: coplanar dual arc VMAT and non-coplanar multi-arc VMAT with a 90° couch rotation. Plans were optimized according to RTOG 0933 criteria: PTV D95% ≥ 95%, hippocampus D100% ≤ 9 Gy, and Dmax ≤ 16 Gy. Dosimetric parameters (hippocampus Dmean, Dmax, D100%; PTV D2% and D95%; conformity index (CI); homogeneity index (HI); monitor units (MU)) were compared using paired t-tests ($p < 0.05$). Quality assurance was performed using ArcCHECK with 3%/2 mm gamma analysis.

Results: Both techniques provided adequate target coverage (PTV D95%: coplanar 29.1 ± 0.3 Gy, non-coplanar 29.3 ± 0.2 Gy, $p = 0.12$). All plans met RTOG 0933 hippocampal dose constraints. Non-coplanar VMAT significantly improved hippocampal sparing. Hippocampal Dmean decreased from 10.8 ± 0.9 Gy (coplanar) to 9.2 ± 0.8 Gy (non-coplanar, ≈15% reduction, $p = 0.01$), Dmax from 15.6 ± 1.2 Gy to 13.9 ± 1.0 Gy ($p = 0.02$), and D100% from 8.4 ± 0.7 Gy to 7.1 ± 0.6 Gy ($p = 0.01$). Non-coplanar plans demonstrated better conformity (CI: 0.86 ± 0.03 vs. 0.82 ± 0.04, $p = 0.03$) with similar homogeneity (HI: 0.12 ± 0.02 vs. 0.13 ± 0.02, $p = 0.28$). Monitor units were higher for non-coplanar plans (742 ± 65 MU vs 681 ± 58 MU, $p = 0.04$). All plans passed QA with gamma passing rates >97% at 3%/2 mm.

Discussion: Non-coplanar VMAT improved hippocampal sparing due to better angular beam separation and reduced entrance dose overlap. The 15% reduction in hippocampal Dmean and decreased Dmax are clinically meaningful given the correlation between hippocampal

dose and neurocognitive outcomes. Although non-coplanar planning increased monitor units and delivery complexity, target coverage and homogeneity were maintained. The dosimetric benefits must be balanced with treatment time, collision risk, and setup reproducibility.

Conclusion: Non-coplanar VMAT provides superior hippocampal sparing and improved conformity compared to coplanar VMAT, while maintaining RTOG 0933 compliance. Despite increased delivery complexity, its dosimetric advantages support its use in HA-WBRT cases where maximal hippocampal preservation is essential.

Stereotactic Radiosurgery with CyberKnife S7: Advancing Precision without Incisions

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Keywords:-SRS, CyberKnifeS7, Robotic Radiosurgery, IGRT, Motion Tracking, Precision Radiotherapy, Frameless SRS, RTT, QA.

Background: - Stereotactic Radiosurgery (SRS) is a high-precision radiation modality that delivers ablative doses to well-defined targets while minimizing exposure to surrounding normal tissues. Technological advances in image guidance and robotics have significantly improved treatment accuracy and safety. The Cyberknife S7system represents a next-generation robotic platform designed to enhance real-time tracking, workflow efficiency, and patient comfort in frameless SRS.

Introduction:-Stereotactic Radiosurgery (SRS) is a well-established high-precision radiation technique that delivers ablative doses to accurately defined targets while sparing surrounding normal tissues. Among modern SRS platforms, the Cyberknife S7 system has gained recognition for its robotic precision and frameless treatment capability. The latest generation, CyberKnife S7, incorporates advanced image guidance, real-time motion tracking, and automated delivery, enhancing both accuracy and clinical efficiency.

Clinical practice: - the CyberKnife S7 is used through a structured workflow involving patient immobilization, high-resolution CT/MRI imaging, target delineation, inverse treatment planning, and real-time image-guided dose delivery. The robotic arm enables non-isocentric and non-coplanar beam arrangements, allowing steep dose gradients and improved organ-at-risk (OAR) sparing. This makes the system suitable for intracranial and extracranial indications such as brain metastases, spine tumors, lung lesions, Prostate and selected breast cases.

Radiation Therapists Role:-Radiation Therapist play a vital role in patients set up, image verification, motion monitoring, and quality assurance, ensuring treatment precision and reproducibility. Their involvement directly contributes to treatment safety and effectiveness.

Conclusion: - CyberKnife S7-based SRS exemplifies “precision without incisions” by combining robotics, imaging, and intelligent planning. Its non- invasive nature, sub-millimeter accuracy, and patient-friendly approach make it a valuable modality in modern radiation oncology. Continued clinical experience and protocol optimization will further strengthen its role in precision cancer treatment.

Effective and precise planning with brachytherapy applicators using library-based and manual catheter reconstruction methods: a preliminary study

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Objective

This preliminary study aims to systematically evaluate both the accuracy and clinical feasibility of brachytherapy applicator reconstruction when using predefined, library-based techniques, as compared with conventional manual catheter reconstruction.

The objective is to analyze and compare dosimetric outcomes, consistency of applicator reconstruction, time efficiency and overall planning efficiency between the two methods.

Materials and Methods

This retrospective analysis included 17 patients who received intracavitary brachytherapy delivered with a Flexitron Co-60 afterloading unit, using Fletcher CT/MR applicators in 10 patients and Geneva applicators in 7 patients. All patients underwent CT-based simulation for treatment planning with the Oncentra brachytherapy Treatment Planning System (TPS Version 4.7), which incorporates an applicator library. Dose Calculation were performed using TG-43 dose calculation Algorithm.

For each patient, two treatment plans were created: one using manual catheter reconstruction and the other using the library-based reconstruction method. Dosimetric variables, including Point A dose, dose to 90% of the High-Risk Clinical Target Volume (HR-CTV D90%), and the dose to 2 cc (D2cc) of the bladder, rectum, and sigmoid, as well as ICRU point-B, Posterior-Inferior Border of Symphysis (PIBS) point, and vaginal point doses, were collected and compared. Statistical evaluation included the Shapiro–Wilk test to assess normality, paired t-tests to compare mean values, and Bland–Altman analysis to evaluate agreement between techniques.

Results

The dosimetric parameters for the manual and library-based reconstruction methods are summarized in Table 1.

Dosimetric Parameters Values (Mean ± SD)	Fletcher CT/MR Applicator	Geneva Applicator
Point A	1.073 ± 0.609%	1.662 ± 1.694%
D90 HRCTV	1.137 ± 0.671%.	1.258 ± 0.967%.
Bladder 2cc	1.288 ± 1.262%	1.933 ± 0.915%
Rectum 2cc	2.001 ± 1.292%	3.019 ± 1.151%
Sigmoid 2cc	1.703 ± 1.244%	1.011 ± 0.666%
Point-B	1.982 ± 1.185%	1.104 ± 0.430%
PIBS	2.148 ± 0.881%	1.856 ± 0.848%
Vaginal Point	2.022 ± 0.704%	2.266 ± 1.426 %.

Table 1: The mean dosimetric parameter difference between the manual and library-based reconstruction plans of two different applicator types.

Using the manual reconstruction method, the average reconstruction times for the Fletcher CT/MR and Geneva applicators were approximately 20 minutes and 15 minutes, respectively, whereas the library-based reconstruction approach reduced these times to 13 minutes and 10 minutes, corresponding to a planning time reduction of about 30–40%.

Discussion

The mean dose differences between manually reconstructed and library-based reconstructed plans for point A and HR-CTV D90% were well within the 3% dose variation, and for OAR 2 cc doses, they remained comfortably within the 3–5% dose criteria.

For ICRU point B, PIBS, and vaginal dose points, the mean dose discrepancies were all below the 5% limit. Statistical evaluation confirmed that the data followed a normal distribution by-Shapiro–Wilk test, and both the paired t-test ($p < 0.05$) and Bland–Altman analysis (95% data points lie in limit of agreement) indicated clinically acceptable agreement between the two reconstruction techniques.

Conclusion

Library-based applicator reconstruction achieves dose distributions comparable to those of manual reconstruction while markedly shortening planning time. This approach can be reliably implemented in a high-throughput brachytherapy setting and enhances both planning efficiency and reproducibility.

Analysis of Breakdown Issues of the Bhabhatron-II TAW Over Three Years and Preventive Actions Implemented.

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Objectives and Background: To analyze breakdown patterns of the Bhabhatron-II over a three-year period and evaluate corrective and preventive measures implemented to reduce downtime. Reliable functioning of telecobalt units is essential to ensure uninterrupted radiotherapy services. Machine breakdowns can compromise treatment schedules, increase patient backlog, and affect treatment accuracy.

Material and Methods: A retrospective review of machine logbooks, service reports, and QA records over three consecutive years was conducted. Breakdowns were categorized into jaw calibration, mechanical faults (couch/collimator), software/control system failures, field light issues, laser alignment problems, LMOS/interlocks, and natural causes. Frequency and cumulative downtime were calculated. Root cause analysis guided corrective interventions.

Results: Software/control system failures contributed the highest cumulative downtime (34 hours). Mechanical issues were most frequent (11 occurrences; 8.5 hours). Jaw calibration errors occurred 10 times (11 hours). Field light issues resulted in 4 hours downtime. A single external electrical failure caused an 8-day treatment interruption.

Discussion: Jaw field size verification was incorporated into the daily QA schedule, and vendor-supported interlocks were requested. The old console computer was replaced following repeated software/hardware failures. Mechanical issues were minimized through structured preventive maintenance. Field light blurring was controlled by scheduled cleaning of the Perspex sheet every 15 days. The laser system was replaced and an additional new laser installed to improve alignment reliability.

Conclusion: Structured QA reinforcement, timely hardware upgrades, and systematic preventive maintenance significantly reduced recurrence of breakdowns and improved machine reliability and patient safety.

Keywords: Bhabhatron-II TAW, Quality assurance; Preventive maintenance; Downtime analysis, Breakdown Issues

Evaluation of Effective Radiation Dose from CT Examinations with Respect to Reference Dose Levels (from U.S. standards)

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Aim

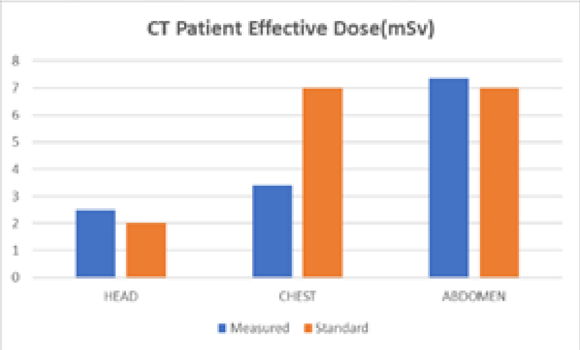
This study aimed to calculate the effective radiation dose received by patients undergoing routine computed tomography (CT) examinations and to compare the estimated doses with established National Diagnostic Reference Levels (DRLs) of the U.S. to evaluate dose optimisation and patient safety.

Materials and Methods

This observational study included a total of 200 patients from all age groups who underwent routine CT examinations of various anatomical regions. All scans were performed using a Siemens SOMATOM Drive CT scanner. Commonly examined regions included the head, chest, abdomen, and combined studies, following standard clinical protocols.

Radiation dose data were collected directly from the CT console after each examination. The dose–length product (DLP) was recorded as the primary dose descriptor. Effective dose was calculated by product of the recorded DLP values with appropriate region-specific conversion coefficients (k-factors). The calculated effective doses were analysed statistically to determine mean values and variations across different examination types. These values were then compared with available national DRLs of U.S. to assess compliance with recommended dose standards and to identify variations in patient exposure.

Result



The calculated effective doses from routine CT examinations showed variations across different anatomical regions but were largely within the recommended Diagnostic Reference Levels. The study highlights the importance of regular dose assessment and comparison with DRLs for optimizing CT protocols. Continuous monitoring of radiation doses, along with protocol standardization and staff awareness, can help minimize patient exposure while maintaining diagnostic image quality, thereby supporting the ALARA principle in clinical practice.

Discussion : The findings of this study shows a minor variations with previously published studies on national diagnostic Reference level from U.S.. Similar investigations have reported that effective dose varies with anatomical region, scan parameters, and protocol optimization. The International Commission on Radiological Protection (ICRP), American Collage of Radiology (ACR), and the American Association of Physicists in Medicine (AAPM) recommend the use of Diagnostic Reference Levels as benchmarks for dose optimization rather than strict limits or constrains.

The effective doses observed in this study were largely within recommended DRLs, and for minor variations further optimization of doses is required, indicating acceptable dose performance of the Somatom Drive CT scanner. Nevertheless, observed dose variations emphasize the importance of regular dose audits, protocol optimization, and adherence to the ALARA principle.

The effective doses estimated in this study were compared with national Diagnostic Reference Levels from U.S. Measured reference values cannot be used as Indian national benchmarks, as reference values represented is national standards for U.S. As the DRL is an investigational level that applies to an easily measured quantity using a standard phantom or representative patient They are established both regionally and nationally, and considerable variations have been seen across both regions and countries. Hence it is important to develop a national standard Diagnostic Reference leve, and optimize the dose to the national or regional standard levels.

For head CT examinations, the Measured and reference effective doses were 2.5 mSv and 2 mSv, respectively. Chest CT showed a higher variation, with Measured reporting a lower reference value (3.41 mSv) compared to reference (7 mSv), reflecting differences in protocol practices. . For abdominal CT, comparable reference values were observed (7.36 mSv for measured and 7 mSv for reference). Most effective doses in this study were within these reference ranges, indicating acceptable dose optimization on the Somatom Drive CT scanner.

Conclusion

This study demonstrates that the effective doses from routine CT examinations performed on the Siemens Somatom Drive CT scanner were generally within recommended national and international Diagnostic Reference Levels, indicating appropriate radiation dose management. Minor dose optimization may further enhance patient safety without compromising diagnostic image quality. Regular assessment of patient radiation dose and systematic comparison with established DRLs are essential for identifying variations in exposure and improving protocol performance. Continuous dose monitoring, protocol standardization, and adherence to the ALARA principle remain fundamental to maintaining effective radiation protection practices in clinical CT imaging.

First Clinical Experience in Total Skin Electron Irradiation: Power of Knowledge Sharing

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Background: Total Skin Electron Irradiation (TSEI) is a specialized radiotherapy technique used primarily for cutaneous T-cell lymphoma, particularly Mycosis Fungoides. Its implementation requires complex dosimetric commissioning and infrastructure, often limiting availability in low-resource settings. This study reports the first clinical implementation of TSEI in Kenya and highlights the impact of structured knowledge transfer.

Materials and Methods: TSEI was commissioned using a 6 MeV high-dose-rate electron beam from an Elekta Infinity linear accelerator. An extended source-to-surface distance (SSD) of 350 cm was adopted following the Stanford technique. A 1.2 cm acrylic beam spoiler was positioned 30 cm from the patient to enhance surface dose and improve beam uniformity. Comprehensive dosimetric evaluation included central-axis percentage depth dose (PDD), horizontal and vertical profile measurements, optimal gantry tilt determination, correction factor estimation (Factors A and B), and X-ray contamination assessment. In-vivo dosimetry and quality assurance procedures were incorporated before clinical delivery.

Results: Optimal gantry tilt angles were identified at 73.5° and 106.5°. Beam uniformity was maintained within ±10% horizontally and ±8% vertically at extended SSD. The degraded beam energy corresponded to approximately 4 MeV (R50-based), suitable for superficial disease. Factor A was 1.01 and Factor B was 0.93, consistent with established TSEI protocols. X-ray contamination was 2.8%, below recommended limits. Nine patients with Mycosis Fungoides received 36 Gy in 18 fractions. Acute toxicities were limited to Grade 1–2 skin reactions, and early clinical responses were encouraging.

Conclusion: TSEI can be safely and effectively implemented in resource-constrained environments through structured commissioning, robust quality assurance, and international knowledge-sharing partnerships. This experience provides a practical model for expanding advanced radiotherapy techniques across the African continent.

Preliminary Evaluation of Setup Errors using Offline Review- A Positional Observation Study of Pelvic Cases

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Introduction: Pelvic cancer treatments are particularly sensitive to internal organ motion, and even with proper setup techniques, small inter-fraction variations are expected and clinically acceptable within tolerance limits. The aim of this study is to evaluate the inter-fraction setup variations in pelvic patients using on-board daily image guidance (IGRT modality) and to calculate appropriate Planning Target Volume (PTV) margins using the Van Herk formula. This is done to cross-verify the clinical practice based on actual patient data.

Materials and Methods: Setup error data were collected for 12 patients undergoing external beam radiotherapy using IGRT by weekly kV-CBCT. Translational and rotational deviations were recorded. Residual errors were calculated after correction. Systematic error (Σ) and random error (σ) were derived from the observed data. The PTV margin was calculated using the Van Herk formula ($2.5\Sigma + 0.7\sigma$) for each translational direction. While online image review during daily setup allows immediate correction of translational and rotational deviations, it reflects only that particular fraction. But Offline Review provides a more comprehensive platform to evaluate cumulative setup trends across multiple fractions. Through offline review, clinicians can assess systematic shifts, identify consistent directional deviations, and apply clinical judgement when deciding whether margin adaptation or protocol modification is necessary.

Results & Discussion: The present analysis of 12 pelvic cases shows that even with IGRT, measurable setup variations are present. Observed deviations can be reasonably attributed to factors such as day-to-day variation in bladder filling, rectal distension, patient relaxation status, weight changes during the treatment course, and slight differences in immobilization reproducibility. The calculated systematic and random errors in this study remain within acceptable radiotherapy practice standards as mentioned in ICRU 62 guideline, supporting the adequacy of current setup protocols.

Axis	Vertical	Longitudinal	Lateral
Σ (cm)	0.184	0.346	0.134
σ (cm)	0.300	0.642	0.165
Margin (Van Herk Formula) (cm)	0.670	1.313	0.449

Systematic and random components both contribute to overall uncertainty. The calculated margins highlight the importance of analyzing institution-specific data rather than relying only on standard textbook margins. Continuous monitoring of setup deviations can help in optimizing margins without compromising target coverage. Therefore, regular offline review by clinically qualified personnel for each patient is essential to confirm that treatment is being delivered accurately and consistently throughout the course. Thus, decision-making is not purely machine-driven but also clinically supervised. Margin decisions are not based solely on single-day observations but on cumulative treatment data.

Conclusion: Based on the observed data and margin analysis, the treatment setup performed by the radiation technologists is proper and within tolerance with respect to ICRU 62 guideline, but according to the Van Herk formula, the margins should be increased to achieve accurate treatment. Thus, to achieve this, we need to gain the confidence by periodic assessments like offline review. The deviations observed can be due to positional variability in pelvic cases and inter-observer variations. This result can be biased due to lack of samples and the practical limitations in correcting rotational errors with 3D couch therefore, more samples should be collected to justify the need for the increase in margin as observed.

Comprehensive evaluation of static and dynamic MLC performance and delivery synchronization for RapidArc VMAT

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Aim

To evaluate multileaf collimator (MLC) positional accuracy, leaf speed modulation, and dose rate–gantry speed synchronization for RapidArc VMAT delivery on a TrueBeam linear accelerator as part of routine quality assurance.

Introduction

RapidArc VMAT combines continuous modulation of MLC positions, gantry speed, and dose rate to deliver highly conformal treatments efficiently. Because of this complexity, routine QA is essential to ensure mechanical precision and dosimetric accuracy. This study evaluates static and dynamic MLC performance, leaf speed modulation, and dose rate–gantry synchronization on a TrueBeam linear accelerator using Varian's standardized QA tests and EPID-based analysis, with tolerances referenced to AAPM TG-142 and RapidArc QA criteria.

Materials and Methods

Rapid Arc QA procedures were performed using Varian test plans including DMLC dosimetry (Test 0.1), static picket fence versus gantry angle (Test 0.2), dynamic picket fence during gantry rotation (Test 1.1), intentional error detection (Test 1.2), dose rate–gantry speed modulation (Test 2), and leaf speed control (Test 3). EPID-based image analysis with defined ROIs was used for quantitative evaluation. Tolerances were referenced to AAPM TG-142 (MLC positional accuracy ±1 mm) and Varian Rapid Arc QA procedural criteria (Δ% <3%, average absolute deviation <1.5%).

Results

DMLC dosimetry showed output variation within ±0.36% across gantry angles (0°, 90°, 180°, 270°), well within the ±3% tolerance. Static picket fence analysis demonstrated MLC positional accuracy of 0.23–0.24 mm at all gantry angles, satisfying the 1 mm criterion. During gantry rotation, dynamic picket fence accuracy was 0.46 mm, confirming stable MLC performance under rotational conditions. Intentional 0.5 mm leaf errors were clearly detectable, validating test sensitivity.

Conclusion

All evaluated parameters met established tolerance criteria, confirming accurate static and dynamic MLC performance, reliable dose rate–gantry synchronization, and robust VMAT delivery. The QA results validate the mechanical precision and dosimetric integrity of RapidArc implementation for clinical VMAT treatments at our institution.

Beyond Conventional Planning: Assessing the Role of Hybrid Techniques in Left-Sided Breast Radiotherapy

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Aim and Background:

Breast cancer remains the most common malignancy among women worldwide, with nearly 2.3 million new cases reported in 2022, and a substantial proportion occurring below 50 years of age. In India, the disease presents at a relatively younger age compared to Western populations. Reflecting this trend, our institute treated 103 breast cancer patients aged 27–63 years(median-48) in the past year. Radiotherapy is a cornerstone of breast-conserving treatment; however, left-sided breast irradiation presents significant Dosimetric challenges due to the proximity of the heart and ipsilateral lung, potentially increasing long-term cardiovascular morbidity. This study aimed to compare three-dimensional conformal radiotherapy (3DCRT), Volumetric modulated arc therapy (VMAT), and Hybrid-VMAT techniques to determine the optimal Dosimetric approach for left-sided breast cancer.

Materials and Methods:

This retrospective study included twenty patients with left-sided breast cancer. For each patient, three treatment plans—3DCRT, VMAT, and Hybrid-VMAT (70% dose contribution from 3DCRT and 30% from VMAT)—were generated using the Eclipse Treatment Planning System for delivery on a TrueBeam linear accelerator. All plans were prescribed 40.05 Gy in 15 fractions according to established hypofractionation protocols.

Plan evaluation metrics included Homogeneity Index (HI), Paddick Conformity Index (CI), and Monitor Units (MU). OAR parameters assessed for the ipsilateral lung included V5Gy, V10Gy, V20Gy, and mean dose (Dmean). Cardiac evaluation included V5Gy, V10Gy, V20Gy, V25Gy, V30Gy, and Dmean. Contralateral lung assessment included V5Gy. Dose–volume histograms (DVHs) were analyzed to evaluate PTV coverage, dose homogeneity, conformity, and OAR sparing.

Results:

Hybrid-VMAT achieved superior dose homogeneity (HI = 0.175) compared to VMAT (0.180) and 3DCRT (0.216). VMAT demonstrated the highest conformity (CI = 0.945), followed by Hybrid-VMAT (0.87) and 3DCRT (0.618). Monitor Units were highest with 3DCRT (839 MU) and lowest with VMAT (614 MU).

In terms of OAR sparing, VMAT reduced high-dose exposure to the ipsilateral lung (V20Gy: 23.15% vs 28.87% for 3DCRT) but significantly increased low-dose spread (V5Gy: 76.15% vs 46.83%). The mean heart dose was lowest with 3DCRT (7.13 Gy), followed by Hybrid-VMAT (7.72 Gy), and highest with VMAT (11.13 Gy). Low-dose cardiac exposure (Heart V5Gy) was also highest with VMAT (49.39%) compared to 24.72% with 3DCRT. Contralateral lung V5Gy was markedly elevated with VMAT (43.12%) compared to 3DCRT (4.27%) and Hybrid-VMAT (2%). Hybrid-VMAT demonstrated intermediate OAR doses while maintaining improved PTV coverage.

Conclusion:

VMAT provides superior target conformity and improved high-dose lung sparing; however, it is associated with increased low-dose exposure to the heart and contralateral lung. 3DCRT minimizes low-dose spread and achieves the lowest mean heart dose. Hybrid-VMAT offers a balanced approach by improving dose homogeneity while limiting excessive low-dose bath. Selection of radiotherapy technique for left-sided breast cancer should prioritize long-term cardiac protection alongside optimal target coverage.

A Comparative In Vivo Study of Contralateral Breast Dose During 3D-CRT, IMRT, and VMAT Using Thermo-luminescent Dosimetry

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Aim:
Breast cancer is the most common malignancy worldwide, with a rising incidence among younger women. At our institute, 103 patients were treated last year, with a median age of 48 years (range: 27–63 years). Modern radiotherapy techniques such as 3D-CRT, IMRT, and VMAT may influence peripheral dose to the contralateral breast (CLB), which is clinically relevant due to the potential risk of radiation-induced secondary malignancy—particularly in younger patients with longer life expectancy. This study quantitatively evaluated CLB surface dose using thermos-luminescent dosimetry and serves as a preliminary study for estimating secondary cancer risk and improving long-term treatment safety.

Materials and Methods:
A humanoid anthropomorphic phantom was positioned in the treatment setup to accurately simulate clinical breast radiotherapy conditions. Verification plans for 3D-CRT, IMRT, and VMAT using a 6 MV photon beam were generated and delivered on a Varian Medical Systems TrueBeam linear accelerator to replicate patient treatment.
During irradiation, the out-of-field dose to the contralateral breast was measured at five predefined surface points using $CaSO_4$: Dy TLD discs. Prior to measurement, the TLDs were calibrated under standard reference conditions and evaluated for reproducibility, linearity, and homogeneity to ensure accuracy. The discs were read 24 hours post-irradiation, and only qualified TLDs were used for dose analysis.

Results:
All three radiotherapy techniques produced measurable out-of-field dose to the contralateral breast (CLB). The highest surface dose was observed with VMAT (578.65 cGy), followed by IMRT (396.09 cGy) and 3D-CRT (312.94 cGy). The increased peripheral dose in modulated techniques is likely due to higher monitor units, greater beam modulation complexity, head leakage, and increased patient scatter.

Conclusion:

Contralateral breast surface dose varies according to the radiotherapy technique, with higher exposure observed in VMAT and IMRT compared to 3D-CRT. This finding is particularly relevant for younger patients, as minimizing peripheral dose may help reduce the risk of radiation-induced secondary malignancy. The study also suggests that Treatment Planning Systems (TPS) may underestimate out-of-field surface dose. Further dosimetric investigations are warranted to validate these findings and to more accurately estimate secondary cancer risk. Based on patient age and long-term risk considerations, careful selection or modification of treatment modality like the hybrid techniques or FFF beam may help reduce potential risks in younger patients.

Dosimetric Evaluation of TLD-100 Chips and Rods for Flattened and Flattening-Filter-Free Photon Beams

Nainsy Singhal

Purpose:
The increasing clinical use of flattening filter free (FFF) photon beams requires reliable dosimetric tools capable of accurate response under high dose-rate conditions. This study aims to evaluate the dosimetric characteristics of TLD-100 chips and rods for megavoltage photon beams delivered using flattened and FFF beammodalities.

Materials and Methods:.

Commercial LiF:Mg,Ti TLD-100 chips and rods were used in this study. All dosimeters were annealed using a standardized annealing protocol. Individual element correction coefficients (ECCs) using TLD reader were determined to correct for intrinsic sensitivity variations. Irradiations were carried out using a solid-water slab phantom with dosimeters placed on the phantom surface and adequate backscatter material. The TLDs were irradiated at a source-to-surface distance of 100 cm, a 10 × 10 cm^2 field size, and 0° gantry angle. Measurements were performed using 6 MV flattened beams and 6 MV FFF beams from TrueBeam and 6 MV FFF beam from halcyon linear accelerators. Evaluations include dose linearity, reproducibility, batch homogeneity, energy dependence, angular dependence, dose-rate dependence, and fading characteristics.

Results:
Preliminary findings demonstrate consistent ECC distributions for TLD-100 chips and rods indicating acceptable intrinsic sensitivity uniformity. Initial measurements show stable thermoluminescent response under megavoltage photon irradiation for both flattened and FFF beams. Detailed quantitative analysis of beam-dependent and geometric response characteristics is currently ongoing.

Conclusion:
This study will provide a comprehensive dosimetric assessment of TLD-100 chips and rods under clinically relevant flattened and FFF photon beam conditions. The results are expected to support their application in routine radiotherapy quality assurance, particularly for modern high dose-rate FFF beam delivery.

Estimation of institutional PTV margin for radio therapy of pelvic cancer using electronic portal imaging device

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Introduction

Radiotherapy For Pelvis Cancer Requires Accuracy Of Radiation Dose Delivery To Target Volume.Set Up Reproducibility In The Pelvic Area Is Particularly Important Due To Proximity Of Many Critical Organs. The Introduction Of New Technology Such As Imrt/3dcrt Poses Now Challenges For Delivering Maximum Target Dose While Minimizing Dose And Toxicities To Critical Normal Structure.Appropriate Margins To Account Of Treatment Uncertainties Are Necessary For Target Coverage This Envelope Around The Ctv(Clinical Target Volume)Is Known As The Ptv (Planning Target Value).Inadequate Ctv – To Ptv Margin Bill Result In Geometrical Miss At Some Or Even All Treatment Fraction. The Commonest Method Of Setup Verification Is Comparison Between Drr (Digitally Recontructed Radiograph) Images & Portal Images From Epid (Electronic Portal Imageing Device).The Aim Of Our Study Was To Determine Institution Specific Ctv- To - Ptv Margin For Conformal Radio Therapy In Pelvis Cancers.

Method and Materials

Study Period = September 2021to March 2023

Translational Shift Data Was Collected From 35 Pelvic Cancer Patient Treated By Conformal Radio Therapy On Electra Compact 6 Mv Linear Accelerator. All Patient Had Undergone Treatment Planning Based On Computerized Tomography (Ct) Images On The (Tps)Treatment Planning System .Weekly Portal Images Of Ap-Pa & Lateral Setup Field Were Taken For Each Patient Using Video Based Epid.These Images Were Matched With Corresponding Drr Images From Treatment Planning System Using The Tps (Elekta).

Result

A Total Of 141 Values Each Of X Lateral And Z (Anterior Posterior)Shifts And 282 Values Y (Craniocaudal) Shift Were Taken .Respective Systematic Error(Sigma)Were X =1.96 Y=1.43 Z= 1.28 And Rendom Errors (Ro) Were X=2.28 Y= 1.47 Z =1.43. Ptv Margins (In Mm) Derived From Van Herk, S Formula(2.5sigma +0.7ro) Are X= 6.51 Y= 4.61 Z =4.23.

Portal Imaging Analysis by Anatomical Matching

- Before Collecting the Patient Data the Image Quality / Image Quality Control Software Work Properly Calibrated
- The Image Work Collected In Antero-Posterior & Lateral Direction For Both Simulator (Drr) & Epid
- Pre-Specified Anatomical Reason Matching Was Used To Verify The Accuracy/ Deviation Of Both Of The Images
- Anatomical Innotation Of Prominent Bony Structure Was Used Symbiosis, Pubis,Cacrum & Coccyx Vertebra (For Lateral Image) & Pelvic Inlet Obturator Foramen & Ischium Bone (For Interior Images)

Discussion

- Σ (Systemic Error)= Standard Deviation (Sd) Mean Errors Of Entire Patient Population & σ (Random Error)=R.M.S Of S. Ds Of Errors Of Entire Patient Population
- Ven Herk Formula Is For A Large Ctv With Smooth Margin Penumbra=5mm & Meant To Ensure The Probability That 90% Of Patients Must Get Minimum Ctv Dose At 95%
- Formula Will Be Different For Small Ctv Dose Prescription At Different Isodose (Rather Then 95%) & Also Different Beam Penumbra
- Since The Formula Is Based On Probability And Derived From Population Statistics, It May Over Or Under Estimate The Ptv Margin For A Given Patient On A Given Day.
- There Is Significant Change In Volume / Shape Of C T V & Weight Loss Of The Patient During Total Treatment Duration & This Also Needs To Be Considered For Determining Ptv
- Epid-Drr Matching Is Based On Skeletal Anatomy Only For An Accurate Idea Of How Set Up Variation Effect The Target & Oars(Which Are All Soft Tissues)3d Imaging (Cone Beam Ct) Would Be Necessery
- While Rotational Errors Can Be Determined By Epid It Is Not Possible To Correct The Same Accurately Without A Special Six Degree Of Freedom Couch.

Conclusions

In This Study The Population Based Margin Was Less Than 5 Mm For Horizontal & Vertical Position 7 Mm For Lateral Position. Thus The Margin Provides Sufficient Coverage For All The Patients. However Determination Of Setup Variation As Described Above Allows More Confidence In Deciding Upon An Institution Specific Ctv-To-Ptv Margin For Pelvic Cancer Patient

Determining End-of-Life of Radiation Generating Equipment Using Bathtub Curve–Based Reliability Analysis: An Institutional Study

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Aim/Objective

Accurate determination of end-of-life (EOL) for radiation generating equipment is critical for maintaining clinical efficiency, patient safety, and optimal resource utilization. In this institutional study, breakdown and maintenance data of CT and clinical linear accelerators were analysed and correlated with the Bathtub Curve model to develop a reliability-based framework for EOL assessment.

Material and Methods

Failure trends demonstrated a characteristic Bathtub Curve pattern, with an initial phase of early failures, followed by a prolonged useful life with stable performance, and a final wear-out phase marked by increasing breakdown frequency. Ageing systems showed a progressive decline in performance with the appearance of downtime clusters, defined as repeated failures occurring within short time intervals. These clusters served as early indicators of transition from useful life to wear-out phase.

Reliability indicators were calculated from maintenance logs. Mean Time Between Failures (MTBF = Total operating time/Number of failures) showed a declining trend in ageing systems, while Mean Time to Repair (MTTR = Total downtime/Number of repairs) increased due to spare-part scarcity and system complexity. System availability $A = MTBF/(MTBF + MTTR)$dropped below the acceptable threshold of 95% in systems nearing EOL. When annual maintenance expenditure exceeds approximately 15% of the current replacement value, the equipment is considered to have reached its economic EOL or Vendor declares the end of support (due to non-availability of spare parts or is considered as EOL).

Discussion & Conclusion

Correlation of downtime clustering, reliability metrics, and Bathtub Curve analysis provides a practical, data-driven method for determining EOL of radiation generating equipment and supports proactive replacement planning and lifecycle management.

Although Bathtub Curve–based reliability analysis helps identify the wear-out phase through declining MTBF, increasing MTTR, reduced availability, and downtime clusters, End-of-life (EOL) cannot be decided on reliability data alone.

From the vendor perspective, EOL may occur when manufacturer support ends due to non-availability of spare parts, discontinued service support, or lack of software and cybersecurity upgrades. From the organisational perspective, management decisions based on patient satisfaction, operational efficiency, maintenance cost, and institutional brand value define the economic end-of-life.

Hence, EOL determination should integrate reliability trends, vendor support status, and organisational priorities for safe, efficient, and sustainable radiology operations.

Keywords: Bathtub curve, end-of-life, downtime clusters, radiology equipment, MTBF, MTTR, availability, reliability analysis, lifecycle management.

Comparison of Dosimetric Leaf Gap measured Using Various Detectors for IMRT and VMAT Applications

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Purpose: Accurate modelling of multileaf collimator (MLC) parameters in treatment planning systems (TPS) is critical for reliable dose calculation in intensity-modulated radiation therapy (IMRT) and volumetric-modulated arc therapy (VMAT). The dosimetric leaf gap (DLG) is a key parameter used to account for the rounded leaf-end geometry of MLCs.

Methods: A series of dynamic sliding-window MLC gap fields with varying gap widths of 2 mm, 4 mm, 6 mm, 10 mm, 14 mm, 16 mm, and 20 mm were delivered on a TrueBeam linear accelerator equipped with millennium MLC for all available photon energies. The sweeping gap field moves from -60 mm to +60 mm at a constant speed to deliver 100MU at 400MU/min dose rate. Measurements were performed using various calibrated PTW ionisation chambers and diode detector in a water phantom in two SAD setup (SSD=95 cm, depth=5cm and SSD=90 cm, depth=10cm). DLG values were derived by linear extrapolation of corrected detector signal versus nominal gap width. The agreement between various detector–derived DLG values was quantified.

Results: A strong linear relationship was observed between corrected detector signal and MLC gap width for all detector measurements ($R^2 > 0.99$). The DLG values obtained using various detector are within sub-millimetre accuracy with maximum deviation of 0.058 mm for SSD=95 cm, depth=5cm and 0.038 mm for SSD=90 cm, depth=10cm). The DLG values for SSD=90 cm setup is higher than SSD=95 cm due to scattering.

Conclusion: DLG determination using various detectors are within sub-millimetre accuracy. Thus, any of the detector can be used for DLG measurements, with negligible impact on clinical dose calculation accuracy that will be incorporated in further studies.

Keywords

Dosimetric Leaf Gap, Multileaf Collimator, Ionisation Chamber, diode detector, IMRT, VMAT

Automated Quantitative Evaluation of CT Image Quality Parameters Using Catphan 504 Phantom: A Comparative Analysis of Pylinac and radiochromic.com Software

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Introduction: Computed Tomography (CT) is vital for radiotherapy treatment planning (RTP), necessitating high image quality for effective anatomical visualization and dose calculations. Routine quality assurance (QA) ensures consistent imaging performance, with phantom-based QA assessing key parameters like CT number accuracy, spatial resolution, low-contrast detectability and image uniformity. The Catphan 504 phantom is commonly used for this purpose, allowing evaluation of multiple parameters in one scan. This study analyzed the CT image quality obtained from the Catphan 504 using Pylinac and Radiochromic.com software.

Materials and Methods: CT images of the Catphan 504 phantom were obtained using a clinical CT scanner for RTP, ensuring accurate positioning with a laser system. The DICOM dataset was analyzed on two software platforms: Pylinac (version 3.38.0) implemented in Pycharm Environment and radiochromic.com (version 6.05). Pylinac identified and evaluated four modules such as CTP404 for CT number linearity, CTP486 for image uniformity, CTP528 for spatial resolution (MTF calculations), and CTP515 for low-contrast detectability. The analysis from radiochromic.com provided automated phantom detection and parameter extraction. Results were compared against American College of Radiology (ACR) CT quality assurance guidelines' tolerance limits.

Results and Discussion: The CT image quality assessment of the Catphan 504 CT Phantom was performed using Pylinac and radiochromic.com Software to evaluate HU linearity, geometric accuracy, spatial resolution, low-contrast detectability, and image uniformity. In CTP 404. HU linearity results obtained are shown in the table below.

Module	Parameter (HU)	Expected value & ACR Tolerance (HU)	Pylinac Result (HU)	Radiochromic software Results (HU)
CTP404	Air	-1000 ±40	-999	-929.4
	PMP	-196 ±40	-196	-178.8
	LDPE	-104 ±40	-104	-101.1
	Polystyrene	-47 ±40	-49	-50.9
	Acrylic	115 ±40	114	106.7
	Delrin	365 ±40	342	327.9
	Teflon	1000 ±40	957	894.5

The linearity failure in Teflon may be due to beam hardening effects and calibration limitations when imaging high-density materials. For the CTP528 spatial resolution module, the measured MTF50 was 0.43 lp/mm, which is below the recommended ≥0.6 lp/mm, indicating reduced spatial resolution can be due to reconstruction kernel smoothing or detector and focal spot limitations of the CT system. In the CTP515 low-contrast module, five cylinders were visible in the supra-slice contrast evaluation by Pylinac and three in radiochromic.com software, satisfying the minimum requirement of ≥3 objects. This variation can be the result of automated detection algorithms and contrast threshold sensitivity. The CTP486 uniformity module showed a center value of 2 HU, while peripheral ROIs ranged between −13 HU and −15 HU, exceeding the allowable ±5 HU deviation from the center. This non-uniformity may occur due to beam hardening, scattered radiation, or detector response variation across the imaging field.

Automated Classification of Metaphase Images for Dicentric Chromosome Analysis Using Deep Learning

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Aim/Objectives

Dicentric Chromosome Assay (DCA) is a gold standard biodosimetry method for evaluating the exposure of ionizing radiation. According to the International Atomic Energy Agency (IAEA), only well-spread metaphase images without overlapping chromosomes were considered scorable for accurate dicentric chromosome assessment, whereas non-scorable images are those with fewer than 45 or more than 48, unclear centromeres, chromosomes too long or too short, unclear boundaries of chromosomes, or tangled or heterogenous chromosome characteristics (size, shapes, or colours). Manual selection of scorable metaphase is time-consuming, labour-intensive, and dependent on expert interpretation, which limits throughput during large-scale radiation emergencies. In this study, we developed and evaluated deep learning-based models for the automated classification of scorable and non-scorable metaphase images.

Material and Methods

A dataset of 510 Giemsa-stained human peripheral blood metaphase images were collected and separated into two classes, scorable and non-scorable, based on IAEA scoring guidelines. The images were divided randomly into training (323), validation (100), and test (87). The present study used two deep learning architectures, ResNet50 and the YOLOv8 classification model, which were implemented using transfer learning. Performance of the models was evaluated on the test set using standard classification metrics, including accuracy, precision, recall, F1-score, and confusion matrix analysis.

Results and Discussion

In the test data set (n = 87 images), the ResNet50 model shows an overall accuracy of 71%. The macro-averaged precision, recall, and F1-score were 0.72, 0.72, and 0.71. Overall YOLOv8 classification model accuracy was 83%. The macro-averaged precision, recall, and F1-score were 0.86, 0.81, and 0.82, respectively. Comparative analysis indicates that YOLOv8 achieved higher overall accuracy and macro-averaged F1 score compared to ResNet50. These findings indicate that deep learning models, particularly YOLOv8, can effectively support automated metaphase image classification and may enhance the efficiency and scalability of DCA-based biodosimetry.

Conclusion

This work demonstrates the feasibility of incorporating deep learning approaches for automated classification of scorable and non-scorable metaphase images for dicentric chromosome analysis based on IAEA guidelines. The YOLOv8 model outperformed ResNet50 and shows strong potential for integration into automated biodosimetry systems. Further validation with larger and multicentre datasets will strengthen its applicability for routine radiation emergency response.

Key words: Dicentric chromosome assay; Biodosimetry; IAEA guidelines; Deep learning; ResNet50; YOLOv8; Metaphase image classification; Radiation exposure; Cytogenetics; Automated image analysis

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